Weather Instruments

Handbook

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Contents

1. Stevenson Screen

The Stevenson screen was invented by Thomas Stevenson Its main purpose is to allow the cold and warmth of the temperature to penetrate whilst preventing direct sunshine, wind or rain. This is done by having louvered sides, and a double roof. It is painted white so that it reflects the direct heat of the sun. Readings should always be taken in the shade.

1.1 Location

The ideal location is one where the distance from any object is 2.5 to 3 x the height of the nearest tree or building. This means that the trees or buildings will not act as a shield, making the measurements unrepresentative. This is the same for the Stevenson screen and the rain gauge.

1.2 Height of the Stevenson Screen

The stand of the Stevenson screen should be set in the ground so that the bulbs of the thermometers are at approximately 1.2m (120cm) to 1.5m (150cm) above the ground.

1.3 Underneath the Stevenson Screen

The surface under the Stevenson screen should reflect the local environment. As grass is the norm in the Zimbabwe most of the weather boxes here are on and surrounded by grass. However, if the norm is bare earth, then bare earth should be under the Stevenson screen.

1.4 Security

It is better to compromise the quality of the weather data collected than risk the damage of equipment by unwelcome visitors. One of the best places in schools is a fenced weather station area. This affords some protection from outsiders. Some weather instruments can be quite expensive and need to be kept secure. You may want to put a padlock on the Stevenson screen door to stop anybody resetting the instruments or tampering with them.

1.5 Using the Stevenson Screen

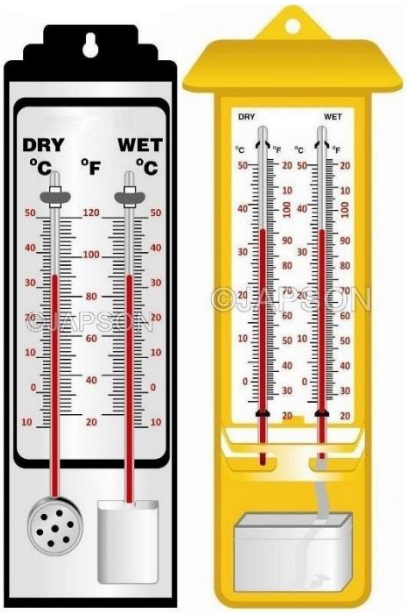
The door of the screen should face south so that when it is opened the sun does not shine directly on the instruments. (This relates to weather stations in the southern hemisphere). When weather monitors want to look at the instruments, they should gently open the doors. Rough handling can cause the instruments to give false readings.

1.6 Maintenance

The Stevenson need to be washed with water or wet cloth once every three months and needs to be repainted when paint wears off.

2. Dry and Wet Bulb Thermometers

An ordinary thermometer is constructed of a glass tube containing a liquid such as mercury or spirit. As the temperature containing a liquid expands and as the temperature falls the temperature rises, thereby changing the length of the column of liquid which can be seen in the tube.



2.1 Thermometer scales

A scale on the thermometer stem indicates the temperature, which can be measured in degrees Celsius (0c), Kelvin (K) sometimes referred to as degrees Absolute (A) and Fahrenheit (f). The Celsius scale: In the Celsius scale, the temperature of boiling water is 100 and the freezing point 0.

2.2 The dry bulb thermometer

The dry bulb thermometer does not normally go wrong and will give accurate readings for many years provided that it is kept clean. In very wet weather it is possible that some water may collect on the bulb. If it does the water must be carefully wiped off before a reading is taken. If this has to be done or the thermometer has to be cleaned it must be done at least ten minutes before an observation is made.

2.3 The wet bulb thermometer

The wet bulb thermometer measures the humidity of the air when the readings taken from it are used with the readings of the dry-bulb thermometer. The humidity air is the amount of water vapour in the air.

The thermometer used for the wet-bulb temperature is the same type as the thermometer used for the dry- bulb temperature. It becomes a wet -bulb thermometer when its bulb is covered by a piece of muslin, which is wrapped around the bulb and secured by strands

of cotton wick. The bulb is kept continuously moistened as the end of the wick dips into a bottle of water which is fed by capillary action to the muslin.

