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MANCLIM

Manual of Climatological Observations

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Record of revisions

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Foreword

The climate of a country is based on the history of its weather elements over a long period of time. Of all the weather elements, precipitation and temperature are probably the most important. Directly and indirectly, all Canadians are affected by the amount of precipitation that falls and by temperature changes in the atmosphere. Every year, more and more Canadians from all walks of life request climatological information. To provide this information, the Meteorological Service of Canada (MSC) maintains various surface networks of weather stations in all parts of the country. Some surface weather stations are operated by full-time meteorological personnel who make frequent and detailed weather observations; some are reported by automatic dataloggers while others are operated by co-operative climate network observers. Co-operative climate network observers make a valuable contribution to the Canadian climate program. In addition to supplementing Canada’s climate archive with observations of temperature and precipitation from standard meteorological instruments, the observations they collect may be used by local newspapers, radio or television stations.

A co-operative climate network observer is supplied with official instruments, stationery, and training, free-of-charge, from the MSC. In return, the observer agrees to take regular climate observations and to report this information daily.

The atmosphere is a shared resource. Climate studies around the globe depend on the free international exchange of weather data. Accordingly, Canadian climate data must meet international standards for data quality. Achieving and maintaining these data quality standards depends on the conscientious efforts and consistent accuracy of all weather and climate observers.

Note to readers

Throughout this document the terms **“should”** and **“must”** are used. The term **should** is used to denote a recommended practice, an established or conventional procedure that is to be followed wherever possible. The term **must** is used to indicate that the instructions are mandatory.

1 Climatological stations

1.1 Background

This manual has been prepared as a guide for observers who observe and report precipitation and temperature observations under the guidance of the Meteorological Service of Canada (MSC). The instructions pertain to the exposure, operation, and maintenance of instruments and equipment used by the observer, as well as providing official observing and reporting procedures.

The primary function of a climatological station is to provide a daily record of the precipitation, temperature, or other meteorological phenomena observed. The information acquired is used in climatic, hydrologic, agricultural sciences and other planning and research sectors.

Instruments and training will be provided by the regional MSC office or MSC Maintainer. The observer should advise the regional MSC Technical Services Office (TSO) or MSC Maintainer promptly when any supplies, advice or assistance is required on any matter concerning the observing program. Damaged or defective meteorological equipment or instruments should be reported promptly so that remedial action can be taken with minimum delay.

1.2 Station inspection and maintenance

A qualified MSC Maintainer will be responsible for the installation of required instruments. The MSC Maintainer will also instruct the observer on weather observing procedures, how to report data, and caring for the instruments and equipment. The station will be visited regularly for maintenance of instruments and equipment and to discuss any observing or reporting problems.

Maintenance of the instruments and equipment by observers should be limited to the instructions in Chapters 2 and 3. **Instruments should not be moved or relocated without prior approval of the local MSC TSO office or MSC Maintainer, unless immediate action is necessary to prevent damage to them or the environment**. Replacement parts supplied to observers may be installed, unless otherwise indicated. The growth of vegetation, trees, shrubs or other changes in the surroundings which affect the exposure of the instruments, necessitating their relocation, should be brought to the attention of the local MSC TSO, the local COOLTAP administrator or the National Monitoring Desk (NMD) through the Interactive Voice Recording (IVR) help line, one of whom will ensure that an

MSC Maintainer makes a prompt visit to improve the instrument exposure or move the equipment.

1.3 Observing procedures

If only one observation a day is possible, it should be taken in the morning around 8:00 a.m. local time. For sites that observe twice per day, it is recommended that observations should be once in the morning around 8:00 a.m. local time, and once in the late afternoon around 5:00 p.m. local time. These recommended times are designed to capture the maximum and minimum temperatures for a climatological day and to promote comparability among stations.

Definition of climatological day

Observations taken based on a calendar day cannot capture the minimums and maximums that are truly reflective of the peaks and lows over a 24-hour period. Normally, the coldest period in any given day is just before sunrise and the warmest period in a day is shortly after the sun reaches its zenith in the afternoon. A climatological day was therefore developed to ensure that the maximum and minimum temperatures could be captured. The climatological day tends to start and end at the same hour of two consecutive days. For example, the climatological day begins at the 0601 UTC observations on Day 1 and ends at the 0600 UTC observation on Day 2.

For sites that report two observations over a 24-hour period, MSC uses the following procedure to determine:

- Maximum temperature: For “today” is calculated from the maximum temperature reported for “today’s” afternoon (PM) observation compared to the maximum temperature reported for “tomorrow’s” morning (AM) observation;
- Minimum temperature: For “today” is calculated from the minimum temperature reported for “today’s” morning (AM) observation and for “today’s” afternoon (PM) observation;
- Rainfall, snowfall and precipitation totals: For “today” are calculated from “today’s” afternoon (PM) observation with “tomorrow’s” morning (AM) observation; and
- Snow on the ground: For “today” is based on “today’s” morning (AM) observation.

For sites reporting only once per day, the calendar day rather than climatological day applies.

A time that best suits the observer for regular observations should be determined and maintained every day.

1.4 Reporting procedures

There are currently two methods for reporting observations:

- An Internet reporting system, known as “COOLTAP”; and
- An online touch-tone telephone acquisition system, known as “IVR” for “Interactive Voice Recording” system.

Both methods allow observers to enter daily observations directly into the National Climate Data and Information Archive. While COOLTAP is a more rigorous data-acquisition platform, implementation of IVR in areas where Internet access is not available has allowed the co-operative climate network to operate where data are sparse. Detailed instructions for reporting data using COOLTAP or IVR are found in the COOLTAP/IVR manual.

1.5 Alternate observers

It is recommended that another member of the observer's family or other competent person be taught to observe and record precipitation and temperature observations as an alternate so that the climate record will not be interrupted should the regular observer be unable to make the observation. Alternate observers should be provided with a copy of this manual and instructed on proper observing procedures.

Your COOLTAP/IVR account and password should be considered confidential and not distributed to alternate observers. Alternates should be instructed to record the observations in the co-operative climate network observer’s handbook or similar observers’ notebook and the regular observer should report the observations using COOLTAP or IVR at their earliest convenience.

2 Precipitation

2.1 General

In meteorology, precipitation refers to water particles, whether liquid or solid, that form when water vapour changes to liquid or solid form and is deposited on the earth's surface. The amount of precipitation, expressed in millimetres (mm), refers to the depth of water which would have accumulated if the surface of the earth were horizontal and none of the water were lost as runoff, evaporation or absorbed into the ground.

Precipitation may occur in these forms:

- Liquid precipitation;
- Freezing precipitation; and
- Frozen precipitation.

2.1.1 Liquid precipitation

Precipitation composed of very small water droplets (less than 0.5 mm in diameter) which are too small to make any noticeable ripple on the surface of still water is called "**drizzle**." These droplets follow the slightest air currents and almost seem to float in the air as they fall to the ground.

