NIWA
Taihoro Nukurangi

CLIMATE MANUAL

April 2014

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PREFACE

This handbook describes the current procedures used by NIWA for capture and transmitting of climatological data. It also describes the quality assurance procedures to ensure the data are consistent and meet the required standards.

Most of the procedures have been transferred from NZ Meteorological Service when sections of this Service was incorporated in the National Institute of Water and Atmospheric Research Ltd (NIWA) in 1992.

Contents

1. Rainfall

Rainfall or, more properly, precipitation is a primary climatological and hydrological process, the measurement of which is simple in concept but imprecise in practice, particularly when assessing the precipitation over an area. A number of factors such as the effects of the gauge itself, wind and topography can interfere substantially with the measurements and their application. For them to be meaningful, care must be exercised that these interferences and inaccuracies are minimised, and in this chapter some background is given and procedures are described to do this.

1.1. Terminology

1.1.1. Precipitation

This ranges through hail, sleet, snow, rain, drizzle, fog-drip and dew. For most practical purposes in NIWA's work they can all be treated as "rainfall", and this term is used here as mostly synonymous with "precipitation". Significant snowfall is an exception, and this will be discussed separately.

1.1.2. Intensity

This parameter of storm rainfall refers to the amount falling in a certain duration. It can be ascertained from automatic raingauges and is often expressed using standard durations such as 05, 1, 2, 4, 12, 24 and 72 hours.

1.1.3. Frequency

In many design studies it is necessary to know the average time period within which an event of specified intensity can be expected to occur once. This is known as the "return period" or "recurrence intervals", and is applied similarly to flood flow data.

1.2. Exposure

Wind and exposure together can account for errors of up to 80% and possibly more.

Exposure is the term used to describe the influence of wind altering the trajectories of raindrops or snowflakes so that some of them, which would otherwise have reached the orifice without this disturbance, are not caught by the gauge. It is noticeable that the effect of the upward convergence in the streamlines on raindrops is the tendency to lift and reflect them over the gauge. Obviously the trajectories of small raindrops are altered more than those of larger ones, while a much greater proportion of snowflakes are deviated because of their larger surface area and lower fall velocities.

In natural field conditions, the wind will tend to be gusty, and obstructions, such as bushes, trees, buildings, up and down slopes of the topography, etc. will influence the degree of uplift to a large degree.

Therefore selecting a raingauge site mainly involves consideration of the airflows of the prevailing rain-bearing winds, and their effects in the vicinity of the gauge.

1.2.1. Minimising exposure problems

Correct exposure for a raingauge then, involves siting it where wind at the gauge is likely to be low. Some shelter is generally required for this, although it must not be so close as to unduly intercept rain or cause droplets from its interception to be blown into the gauge. Such a situation would be termed under-exposed.

Over-exposure is the term used for a gauge situated in a position where significant wind and/or turbulence in the airflow will affect the catch, almost always reducing it.

Correct exposure is often difficult to obtain, particularly in mountainous areas. A clearing in a forest is probably the most ideal situation commonly found. Shelter belts which are permeable and slow the wind are more useful than solid ones which produce turbulence in their lee.

Trees and other objects shall generally be between 2 and 4 times their height away from the gauge, although between 1 and 2 times is preferable when the object is are encircling, such as in a clearing in a forest (WMO 1981).

Further details on correct exposure are given in the criteria for selecting a raingauge site, below.

1.3. Selection of a raingauge site

Site selection can be considered at two different scales; firstly the locality required to best provide the rainfall information (considering altitude, aspect, topography and relationship to the rest of the catchment), and secondly the characteristics of the site taking into account the exposure.

1.3.1. Locality

Considerations are:

- The data requirement; whether it is for data at a specific locality, flood warning.

- The aspect; one side of a valley or a range of hills can have different precipitation due to orographic effects, rain shadow, or larger-scale wind effects.

- The altitude; orographic uplift of the air mass often has marked effects on rainfall, as do other temperature changes with altitude.

- The slope of the general area will affect the rainfall. In mountainous terrain it may be questionable as to whether there will be any site at all with adequate shelter, and an over-exposed site may have to be accepted, with provision made to minimise its effects as detailed below.

1.3.2. Site

Selecting a raingauge site, particularly in mountainous country, can often be a matter of picking the "least unsuitable" one rather than having a number of suitable sites to choose from.

Select a site with the following characteristics:

- Where possible, the gauge site should have protection from wind movement in all directions by encircling objects (trees, shrubs, etc.) of as nearly uniform height as possible. This type of protection must be considerable, and in all directions. In this case it is preferable that the angle from the gauge orifice to the top of the objects is at least 30° but no more than 45°. Note that windbreaks such as a single row of trees will not meet these requirements due to their tendency to increase turbulence; however a belt of trees which are somewhat permeable to the wind and at some distance may provide a beneficial "filtering" effect to slow the wind. Shelter from trees may not be ideal if the site is required for a long-term record and they are of a fast-growing species, or likely to be felled.

- Where adequate shelter from wind is not available as described above, individual objects should be no closer than two to four times their height depending on the strength of the winds likely to be experienced. This criteria is to avoid both turbulence and disturbance to the airflow, and the possibility of water being blown from the objects into the gauge. This includes fences erected around the gauge for the purpose of excluding stock, and vegetation which may grow rapidly close to the gauge.

- Avoid sites on a slope where the ground slopes away sharply in one direction, particularly if this direction is the same as the prevailing rain-bearing wind.

- An alternative is to install a windshield, which will reduce but not eliminate wind-caused measurement errors. The most effective design appears to be the modified "Alter" shield (Warnick 1953), and these have been made by NIWA and used in mountainous areas, particularly the Southern Alps.

- The surrounding ground should ideally be covered with short grass or fine gravel; avoid a hard, flat surface such as concrete or rock which will cause excessive splashing.

1.4. Gauge design

Design of the gauges also has a significant effect on their catch. Orifice height and the gauge's geometry affect the wind pattern immediately above the gauge, as well as the likelihood of splash-in.

Splash-out, evaporation, snow capping, freezing and leakage and further error-producing mechanisms which must be gauged against in gauge design.

All raingauges used by NIWA should conform to the following specifications (WMO 1983):

- The rim of the collector shall have a sharp edge, fall away vertically inside, and be steeply bevelled outside; the design of gauges used to measuring snow shall be such that any tenancy to constrict the orifice by accumulation of wet snow about the rim is small.

- Where there is significant solid precipitation, the area of the orifice should be 200 cm^2 or greater. (This equals a diameter of 160 mm; c.f. the Ota which is 200 mm and the Octapent which is 127 mm.)

- The vertical wall of the collector shall be sufficiently deep and the slope of the funnel sufficiently steep (at least 45°). However it is noted that few gauges available (including those used by NIWA) fully comply with this requirement. Future gauge acquisition and construction shall consider this.

- The interior surfaces of the collector and funnel shall not be painted, unless this is a baked-on coating which is unlikely to crack and peel and hence promote evaporation. Once any coating begins to crack it shall be removed and re-coated.

- The area of the orifice shall be accurate to within ±0.5% and this shall remain constant whilst the gauge is in normal use.

- The liquid container shall have a narrow entrance and be sufficiently protected from radiation to avoid the loss of water by evaporation. Alternatively it shall have an oil film of at least 8 mm thick added to the water to prevent evaporation.

NOTE: Automotive, transformer and silicon oils have been found unsuitable. The light mineral oil BP WM2 has been trialled in New Zealand and found suitable. It is now called Enerpar M002 and is available from BP in 20 or 200 litre containers.

- Have protection to cope with freezing where this can occur.

- Where significant snowfall occurs, collectors should be deep enough to store the expected snowfall between visits; this is also important in order to avoid the drifting of the caught snow out of the collector. (In practice this will tend to mean that storage gauges are of the standpipe type and automatic ones are weighing buckets.

1.5. Check gauges

All automatic gauges should have a storage gauge of sufficient capacity within a few metres of it. They shall be at a height of 0.3 m or at ground-level with an anti-splash surround, as described earlier.

If other gauges in the network are of a different type and orifice height, an additional gauge of this type should be employed to determine whether this has a significant effect on the catches.

The check gauge provides an independent check on the operation of the automatic gauge and should be more accurate because:

- Tipping buckets may alter in calibration.
- The buckets may under-register in intense rainfall because of drops falling into an already full bucket as it tips.
- The automatic gauge may not be at the correct height and be over-exposed.

1.5.1. Adjusting the automatic record

It is standard practice to adjust the automatic gauge record to the check gauge total for the same period. However where there is a considerable discrepancy the reason for it shall be investigated and action taken according to the Office Practice Manual or in the case of the Tilting siphon raingauge network these adjustments are made by the Climate Databank.

1.6. Snowfall

Snowfall can be difficult to measure in a rain (or precipitation) gauge, as described in preceding sections. Difficulties include:

- Capping of the orifice with snow.
- The possible need to melt the snow to read the gauge’s catch.
- The need to have a deep or no collector to accommodate the snow before it melts.
- In windy conditions, the exacerbating of any over-exposure of the gauge and the consequent under-registration of catch.
- The need for more complex automatic gauges, e.g. weighing bucket gauges.

When conditions are sufficiently cold, a snowfall will remain on the ground more or less intact enough to enable a measurement within a feasible time. At high altitudes and locations such as glacier neves a snowpack will remain intact for longer periods and a measurement of the water thus stored may be feasible.

1.6.1. Measuring a snowpack

The amount of precipitation in a snowpack is termed its *water equivalent*. It can be obtained by multiplying the depth of snow by its average density, but the latter can be difficult to measure.

Water equivalent is usually obtained more directly, by:

- Cutting a "core" of snow vertically down through a snowpack from the surface to the ground using a snow corer.
- Weighing the core in the sampler.
- Subtracting the sampler weight to obtain the weight of snow.
- The weight (in grams) is divided by the cross-sectional area of the sampler (in cm^2) to obtain the water equivalent in cm.

In soft fresh snow the snow corer can be substituted by a thin cylindrical tube with a sharpened end; a standpipe raingauge may work, although a smaller diameter would be easier. The "core" of snow obtained can be weighed or melted and measured volumetrically. If the depth of snow is low, the removable collector of an Octapent or daily manual gauge may suffice.

The more precise equipment for smaller, fresh snowpacks is a snow tube, which is a short cylinder sharpened at one end (and with rubber bungs for each end to hold in the sample), in conjunction with a sensitive set of scales. In an emergency, a snow tube could be made from any rigid pipe and samples stored in wide-mouth sample bottles for later volumetric or weight measurement.

1.6.2. Severe snowfall events

Heavy snowfalls are unusual events in New Zealand and can be of considerable interest. If a snowfall causes considerable damage, distress or economically-significant problems in a populated area it may be useful to immediately carry out a survey of the region to record the extent and severity of the fall. Maximum depth, density during the snowfall, and water equivalent would be the parameters of interest. With such an event, time will be of the essence, as it will most likely begin to melt within a very short time.

1.7. Operation of daily manual raingauges

The instructions that follow are intended for reference by both NIWA and voluntary observers for those gauges required in the Rainfall Network and may duplicate in some way instructions previously mentioned in this document.

1.7.1. Conditions for supply of raingauges to voluntary observers

Raingauges are supplied by the National Institute of Water and Atmospheric Research Ltd (NIWA) to persons residing in approved localities subject to the observer undertaking to comply with the following conditions:

(a) That the raingauge will be installed according to instructions on an open level space of adequate size, which will be kept clear, and that the gauge will be properly protected from damage.

(b) That there is every prospect of regular observations being continued over a long period of time.

(c) That the raingauge will not be moved without the consent of NIWA having first been obtained.

(d) That the rainfall be measured daily at 9 am or at some other hour during the morning approved by NIWA.

(e) That monthly returns be forwarded promptly after the end of each month, i.e., on the first day of the following month or as soon as possible thereafter.

(f) That in the event of the observer leaving the district the raingauge be returned in good order or transferred as authorised by the nearest NIWA office. The raingauge and measure remain the property of NIWA.

1.7.2. Selection of site for raingauge

The site for the exposure of a raingauge should be carefully selected, as the quantity of rain collected depends to an appreciable extent upon the exposure of the gauge. In order that rainfall observations from the different stations may be comparable, all raingauges must exposed under similar conditions. An over-exposed position, such as a hilltop or ridge, is as objectionable as one which is too sheltered. A position sheltered from wind is preferable to an exposed one such as on a windswept ridge. In such windy locations care should be taken to ensure that the gauge is not unduly exposed to the sweep of the wind.

1.7.3. Permanency of raingauge site

Every endeavour should be made to maintain suitable conditions surrounding the gauge. As long as this is done, no change should be made in the site unless absolutely necessary, as the rainfall recorded at different sites is rarely absolutely comparable. Even if a small change of site occurs, past records cannot be safely compared with present ones. Try to select a site that will not be required for any other purpose for at least five years – preferably a much longer period. If the gauge is placed in a garden where flowers, vegetables, shrubs or trees are growing, allowance must be made for the height to which these will grow, also the possibility of their removal. Avoid sites where it is known that buildings are scheduled for erection or removal.

1.7.4. Siting a raingauge near obstructions

The site should be an open one unobstructed by high trees, fences or buildings. Low fences or hedge are, however, an advantage, if at a distance of not less than twice their height. The ground should be as near to level as possible, well turfed and well drained. A raingauge should be placed on a level piece of ground wherever possible rather than upon a slope, and never on a wall or roof. Avoid siting a raingauge near the edge of a terrace. The distance of the gauge from every object should be not less than twice the height of the object. Preferably, the distance of the raingauge from every object should be four to five times the height of the object. For example, if there is a tree 12 metres high and a building 5 metres high in the vicinity of the site, the raingauge must be at least 24 metres away from the tree and 10 metres away from the building.

1.7.5. Time of observation

The raingauge should be read at 9 am. However, should this be inconvenient, a more suitable time during the morning may be adopted, provide that the observations are made at the same hour each day and the actual time of measurement entered on the rainfall form Met.302.

The gauge must be inspected every morning whether or not the observer thinks there has been any rain in the previous 24 hours. Daily examination also acts as a safeguard against errors caused by accidental or mischievous addition of water.

1.7.6. Description of glass rainfall measure

For measuring the rainwater collected by a 5” manual raingauge a graduated glass measure is provided. This glass measure holds ten millimetres of rain and is graduated to show tenths and whole millimetres. The whole millimetre graduation marks, which are repeated on the back of the measure, will be found useful in ensuring that the eye is at the correct level to avoid parallax errors.

1.7.7. Measuring the rainfall

Carefully pour the collected rain from the raingauge into the glass measure, taking care not to spill any rain. Hold the measure lightly between the thumb and forefinger, near the top of the glass, so that the measure hangs vertically. The water level of the measure is then held at eye level to avoid errors of parallax. See Figure 1.1.

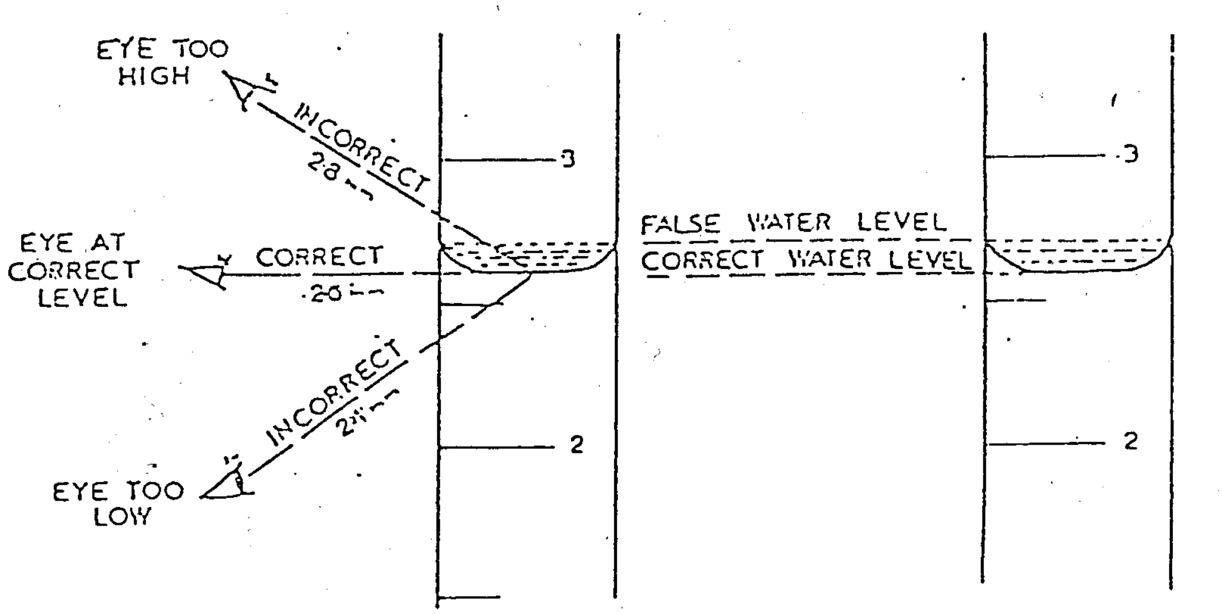


Figure 1.1: Errors of prallax

It will be noticed that the liquid is curved at the top of the water level. This is called a meniscus. The <u>lower</u> edge, of the meniscus is where the reading should be taken from. See Figure 1.2.