The wet –bulb thermometer usually reads lower than the dry-bulb thermometer. When the air is very dry, it reads much lower, or if there is a thick fog, the wet-bulb and the dry –bulb can read the same temperature. In winter, when the temperature is near or below freezing point (0c) the wet bulb may read higher than the dry bulb. In some circumstances the water on the wet bulb may become frozen and in order to obtain a suitable reading from it, the following procedure is necessary-

2.4 Maintenance of the wet-bulb Thermometer

In order to ensure accurate wet-bulb thermometer readings, observers must pay particular attention to the following points –

Changing the muslin and Wick on the Wet –Bulb Thermometer

Muslin and wick are changed on the wet bulb thermometer every Saturday morning, and also on any other day when the muslin and wick are dirty, as for example, after a windy dusty day. Before changing the muslin and wick and before handling the new supplies, observers must wash and dry their hands

Muslin is supplied in the form of a roll .A piece is cut off about seven-an-a -half centimeters long ,folded into two and dampened with clean water .It is placed around the bulb of the thermometer so that they are two thicknesses of muslin over the bulb Two strands of wick each thirty to forty centimeters long are folded into a loop .This loop is placed over the ,muslin immediately above the bulb and made tight enough to secure the muslin around the bulb .Care must be taken , however, that is not too tight, for this stops the flow of water on to the muslin .The muslin must be carefully trimmed with scissors, so that not too much is left above the bulb on the stem of the thermometer, nor should it be left too short.

Immediately after the, muslin and wick are changed, the new muslin and wick be thoroughly wet; this is achieved by dipping the bulb of the thermometer into the mouth of the constant –level water bottle. The length of wick which dips into the mouth of the bottle must be lightly twisted so that the flow of water to the bulb is maintained. If the wick is allowed to spread, evaporation takes place rapidly from it in dry weather and the bulb is consequently starved of water, leading to incorrect wet- bulb temperatures.

A reading of the wet bulb thermometer should not be made of at least a quarter of an hour after muslin and wick have been changed

Care of the Wet-Bulb Thermometer

The wet bulb thermometer must be examined each time muslin and wick are changed. If a deposit is seen on the bulb, it should be removed by carefully scrapping the bulb with a razor blade. A report of the condition of the wet bulb thermometer is entered in a check Reading and Instrument Report Form.

Water Supply, Wet-Bulb Thermometer

Distilled water should be used for wet-bulb thermometers whenever possible. Where distilled water is not available, sufficient rain water must be collected from the rain gauge, or by placing dishes outside when it is raining .it is the duty of observers sees that enough water is collected to ensure a supply throughout the year.

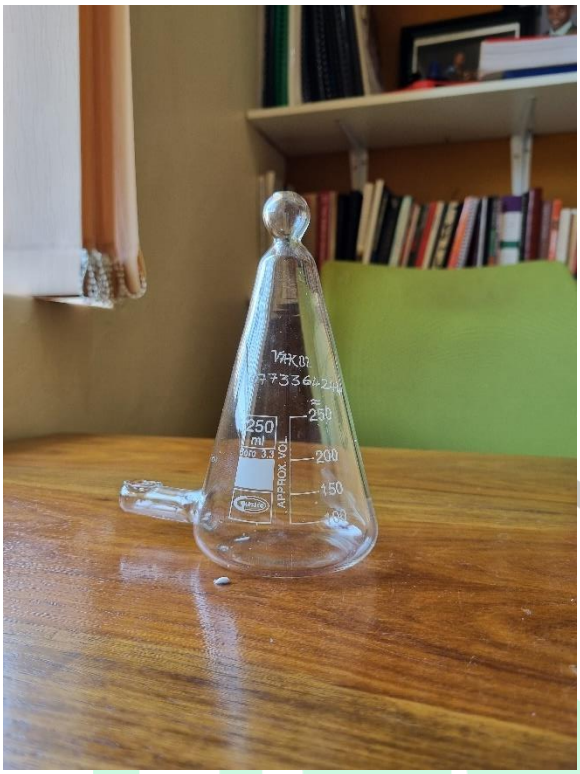
The observer must see that the container collecting rain water is kept clean. The rain water is kept clean. The rain water must be stored in clean, corked bottles. if, some reason, observers have to use other types of water, clean water must be boiled and, if necessary, filtered through cloth , before being used for the wet- bulb .