Precipitation composed of water droplets of various sizes (most greater than 0.5 mm in diameter) is called **"rain."**

2.1.2 Freezing precipitation

When drizzle droplets freeze on impact with unheated objects at or near the earth's surface they are called **"freezing drizzle."**

Rain that freezes on impact with unheated objects at or near the earth's surface is referred to as **"freezing rain."**

2.1.3 Frozen precipitation

Snow, snow grains, snow pellets and **ice pellets** are categorized as frozen precipitation.

Snow is precipitation composed mainly of hexagonal ice crystals, mostly star shaped, and usually clustered together to form snowflakes.

Snow pellets are white, opaque balls of snow. They range from 2 mm to 5 mm in diameter and usually bounce or shatter when striking a hard surface.

Snow grains are very small white and opaque grains with a snow-like structure. The grains are somewhat flat or elongated. Their diameter is generally less than 1 mm. When they strike a hard surface they do not bounce or shatter. They usually fall in small quantities.

Ice pellets are pellets of ice which form when raindrops freeze before reaching the ground. Ice pellets can also form when pellets of snow are covered by a thin layer of ice before reaching the ground. Ice pellets are 5 mm or less in diameter. They usually bounce and make a noise when striking a hard surface.

Hail is precipitation of small balls or pieces of ice (hailstones) ranging in size from 5 mm to 50 mm or more in diameter. These balls of ice can form separately or fuse into irregular lumps. Hailstones can be composed of transparent layers of ice or they can be made up of a series of transparent layers alternating with translucent layers. The layers are at least 1 mm in thickness. Cut in half, the layers of a hailstone resemble those of an onion.

2.2 Equipment

The equipment normally supplied for the measurement of precipitation consists of:

- One type-B rain gauge; and
- One snow ruler.

2.2.1 Rain Gauge – type-B (large capacity)

The type B rain gauge is used to measure liquid and freezing precipitation types, including hail. This rain gauge was developed to eliminate loss of data due to overflow of rainwater during heavy storms or during long periods of exposure. This gauge consists of a collecting funnel, an outer container, a graduated inner container made of a high-strength plastic, a metal mounting/leveling bracket, and a pipe stake to support the gauge.

Other features of this gauge are:

- Its large capacity—over 250 mm of rainfall;
- The collecting funnel empties directly into the attached graduate, which holds 25 mm of rain; and
- The gauge can be leveled quickly and easily by adjusting the leveling bracket.

Figure 2-1: Rain gauge – type-B (collector, funnel and graduate)

2.2.2 Snow ruler

The snow ruler is a one-metre-long ruler in 0.2 cm increments. It is used to measure newly fallen snow and snow accumulation on the ground.

2.3 Measurement of precipitation

Precipitation measurement falls under two categories:

- Rain
- Snow

2.3.1 Measurement of rain

The amount of rain is determined by using the type-B rain gauge. It is used to collect and measure the amount of **rain, drizzle, freezing rain, freezing drizzle** and **hail**. The amount of rain is always measured to at least the nearest 0.2 mm.

2.3.2 Operation – rain gauge – type-B

The following general instructions must apply for the operation of the rain gauge:

- The rain gauge should be examined at each observation to ensure that it has not been damaged and that no obstructions are shielding it.
- Ensure that there are no obstructions to the funnel of the gauge such as leaves, grass, or dirt which might prevent the water from running into the collectors inside the gauge.
- The top rim of the gauge must be kept level. Check the level of the gauge frequently during spring because it might be affected by frost heaving.
- The rain gauge graduate must be kept clean so that the water level is readily seen. Because the graduate is stored within the gauge, it is likely to collect dirt and foreign objects more readily. Cleaning can be done with mild soap and water and a bottle mop or sponge. The outer container should also be cleaned as required.
- Do not allow grass to grow longer than about five centimetres (cm) for a distance of about two metres (m) around the gauge.

During periods of cold weather, the observer should try to ensure that no rainfall measurements are missed. In areas where it is likely to rain every month of the year, the rain gauge should remain exposed at all times. However, in the event that the rain gauge is also exposed to snowfall, any accumulated snow and ice should be removed from inside and around the gauge.

In areas where it is unlikely to rain for several months during the winter, the rain gauge may be removed from the mounting stake and stored indoors. When this procedure is adopted, observers must keep a close watch on the general weather conditions, as it is their responsibility to make sure that all occurrences of rain are measured. When rain or freezing rain is likely to occur, the rain gauge should be prepared to collect rain as follows:

- Return it to its outdoor position; and
- Make sure that the collecting funnel and container are free of snow, ice and dirt.

2.3.3 Rainfall measurement – rain gauge – type B

Rainfall up to 25 mm can be read directly from the graduate. It is not necessary to remove the graduate from the collecting funnel. To empty the graduate after measurement, simply invert the funnel and the attached graduate.

The level of water in the plastic graduate is correctly taken to be the lowest part of its curved surface, or meniscus. When this lies between two scale marks, its amount is that of the nearer mark (see Figure 2-3). In the case where the level is exactly midway between two scale marks, the amount reported is the intermediate (odd) value, e.g. 0.3 mm. Precipitation amounts up to 0.2 mm are exceedingly difficult to measure. Whenever the level of the meniscus is below the 0.2 mm scale mark—that is, less than 0.2 mm—the amount is called a trace, which is reported as "T" in the COOLTAP or IVR application.

For rainfall amounts greater than 25 mm, the rain water overflows from the graduate into the outer container. The procedure for measuring the overflow is as follows:

1) Record the amount of water in the graduate (25 mm) without removing the funnel.
2) Leaving the collecting funnel attached to the graduate, empty the graduate.
3) Pour the water from the outer collector into the empty graduate to an amount less than 25 mm. Pour the water slowly to prevent spilling or overflow.
4) Record this amount and drain the graduate.
5) Repeat this procedure, recording each measurement, until all the water has been measured.
6) Total the recorded amounts.

Extremely heavy rainfalls are very important statistically; the greater the rainfall, the greater the care that should be taken in measuring the rainfall and in preventing any loss through spilling.