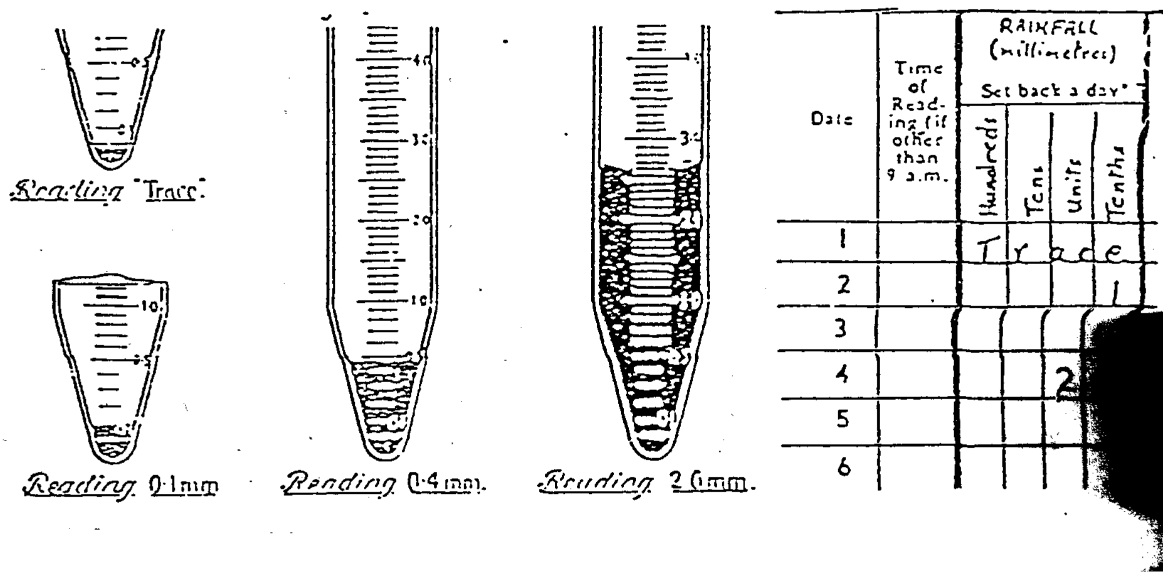


Figure 1.2: Examples of reading a rangauge measuring glass and the correct method of recording rainfall on form MET 302.

If the lower edge on the meniscus does not coincide exactly with a graduation mark on the glass measure, <u>read which ever graduation mark is nearer to the lower edge of the meniscus</u>. This applies to all readings 0.1 millimetre and above.

Whenever the lower edge of the meniscus is equivalent to 0.05 millimetre and up to 0.1 millimetre the reading will always be recorded as 0.1 millimetre. See Figure 1.2 for the correct method of reading the glass measure.

1.7.8. Trace of rain

Rainfall is to be recorded as a "trace" whenever the following conditions apply:

(a) When there is less than 0.05 millimetre of rainwater in the glass measure, and the observer know that this is not the result of a drop or two draining from the inner can after emptying out the rainfall at a preceding observation.

(b) When the quantity of rainwater is too small to measure, i.e. if a very small quantity of rainwater is poured from the inner can no water will be collected in the measuring glass due to the water adhering to the walls of the inner can.

(c) When no water is observed in the raingauge, but the observer know from their own observation that some light rain or other precipitation (snow hail, sleet or drizzle) has fallen since the last observation. The explanation for this occurrence is that the rainwater in the inner can often evaporates, especially in hot, dry weather.

NOTE:

- A trace of rain is always recorded as a "trace".
- It should be noted that "trace" entered on a rainfall return is not to be counted as a "rain day".

1.7.9. Rainfall measurements when measuring glass is broken

If, the rainfall cannot be measured because the glass measure is broken, the water should be poured from the gauge into a bottle, firmly corked and labelled clearly with the day and date to await the supply of a new measure.

1.7.10. Heavy rains

Measurement of rainfall greater than 10 millimetres

The glass measure has a capacity of 10.0 millimetres of rain, and if the rainfall for the period exceeds this amount, the measurement is made in two or more stages.

Difficulty will usually be experienced in filling the glass measure accurately to the 10.0 mm mark. To overcome this problem the measure should be nearly filled to the 10.0 mm mark, and the reading taken. This should be repeated as often as necessary and the readings totalled, e.g. 9.9 + 9.7 + 9.8 + 2.6 = 32 millimetres. To ensure that no individual measurements are omitted from the total, it is recommend that ach measurement be written down as it is made.

Rainfall measurement when inner can overflow

Occasionally it may happen that the fall is so heavy that there is danger of the inner can overflowing. If the observer considers this likely to happen the amount that has fallen should be measured, noted, and not returned to the raingauge. Care should be taken to add this amount to the amount measured at the reading next morning. Observers should note that the inner can of the 5" manual raingauge holds approximately 180 millimetres before overflowing.

If the inner can overflows into the outer can, the gauge must be dug out and the water poured out into a suitable container for measuring. The gauge must be firmly replaced after this operation, care being taken that the rim is level and 30 cm above the level of the ground.

Measurement of unusually intense rainfalls

Great interest is attached to the rate at which rain falls, especially during unusually heavy rain. A keen observer can furnish useful data by noting the time (to the nearest 5 or 10 minutes if possible) of the beginning and ending of any unusually heavy shower and measuring the amount at its cessation. These particulars are entered on the return in the "Special Phenomena" column.

1.7.11. Management of raingauges during frost, hail and snow

Melting of frost, hail or snow to obtain equivalent rainfall measurements

Special methods of measurement are required when the raingauge contains solid precipitation whether originating from sleet, snow or hail, or from rainwater which has frozen after falling. In the similar instances, resulting from comparatively slight falls, the snow or ice in the funnel and inner can must be melted by warming, and the water thus obtained must then be measured in the ordinary way to give the equivalent rain. Three methods may be employed; the first described below should be adopted only when precipitation is not falling at the time observation; the second and third may be used in any circumstances.

(a) The funnel and inner-can are brought indoors, the contents melted and the water measured. To prevent significant losses from evaporation it is necessary to cover the top of the funnel with a flat plate; meanwhile it should remain in position to deliver into the receptacle. The observer should arrange for the gradual application of moderate warmth; excessive heat, such as that from a hot fire, would not only lead to evaporation but could also damage the instrument by melting the solder.

(b) A cloth dipped in hot water is applied to the outside of the funnel or inner can or both, as necessary, to melt the snow or ice and collect it as water. Care is required to avoid the possibility of water from the cloth entering the gauge and falsifying the reading.

(c) A definite amount of very warm water is accurately measured in the measuring glass and then poured into the gauge. Care is needed not to crack the measure. The total amount of water in the gauge is then measured and the amount added to the gauge is subtracted to give the equivalent rainfall. To avoid errors caused by evaporation from warm water and by its contraction on cooling, the amount of warm water to be used should be calculated, after estimating the solid contents of the gauge, to be just sufficient to melt the snow or ice. An approximate guide to follow is that if the funnel is full of snow it will be necessary to use about twenty millimetres of water at about 35°C - 40°C to melt the snow.

Methods for obtaining rainfall and snow measurements

When there has been a fall of snow, the observer should endeavour to make <u>three</u> measurements.

(a) The amount of precipitation

This is the total amount of rain, thawed snow or ice plus any snow or ice the observer has melted s explained above.

Any snow, either in or immediately above the funnel, should be pressed into the funnel and melted. Care should be taken to ensure that any snow above the gauge is genuine snow fall and not drifted snow.

(b) The vertical depth of fresh undrifted snow

When measuring this the observer should select an open level place where the snow appears to be evenly distributed. A mean of several vertical measurement should be made in places where there is considered to be an absence of drifting. An ordinary ruler will suffice for most rainfall stations in New Zealand. Measure snow depth to the nearest centimetre.

Record fresh snow depth in the "Remarks" column taking care to qualify the total thus: "fresh snow 14 cm". Avoid ambiguous entries, e.g. "snow 11 cm" as this measurement refers only to snow which has fallen since the last observation, special precautions should be taken not to measure any old snow. This can be done by clearing the snow from a suitable patch approximately 2 m x 2 m where the snow measurements are made. Snow cleared from any such measuring area should not be piled at the edge of the cleared patch, but thrown well clear so as not affect future falls of snow. Note that it is not correct to calculate the depth of fresh snow from the difference between two consecutive measurements of the total depth of the snow layer.

(c) Snow-pack measurement

Snow-pack (or snow cover) is the accumulated snow on the ground at the time of the observation. As in the case of fresh snowfall there are numerous properties of snow-pack which are of value for special purposes, e.g. its depth and water equivalent are of recognised climatological and hydrological significance.

The vertical depth of snow-pack is measured by a ruler to the nearest centimetre. A mean of several vertical measurements should be made in open level places where there is an absence of drifting and where the snow-pack is undisturbed. The total depth is recorded in the "Special Phenomena" column. Care should be taken to distinguish the snow-pack depth from fresh snowfall, e.g. "snow pack 41 cm".

NOTE:

- Care should be taken to record the depth of fresh snowfall on every day that fresh snow is lying on the ground at the raingauge site when the daily rainfall observation is made. If measurements of fresh snow depths are made at other times of the day, then the time of observation must be shown also.

- The depth of snow-pack is to be recorded every day snow is lying on the ground at the raingauge site when the daily rainfall observation is made.

- When there is no snow on the ground at the raingauge site, but it is to be seen in adjacent areas, this should be noted in the "Special Phenomena" column, e.g. "fresh snow on nearby hills", or "patches of snow still lying near homestead", or "snowline down to 3000 ft (900 metres) above MSL".

Heavy snowfalls

Heavy snowfalls are unusual events in New Zealand, are therefore occasions of considerable interest and importance. It is therefore worth going to considerable effort to get a reliable measure of snowfall and of the total precipitation on these occasions.

If the raingauge is occasionally completely buried by fresh snow, an observer should first press the snow above the funnel down into the funnel then melt the snow content of the funnel and the inner can, and measure the melted water in the way already described.

On completion of the observation the snow around the raingauge should be cleared down to ground level for a radius of approximately 2 metres. Snow which is removed should be thrown well clear of the cleared area so as not to affect the exposure of the raingauge.

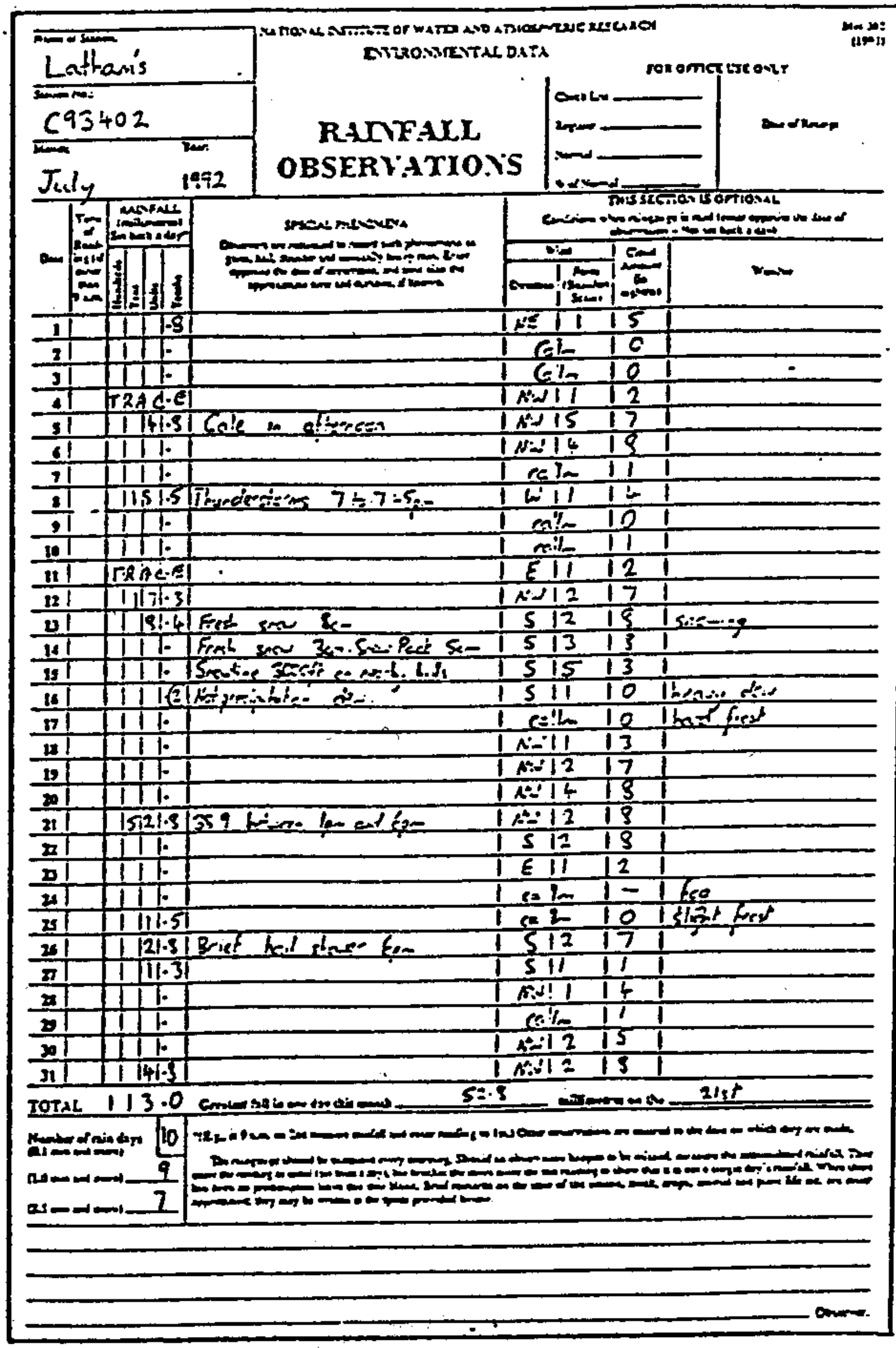
(See also Section 1.6.)

1.8. Recording rainfall on Met forms

1.8.1. Types of forms in use for recording rainfall

For permanent records of rainfall the following forms will be used:

At rainfall stations	NZ Met Forms 302
At climatological stations	NZ Met Form 301 or 371



NATIONAL INSTITUTE OF WATER AND ATMOSPHERIC RESEARCH
ENVIRONMENTAL DATA

Met 302

RAINFALL OBSERVATIONS

FOR OFFICE USE ONLY

THIS SECTION IS OPTIONAL

Name of Station: Latham's
Station No.: C93402
Month: July Year: 1992

Date	Rainfall (millimetres)	Special phenomena	Wind	Cloud amount (in eighths)	Weather
1	.8		NE 1	5	
2	.		Calm	0	
3	.		Calm	0	
4	TRACE		NW 1	2	
5	4.8	Gale in afternoon	NW 1 5	7	
6	.		NW 1 4	8	
7	.		calm	1	
8	15.5	Thunderstorms 7 to 7-5pm	W 1	6	
9	.		calm	0	
10	.		calm	1	
11	TRACE		E 1	2	
12	17.3		NW 1 2	7	
13	8.4	Fresh snow 8cm	S 1 2	8	snowing
14	.	Fresh snow 3cm. Snow Peak 5cm	S 1 3	8	
15	.	Snowing [illegible]	S 1 5	3	
16	(.2)	Not precipitation: dew.	S 1	0	heavy dew
17	.		calm	0	hard frost
18	.		NW 1	3	
19	.		NW 1 2	7	
20	.		NW 1 4	8	
21	52.8	35.9 between 1pm and 6pm	NW 1 2	8	
22	.		S 1 2	8	
23	.		E 1	2	
24	.		calm	–	fog
25	1.5		calm	0	slight frost
26	2.8	Brief hail shower 6pm	S 1 2	7	
27	1.3		S 1	1	
28	.		NW 1	4	
29	.		calm	1	
30	.		NW 1 2	5	
31	4.5		NW 1 2	8	

TOTAL 113.0 Greatest fall in one day this month 52.8 millimetres on the 21st

Number of rain days (0.1 mm and more) 10
(1.0 mm and more) 9
(2.5 mm and more) 7

Observer.