3. Constant-level Water Bottle

The use of the constant –level bottle ensures that the most accurate wet-bulb recordings are made provided of course that the bulb is kept clean and muslin and wick are changed correctly. The constant-level bottle must not be filled immediately before an observation as this will make the wet-bulb reading change; it will be only filled after an observation, or when muslin and wick are being changed. The constant –level water bottle must be cleaned at the same time as the Stevenson screen is washed, on the last Friday of every month.

In order to clean it, put about 10 strips of newspaper, each about the width of the bottle mouth, into the bottle and half and half fill it with water. Block the opening and shake the bottle vigorously until it is clean, then wash the newspaper out the bottle and rinse the bottle thoroughly before refilling it with the type of water used at the station. Repeat the process with the new strips of newspaper if necessary. If no newspaper is available, use a small quantity of sand instead. Care must be taken to ensure that the bottle is not broken. Nothing must ever be added to the water in the constant –level bottle to prevent the growth of algae, as this will induce incorrect readings from the wet-bulb thermometer.

A note that the bottle has been cleaned must be made on the last page of the Daily Register under “Report on Working of instruments ‘’.



The constant-level water bottle is filled as follows

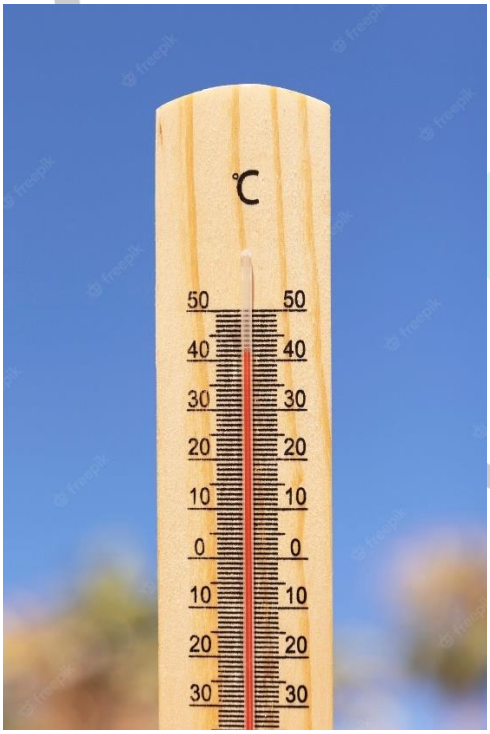
(1) Some distilled water, rain water or boiled water is poured into a clean rainfall measuring glass
(2) The constant-level bottle is taken carefully from the Stevenson Screen.
(3) The bottle is held so that the thumb closes off part of the opening. When holding the bottle, the observe must see that the top of the bottle, marked A in the picture, is sloping downwards
(4) Water is [poured over the top if the thumb until the bottle is full.
(5) When the bottle is held upright again, the water must be higher than the level marked B if it has been correctly filled. When the water drops to the level marked C, it should be filled again.
The bottle, whilst standing upright, can be filed only as far as the level marked D in the diagram. This is insufficient to ensure that the muslin will not dry out between observations
(6) When the bottle is returned to the Stevenson screen, the mouth of the bottle should be about two-and- a- half centimeters below and two –and- a–half centimeters to the side of the thermometer bulb. Care must be taken to see that the wick does

not loop below the mouth of the bottle .If this happens, water drips from the loop, does not reach the muslin, and soon empties the bottle.

4. The Maximum Thermometer

Maximum means highest. The maximum thermometer is used to measure the highest temperature from 08.00B one day to 08.00B the next day. This usually occurs between 13.00B each day, but not always. The mercury in the thermometer rises until it reaches the highest temperature and then stays there due to a constriction in the tube near the bulb.