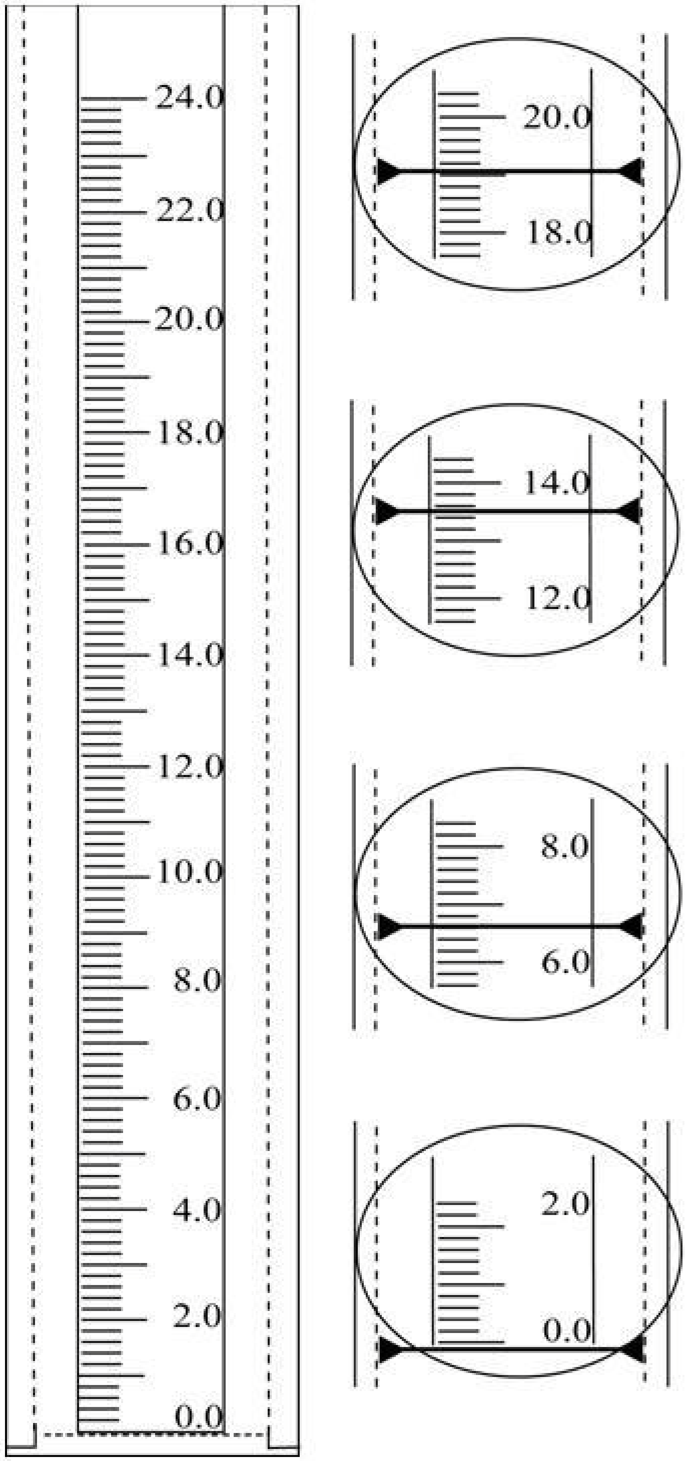
Occasionally, rain can freeze in the container or in the funnel. In such a case, pour a measured amount of hot water into the gauge (e.g., using a spare graduate or measuring cup) to completely melt the ice in the funnel and container. The rainfall can then be determined by subtracting the added amount of hot water from the total measurement.

For example:

- The measurement of hot water is 4.6 mm.
- The measurement of hot water and ice totals 8.4 mm.
- Subtract the hot water measurement from the total: (8.4 mm - 4.6 mm).
- Rainfall = 3.8 mm.

If, for any reason, the outer container does overflow and rainfall is lost, this fact should be noted in the "Comments" section of the COOLTAP report. In such cases, it would be helpful if the observer would check to see if the heavy rainfall might have collected in other containers (suitably exposed), such as a can or a bucket, and measure the depth of the water in the container using an ordinary ruler, then record this depth in the "Comments" section.

Should rain occur when the rain gauge is not operational—during an unexpected winter rainfall, for example—estimate the rainfall and record the amount in the COOLTAP report in the “Comments” section.



Meniscus is closest to 19.2 mm.

Meniscus is exactly halfway between graduations 13.4 and 13.6 at 13.5 mm.

Meniscus coincides with graduation 6.6 mm.

Bottom of graduate is not completely covered. Surface tension holds water against sides unevenly and may cause water globules to form on bottom. Average amount is less than 0.2 mm and is reported as TRACE.

Figure 2-2: Reading the graduate

2.3.4 Snowfall measurement

Where snow has fallen without drifting, snowfall is measured easily with the standard snow ruler, which is one metre (m) long and marked in centimetres (cm) and fifths (i.e., to the nearest 0.2 cm). In an area where the snow has fallen undisturbed by the wind, the ruler is inserted vertically to the depth of the new snow that has fallen since the last observation. Several different probes should be made. The average of all these depths of new snow will be taken as the actual snowfall and reported to the nearest 0.2 cm. A "trace" of snow is an amount measuring less than 0.2 cm, and is recorded as "T" in the COOLTAP application. Traces must be recorded, but two or more traces add up to only a trace.

After the snowfall measurement has been recorded, the area should be swept clean to ensure that the next new snowfall can be recorded accurately. The use of a snow board can be useful as a tool to keep the snowfall measurement area consistent. This may be a sheet of plywood measuring at least one square metre and is suggested for locations where the site for measuring snow is not ideal. When a snow board is used, it may be covered with white flannel to reduce melting. White paint, while not as efficient, can serve the same purpose. As an alternative, a Weaver Snow Board 2000 can be supplied by the MSC.

The measurement of snow where drifting occurs is quite difficult and no fully satisfactory method has yet been developed for taking accurate snowfall measurements. The measurement of snowfall under drifting conditions requires a great deal of judgment and careful consideration on the part of the observer. When snow has been drifted by the wind; the depth of fresh snow in the drifts and in exposed areas should be measured, and the observer should then estimate the depth of snow that would have accumulated if the fall had been undisturbed by the wind.

There will be occasions when the snow melts as it falls to the ground or into the rain gauge. Under these conditions the amount of snowfall is obtained by measuring the water in the collector and converting it to snowfall equivalent by multiplying by ten. For example, if 2.4 mm is the amount of water in the gauge and this resulted from melting snow, its snowfall equivalent is 2.4 cm. In this case, a snowfall of 2.4 cm should be recorded with an appropriate remark indicating that the snow was melting as it fell and that the snowfall was estimated.

2.3.5 Snow on the ground

This is a measure of the total accumulated depth of snow on the ground regardless of whether there has been snowfall or not. It is measured once per day using the snow ruler. At sites that perform two observations per day, “Snow on ground” must be included with the morning observation. “Snow on ground” is reported every day, even if there is no accumulation present.

To obtain an accurate representation of the “Snow on ground,” the observer should take a number of measurements in the general area of the station and average them. “Snow on ground” is reported to the nearest whole centimetre (no decimal value).

Note: This differs from newly fallen snow, which is reported to the nearest 0.2 cm.

For example:

- An average depth of 10.8 cm would be reported as 11 cm.
- An average depth of 8.2 cm would be reported as 8 cm.
- An average depth of 5.5 cm would be reported as 6 cm.