Figure 1.3: **Method of entering rainfall on Met 302 when dew is collected and snow occurs.**

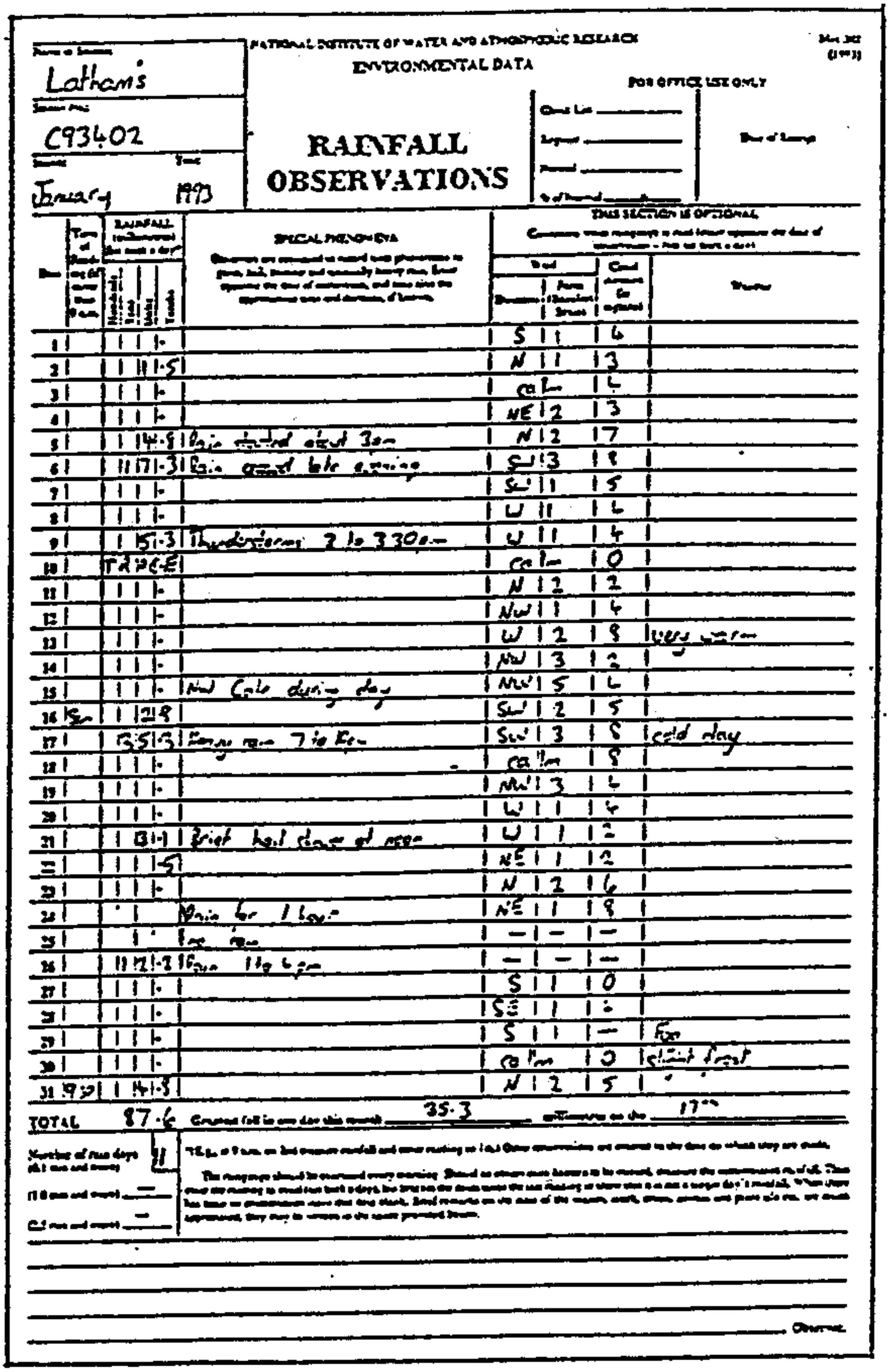


Figure 1.4: **Method of entering rainfall on Met 302 when rainfall not read every day.**

1.8.2. Dates for recording rainfall observations

As the major part of the 24 hours covered by the rainfall measured lies in the day before the day of measurement, the standard practice is to enter the amount measured to the day before that of measurement, i.e. a measurement made on Wednesday 2nd is entered on Tuesday 1st, and so on through the month when that measured on the 1st of the next month is entered to the last day of the preceding month, completing that return. Even if the rainfall is definitely known to have fallen early on the day of measurement, the rule should be observed and the rainfall entered on the return to the previous day.

1.8.3. Accumulation of rainfall over more than one day

The rainfall record loses a great deal of its value if the readings are irregular. If for any reason, e.g. illnesses, holidays, business commitments, etc. the rainfall is not measured for two or more days, the total rainfall accumulated should be measured by the observer on their return and entered on the rainfall forms Met. 302 and Met. 330 back to the previous day in the usual manner. It should be noted that such a rainfall total is cumulative and it is important to distinguish it from daily rainfall totals. To do this, enter the reading as usual (set back one day), but bracket the dates since the last reading to show it is not a single reading. No attempt should be made by a rainfall observer to apportion the total rainfall measured to the dates throughout any period of missed observations. However, whenever possible an entry should be made in the "Remarks" column giving the dates when rainfall occurred. If it is possible to do this then the number of rain days can be counted. See Figure 1.4 for example, showing how cumulative rainfall totals should be recorded. Refer to dates 24th, 25th and 26th.

NOTE:

- The attention of all rainfall observers is drawn to the necessity for avoiding cumulative rainfall totals covering periods extending from the end of one month into the beginning of the following month if at all possible.

1.8.4. Days when no rainfall occurs

On days when no rainfall occurs, the rainfall column on form Met. 302 should be left blank. "Nil" or "0000" should not be entered.

1.8.5. Precipitation resulting from heavy dews or wet fogs

Sometimes during heavy dews or wet fogs a small quantity of water will be collected in the raingauge.

This is to be measured in the normal way as though it were rainfall and is to be entered onto the Met 302 form with a ring drawn around it and a note added in the "special phenomena" column that the precipitation was caused by either dew or wet fog.

If the water measured is known to be the result of dew or melted frost, the amount is not to be included in the monthly total, nor the number of raindays. See Figure 1.3

When wet fogs produce measurable quantities of water in any manual or automatic raingauges, this is to be regarded as normal precipitation and the measured values are to be included in all totals and summaries on Forms 302. A note should be shown in the "Remarks" section on this form to the effect that the values meas8red were the result of the deposition from wet fog.

1.8.6. Posting of rainfall returns

The early posting of monthly rainfall returns by all observers is most important. Every month NIWA prepares various tabulations, summaries and a departure map from rainfall data.

Before posting please ensure that the station name and month are entered on every rainfall return.

1.9. Standard 5-inch daily raingauges

This is the standard manual raingauge used by NIWA. The raingauge (Figure 1.5) has a funnel diameter of 5 inches (127 mm). It is 489 mm high and has a splayed base. From the top of the splayed section to the top of the rim is 305 mm.

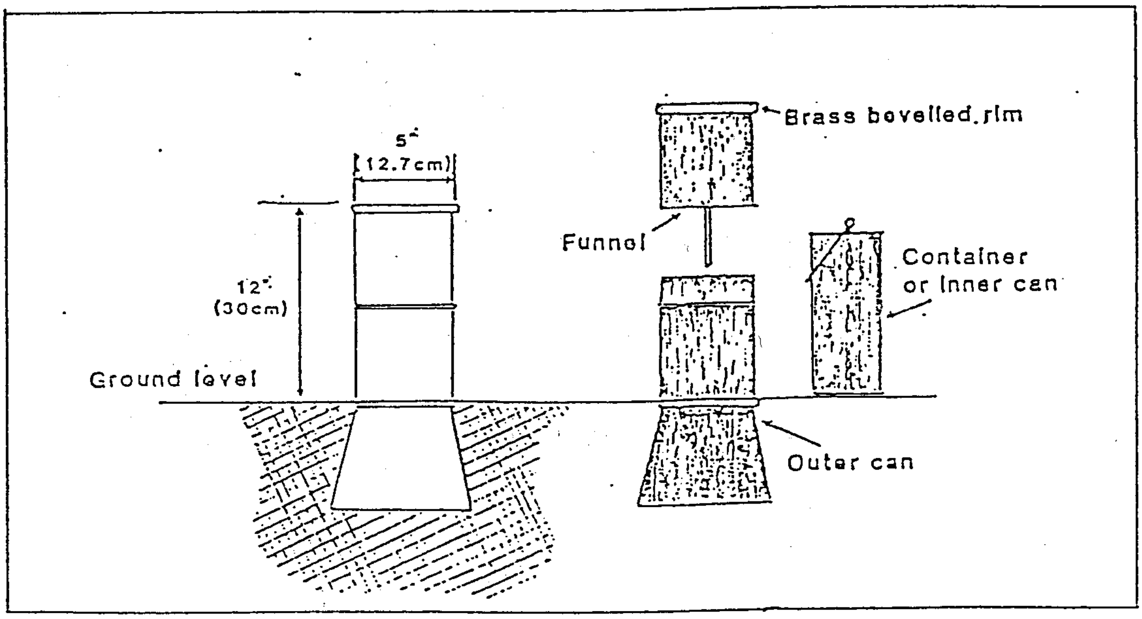


Figure 1.5: Standard 5-inch (127 mm) raingauge.

The upper section of the gauge is a funnel with an accurately turned and bevelled brass rim. It fits closely onto the outer case with the splayed base. Inside the outer can is a cylindrical inner can with a brass wire handle in which the rainwater is collected.

Apart from the brass rim and inner can wire handle the gauge is made of sheet copper or stainless steel with soldered seams.

1.9.1. Installation

The raingauge should be buried in the ground so that its rim is level and 30 cm above the surface; that is, the ground level should be at the top of the splayed portion of the base. Avoid digging out more soil that is not absolutely necessary when installing a raingauge. Removing more soil only increases the time required for it to consolidate. A small hole just deep enough for the splayed base to fit into is recommended.

Levelling of raingauge rim

A spirit level should be used to see that the rim is level. The base must be firmly fixed in the ground so that the gauge cannot be displaced by the strongest wind or when the funnel is being removed to measure the rainfall. The turf should be replaced right up to the gauge unless it is removed and replaced by pebbles, gravel or sand. If grass is allowed to grow around the raingauge, it must be kept short.

Soil that is packed around newly installed raingauges sometimes does not consolidate readily. Whenever this occurs the level of the raingauge rim is easily dislodged when removing or replacing the funnel – particularly if the funnel is very tight-fitting. Rainfall observers should keep checking the level of the rim of newly installed raingauges until the soil consolidates.

1.9.2. Care and maintenance of 5” daily raingauges

Protective fence for raingauge

The gauge must be protected from damage by animals or by accident. If it is in an open field to which cattle or horses have access, an open type wire fence must be provided.

Sometimes it is practicable to have only two wires or a rail of some kind on the top of this fence to prevent access by cattle or horses, but yet allow sheep to get in and graze, thus keeping the grass short.

Condition of raingauge rim

The rim of the raingauge must be perfectly circular and sharp. If it gets dented or the edges burred or rough, the gauge should be replaced.

Checking for leaks

Water may occasionally be found insider the outer can of the raingauge. This is usually caused by the condensation of moisture in the atmosphere, and it should be removed.

If water persistently reappears on days when there has been rain, then it is possible that the outer can, inner can or funnel is leaking, and the gauge should be tested. This is done by removing the gauge from the ground and filling both the inner and outer cans with water. The funnel should also be tested. If leaks are found they should be repaired or a replacement gauge obtained.

Maintenance of raingauge site

It is most important that the grass surrounding the raingauge is kept closely cut for a distance of at least 1 metre in all directions.

On no account is concrete or asphalt to be laid around a raingauge. However, to make it easier to keep the grass short around the raingauge it is permissible to remove the turf for about 15 cm all round the outer can and put pebbles, gravel or sand in its place. When mowing grass near raingauge care is to be taken not to damage the side of the instrument. The grass immediately around the raingauge is best cut with a pair of hand clippers.

Care of glass rainfall measure

The graduated measuring glass must be kept clean and therefore should be washed from time to time. The glass measure is best kept indoors in a safe position where it will not get broken.

1.10. The tilting siphon recording raingauge

The tilting siphon recording raingauge has been the standard type of recording raingauge used by NIWA in the Climate Network to determine the duration and intensity of rainfall.

This gauge has a collecting funnel usually 28.75 cm in diameter mounted on top of an approximately cylindrical case, the base of which is splayed to enable the gauge to be mounted firmly in the ground.

The mechanism of the gauge is illustrated diagrammatically in Figure 1.6. This mechanism is mounted directly beneath the funnel from which the rain passes down a tube, through a filter of wire gauze, G, into the float chamber, A. As water is collected in the float chamber, the float, B, and attached float rod rise, the after passing through two guides one in the top and one in the bottom of the float chamber. A pen arm is attached to the top of the float rod and the attached pen records the float movement on a chart on the clock drum. When the mechanism is properly adjusted each traverse of the pen across the chart is equivalent to 5 mm of rainfall.

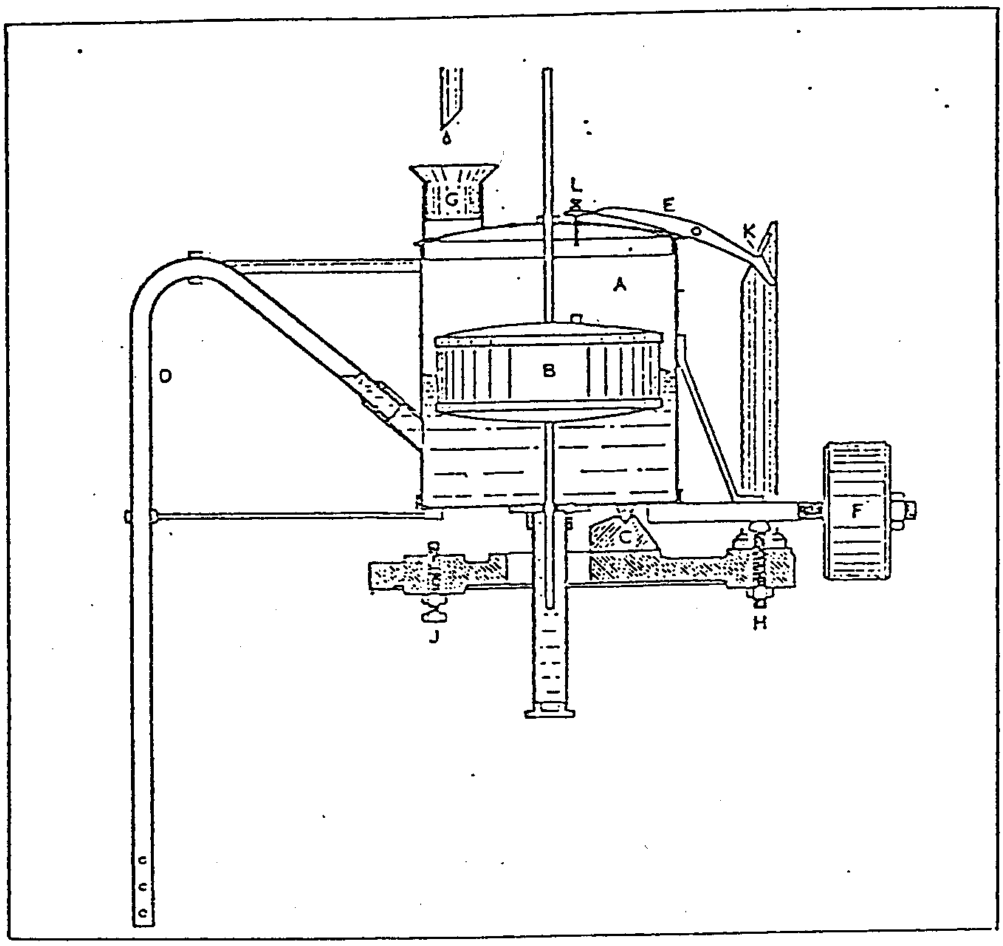


Figure 1.6: **Tilting siphon recording raingauge.**

The chamber A, counterbalanced by the weight F, is mounted on a knife edge C. The position of the weight is so adjusted that when the chamber contains less than the equivalent of 4 mm of rain it rests on the backstop H. When it contains more than the equivalent of 4 mm of rain the chamber would tip forward to rest on the front stop J, but is retrained from doing so by the trigger E which is engaged in the catch K. When the water level in the chamber is equivalent to 5 mm of rain a stud on top of the float pushes against the screw L on the end of the trigger arm and releases the trigger. The chamber then tilts forward on to the front stop and release the trigger. The chamber then tilts forward on to the front stop and siphoning commences through the siphon tube D. At the same time a pen lifting arm, not shown in Figure 1.6, lifts the pen off the chart as the float sinks in the chamber. When the water level in the chamber is equivalent to about 1 mm of rain the chamber tips back to the vertical position (i.e. resting on the backstop) and the pen returns to the chart so that during siphoning the trace should appear only over the lower fifth of the chart. Siphoning continues till the float and pen return to the zero position. It should be noted that a certain quantity of water will always remain in the chamber even after siphoning has finished and the pen has returned to the zero position. The tilting mechanism ensures that siphoning will commence in a positive manner at the correct level.