The glass tube is fixed on to a wooden board which has a metal frame to protect the bulb. The scale is marked in degrees in the same way as on a dry-bulb thermometer. The thermometer is hung on horizontally in the screen and has to be taken out every day to be reset. This means that the mercury must be shaken back into the bulb, so that the highest temperature for the next 24-hour period can be measured.



4.1 Resetting the Thermometer

The thermometer is removed carefully from the screen. The observer then moves well away from the screen and all other obstructions, and holding the thermometer at the end furthest from the bulb, swings it up and down two or three times at arm's length.

He must take the following precautions: -

(I)His coat must be buttoned and there must be nothing heavy in his pockets.
(ii) If it is raining, he must make sure his hands are dry before taking the thermometer out of the screen.
(iii) He must see that he is standing clear of the any object which might break the thermometer when he is swinging it.

After the thermometer has been reset, it must be replaced carefully in the screen, the bulb end being held lower than the other end during replacement.
After resetting the thermometer, the maximum thermometer should show approximate the same reading as the dry bulb thermometer. If this is not so it must be taken from the screen and shaken again. The observer should bear in mind however, that whilst it is out of the screen and been shaken, the thermometer may have been in the sun and therefore it may not be possible to get it to read exactly the same as the dry-bulb thermometer; the difference however should be less than one degree.

4.2 Faults in the Maximum Thermometer

Occasionally a maximum thermometer "retracts". It is said to have retracted when it reads half a degree or more lower than the previous day's reading for the previous reading at 14.00B, or lower than the highest dry- bulb thermometer reading for the previous day.
When a maximum thermometer is known to retracting, it must be replaced by the spare.

5. The Minimum Thermometer

Minimum means lowest and the minimum thermometer measures the lowest temperature in the screen from 08.00B one day to 08.00B on the next day. This usually occurs about sunrise each day but not always.
The glass tube is fixed on to a piece of wood which is has a metal frame to guard to guard the bulb in the same way as the maximum thermometer. The liquid in the glass tube of this thermometer is spirit. Inside the tube there is also a small glass pointer called an index. The index moves only when the temperature is going down. When the temperature stops going down, i.e., when it has reached its lowest value the index stops moving and remains at the lowest or minimum temperature. Readings must be taken at the pan of the index furthest from the bulb, i.e the right-hand end.

5.1 Resetting the Minimum Thermometer

This thermometer must be reset every day by taking the end nearest bulb off its hook and lifting it up so that the index moves away from the bulb. It is held until the index reaches the end of the spirit column and stops moving. The thermometer must be shaken. The

index will move by it as soon as the bulb end of the thermometer is held high enough. Then the bulb end of the thermometer is moved carefully down and hung again on its hook. The minimum thermometer should be reset after the maximum thermometer has been put back into the screen. After resetting, the minimum thermometer should read approximately the same as the dry –bulb thermometer.

5.2 Position of the Thermometers in the Stevenson Screen

The positions of the thermometers in the screen vary a little, depending on the type of the screen in use, but following rules always apply. The wet bulb must always be placed to the east of the dry bulb, the dry bulb is therefore nearest to the center of the screen.
The maximum and minimum thermometers are hung so that their bulbs are near the center of the screen, and the thermography is placed so that the metal strip, which reacts to temperature changes, is also near the centre.

The wet – and dry –bulb thermometers are placed in front of the maximum and minimum thermometers. It is very important that, if the observe cannot get his eyes level and directly opposite to the mercury or the index, the thermometer stands should be moved to one side in order that an accurate reading can be made. The stands should be replaced in their correct positions.

5.3 Correct Method of reading Thermometers

For good thermometer readings it is necessary that all observers must take readings quickly and accurately and read the thermometers in exactly the same way. This means that if two different observers read the same thermometer at the same time, they should each get exactly the same figure. In order to do this, the rules below must be carried out.

(i) The observer must always stand straight in front of the thermometer which is being red

(ii) He must always make sure that his eye is in a straight line with the end of the mercury, or the index, in a vertical sense in the case of a maximum and minimum thermometers, and in a horizontal sense in the case of a dry – and wet- bulb and thermometers .to ensure this when reading the maximum and minimum thermometers, it may be necessary to move to the stand containing the dry-bulb thermometers.