An average depth of less than 0.5 cm is considered a “trace” and reported as such. If there is no snow on the ground, then zero is reported.

There are situations in which the ground is only partially covered by snow and observers must use their best judgement. An example is in the spring, when significant melting has occurred and the ground is generally exposed, with the exception of snow and/or ice in the form of drifts. As well, accumulations can persist for extended periods in shady areas. Quite often, the depth of snow in these persistent accumulations can be several centimetres, even though the ground is essentially bare. Under these conditions, the “Snow on Ground” should be reported as a “trace.”

2.3.6 Measurement of mixed rain and snow

When both rain and snow have occurred within the observation period, it is desirable to separate the rainfall from the snowfall so that the precipitation records will be complete. The best method is to melt the snow in the gauge, including any accumulation in the funnel portion, and measure the water collected. At the same time, with the snow ruler, measure the average depth of newly fallen snow and record this for the snowfall. From the amount of water collected in the gauge, subtract the water equivalent of the snowfall measurement (using the 1 mm to 1 cm ratio). The remainder will be the rainfall.

For example:

- The rain and melted snow collected in the gauge total 3.8 mm.
- The average new snowfall measured is 2.0 cm.
- 2.0 cm of snow is equivalent to 2.0 mm of water.
- The rainfall is 3.8 mm - 2.0 mm = 1.8 mm.

When both rain and snow have occurred within the observation period, and all or part of the snow has melted, the total precipitation is that amount measured from the container of the gauge. The relative amounts of rainfall and snowfall should be estimated to the best of the observer's ability, taking into consideration the length of time the snow fell and whether the rate of fall was heavy or light. Appropriate “Comments” should be made in COOLTAP or IVR.

2.3.7 Measurement of hail

The rain gauge is not a satisfactory instrument for measuring hail directly. Usually, a great deal of hail will bounce out of the gauge, so that less than the correct amount that would fall on a horizontal surface is collected in the gauge. The most practical method of measuring hail is to take the top section of the gauge and invert it over the ground where a uniform hail cover exists. Collect the hail contained within the area of the top, melt it to obtain the water equivalent, and include it with the rainfall amount that has just been measured.

Hail usually falls when the air temperature is above freezing; therefore, the water equivalent of the hail should be determined as soon as possible after the shower of hail ends.

2.4 Reporting precipitation observations

At climatological stations that are equipped with MSC instruments for measuring precipitation only or both temperature and precipitation, the official station record is reported using COOLTAP or IVR. Refer to the COOLTAP or IVR manual for instructions on how to use these applications.

3 Temperature

3.1 General

Temperature may be defined as the degree of warmth or cold as measured on some definite temperature scale. The temperature scale most commonly used in meteorology is the Celsius scale.

The Celsius scale is devised so that there are 100 divisions, or degrees, between the freezing point and boiling point of water (see Figure 3-1). Note that water freezes at 0°C and boils at 100°C. Other references on the Celsius scale are body temperature (37°C), room temperature (20°C), and the freezing point of mercury (-39°C).

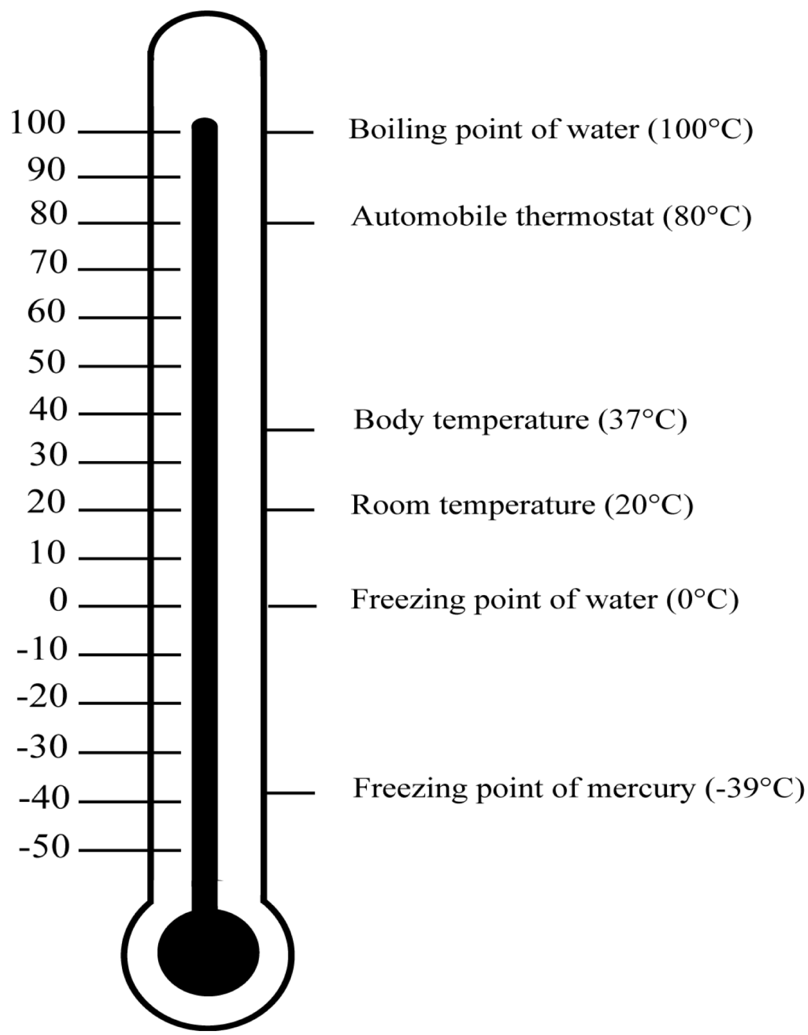


Figure 3-1: Celsius temperature scale

3.2 Equipment

The equipment normally supplied for the measurement of air temperature consists of:

- A Stevenson Screen complete with stand;
- A maximum thermometer; and
- A minimum thermometer.

If spare thermometers are available, they may be provided for back-up purposes. Spare thermometers must be stored according to the MSC guidelines (see 3.7).

3.2.1 The Stevenson Screen

The Stevenson Screen was designed by Thomas Stevenson (1818 - 1887), a British civil engineer and father of the author Robert Louis Stevenson. The Stevenson Screen is a double-louvered wooden box (see Figure 3-2), painted white and specially designed to shield the thermometers from the direct rays of the sun, from precipitation, and from heat radiation from the ground. The louvered construction allows the free flow of air over the thermometer bulbs. So that meaningful comparisons can be made with other stations, the screen is always mounted on a stand at such a height that the thermometer bulbs are between 1.25 m and 2 m above ground level. The door faces north and opens downward.