1.10.1. Installation

The gauge is to be installed with the orifice at a height of 60 cm, ± 4 cm, above ground level. See Sections 1.2 and 1.3 and Chapter 2 for details on siting the gauge. A standard 5 inch manual raingauge must always be installed alongside a recording gauge, the minimum spacing being 2 metres apart. The manual gauge is used as a check gauge.

Mounting the tilting siphon raingauge

Unless there is natural drainage in the soil at the site selected, it will be necessary to provide drainage to a soak pit to ensure that the ground beneath the gauge does not become waterlogged.

The base should be sunk into the ground so that the top of the funnel is 60 cm above ground level. The top of the rim must be level in all directions and this should be tested with a spirit level.

The sub-base can be levelled by means of three screws (D in Figure 1.7) provided for that purpose, but with the rim of the funnel level this levelling should not normally be required.

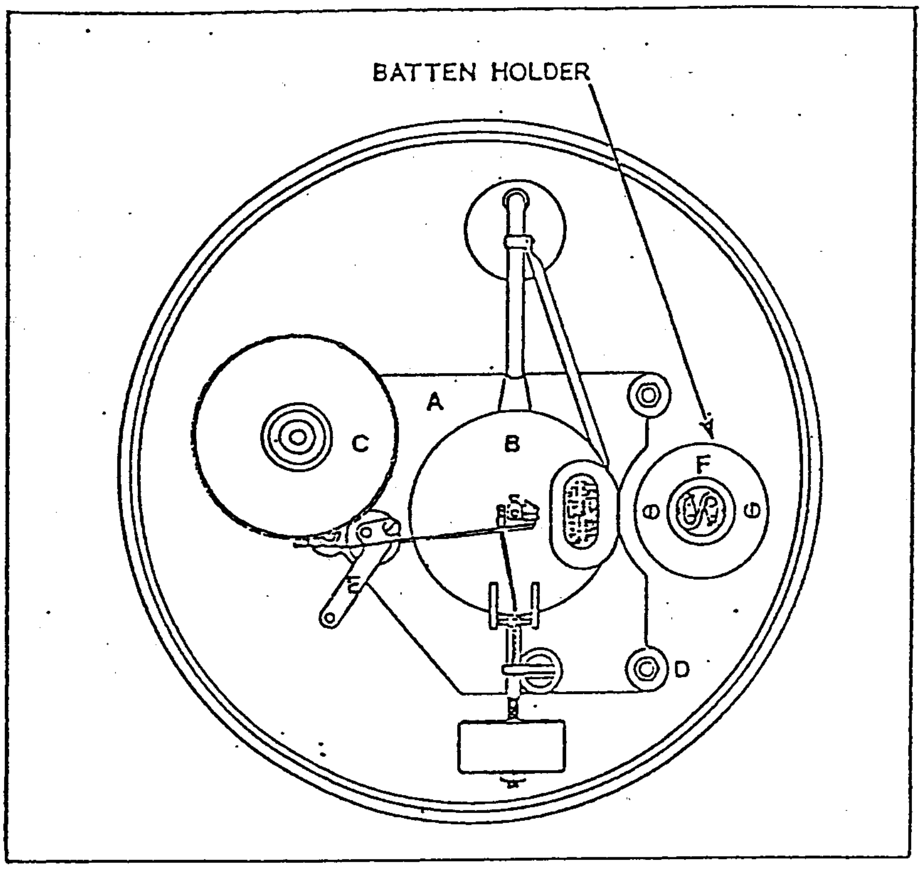


Figure 1.7: The sub-base

1.10.2. Operation

Changing charts

The chart should be changed each morning at approximately the same time as the manual raingauge is read (normally 0900 hours NZ Local Time).

The chart must be held tightly on the drum with the lower edge of the chart touching the clock drum flange.

After changing the chart the drum must be turned backwards to the correct time in order to overcome any backlash. The actual time of commencement of the record, obtained from the observer's watch or clock, should be noted on the chart in pencil.

The clock should be wound daily.

Heading charts

The time correct to the nearest minute, day of week, date, month and year of commencement and end of the record, together with the name of the station, must be entered on each chart in the appropriate place. Entries must be completed immediately after removing each chart from the gauge.

The figures for the daily rainfall taken from the manual check gauge must be entered in the spaced provide at the bottom of the chart.

Any necessary remarks explaining the failure of the pen to write, etc., should also be written on the face of the chart.

Precautions against frost

On all occasions when temperatures below freezing point are expected, precautions should be taken to prevent damage to the float by ice.

At most stations "Kilfrost" marine paste is applied to the float and float chamber by visiting Field Officers. The paste reduces ice adhesion and the likelihood of the float being crushed.

Where heavy frosts are experienced and the "Kilfrot" paste does not offer sufficient protection, a 25 watt electric lamp may be installed insider the gauge where electric power is available. This lamp is then switched on whenever frost is expected. Its location on the base casting of the gauge is illustrated in Figure 1.7 (F).

1.10.3. Maintenance

As well as on a routine basis by the observer, the following checks are all to be made at the time of the annual inspection.

The working parts, and in particular the water passages, must be kept clean if the gauge is to operate satisfactorily. The funnel, funnel tube, and wire gauze filter on the top of the float chamber must be kept clean and free from dust, leaves, etc. A routine cleaning of these parts should be made. A length of expanding wire curtain rod is very suitable for testing for, and clearing, any blockages in the funnel tube.

Whenever necessary the following checks and maintenance should be carried out.

Place a chart on the drum taking care to see that the bottom of the chart fits closely against the flange on the bottom of the drum. Pour water slowly into the float chamber until siphoning takes place and repeat as often as necessary.

Check:

(a) That the pen returns to within a division of the zero line on the chart after siphoning is complete. If not, adjust the position of the pen by raising or lowering the pen arm on the float rod.

(b) That siphoning takes about 15 seconds (no longer than 20 seconds) from start to finish. If it takes longer it is likely that the siphon tube is blocked and it should be cleaned, with a length of curtain wire.

(c) That a measured quantity of water produces the correct chart reading. Use the measuring glass for the 5 inch manual gauge; 9.2 mm in this measure corresponds to 1.8 mm on the raingauge chart when the funnel diameter is the normal 28.75 cm.

(d) That the siphoning action is normal with the funnel restored to the upright position.

The timing of the clock should also be checked once a month by the observer, although this is also checked by the Climate Databank when digitising the charts.

Removal or replacement of float

The procedure set out below should be followed when it becomes necessary to replace the float or to remove it so that the chamber may be cleaned or “Kilfrost” paste applied.

Slacken the screw holding the gate suspension on the float rod and remove the pen arm and gate suspension from the float rod.

Unscrew the three small screws securing the top of the float chamber. Remove the top and lift the float clear.

When replacing the float, care must be taken to ensure that the projection on the side of the float engages in the guide channel in the chamber. When replacing the pen arm ensure that it is orientated as before and that the pen arm is correctly located on the side of the pen arm lifter away from the clock.

When the float has been replaced perform the checks and adjustments detailed above.

Major adjustments

If the instrument fails to record correctly after the normal maintenance and checks described above have been carried out, the following major adjustments are to be carried out. It is essential that these adjustments are carried out in the order set out below. Most gauges should operate satisfactorily if these adjustments are done correctly and in order.

These checks are also to be carried out at the time of the annual inspection.

(i) Ensure the sub-base plate is level, the float chamber is resting properly on the knife edges, and the knife edge vee blocks are clean.

(ii) The backstop should be adjusted so that there is only a minimum amount of play (about the thickness of a visiting card) between the trigger and the trigger catch.

(iii) Set the counterweight (which restores the float chamber to its normal position after siphoning) as far from the float chamber as possible.

(iv) Put on a chart and adjust the pen to read zero after siphoning, having made sure that the gate bearings of the pen are neither stiff or nor unduly loose.

(v) Set the frontstop as high as possible. Pour water into the float chamber until the pen rises a little above 4 mm.

(vi) Release the trigger and tilt the float chamber by hand onto the front stop. Lower the front stop until siphoning begins, and lock it in that position.

(vii) Pour in water again to a little over 4 mm and move the counter weight nearer to the flat chamber until the gauge would tilt if the trigger were released.

(viii) Pour more water into the float chamber until the gauge automatically tilts and siphons, and note at what point the pen returns to the chart after the float chamber has returned to the vertical. The ideal position for the counterweight is such that the pen returns to the chart at a distance above zero, equal to the greatest distance below the top line at which the gauge will tilt when the trigger is released by hand, e.g., if the latter point is reached when the pen has risen to 4.2 mm and the pen returns to 0.8 mm on the chart after siphoning the adjustment is satisfactory. The counterweight should then be locked in position.

(ix) Pour in water again until the gauge automatically tilts and siphons, and note whether the pen resets exactly on the chart zero line. If it does not, then keep repeating the siphoning process and at the same time raise or lower the pen arm setting on the float rod until the pen does reset exactly on the chart zero line on completion of every siphon.

(x) The adjustment screw for the trigger should be set so that the trigger released the float chamber when the pen is exactly on the top line of the chart (i.e. 5 mm exactly). After adjusting this screw ensure that the lock-nut on the trigger set screw is tightened.

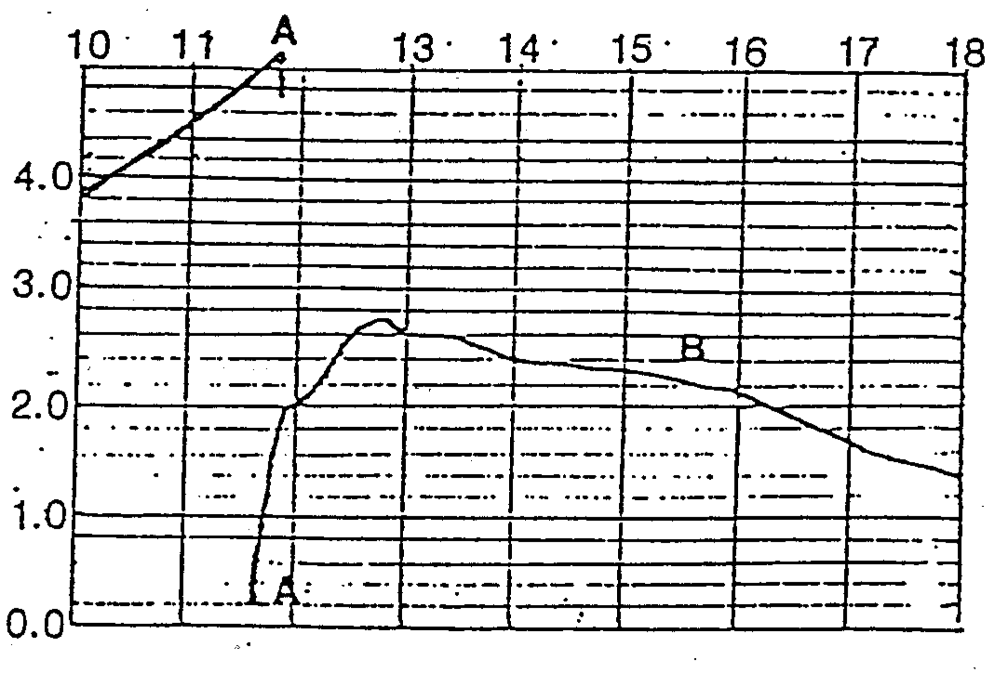
(xi) Pour water into the float chamber until the pen reaches 1 mm. Release the trigger by hand and tilt the float chamber – the pen should be lifted from the chart automatically. If this does not happen the pen arm of the pen lifter or has become bent. The pen arm, when the float chamber is upright, should be close to but not actually touching the pen lifter rod. If the rod is found to be bent, then gently straighten it in such a way that the pen arm is lifted correctly from the chart during the siphoning process. Also ensure that the lifting arm pivot bolt is reasonably tight, so that the arm is rigid.

TYPICAL FAULTS

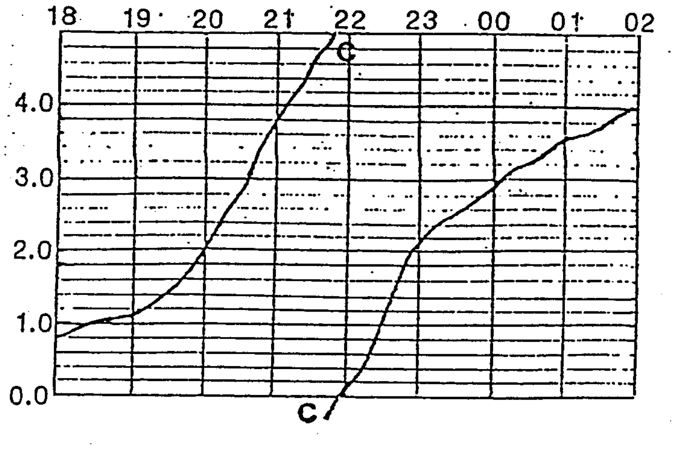
As it is normally possible to determine the nature of a defect in the raingauge by an examination of the record, all charts should be checked. The examples which follow contain one or more typical faults.

A. Pen set too high on float rod.

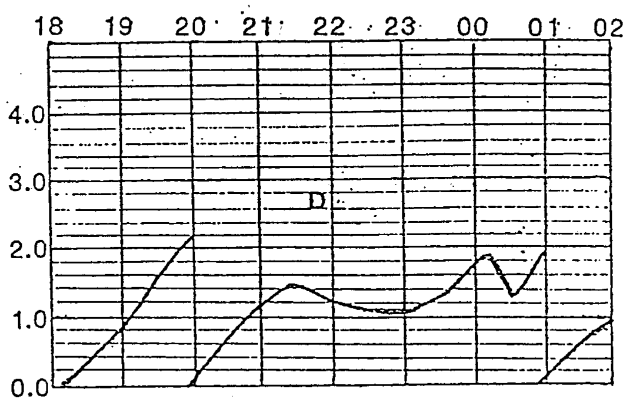
B. Leaking float, probably caused by frost damage. The float should be replaced.



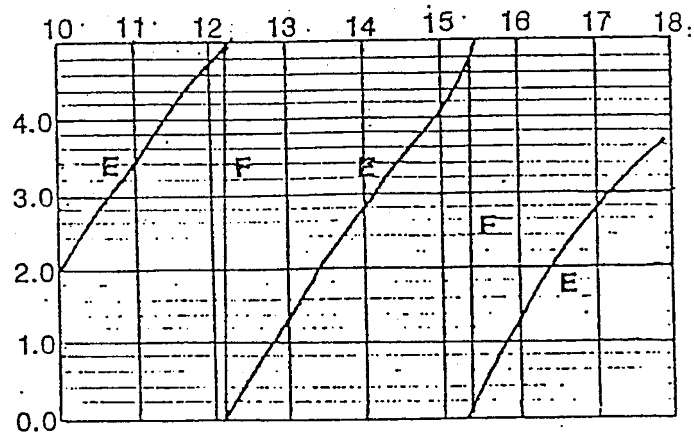
C. Pen set to low on float road. An upward adjustment and the subsequent check, will result in the mechanism tipping above the top of the chart. This is corrected by adjusting the trigger (L in Figure 1.6).



D. Float crushed by frost. The float should be replaced.

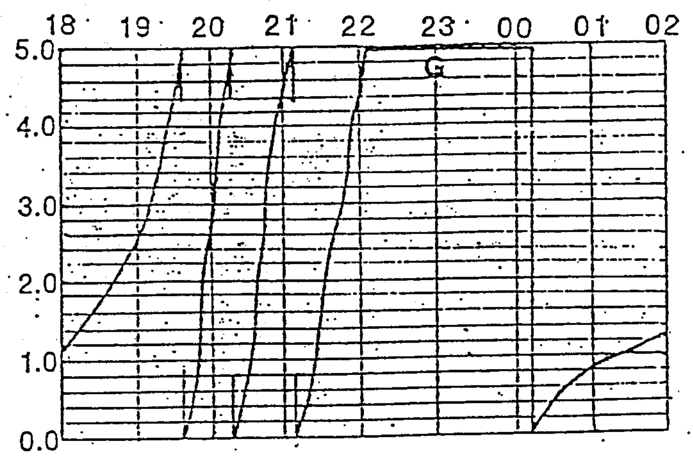


E. A regular trace which may not indicate a fault but which could be due to a partially blocked funnel or gauze filter.



F. Mechanism siphoning without tipping. Adjustment as detailed.

G. Mechanism failing to siphon or tip. Drain pipe in base of gauge flooded. Alternatively, trigger mechanisms fouling or not activated by a distorted float. In this case, siphoning normally occurs without tipping of the rainfall continues



In all cases when the observer detects a fault in the operation of the gauge a special note of the circumstances must be entered on the chart. This applies particularly where the funnel outlet is found to be blocked and there is an accumulation of water in the funnel.