(iii) He must keep his head outside the screen.

(iv) He must not touch any thermometer before it is read

(v) He must read the thermometers quickly in the order: Dry, Wet, Maximum, Minimum

(vi) He must write down the reading of each thermometer before reading the next and find the whole degrees and decimals before writing anything.

The reason for rules (i) and (ii) is so that errors of parallax may be avoided. Parallax is an apparent change in the position of an object caused by a change in the position of the observer. In connection with the reading of meteorological instruments, an error of parallax may occur whenever the index or the end of the column of liquid in the tube and the scale against which it is to be read are at a distance from one another in such case, movement of the observers head may cause his line of vision to the indicator to intersect the scale at different points and so give rise to the incorrect reading. The error is eliminated by ensuring that the line of vision to the indicator is at right angel to the scale when the reading is made.

Errors of parallax can occur with thermometers, barometers, rainfall measuring glasses and any instrument which has a scale in front of or behind the marker or index.

Rule (iii) ensures that the nearness of the observer to the thermometers will not cause a change in the readings.

Rule (IV) is necessary to ensure that the temperature is not altered by the thermometers coming into contact with the observers' fingers.

6. Relative Humidity

At all times the atmosphere contains a certain amount of water vapor; it is never completely dry. The amount of water vapor in the atmosphere can be determined and expressed quite accurately in several ways. In meteorology, unless otherwise stated, the word humidity when used alone generally signifies Relative Humidity. It is expressed as a percentage and when the air is saturated the relative humidity is 100 per cent. When the air is unsaturated the relative humidity is less than 100 percent. Humidity has diurnal variations which tend to be opposite to the diurnal variation of temperature. It reaches a minimum value when the temperature is higher in the early afternoon and a maximum value the temperature is low, about sunrise.

6.1 The Relative Humidity Chart

Relative humidity and dewpoint charts are designed for use at or near one particular level and relative humidity should be calculated from them by using dry –bulb readings and the dewpoint obtained from the correct level charts, otherwise some slight discrepancies may result.

SEE ATTACHED CHART

Relationship between Dry-bulb and Wet-bulb and Dewpoint Temperatures

It should be remembered when calculating dewpoints and relative humidity that the dewpoint can never be higher than the wet-bulb temperatures and the wet –bulb temperature can never be higher than the dry bulb temperature. If the air is absolutely saturated then all three will be the same. This is when relative humidity is 100 %. Similarly relative humidity can never be more than 100%.

7 The Raingauge

Rainfall is the total liquid product of precipitation or condensation from atmosphere, as received and measured in a raingauge. Snow, sleet and hail in addition to rain and drizzle, make up the major part of the total rainfall.

The rainguage is an instrument for collecting any precipitation that occurs. It should be placed in an open space close to the Stevenson screen, but no nearer than four metres. It must be at least twice as far away from any object as the height of that object. For example, if there is a nearby tree three meters high, the gauge must be six meters or more away from the tree. The rain gauge must be kept clean and must be protected from animals. It must be installed with the rim of the gauge about 3/4metre above the level of the surrounding ground.

7.1 Description

For very many years rain gauges were manufactured from copper with a brass knife – edge ring at the circumference of the collecting funnel. This type of rain gauge was very durable but became the target of copper thieves to such an extent that a substitute material was sought and stainless replaced the copper components. This proved very expensive and further research led to the introduction in 1980 of rain gauges manufactured in PVC.

At any rainfall recording station therefore one might find a rain gauge manufactured in any one of these three materials, but their components comprise:

(i) The funnel, which is removable, and whose diameter is 127mm
(ii) The container, onto which the funnel fits.
(iii) The bucket which collects the precipitation, and is removable

With good handling, rain gauges last four many years. IF, however, the pipe on the funnel becomes looser or is broken off, this must be reported. A leaking bucket can usually be detected by finding drops of water in the container after precipitation.