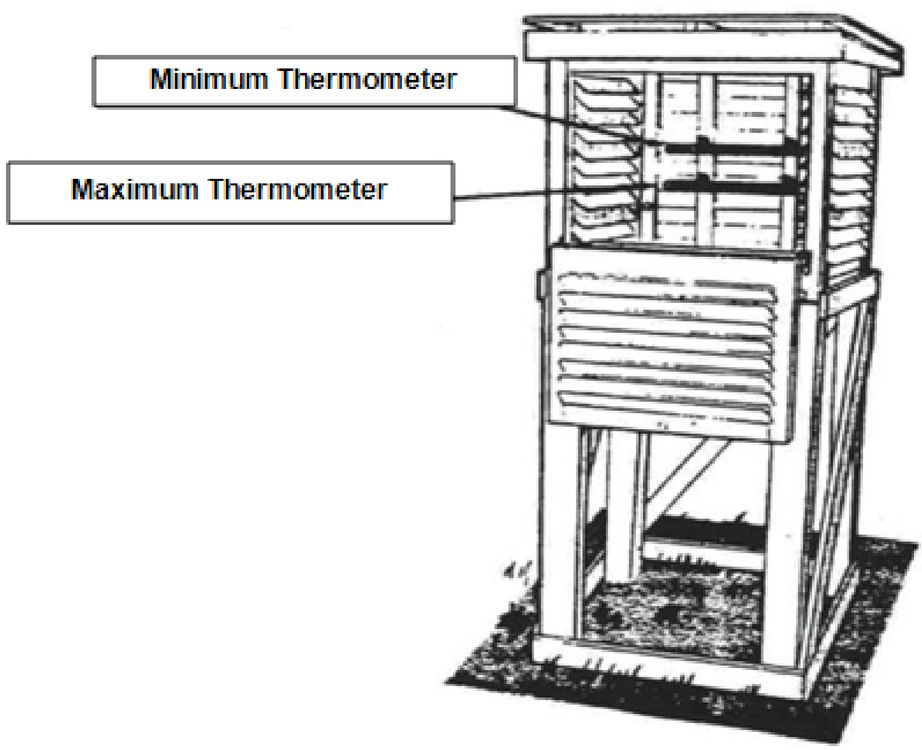


Figure 3-2: Stevenson Screen (mounted on stand)

The site for the Stevenson Screen is usually chosen by the MSC Maintainer and should not be changed without this person's approval. The Stevenson Screen should be positioned as follows:

- Ideally on a level plot of ground at least 7 m x 7 m in size and covered with grass that is kept short;
- Removed from any tree or building, etc., by a distance at least twice the height of the tree or building, etc.; for example, the screen should be at least 20 m away from a tree that is 10m high;
- Screen must be level;
- Screen door must face north so that the sun will not shine on the thermometers when the door is open; and
- The stand on which the screen is mounted comes prefabricated and, if installed as shown in Figure 3-2, the floor of the screen will be approximately 115 cm above ground level. One side of the stand does not have a cross-brace. This will be the north side.

The inside of the screen should be kept clean and free from debris. Care should be taken not to block airflow by storing large objects in the screen. The screen will be replaced or painted by an MSC Maintainer as required.

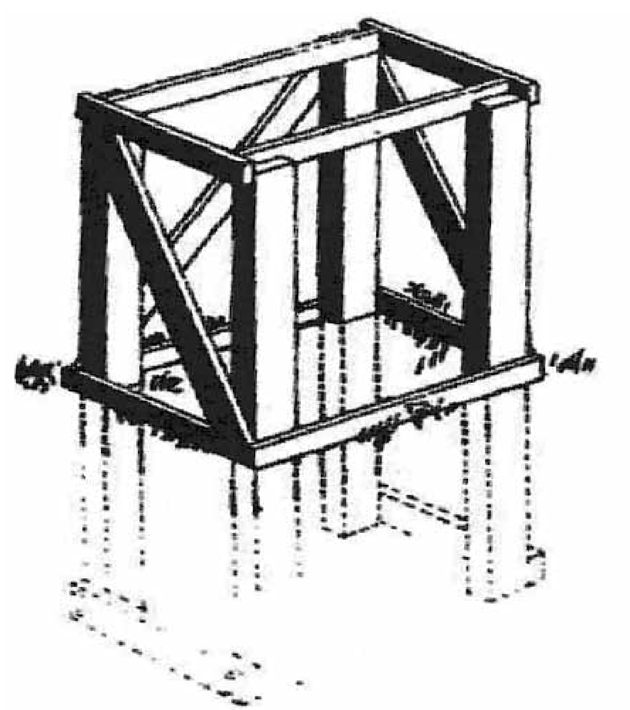


Figure 3-3: Stand for Stevenson Screen

3.2.2 Thermometers

The liquid-in-glass thermometer is the standard used by official climatological observers. Liquid-in-glass thermometers operate on the principle that the volume of the liquid increases as the temperature rises, thus causing the liquid in the tube to expand. As the temperature falls, the liquid in the bulb decreases in volume and the liquid column becomes shorter in most thermometers, the maximum thermometer being the exception.

Each thermometer is inserted into a protective sheath to which two rings are attached. The sheath containing a thermometer hangs from brass hooks in the screen. The bulb end of each thermometer should be to the left so the figures on the stem of the thermometer will be upright.

The minimum thermometer, in its protective aluminum sheath, is hung on the appropriate hooks in the thermometer shelter in a horizontal position (see Figure 3-2).

The maximum thermometer, in its protective aluminum sheath, should be hung in the screen nearly horizontally but with the bulb very slightly lower than the stem (see Figure 3-2). It should hang below the minimum thermometer, because the upper part of the screen is more likely to be warmed by the sun near the time of maximum temperatures, thus giving an exaggerated high reading.

3.2.3 The maximum thermometer

The maximum thermometer is a mercury-filled thermometer. A maximum thermometer records the highest temperature which has occurred since the maximum thermometer was "reset."

In the maximum thermometer, the tube through which the mercury rises has a constriction just above the bulb (see figures 3-4 and 3-5). This constriction in the maximum thermometer permits the expanding mercury to pass through the narrow opening, but as the temperature decreases the mercury is trapped above the constriction and remains there until the observer reads the maximum temperature. The thermometer must be reset by forcing the mercury to return through the constriction into the bulb. When this thermometer has been properly reset, it will indicate the air temperature at the time of resetting.

Figure 3-4: Maximum thermometer in protective sheath

Figure 3-5: Maximum thermometer

The maximum thermometer is graduated in half degrees to indicate temperatures within the range 50°C to -39°C. There are no graduations below -39°C because the mercury freezes at this temperature. To avoid damage which would result from the freezing of the mercury, the maximum thermometer **must** be taken indoors when the air temperature drops to -37°C. It then becomes necessary to estimate the maximum temperature from the minimum thermometer (see 3.3.1).

3.2.4 The minimum thermometer

The minimum thermometer is alcohol-filled. The identifying feature of the minimum thermometer is the small dark dumbbell-shaped rod called an index, which is immersed in the alcohol and moves freely through the column (see Figure 3-7). As the temperature drops, the index remains at the end of the retreating alcohol column. When the temperature begins to rise, the end of the index farthest from the bulb will indicate the lowest temperature that was reached.