1.10.4. Recording of rainfall

Where daily rainfall observations are made, both the manual and recording raingauges should be read as close as practicable to the same time. Please ensure that the station name, time (to the nearest minute) and date on and off are shown on every rainfall chart.

The daily rainfall reading to be entered on forms Met. 301 and 302 is from the manual raingauge. This total is also to be entered on the automatic chart against "total by manual gauge".

1.11. Lambrecht recording raingauge

In areas where it is not possible to install a daily tilting siphon raingauge but where a record of rainfall intensity, duration, time of fall, etc., is required there is a need for a simple, easily maintained gauge capable of recording for periods of a day, a week or a month with a minimum of attention. For stations with this requirement, the Lambrecht natural siphon recording raingauge type 1507 (daily/weekly) or type 1509 (monthly) is used.

1.11.1. Descriptions: Type 1507 weekly/daily and type 1509 monthly

The gauge has a collecting funnel 16.5 cm in diameter on the top of a cylindrical body 1.2 m in height. The rain collected in the funnel is led through a metal pipe into a float chamber (see Figure 1.8) and as the water collects in the chamber so the float (e) and the attached float rod (c) rise. A pen arm (a) attached to the float rod records the float movement upon a chart. A tube (f) rises at an angle from near the base of the float chamber and the metal end of the glass siphon tube is fitted into this pipe. When the float has risen to the top of the chamber one complete traverse of the chart, equal to 10 mm of rain, has been made and the water has reached the top of the siphon tube at which time siphoning takes place. The float drops to the bottom of the float chamber, the pen returns to zero on the chart and the water siphoned off is caught in a collecting can housed in the base of the gauge thereby providing a check of the total amount of rain to fall over the period.

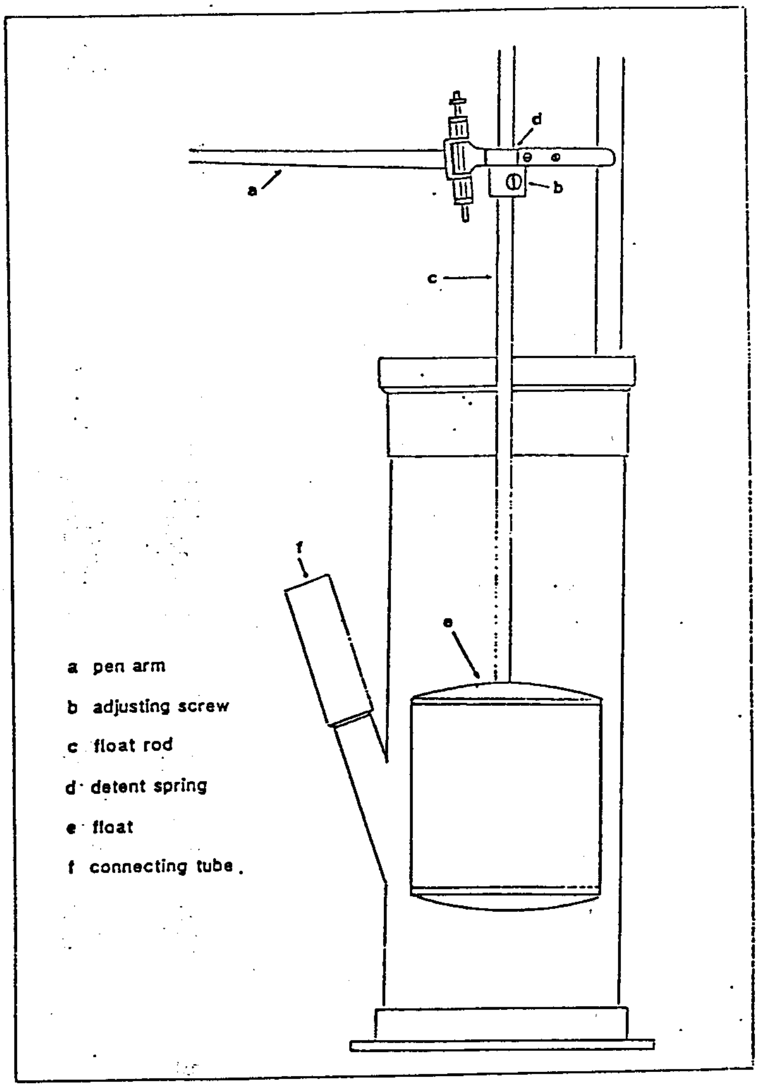


Figure 1.8: Float chamber and pen arm of the Lambrecht recording raingauge.

The chart on the daily/weekly gauge is mounted on a standard “S: drum and is driven by a Horstmann clock, while the monthly gauge employs a strip chart driven at a speed of 10 mm/hr by a clockwork mechanism.

It has been found that although a correctly set up and adjusted gauge records the rainfall accurately, some small discrepancies may arise. After a prolonged dry spell the record may show that the pen has risen somewhat above the 10 mm line on the chart before the first siphoning took place. This is a result of dust in the siphon tube, and should correct itself after one siphoning cycle.

In very heavy rain some difference between the recorded and measured rainfall may occur due to the fact that the siphoning cycle takes some 10 seconds, and during that time an appreciable amount of rain will have entered the float chamber and been siphoned out without being recorded. The amount of rain siphoned is therefore directly proportional to the rainfall intensity.

NOTE: Unless otherwise stated the following instructions apply equally to the daily/weekly and monthly gauges

1.11.2. Installation

For site selection see Selection of a Raingauge Site elsewhere in this chapter and see also Chapter 2, “Exposure”.

The gauge must be mounted on a solid foundation; a concrete slab 0.6 m x 0.6 m with bolts appropriately placed so that the three feet on the base of the gauge match up with them will be the most satisfactory. It will be necessary to locate the bolts after receipt of the gauge as the positions of the feet vary with individual gauges. To ensure rigidity of the gauge, especially in strong wind conditions three eye-bolts are provided below the shield at the top of the body and wire stays should be attached to these to prevent vibration which affects the reliability of the siphoning action. The gauge should be so mounted that the rim is level in both directions and the collecting surface (the funnel inside the rim) is 1.2 m ± 0.06 m above the ground.

1.11.3. Operation: Type 1507 daily/weekly

Charts should be changed every day/Monday at approximately the same time as the reading of the manual gauge (0900 hours) at which time the clock should be wound.

The charts should be held tightly onto the drum and the bottom of the chart should make contact with the clock drum flange all the way round.

After changing the chart the drum should be turned backwards to the correct time in order to take up any backlash in the mechanism.

Immediately after removing the chart enter on it the time correct to the nearest minute, date, month and year of the beginning and end of the record, together with the name of the station.

The total from the collecting can measured in millimetres with the plastic measure should be recorded on the face of the chart and appropriately identified.

Any remarks considered necessary to explain deficiencies in the record should be written on the face of the chart.

1.11.4. Operation: Type 1509 monthly

Chart rolls are changed monthly or more frequently if necessary, and at the same time the clock is wound and the water in the collecting can emptied.

Life the pen from the chart, swinging it to the right until it is held by the detent spring.

Undo the blue knurled screw above the drive mechanism and draw the clockwork forward from the slide bars.

Raise the two chromed retaining strips from the sides of the chart and release the spool carrying the marked chart by moving both blue tipped levels forwards against the pressure of their retaining springs. The chart can be removed from the spool by sliding the limit disc carrying the small cog from the hollow axle of the spool.

Wind the clock fully. The winding spindle is reached through a hole in the recording plate over which the chart runs.

Measure the water in the collecting can with the plastic measure and enter this total, together with the time correct to the nearest minute, date, month and year on the chart jut removed.

To fit a new chart roll raise the recording plate by releasing the red tipped levers, remove the chart roll holder from the carrying arms and fit the new chart roll to it.

Thread the chart under the bar, over the pin roller and across the recording plate which should then be pressed back into position so that the red tipped levers re-lock into position.

Fit the end of the chart roll under the retaining spring on the take-up spool and replace, ensuring that the blue tipped levers are holding it firmly.

Record the time correct to the nearest minute, date, month and year on the chart, replace the mechanism in the slide bars, and tighten the blue knurled screw.

Bring the pen gently forward on to the chart, making any adjustments to the time by moving the chart backwards to the correct time thus ensuring that any backlash is taken up. Check that the pen is writing on the chart.

1.11.5. Maintenance

Beyond ensuring that the funnel and the tube leading to the float chamber are kept clear of obstructions, little regular maintenance is required.

Pens should be changed when the trace becomes faint to ensure a clear trace, but as long as the gauge functions satisfactorily there is no need to disturb the float chamber.

Irregularity in the record due to erratic siphoning is usually caused by vibration of the whole instrument in gale for ce winds, or by dirt in the siphon tube. In the latter cases the siphon tube should be removed from the float chamber and washed, and the float chamber removed from the gauge and cleaned out

To remove the float chamber, unscrew the wing nut under the mounting plate and withdraw the float chamber from the gauge. Loose the small screws on either side of the float chamber and remove the top, taking care not to drop the screws, which are very small. Dirt can then be washed from the float chamber, paying special attention to the connecting tube.

After the float chamber has been reassembled and replaced in the gauge the siphon action should be checked as follows.

Slowly pour just sufficient water into the funnel to cause the mechanism to siphon. When the siphoning is complete the pen should be resting on the zero line of the chart. If not adjust as described below in Adjustment of Zero.

From the plastic measure pour the equivalent of 10 mm of rain slowly into the funnel. This amount of water should cause the siphoning action to commence with the pen on the 10 mm line on the chart. If, not, adjust the siphoning point as described in Adjustment to Siphoning Point.

The timing of the clock should be checked at regular intervals, and any discrepancy which cannot be adjusted by the regulator should be reported. The regulator on gauge type 1509 (monthly) will be found by raising the recording plate while that on gauge type 1507 (daily/weekly) is located beneath the clock body. Access to this regulator is gained by removing the thee screws from the base flange of the clock and removing it from the mounting plate.

1.11.6. Adjustments

Adjustment of zero

This should be carried out when the pen has reached the lowest point of its travel after having completed a siphoning cycle. Adjustment is made by mean of the red painted screw above the swivel joint on the pen arm.

Adjustment to siphoning point

This is effected by moving the siphon tube in the float chamber connecting tube. If the siphoning point occurs below 10 mm, the siphon tube should be pulled out of the connecting tube, or pushed in if siphoning occurs above 10 mm. These adjustments should be made with the greatest of care, as the glass siphon tube is particularly susceptible to breakage at the bend near the float chamber.

Loosen the stopping clamp on the siphon tube, make the necessary adjustments, bring the stopping clamp into contact with the top of the connecting tube without moving the siphon tube and then retighten the screw of the stopping clamp.

1.11.7. Recording of rainfall

Where daily rainfall observations are made, both the manual and recording raingauges should be read as close as practicable to the same time. Please ensure that the station name, time (to the nearest minute) and data on and off are shown on every rainfall chart.

<u>The daily rainfall reading to be entered on rainfall forms MET 302 is from the manual raingauge</u>. This total is also to be entered on the automatic chart against "Total by Manual Gauge".

1.12. The 4-inch plastic raingauge

The 4 inch (100 mm) plastic raingauge differs from the standard pattern 5 inch raingauge in being made of transparent plastic. The diameter of the funnel is 4 inches (100 mm) and the raingauge is not dug into the ground. Instead it rests on the ground (a grass or gravel surface) and is held by a light metal or heavy plastic bracket which is attached to a short wooden stake. The funnel rim must be level, and will be 35 cm above the ground (see Figure 1.9).

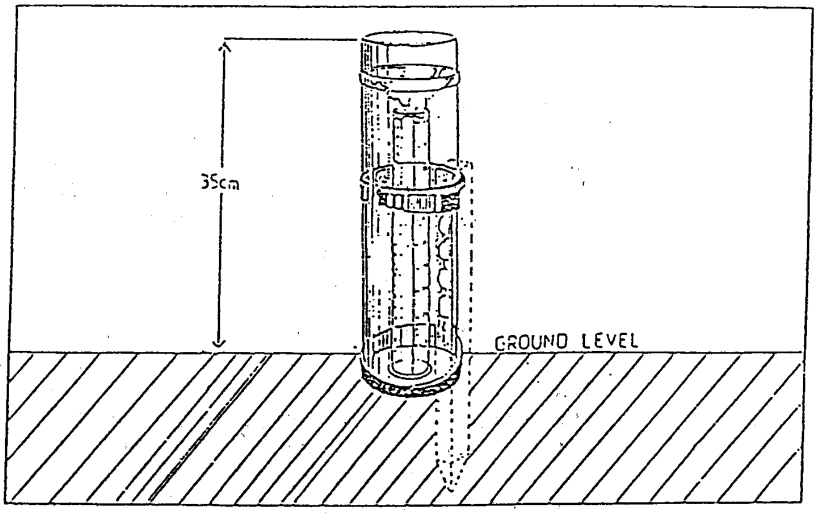


Figure 1.9: The 4-inch plastic raingauge.

The raingauge consists of three parts: outer container, funnel and measure. The measure fits into a small socket in the base of the outer container. In this position, the open end of the measure is directly under the funnel outlet. Thus rainwater collected in the funnel drains straight into the measure.

1.12.1. Assembly of raingauge

This entails attaching an aluminium or plastic bracket to a wooden peg, driving the peg into the ground and inserting the plastic raingauge in the bracket. The raingauge comes complete with the bracket, but the peg is supplied as a separate item.

At some locations a weight is fitted to the funnel to prevent it from being blown away. The weight is a semi-circular band of mild steel which is sprung into place around the outside of the funnel. This is supplied as a separate item.

It is normally more convenient to attach the bracket to the peg before the latter is driven in. If an aluminium bracket is supplied the "L" shaped base support is laid on the peg and the two semi-circular brackets are screwed through this into holes predrilled in the peg. The screws should be tightened until the two semi-circular brackets are firmly held at right angles to the peg.

If a hard plastic bracket is supplied the small lip at one end of the straight part fits into a slot in the circular, bottom, bracket and the other end fits into a broad groove in the semi-circular, top, bracket before it is screwed to the peg.

Installing peg and raingauge

Driving the peg requires care. Where the peg has to be driven into hard ground a small crowbar should be used to make a hole. The peg should be lifted from the ground several times during driving. This will free the peg so that it can be removed whenever required, e.g. to facilitate lawn mowing. However, the peg must fit as firmly as possible into the ground so that it does not have any sideways movement. The peg is driven in until the bracket leg is at soil level.

Levelling of raingauge rim

A spirit level should be used to check that the rim is level in all directions.

1.12.2. Measuring the rainfall

This is the same as stated in the section on the Operation of Daily Manual Raingauges, however the accuracy will be less due to the resolution of the plastic measure being in 0.5 mm graduations. Also with the measure having a flat base, it is not as sensitive to low rainfalls ie. 0.05mm.

1.12.3. Care and maintenance of the 4" plastic raingauge

Protective Fence for Raingauge

The gauge must be protected from damage by animals and the carelessness of human beings. If it is in an open field to which cattle or horses have access, an open type wire fence must be provided. This fence must be a minimum size of 3 m x 3 m and at least 1 m high. Sometimes it is practicable to have only two wires or a rail of some kind on the top of this fence to prevent access by cattle or horses, but yet allow sheep to get in and graze, thus keeping the grass short.

Maintenance of raingauge site

It is important the grass surrounding the raingauge is kept closely cut for a distance of at least 1 metre in all directions.

On no account is concrete or asphalt to be laid around a raingauge.

If the raingauge is not removed when mowing, care is to be taken not to damage the side of the instrument. The grass immediately round the raingauge is best cut with a pair of hand clippers.

Condition of raingauge rim

The rim of the raingauge must be perfectly circular and sharp. If it gets dented or the edges burred or rough, the gauge should be replaced.

Precaution against leaks

Because the raingauge is made of plastic, observers should take care of these points:

1. Watch for cracks in plastic walls of the outer container and funnel rim.

2. Watch for leaks around the seams at the bases of the outer container and measure.

Care of plastic raingauge measure

The graduated measuring glass will require cleaning from time to time. It should be washed with mild soap or detergent and water. Do not use solvents or abrasives. Any ordinary bottle brush is useful in removing *any* collection of dust or grime at the bottom of the measure.

Replacement of plastic rainfall measure and/or raingauge

Should the plastic rainfall measure or raingauge be broken or develop a leak advise your nearest NIWA office.

1.13. The Octapent raingauge

The "Octapent" raingauge is a long period manual gauge which is used for measuring rainfall over weekly or monthly periods. It is a 5 inch raingauge with a greatly enlarged inner can, so arranged to reduce evaporation of the contents to a minimum (Figure 1.10).