7.2 Measuring Rainfall

In order to measure rainfall accurately it is necessary to give an explanation of the word meniscus. The meniscus is curved upper surface of liquid in a tube. A meniscus is concave, or rounded inwards for water and convex, or curved outwards for mercury. The curviness is caused by the tendency of the liquid to wet (or not to wet) the sides of the tube in which it is contained. Scales and measures are graduated so that readings are taken at the center of the meniscus, in the case of water, this is at the lowest point; meniscus in case of mercury as in a barometer, the centre of the meniscus is at the highest point.

The precipitation collected by the raingauge is measured with a measuring glass. Some glasses area marked in tenths of a millimeter from 0 to 2,0mm; then in millimetres with

half millimeter divisions to 20, 0 mm. Another version is mark from 0 to 25, 0 mm in millimeter and half millimeter and half millimetre divisions.

To measure the rainfall, the water is poured from the bucket into the measuring glass. The observer must make certain that all the water is poured into the measuring glass, and special care must be taken after heavy rains as there may be more water in the bucket than will go into the measuring glass at one time.

After the water has been poured into the glass, the latter is placed on a table or chair that is quite flat. The observer then bends down until the eye are opposite the lowest point of the meniscus. The head should be raised and lowered slightly once or twice to ensure that the line of the sight is level with the comparatively flat part of the meniscus in the middle of the measuring glass. The rainfall must be measured in whole millimeters and tenth of a millimeter. Millimeters and half-Millimeters are marked on the measuring glass, but the tenths, or decimals have to be estimated. When all the water in the bucket will not go into the measuring glass at the same time, water is poured into the measuring glass until it nearly reaches the top line marked on the glass. Then a reading is taken and the amount written down. This water is then poured into an empty bottle. More water is poured into the measuring glass, the reading taken and the amount written down under the first one. This is done until all the water is measured. The amount must be written down each time. Then the amounts written down must be added and the total rainfall will be found. This is checked by pouring the water from the bottle into the measuring glass and writing down the amount each time. These amounts are added and the answer must be the same as the first total. If it is not, the water must be measured again.

8 Wind vane

Tool used for measuring **wind direction** is a wind vane. It spins and points in the direction from which the wind is blowing. The wind can blow in every direction, but in many places most winds will blow in the same general direction.

In order to read the wind vane correctly the following procedures must be carried out; -

(i) The observer stands near the wind vane so that the movement of the tail of the vane can be noted. The tail of the vane moves to and fro close to the wheel which is fixed to the top of the mast and which is marked on its circumference in tens of degrees from true north. The observer must watch the swinging of the vane for not less than five minutes, starting about 10 minutes before the observation

(ii) As the tail of the vane swings across the direction point marked on the wheel, the observer estimates the correct mean position of the vane during the period of observation. This mean direction is written in the daily Register. In determining the mean position of favour the directions which are identified by their code figures, i.e. . . . ,03 , 06, 09, 12, 15, 18,21,,24,27,30,33,and 36, at the expenses of the intermediate directions shown by markers only, but no figures.

NB: The arrow points in the direction the wind is blowing from. So if your wind vane is pointing north, the wind is actually blowing south.)

9 Cup Anemometer

The cup anemometer measures wind speed in knots. 1 knot = 0.5144m/s

9.1 Readings at the observation Hours

To obtain the wind speed it is necessary to know the difference and the time interval between two cup anemometer readings. Instructions for obtaining the various speeds required for observations and returns are given below. But the cup anemometer is installed at a height of only 2 metres above the ground the standard height of 10 metres , and so is exposed to a reduced wind speed .

- When you enter the instrument site, the first thing to do is to write done the number which will be showing on the cup anemometer.
    - For example, reading can be **248076**
- You will then take your second reading exactly 5 minutes after you have taken your first reading. Use timer or stop watch.
- After 5 minutes take your second reading
    - For example, second reading can be **248082**
- Subtract first reading from second reading to get your wind speed in knots
    - For example, **248082 – 248076 = 6 KNOTS**
- To convert knots to meters per second (m/s), you use the formula:
    - **1 knot = 0.51444m/s**
- From our example **6 knots = 3.08664m/s**