The minimum thermometer is graduated in half degrees to indicate temperatures within the range 45°C to -70°C.

The freezing point of the alcohol thermometer is much lower than the mercury thermometer; therefore, there is no requirement to bring it indoors at any time.

Figure 3-6: Minimum thermometer in protective sheath

Figure 3-7: Minimum thermometer showing the index

3.3 Reading of thermometers

Do not stand any closer to the thermometer than is necessary to get an accurate reading. The observer is cautioned to avoid breathing on the thermometers or using matches to light the interior of the screen after dark. These actions could increase the temperature appreciably, especially during cold weather. When additional light is needed in the screen, a flashlight should be used.

To read a maximum mercury thermometer accurately, the eye should be level with and at right angles to the end of the column. In mercury thermometers, the meniscus is convex (see Figure 3-8)—that is, the end of the mercury column bulges out, or away from the bulb end. This bulging may not be noticeable, but in any event, it is the extreme end of the column that should be observed.

When reading the minimum alcohol thermometer, it should be at right angles to the end of the index farthest from the bulb. The reading should be taken from the right-hand end of the index.

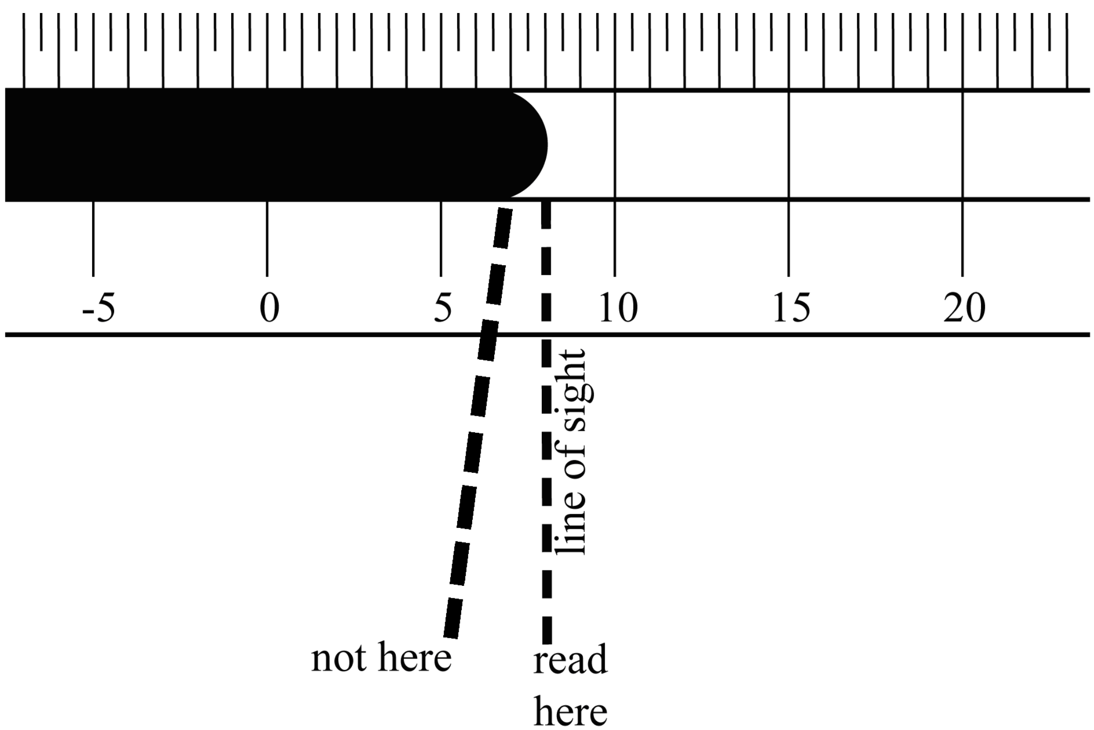


Figure 3-8: Reading a maximum thermometer

Temperatures are more reliable when they are observed according to a routine plan. To achieve this reliability, the following steps are recommended:

1) Immediately after opening the door of the screen, read the maximum thermometer to the nearest half-degree, without removing it from the screen. The end of the mercury column will indicate the maximum temperature since the thermometer was reset (see Figure 3-9, temperature 24°C).

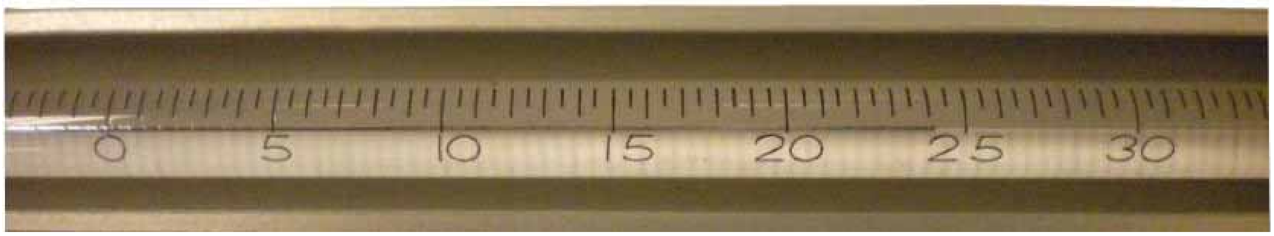


Figure 3-9: Maximum thermometer

2) Without handling it, read the minimum thermometer to the nearest half-degree. The end of the index farthest from the bulb indicates the minimum temperature since the thermometer was reset (see Figure 3-10, temperature 18.5°C).

Figure 3-10: Minimum thermometer

3) After the maximum and minimum temperatures have been read and recorded, recheck the thermometers to ensure that your readings are correct. Thermometers are sometimes misread by five or ten degrees, especially when temperatures are below freezing.
4) Remove the maximum thermometer from the screen and reset it to the current air temperature (see 3.4).
5) Reset the minimum thermometer to the current air temperature (see 3.4).
6) Note the "**after reset temperature**" on the minimum thermometer. This temperature will be indicated by the end of the alcohol column, where the end of the index farthest from the bulb comes to rest (see Figure 3-11).
7) Check both thermometers to see that the reset readings (air temperature) are within half a degree of each other.