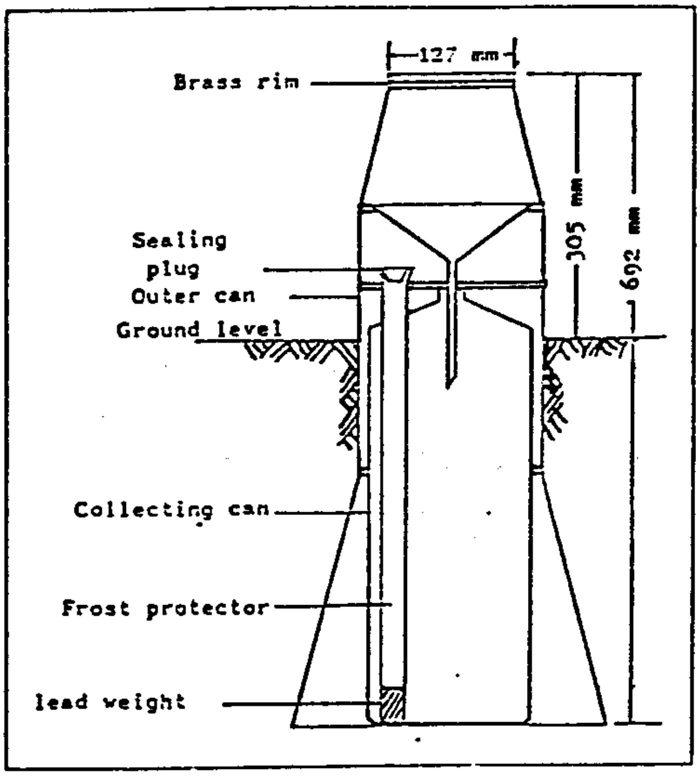


Figure 1.10: The Octapent raingauge

The raingauge is supplied with a frost protector in the form of a length of rubber tube in the inner can which absorbs the expansion caused by the freezing of collected rainwater. This avoids damage to the container under normal circumstances. The lower end of the length of tube is sealed and the top is spread by a plug where it enters the container. The spreading seals the hole in the container and contributes to the reduction in loss by evaporation referred to above.

The raingauges are made in two sizes, with inner cans of 680 mm and 1270 mm capacity respectively.

1.13.1. Installation

The octapent raingauge should be buried in the ground so that its rim is level and 30 cm above ground level. A spirit level should be used to see that the rim is level. The base must be firmly fixed in the ground so that the gauge cannot be displaced when the funnel is removed.

1.13.2. Measuring the rainfall

These gauges are read in two ways, with a dipstick and with a glass measure. The dipstick is used first and is used as a check against the glass measure in case of spillage or incorrect additions if more than one glass measure full is collected.

As these gauges are storage gauges and are only read periodically, great care must be taken when pouring from the inner can into the glass measures.

Fifty millimetre measures are usually used for this purpose, although their accuracy is not as great as the 10mm measure.

The following steps should be taken when reading the gauge:

1 Remove the frost plug and take a dipstick measurement and record the amount.

2 Carefully pour the water into the glass measure. Record the amount and empty the measure. Repeat this step as many times as necessary until all the water has been measured.

3 Sum the measurements and check with the dipstick reading which is a check in case of adding errors or spillage.

4 File the glass measure reading, unless it is in error due to spillage or other causes in which case file the dipstick reading with a comment.

1.13.3. Checking for leaks

If water persistently reappears in the outer can then it is possible that the outer can, inner can or funnel is leaking, and the gauge should be tested. This is done by removing the gauge from the ground and filing both the inner and outer can with water. The funnel should also be tested. If leaks are found they should be repaired or a replacement gauge obtained.

1.14. Other storage raingauges

1.14.1. PVC stand-pipe gauges

These are generally constructed from 150 mm nominal bore pressure pipe, and have been made in 1200 mm, 1500 mm and 3000 mm capacities. As the gauge height is the same as their capacities, they are often difficult to install at the standard 0.3 m height. They are often employed in localities with significant snow, and in such cases the standard orifice height would cause it to be buried.

Installation

Their height causes problems with wind, and hence they are best **in** a well sheltered location or equipped with an Alter shield.

- Where possible to excavate it (perhaps with a post-hole borer), a section of slightly larger diameter pipe should be installed like a "well" in the ground, to a depth which will enable the orifice to be at a suitable standard height (preferably 0.3 m, but 1.0 m could be suitable).

- Ensure that the orifice is horizontal (use a spirit level) and that the gauge is not loose to move around.

- Where necessary because of wind, the installation of a shield or the gauge's height, guy ropes are used to hold the gauge vertical. These should be of galvanised wire rope, with suitable spring tensioners to keep them taut. A quick-release hook on one of three guys will enable the gauge to be tipped over for quick emptying, an important factor if visits are by helicopter.

- An anti-freeze solution will be required in cold climates, so that the gauge can be read if any of the water is frozen. A mixture of methylated spirits and glycol antifreeze, in proportions to give a density just less than water, will be necessary in order that the antifreeze will not settle out.

An amount adequate to cope with the expected rainfall should be added, not forgetting to leave sufficient capacity in the gauge. The amount will depend on the temperatures, and some experimentation may be required. McSaveney (1979) suggests using between 10 and 20 % of the expected rainfall volume over the period.

The mixture should be prepared beforehand, using commercial glycol antifreeze and methylated spirits in the ratio of 1:1.12, and using a vintner's hydrometer to adjust the density to 0.995 kg/l, as both components may contain various amounts of water.

For more details on the use of this antifreeze, refer to McSaveney (1979).

- Oil shall be added to prevent evaporation. A layer of at least 8 mm is required. Normal lubricating oils have a tendency to evaporate themselves and to emulsify with water and coagulate. A light mineral oil normally used as a anti-stick agent in commercial baking has lower volatility and is clear and cleaner to use. BP Enerpar M002 (formerly WM2) has been trialled for this purpose and is recommended. See section 5.6 for more details.

Field servicing

Reading this type of raingauge consists of the following steps.

Oil shall be added to prevent evaporation. A layer of at least 8 mm is required. Normal lubricating oils have a tendency to evaporate themselves and to emulsify with water and coagulate. A light mineral oil normally used as a anti-stick agent in commercial baking has lower volatility and is clear and cleaner to use. BP Enerpar

M002 (formerly WM2) has been trialled for this purpose and is recommended. See section 5.6 for more details.

- Measure the depth from orifice to water-level (actually oil level) and record as " mm 0 to W.L.".
- Calculate the rainfall from the previous such measurement.
- Empty the gauge by tipping out, pumping or a plunger.

NOTE: A plunger can be used to empty a standpipe gauge quickly, but it can be messy for the person doing it. On the end of a stout rod mount a rigid perforated disc slightly smaller in diameter than the bore of the gauge. Above this mount a similar size disc of flexible rubber sheet. The device can be plunged to the bottom of the gauge then raised quickly to empty most of the contents over the top (and perhaps the observer...).

- Add the required amount of anti-freeze mixture calculate the rainfall from the previous such measurement.
- Add sufficient oil to give about a 8 mm layer.
- Measure the distance from orifice to oil level and record
- Also record whether emptied, oil added, anti-freeze added, and clearly indicate whether readings are orifice to water-level, net rainfall, etc.

Calibration

As the measuring container has the same diameter as the orifice and a measuring glass is not normally used, calibration involves checking the tape or dipstick used. Even steel tapes should be checked against each other, and any discrepancies resolved by checking against a traceably-calibrated tape (one is held by the QA/SD Unit).

1.15. Tipping bucket event raingauge

This gauge is typified by the "Ota", the most common brand in use in New Zealand_ It has a 200mm diameter orifice and collector which feeds rainwater into a pivoted double-sided tipping bucket mechanism. The buckets are sized at 0.2mm or 0.5 mm of rainfall equivalent (although other sizes are available) and when full the bucket tips the water out, providing a momentary switch closure on a magnet-driven reed switch for a datalogger. As one bucket tips out, its attached twin moves under the spout of the collector. The gauge is shown diagrammatically in Figure 1.11. Further details are as follows:

1.15.1. Installation

- Install at a standard orifice height of 0.5 m, ±0.05m, but ensure relativity with any previous records.

- Bolt the instrument to a mounting base, preferably set in concrete.

- Ensure that the instrument is set level according to the levelling bubble set into the base. This bubble is used to set the gauge's attitude during initial calibration at NIWA Instrument Systems, rather than using a spirit level across the orifice

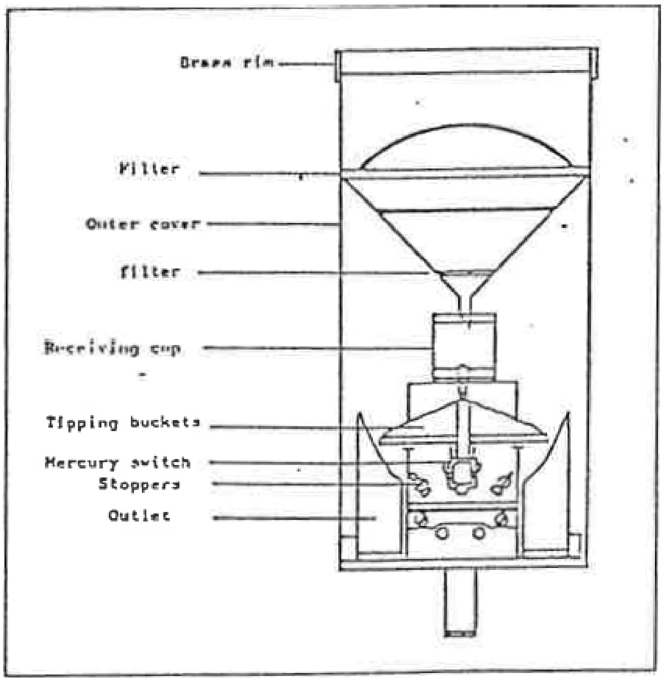


Figure 1.11: Tipping bucket raingauge

- Connect the cable to the datalogger, routing it through polythene tubing for protection, and ensure that any joints are thoroughly waterproofed (e.g. with *neutral-curing* silicone rubber glue).

1.15.2. Servicing visits

- Remove the cover to provide the tips required for the datalogger procedure. Do not just tip in water until 2 tips are heard - it provides no check on operation, which could be affected by dirt, insects, mechanical faults, etc.

- Check that the buckets tip freely, and remove any dirt or insects.

- Clean all filters and ensure that insect guards are in place.

- Inspect the receiver for dirt, cracking paint, dents, etc.

- Check that the levelling bubble is central, and adjust if necessary

1.15.3. Calibration

At each annual inspection, fill out the Form AIR and carry out a check calibration using pipettes as described in the green instruction sheet IS 12 (see section 8.1.6).

Re-level the bubble if necessary, checking that it is secure in its mount.

Ensure that the pipettes drip the water in slowly (< 7 ml/min) prior to the tip, and that the pipettes are held near the inlet from the collector.

If the calibration is outside the allowable ±3% repeat at least twice for each bucket, ensuring that the drip rate, etc., is correct before sending to Instrument Systems for servicing.

Watch for interference from wind; even a slight breeze will tend to cause a bucket to tip prematurely. Replace the cover and drip the water in via the collector if there is any wind.

1.16. Telemetered raingauges

Some telemetered water-level stations may be equipped with tipping bucket raingauges for flood warning purposes. Because their purpose is for largely internal operational purposes they may, for convenience and economy, be non-standard installations. However such stations should not normally be filed on the Databank, unless they:

- Have a standard orifice height of ground-level or 0.5 m. A height of 1.0 m could be used if necessary, but anything over 2.0 m is not permitted (WMO, 1989).

- Are not greatly under- or over-exposed.

- are corrected to a ground-level or 0.3 m orifice height check gauge which itself has correct exposure, is of a standard type and is installed and operated according to the requirements of this chapter.

If such a station is not operated to these standards, careful consideration should be given to the cost-benefit of doing so.

2. Exposure

Exposure refers to the "micro-climate" at the measuring station which relates to the local air movements and shelter from wind and sun. The exposure requirements of a climate or rainfall station are:

- That all the measured parameters are typical of the surrounding region, and

- That the features of the site do not cause interferences with the parameters, for example by wind turbulence altering the trajectories of raindrops or cold air draining to or from the site.

2.1. Site selection

2.1.1. Selection of site

Climatological stations must, whenever possible, be set up on a level grassed site where the surrounding ground is also level or has only a very slight slope. The exposure should be open and generally representative of the district although a very exposed windswept site should be avoided if possible. The rule regarding obstructions such as trees, hedges, buildings, etc., is that these should be at least twice and preferably four times their height away from the boundary of the plot. Due regard must be paid to the possible future growth of trees or hedges and the erection of buildings.

2.1.2. Permanence of site

It usually takes ten years to establish reasonable temperature normals and thirty years for rainfall normals, therefore every endeavour should be made when setting up a climatological station to ensure that there is a reasonable chance of the station remaining permanent and with the same exposure for at least twenty years.

2.1.3. Size of Enclosure

The optimum size of an enclosure for a standard climatological station is 15m x 12m (Figure 2.1). When only basic instruments, namely thermometer screen, manual raingauge and grass minimum thermometer, are to be used the size can, if desired, be reduced to a minimum of 9 m x 7.3 m provided the surrounding ground is open pasture land or grass. When autographic instruments, in addition to a Dines raingauge, are to be installed the 15 m x 12 m enclosure should be provided and stations where special climatological investigations are to be made require an even larger enclosure, up to 18 m x 18 m.

However occasionally these standards cannot be adhered to. Provided the rules regarding obstructions in 2.1.1, 2.1.4 and 2.2.1 are met, an elongated site or circular site can be set up.

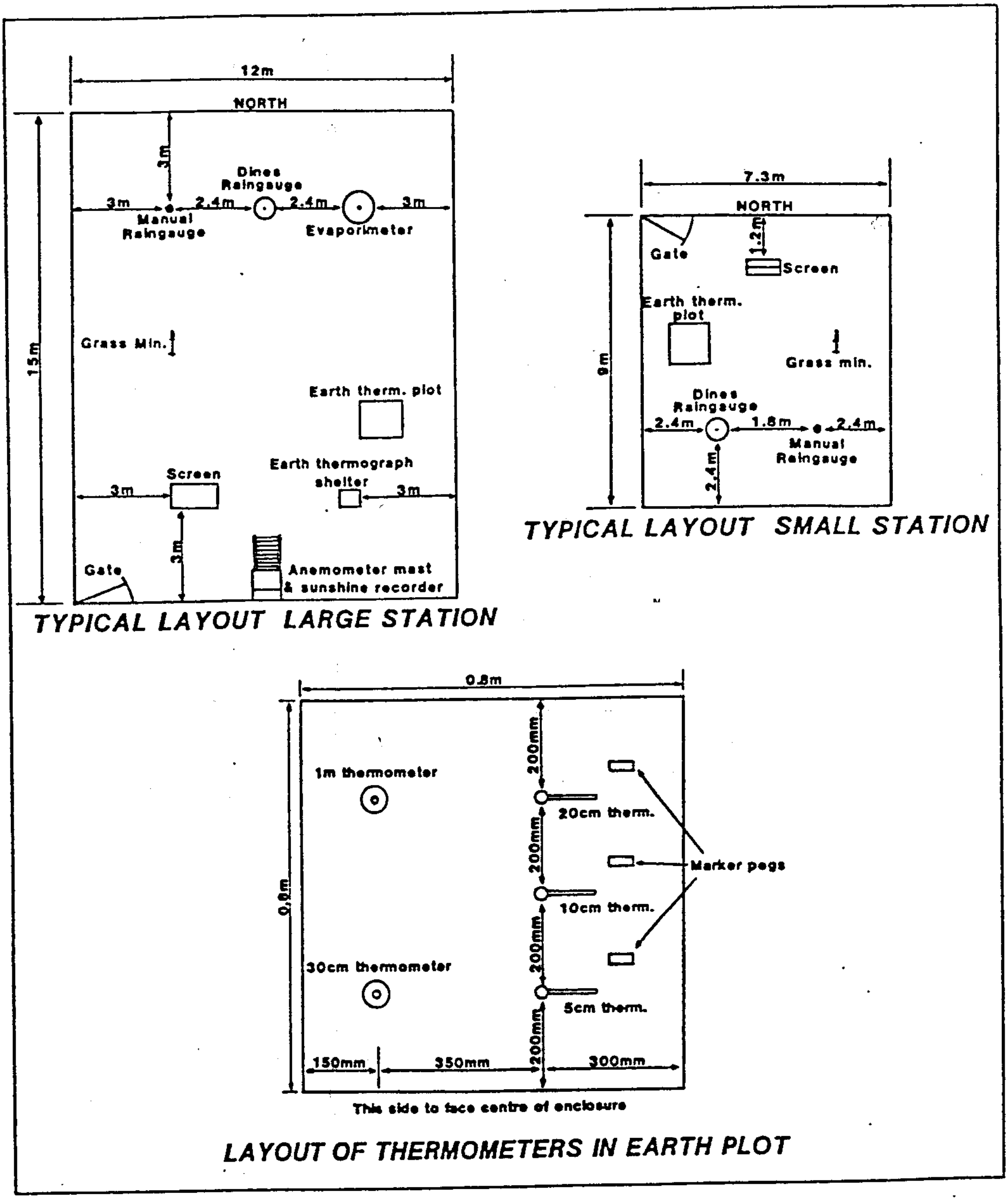


Figure 2.1: Enclosure layouts.

2.1.4. Fencing of Enclosure

This must always be an open type of fence such as standard post and wire or wire-netting. If interference from the public is not likely a standard 1 metre high fence is usually adequate. In public areas a close-wired or wire-netting fence at least 2.5 m high is necessary with barbed-wire around the top.

If for some reason it is necessary to use a close fence or hedge as one or more sides of the enclosure the size of the enclosure must be increased - usually by twice the height of the close fence. Corrugated iron fences are to be avoided.

In very exposed and windswept areas it is sometimes desirable to provide a closed fence or brushwood windbreak, but if this is the case the size of the enclosure should be increased as indicated above.

NOTE: If a local body or authority requests the establishment of the station it is usually responsible for providing and maintaining all fencing.

2.2. Exposure of instruments

2.2.1. Layout of Instruments in Plot

This depends on local conditions but there are certain fundamental requirements that should be met. These are:

The fence must be considered an obstruction and raingauges, evaporimeter and grass minimum thermometer kept twice the height of the fence away from it.

The raingauges require the best exposure and should be grouped together near one end of the plot preferably to windward of any other instruments, thermometer screen, etc., for the prevailing winds. The distance between the rims of the Dines and manual raingauges must be at least 1.8 m. The evaporimeter can be installed with this raingauge group.

Thermometer screens, anemometer poles, and any other tall instrument should be grouped together towards the south end of the plot.

The anemometer pole can, if desired, form part of the fence such as the corner post. The ladder must however come inside the enclosure and also face approximately north so that the platform will be correctly orientated if a sunshine recorder is to be installed.

Thermometer screens are to be installed with the door opening to true south. If for some reason this is not possible, the door opening to west of south is preferable to east of south.

The earth thermometer plot should have a bare earth surface, which should be kept free of weeds and growth. An edging of suitable 75mm x 25mm timber should be sunk in round the edge of the plot so that the top is flush with the surface. This helps to keep the edge of the grass defined. The plot is to be level with the surrounding area.

The sunshine recorder is best mounted on the platform of the anemometer pole if this is provided. If not, any convenient site on the roof of a nearby building which gives the desired exposure can be employed. However such a site should be readily accessible for changing the sun cards and must not present any undue risk to the observer climbing to it. A post in the enclosure near the screen and level with the top of the fence is another possible site provided the exposure is satisfactory.

Typical layouts for a small and large station and the layout of the earth thermometers in the earth thermometer plot are shown in Figure 2.1.

2.2.2. Setting up of Individual Instruments

The appropriate instruction must be carefully studied before any instrument is set up. Copies of the instructions covering instruments are in following chapters.

2.3. Instrument screens

2.3.1. Introduction

Instrument screens are provided to shield the instruments from radiation from the sun or nearby bodies, and to protect them from precipitation while allowing adequate ventilation so that temperature and humidity values within the screen correspond with those in the free air.

2.3.2. Construction

The walls and doors of most thermometer screens have double louvres. This type of construction minimises the transmission of radiation while permitting a reasonably unobstructed passage of air through the screen.

All woodwork both inside and outside the screen must be painted white in order to minimise the absorption of solar radiation.

All metal fittings used in screen construction or repair must be non-ferrous, e.g., hinges, screws, hasps and staples etc., are usually brass.

In order to prevent movement it is most important that screens be firmly secured to the stand. In some very exposed sites it is necessary to fix guy wires or wooden stays in order to prevent vibration in strong winds. Vibration can affect maximum and minimum temperatures recorded.

2.3.3. Screen types

Instrument screens used by NIWA are:

Large

Internal dimensions are 1042mm wide, 318mm deep and 456mm high. The maximum and minimum thermometers are mounted parallel, with the bulb end of each thermometer approximately 6mm lower than the top end. The wet and dry thermometers are mounted vertically.

Instruments such as thermographs, hygrographs, etc. may also be housed in this screen.

Small

Internal dimensions 419mm wide, 159mm deep and 305mm high. This screen houses wet and dry bulb and maximum and minimum thermometers all mounted parallel with the bulb ends of each approximately 6mm lower than the top end.

2.3.4. Installation

The legs of all screens should be buried in the ground to such a depth that the base of the screen is 1.08m above ground level and the minimum amount of soil dug out.

The soil that is replaced must be firmly rammed around the legs to ensure there is no movement of the stand in strong winds.

Turf should be placed on top of the replaced soil to enable the grass to cover all the ground underneath and around the screen. Under no circumstances is concrete or asphalt to be laid under or around a screen.

The screen door must open towards true south. This is necessary to reduce to a minimum the risk of solar radiation reaching the thermometer bulbs when the door is opened.

A carpenter’s spirit level must be used to check that the screen base is level in all directions also that the screen sides are truly vertical.

2.3.5. Maintenance

A good sward of grass must be maintained at all times under and around the screen. This grass must be kept cut short.

Occasionally hollows develop under or in front of the screen thereby enabling rainwater to form pools. Whenever this occurs the ground level should be brought up to the level of surrounding ground. Hollows or dead patches of grass often occur in front of the screen where persons normally stand to take the instrument readings. To help avoid these occurring, small wooden duck-boards may be laid in front of the screen on which persons should stand when taking instrument readings.

Some soil types will often contract appreciably from around the screen legs during dry spells. Whenever this occurs the soil should be tightly rammed in order to prevent movement of the stand in strong winds.

Following periods of wet weather some soils become very soft and if strong winds should occur the screen and stand will be tilted from the vertical. At the first opportunity the stand must be dug out of the ground and replaced in the correct vertical position.

Weathering can cause the woodwork of some screens and stands to shrink, thereby causing loosening of joints. Periodic checks should be made to ensure that all screws are screwed as tightly as possible into the wood, in order to avoid movement in strong winds.

Screens must he kept perfectly clean and the paintwork as white as possible. As soon as the paintwork shows signs of peeling or weathering it should be thoroughly cleaned by washing then sanding or rubbed down with a wire brush and repainted using 100% acrylic high-gloss white paint.

Where any material damage occurs to the screen or stand that necessitates repairs, this should be reported to your nearest NIWA team.

3. Temperature and humidity

Meteorology, climatology and hydrology frequently require the measurement, and often the continuous recording, of the temperature of one or more of the following:

- the air near the earth's surface
- the soil at various depths
- the waters of rivers lakes and sea, and
- the air in the upper atmosphere.

This manual deals only with the first two.

The standard unit of measurement is degrees Celsius (°C).

Relative humidity is one of various ways of specifying the water vapour content of atmospheric air.

It is defined as the ratio, expressed as a percentage, of the actual vapour pressure of the air to the saturation vapour pressure at that air temperature. In simple terms it is a measure of the amount of water in the atmosphere, expressed as a percentage, at a particular point in time.

3.1. Operation of thermometers

3.1.1. Cleanliness of thermometers

All thermometers must be kept clean and this should be ensured by carrying out a routine cleaning once a week.

If water has condensed on any portion of a thermometer the water should be wiped off and the readings delayed for several minutes.

3.1.2. Broken spirit column

Occasionally a break appears in the thread of spirit in a spirit thermometer. See section 3.4 "Minimum Thermometers" for detail.

If a break appears in the mercury thread of a mercury thermometer (other than a maximum thermometer at its constriction) it should be replaced.

3.1.3. Reading thermometers

All thermometers should wherever possible be read to the nearest tenth of a degree. This is particularly necessary for readings of the wet and dry bulb thermometers from which are calculated the relative humidity of the air.

The whole degrees are read directly from the scale on the thermometer.

The tenths of a degree have to be estimated as nearly as possible. Use the following method to obtain an accurate estimate of the tenths of a degree:

First subdivide visually the space between the appropriate two divisions of the thermometer scale into quarters.

With these subdivisions in mind, obtain the tenths of a degree registered by the mercury column from the table below:

- Number of tenths is .0 when end of column is exactly on whole degree division.
- Number of tenths is .1 when end of column is very slightly past whole degree division.
- Number of tenths is .2 when end of column is not quite at first quarter.
- Number of tenths is .3 when end of column is very slightly past first quarter.
- Number of tenths is .4 when end of column is not quite half way.
- Number of tenths is .5 when end of column is exactly half way.
- Number of tenths is .6 when end of column is very slightly past half way.
- Number of tenths is .7 when end of column is not quite at third quarter.
- Number of tenths is .8 when end of column is very slightly past third quarter.
- Number of tenths is .9 when end of column is almost but not quite up to whole degree subdivision.

A serious error to avoid is known as the error of parallax (Figure 3.1). To avoid this error, a thermometer hung vertically should be read with the eyes exactly level with the top of the mercury column and a thermometer lying horizontally should be read with the reading eye directly opposite the end of the mercury column. The difference in the apparent reading can easily be noticed if the eye is moved towards or away from the bulb of the thermometer.

Before closing the screen all readings should be checked, as it is very easy to make a mistake of 1, 5 or 10 degrees unless the greatest care is taken.

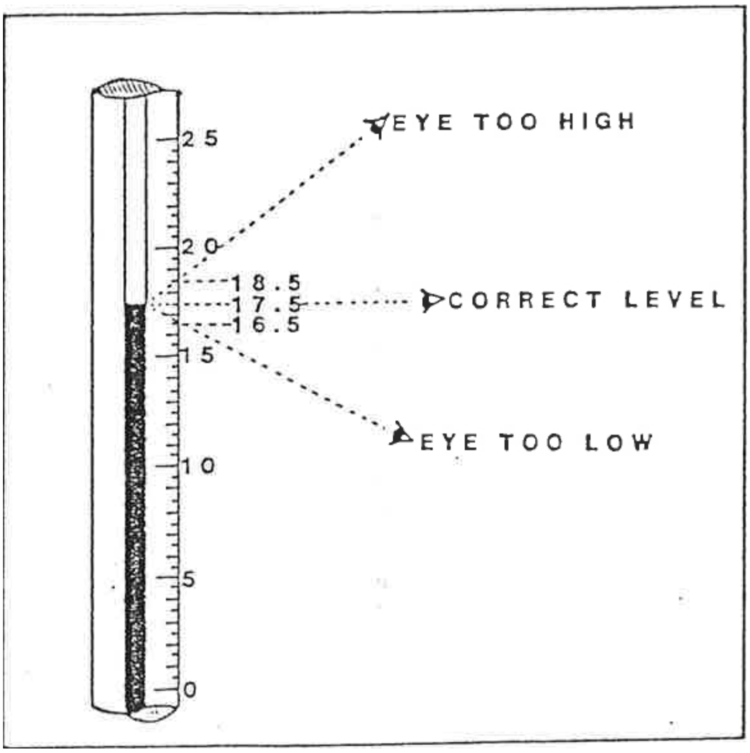


Figure 3.1: **Errors of parallax**

3.2. Management of wet bulb thermometers

The difference between the readings of two thermometers, similarly exposed, is used to indicate the humidity of the atmosphere. One thermometer is uncovered and indicates air temperature; the bulb of the other is covered by moist muslin and so indicates a temperature which will be reduced by the cooling associated with evaporation. The drier the air the greater the evaporation and so the greater the difference between the readings of the two thermometers. The accuracy of the humidity obtained will depend on the degree of care with which the covered (wet bulb) thermometer is maintained.

3.2.1. Description

The bulb of the wet bulb thermometer is covered with a Single thickness of muslin which should be stretched smoothly and closely over the element with the mini-mum number of creases. The muslin is secured in position by looping two strands of the cotton used for supplying moisture to the bulb in a clove hitch or doubling and looping the two strands as shown, so that four threads actually convey water to the bulb. The loop or clove hitch is drawn tightly around the throat of the bulb as shown. Any surplus muslin should be trimmed off with a pair of scissors.

The wick feeds from a glass or plastic reservoir located near to but not immediately below the bulb

3.2.2. Exposure

The rate of evaporation, and so the difference between the readings of the wet and dry bulb thermometers, is dependent to some extent on the rate at which air flows over the bulbs. The thermometers are therefore exposed in an instrument screen which gives adequate ventilation but at the same time prevents the wet bulb from being exposed to too strong a blast of air. Humidity must always be calculated from tables for non-aspirated thermometers (thermometers without forced ventilation). Other tables are used with instruments in which air is drawn past the bulbs with a fan.

3.2.3. Reading

The wet bulb thermometer is read to the nearest tenth of a degree after the dry bulb has been read. Unless the temperature is falling rapidly, when the wet bulb thermometer is subject to time lag, the dry bulb temperature will be equal to or higher than that indicated by the wet bulb. If the wet bulb reads higher than the dry bulb change the muslin, wicks and water. If, after at least 15 minutes the wet.' bulb still reads higher remove the muslin and wick and compare the two thermometers as dry bulb ones. If after several minutes the readings differ by more than 0.3°C, replacement thermometers should be requested.

3.2.4. Maintenance

The following action is essential to the provision of consistently reliable wet bulb thermometer readings.

- Use a water bottle with a narrow neck.
- Do not allow the water bottle to become dirty or discoloured. If it cannot be cleaned, request a replacement.
- Secure or locate the bottle slightly to one side of and below the thermometer bulb.
- Use distilled water if available. Distilled water should not be obtained from a garage as it may be contaminated with battery acid. If distilled water is not available use clean rain water and if this is not available use tap water.
- Do not allow the water level **in** the bottle to fall below half full.
- Top-up water in the bottle after an observation.
- Empty, rinse then replace the water in the bottle each time the muslin and wick is replaced.

- Only use clean muslin and wicks. If the supply issued once a year becomes soiled, request a further issue.
- Use one clean muslin disc and two clean strands of cotton, doubled as illustrated, in Figure 3.2.
- Keep the wick strands twisted together.
- Keep the wick as straight as possible. A loop or sag will allow water to drip from the wick. Also, too great a length of exposed wick allows excessive evaporation from the wick.
- Replace the muslin and wicks after the Monday morning observation. The muslin and wicks should also be replaced (after an observation) when dust is evident on the wick or at coastal stations when there has been a storm with an on-shore salt-laden wind.
- If it is unavoidable that the bottle be filled before an observation, for example, when the bottle is found to be empty, allow at least 15 minutes to elapse before reading. If the water supply is not at air temperature a much longer period is required.

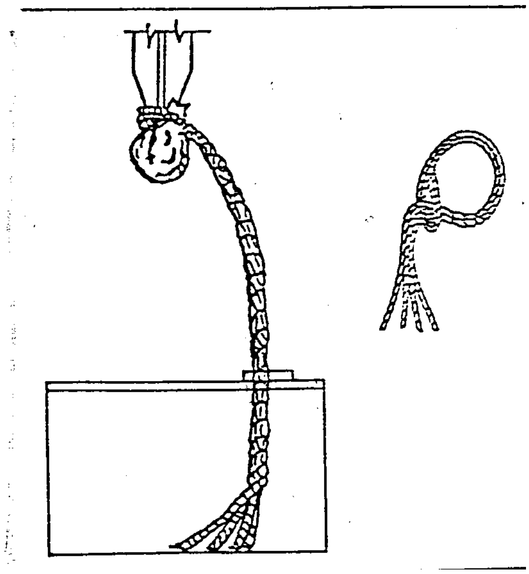


Figure 3.2: Wet bulb thermometer

3.2.5. Management during a frost

When either the air temperature or the wet bulb temperature is below freezing, normal functioning of the wet bulb thermometer ceases. When ice forms on the wick normal conduction of water ceases, the ice or water on the muslin evaporates and the thermometer gives the same temperature as the dry bulb. The following action will be required:

- Commence the observation 15 minutes before the usual time when the air temperature is expected to be below freezing.

- Examine but do not touch the muslin.

- If the temperature is below freezing but the muslin appears wet, the moisture is probably super-cooled. Induce the formation of ice by touching the muslin with snow or ice crystals on the end of a twig or matchstick.

- If the muslin appears to be dry, moisten by brushing it with a camel-hair brush dipped in water as near as possible to freezing (preferably taken from under ice). Use the minimum amount of water necessary to moisten the muslin.

- Once ice has formed the thermometer will read near to freezing. The ice will commence to evaporate by sublimation and the reading will drop steadily, become stable for about a minute, and then commence to rise.

- If it is obvious what this minimum temperature was, enter it as the wet bulb reading. If the minimum is uncertain or if temperature movement was difficult to determine, do not enter a reading.

3.2.6. Dew point, relative humidity tables

The dew point and/or relative humidity readings must be obtained by reference to tables. The following is a list of tables to be used at various elevations for thermometers exposed in instrument screens.