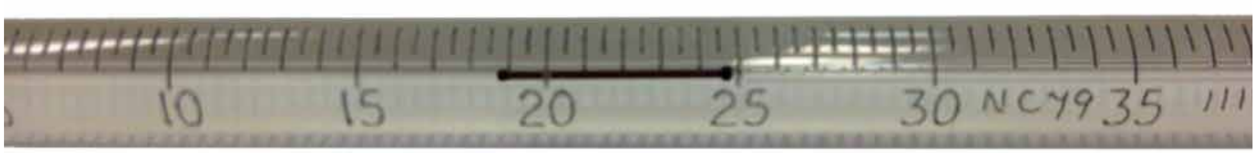


Figure 3-11: Minimum thermometer showing current temperature

3.3.1 Estimating maximum temperature

The maximum temperature may be estimated from the minimum thermometer. If the maximum thermometer has been brought indoors because the temperature has dropped to -37°C or colder, the observer should estimate the maximum temperature from periodic readings of the minimum thermometer. If this is not possible, an estimate should still be made, based on the **reset** temperatures. Whenever extreme cold weather makes it necessary to estimate the maximum temperature, report the value as “estimated” in the “Comments” section of COOLTAP.

3.4 Resetting of thermometers

Caution must be used in resetting the maximum thermometer. More maximum thermometers are broken than any other type. Usually, the breakage is avoidable if ordinary care in handling the thermometer is taken. The breakage is often caused by the thermometer hitting a nearby object such as the screen. Breakage may also occur if the thermometer is dropped while removing it from the screen or when replacing it. The observer must keep in mind that the thermometer being handled is a fragile piece of glass.

To reset the maximum thermometer:

1) Remove it from the screen, grasp the sheath at the end farthest from the bulb, taking care that the hand does not touch the glass stem. **Never attempt to reset a maximum thermometer that is not mounted inside a protective sheath**.
2) The thermometer is first held with the bulb end down, as shown in Step 1, Figure 3-12. This allows the mercury to rest against the constriction.
3) The arm is then raised no higher than the height of the shoulder, keeping it straight, but also keeping the bulb end of the thermometer slightly lower than the stem (Step 2). Now, swing the arm downward in a steady arc as rapidly as practicable (Step 3). The swing, though vigorous, must begin and end smoothly. The mercury is forced down into the bulb by the centrifugal force (Step 3).
4) Repeat steps one, two and three, as necessary, until the thermometer has been reset to the air temperature, as indicated by the end of the alcohol column in the minimum thermometer.

It is important that the resetting procedure always be carried out in the above-described order. If the mercury in the bore is not in contact with the constriction at the beginning of the downward stroke, it may bang against it on the downswing and break or shatter the constriction. This undoubtedly leads to the failure of many maximum thermometers, especially in cold weather.

Note: Maximum thermometers manufactured by the JUMO Company may appear to have a break in the mercury column in the area of the constriction. No attempt to reunite the column in this area should be made after the thermometer has been reset to the current air temperature. This does not indicate that the thermometer is broken.

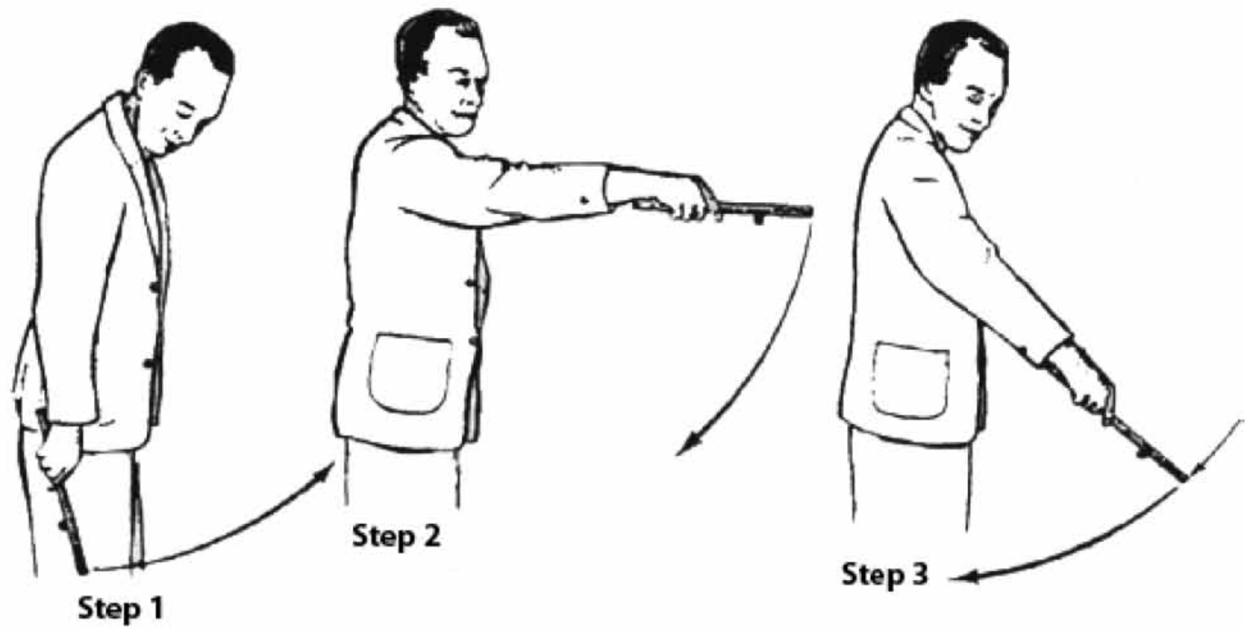


Figure 3-12: Procedure for resetting maximum thermometer

When handling the thermometer, never hold it at the bulb end because the heat from your hand will heat the mercury in the bulb and it will not be possible to correctly reset it to the current air temperature until the thermometer cools down again.

When the sun is shining, try to keep the thermometer out of the direct rays of the sun (by shading it with your body) because the mercury reacts very quickly to this heat source and warms up, thus making it impossible to reset the thermometer to the current temperature.

Some maximum thermometers prove very hard to reset in cold weather and it may sometimes be entirely impossible to do so. In this case, replace the thermometer with a spare. In all cases when a thermometer is replaced by a spare, report it to your supervising office and a replacement will be sent.

The minimum thermometer should be reset without removing it from the screen. Simply unhook the right eyelet of the protective sheath and lower the right end of the thermometer until the index slides to the end of the alcohol column. Re-hook the right eyelet of the protective sheath to return the thermometer to its horizontal position. Check again to make sure that the index is resting against the end of the alcohol column.

3.5 Defects in thermometers

In a maximum thermometer, if the constriction is damaged by improper resetting, it may act as an ordinary thermometer, because the mercury thread fails to break off at the constriction. Such a thermometer is known as a "retreater." If the thread does not break at all, the defect is soon discovered, since the readings of the maximum thermometer will always coincide with the air temperature at the time of the observation. Occasionally, a thermometer is found in which the column will "retreat" for a degree or two and then break off. This is much more serious, because it is more likely to remain undiscovered, especially at climatological stations where readings are not necessarily taken near the normal time of the maximum temperature. This fault is also more likely to occur in cold weather. A thermometer showing this defect should be taken out of service and replaced by a spare maximum. If there is doubt about whether or not the maximum thermometer is defective, and a spare is available, the observer may run a test for a few days with both thermometers installed in the screen.

In a minimum thermometer, the alcohol column can quite often develop breaks or separations (see Figure 3-13). This defect could be caused by rough handling during shipment or it could occur in the screen due to vibrations caused by the wind, banging of the screen door, etc.

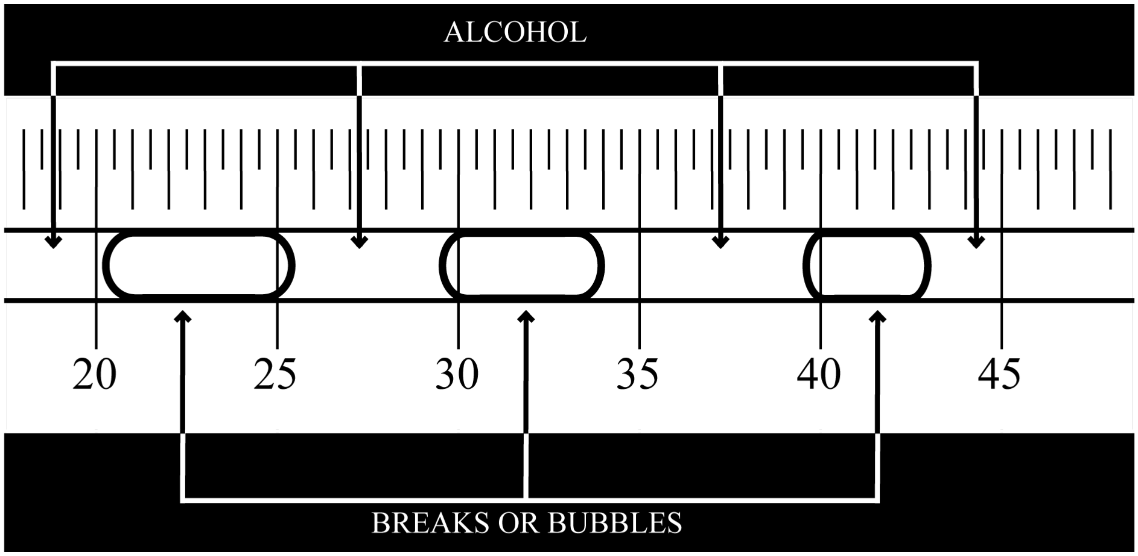


Figure 3-13: Broken alcohol column

Alcohol separations are caused by distillation. The alcohol that separates from the main column will usually collect in the extreme end of the thermometer farthest from the bulb. The observer must carefully inspect the condition of the alcohol column from end to end. If the alcohol column is found to be broken into sections, the thermometer should be taken out of service and replaced by a spare.

The defective minimum thermometer may be repaired by the observer. The broken alcohol column can be reunited by holding the thermometer with the bulb end down and tapping it gently on the palm of the hand, the inner pages of a book or a piece of soft rubber (see Figure 3-14).

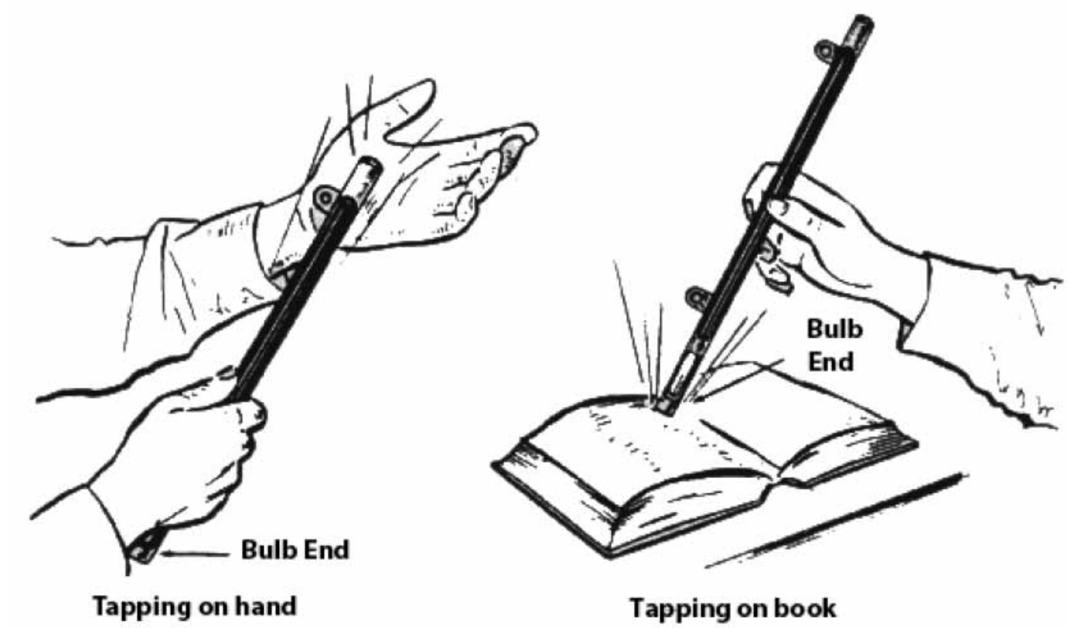


Figure 3-14: Reuniting a broken column

After all the bubbles or breaks in the column have been removed, the thermometer should be kept indoors for at least two hours in a vertical position, bulb downward, to allow any liquid that may have collected on the walls of the bore to drain down into the main column. This thermometer can be retained as a spare.

When the above-mentioned methods fail to unite the column, or if for any other reason the thermometer is defective, the nature of the defect should be reported to your supervising office with your request for a replacement thermometer.

3.6 Maintenance of thermometers

Thermometers supplied to climatological stations have low maintenance requirements. Thermometers should be cleaned occasionally to remove dust and dirt that can accumulate on the outer surface and make readings difficult. This is done simply with a damp cloth.

During periods of heavy blowing snow, it may be necessary to remove any accumulation that has entered the screen through the louvers.

Care should be taken never to let thermometers be unduly heated. Close proximity to a strong source of heat can cause the thermometer to burst.

3.7 Storage of thermometers

The amount of mercury in a maximum thermometer is not large but a spill indoors can be hazardous to your health. Mercury thermometers should never be stored indoors. Mercury is a hazardous substance. Observers should store spare maximum thermometers outside whenever possible. Maintenance on maximum thermometers should also be performed outdoors. Spare thermometers must be stored as recommended in the MSC guidelines. Care should be taken never to store the thermometers in close proximity to a strong source of heat as the thermometer can burst.

The MSC Maintainer for your site must be informed immediately if breakage occurs and mercury is spilled.

3.8 Reporting temperature observations

For thermometers at climatological stations that are equipped with the MSC instruments only for measuring temperature and precipitation or precipitation, the official station record is the entry in COOLTAP/IVR system. Refer to the COOLTAP or IVR manual for instructions on how to use these applications.