Dew Point Tables

Elevations up 600 m	Met Form 326
Elevations 600 to 1400 m	Met Form 363
Elevations 1400 to 2400 m	Met Form 364
Elevations 2400 to 3600 m	Met Form 365

Relative Humidity Tables

Elevations up to 600 m	Met Form 325
Elevations 600 to 1400 m	Met Form 367
Elevations 1400 to 2400 m	Met Form 368
Elevations 2400 to 3600 m	Met Form 369

Combined Dew Point/Relative Humidity Tables

Elevations up to 600 m	Met Form 361

3.3. Maximum thermometer

The maximum thermometer is used to record the highest air temperature reached during a given period.

3.3.1. Description

The maximum thermometer is a mercury-in-glass thermometer with a small constriction in the bore of the stem about 25 mm from the bulb. As the temperature rises mercury is forced past the constriction and the thread of mercury advances along the stem as with an ordinary thermometer (Figure 3.3). As soon as the temperature begins to fall, however, the mercury in the bulb contracts, but the thread of mercury breaks at the constriction leaving its upper end in position at the maximum temperature reached. The mercury column can, however, be forced back past the constriction when resetting the thermometer as described later in this section.

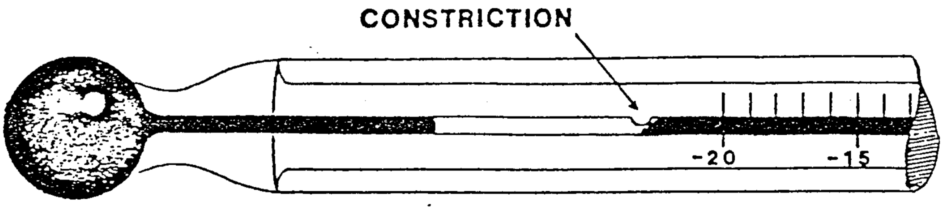


Figure 3.3: Enlarged view of bulb and part of stem of maximum thermometer sheathed pattern, showing constriction near bulb.

The maximum thermometer is a thermometer which has a glass sheath covering the stem. It is manufactured to the relevant British Standard Specification (B.S. 692(1958)), or an acceptable equivalent. This instruction does not describe the low temperature maximum thermometer used in Antarctica.

3.3.2. Exposure

The maximum thermometer is mounted in the thermometer screen in a nearly horizontal position with the bulb end about 6 mm lower than the other end. It should be held firmly by its supports or clips as the mercury column may be displaced from its maximum position if the thermometer is shaken in a strong wind. The maximum thermometer is usually placed above the screen minimum thermometer.

3.3.3. Reading

The maximum thermometer is read in whole degrees and tenths, and a second check reading should always be made, particular care being taken to avoid errors of 5°C or 10°C. This reading is entered in the field book under the heading "Before Setting".

3.3.4. Resetting

The thermometer is reset by swinging it at arms length (Figure 3.4) in a smooth motion with the bulb end downwards four or five times until the mercury thread is forced down past the constriction and joins with the mercury in the bulb.

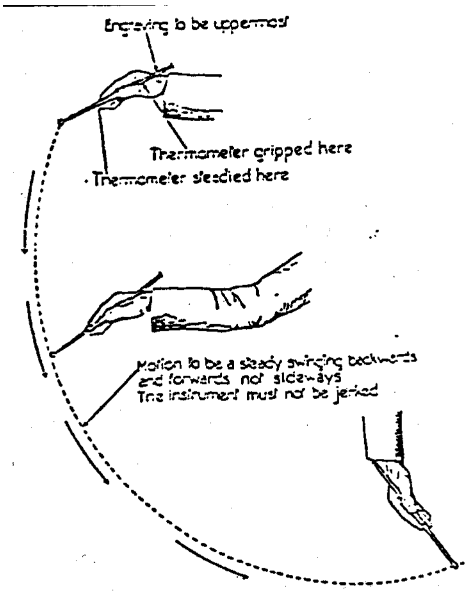


Figure 3.4: Resetting the thermometer

Care should be taken not to strike the thermometer <u>against</u> the body, loose clothing or any solid object.

Note that after resetting on the majority of occasions there will still be a small break in the mercury thread about the constriction. As long as the reset value is within 0.5°C of the dry bulb reading, the maximum thermometer is still functioning correctly.

After setting, the thermometer should be placed back in the screen and then read again, the reading being entered in the field book under the heading "After Setting". This after setting reading should agree with the dry bulb reading to within about 0.5°C. If the difference is greater than 0.5°C the thermometer is not properly shaken down, or it may be defective.

When reading the reset value, ensure that the bulb end is downwards and that the thermometer is not being heated by the sun, hands and/or body which will all affect the reset value.

3.3.5. Defects of maximum thermometers

If the constriction is too narrow there is difficulty in resetting the thermometer, and if it is too wide the thermometer acts as an ordinary dry bulb and does not remain at the maximum temperature reached.

Maximum thermometers that are difficult to shake down, usually have a slightly narrow constriction. However, if the thermometer is held and swung as described in the section on resetting and illustrated in figure 3.4, it should be possible to reset it properly.

If the constriction is too wide, the maximum thermometer may act as a "retreater", that is, the mercury column may retreat from the maximum position when the temperature falls. This defect can develop in an otherwise serviceable thermometer, the constriction being widened by the chipping of the glass surrounding it, apparently being caused by frequent shaking down of the mercury column.

Observers should therefore check for this defect, and if they find that the maximum thermometer reading is consistently lower than any reading of the dry bulb thermometer made since the maximum was last reset, they should suspect this defect and make a further check as follows:

> With the maximum thermometer still mounted in the screen warm the bulb with the fingers until the mercury reads higher than the dry-bulb temperature then withdraw the fingers and watch the mercury carefully to see that it does not retreat from its maximum position. If it does, the thermometer is defective.

Another defect of some maximum thermometers is the tendency of the mercury column to run up the tube a little when the thermometer is lying at the normal slope in the screen. Some thermometers do this when placed back in the screen after resetting, while vibration can also cause this defect. If it is present and a reading is taken in the normal manner, it may be 0.5°C or more higher than the true maximum temperature. If an observer suspects the maximum thermometer is reading too high, it should be tested for this defect, preferably on an overcast morning when there is some wind by noting the reading to the nearest 0.1°C after resetting and when the thermometer is still held in a vertical position bulb downwards. It should then be replaced in the screen and the door of the screen opened and closed once or twice in the customary manner to expose the thermometer to the normal amount of vibration. If the reading has risen by more than 0.1°C or 0.2°C and the dry bulb shows that such a rise is not due to a rise in temperature, this indicates that the thermometer is defective. A correct reading can often be made with such a thermometer by carefully lifting up the right-hand end until it is about 150 mm above the bulb end, when the mercury thread will fall back against the constriction and so give a true reading.

If the thermometer is defective, a replacement is to be requested.

3.4. Minimum thermometer

Minimum thermometers are used to record the lowest air temperature reached during a given period.

3.4.1. Description

The minimum thermometer is a spirit thermometer designed to operate in a horizontal or nearly horizontal position. Immersed in the spirit is a small index which is free to move along the stem of the thermometer. As the temperature falls, the retreating end of the spirit column drags the index back until the minimum temperature is reached. If the temperature rises, the expanding spirit flows past the ends of the index which remains stationary. Thus the end of the index furthest from the bulb indicates the minimum temperature reached since the previous setting of the instrument.

The minimum thermometers used are thermometers which have a glass sheath covering the stem. They are manufactured to the relevant British Standard Specification (BS 692 (1958)), or an acceptable equivalent.

3.4.2. Operation, general

Readings

The lowest or minimum temperature reached is shown by the index, and the reading is always taken off the end of the index nearest the top of the spirit column, that **is,** the end furthest away from the bulb. This reading should be made to the nearest tenth of a degree (see Figure 3.5).

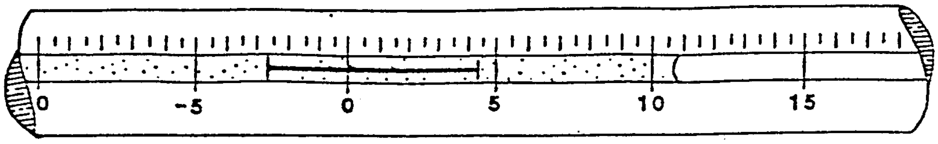


Figure 3.5: Enlarged view of part of stem of minimum thermometer, sheathed pattern, showing index immersed in spirit. The minimum temperature is 4.3°C.

Resetting

To make the thermometer reading to record the minimum temperature for the next period, it must be reset. This is done by tilting the thermometer, bulb end upper-most, until the index moves to the end of the spirit column.

After the thermometer is reset, a reading is taken and entered in the field book against the space marked "After Setting".

The "After Setting" value of the screen minimum thermometer should always be compared with the simultaneous reading of the dry bulb thermometer. If the two readings consistently differ by more than 0.5°C, the accuracy of the minimum thermometer should be suspected.

3.4.3. Operation as screen minimum

The screen minimum thermometer is used to record the lowest air temperature and is mounted in the thermometer screen in a nearly horizontal position with the bulb end about 6 mm lower than the other end. It should be held firmly by its supports or clips as the index will tend to be displaced if the thermometer shakes in a strong wind.

3.4.4. Operation as grass minimum

The grass minimum thermometer (Figure 3.6) is used to record the lowest temperature when exposed just above a grass surface. It is important that the thermometer does not touch the grass nor be more than 25 mm above the grass otherwise the minimum temperature recorded can differ considerably from the standard. The grass must be kept cut short under and around the thermometer.

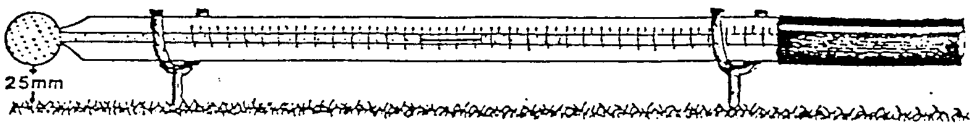


Figure 3.6: Grass minimum thermometer

A black shield is fitted over the outer sheath at the end opposite the bulb. The purpose of the shield is to prevent spirit in the tube vapourising, thereby forming breaks in the spirit column and/or forming drops of spirit in the upper part of the tube.

When the ground is covered with snow the thermometer should be supported above the snow surface and as near to it as possible without touching it. If snow has fallen during the night in sufficient quantity to cover the thermometer, the observer should carefully remove the snow at the climatological observation hour and then read the thermometer. The reading should be entered in the Met. 303 or 371, and on Met. 301, and marked with a question mark, e.g. -8.4? A note should be made in the remarks column "grass minimum buried in snow".

A small fence consisting of a single wire held on white painted pegs 152 mm to 228 mm high at the corners of a 0.9 m square can be erected around the thermometer to prevent it being accidentally trodden on, but no other protection or wire cage is to be used.

3.4.5. Faults in minimum thermometer

Minimum thermometers are prone to faults common to spirit-in-glass (as opposed to mercury-in-glass) thermometers. The fault which can most seriously affect the accuracy of the readings is a tendency for the spirit column to break. It is important to examine the thermometer carefully each time before reading to make sure the spirit column is intact and that no drops of spirit have collected higher up the bore, or in the safety chamber at the top. It is particularly important to examine a new thermometer which has come through the post as some of these separations of the column could have occurred in transit. Also, unlike, mercury, spirit wets glass and consequently if the temperature falls rapidly a thin film of spirit may be left on the walls of the bore, causing the thermometer to read too low. The same effect may be caused in hot weather by distillation of spirit from the liquid column to the upper walls and even to the safety chamber at the top of the bore.

Figure 3.7 shows:	Breaks in the column	(1,2,3)
	Index protruding through the end of the column	(4)
	A drop of spirit in the bore above the column	(5)
	Spirit in the safety chamber	(6,7)

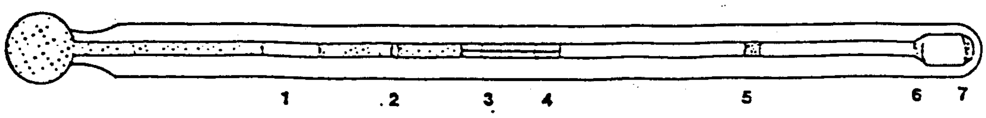


Figure 3.7: Fault areas affecting minimum thermometers

3.4.6. Treatment of defects

By swinging

This method involves swinging the thermometer in the same way as when resetting the maximum thermometer.

Grip the thermometer firmly and swing the thermometer, bulb end downwards, until the bubbles disappear. Four or five swings should be sufficient. Use a steady swinging motion back and forth, not sideways.

By jolting

This method involves holding the thermometer upright with the bulb end down and tapping the bulb lightly on a thick book (e.g. phone book) until all the bubbles have disappeared.

By heating

Only use this method if the other two haven't worked. Stand the thermometer in a vessel of water which is just hot enough so that the spirit in the thermometer rises just enough to reach the expansion chamber to clear the bubbles. Allow the thermometer to cool slowly.

Be careful not to heat the thermometer too much so that all the spirit extends into the expansion chamber, as this may break or damage the thermometer.

Do not stand the thermometer in boiling water.

i

3.4.7. Testing

Before use and after remedial action has been taken, test the thermometer as follows: Immerse the minimum thermometer and the dry bulb thermometer in a bucket of water up to the top of the spirit and mercury columns and take simultaneous readings after stirring the water. The thermometers should be within 0.3°C and a replacement should be requested if the difference exceeds 0.3°C.

3.5. Earth thermometers

Thermometers may be used to obtain temperature readings at various depths below the surface. Standard depths are 5 cm, 10 cm, 20 cm, 30 cm and 1 m. The 5 cm thermometers are used at only a few stations.

3.5.1. Description

The earth thermometers used are manufactured to the relevant British Standard Specification (BS 692 (1958)), or an acceptable equivalent.

5 cm, 10 cm and 20 cm earth thermometers

The temperature of the earth at 5, 10 or 20 cm is measured by means of a mercury thermometer which has a right-angle bend in the stem so that when the thermometer is inserted in the ground, with the horizontal graduated portion lying along the surface, the centre of the bulb will be at the correct depth. A thermometer of this type is shown below (Figure 3.8).

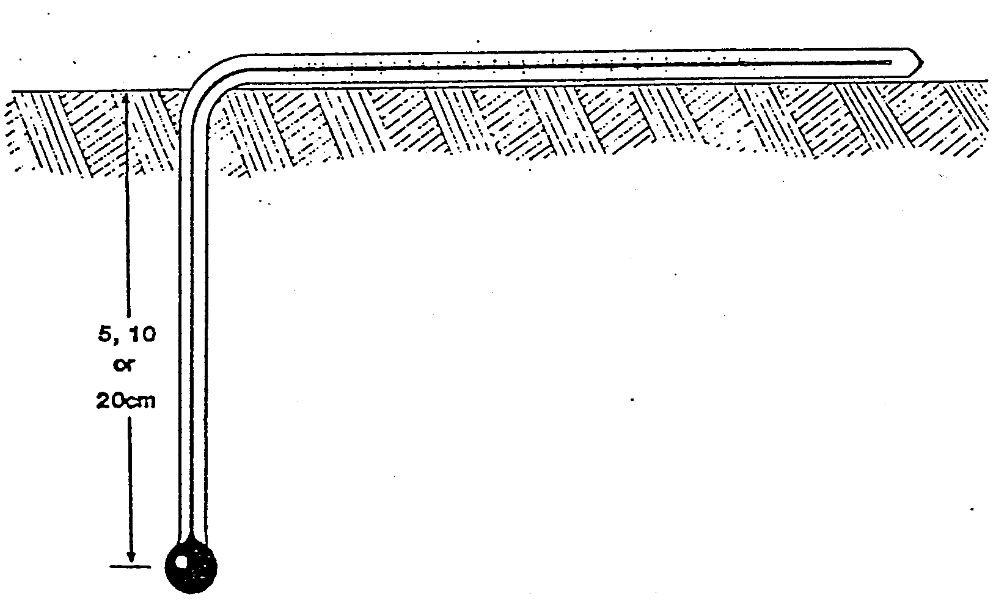


Figure 3.8: Right-angled thermometer

30 cm and 1 m earth thermometers

Readings are taken from thermometers suspended in individual tubes sunk in the ground, a similar type of thermometer being used for each depth. As there is often a very marked difference between the temperatures at the level of exposure and of the air where the reading is made, the thermometer bulb is embedded in wax within an outer protecting glass tube to give a large lag coefficient. There will then be time to read it before its temperature changes, but it must be shielded from direct sunlight when read. The thermometer is further protected by rubber rings which surround the outer glass tube. The tube in which the thermometer is exposed is constructed from seamless mild steel of 32 mm bore and of appropriate length. There are some 100 mm to 150 mm of tube extending above the ground, a 76 mm diameter flange surrounds the tube at ground level and the bottom of the tube contains a cone of solid steel. A plastic plug covers the exposed top of the tube and the thermometer is suspended directly from this plug on a chain of the required length (Figure 3.9).

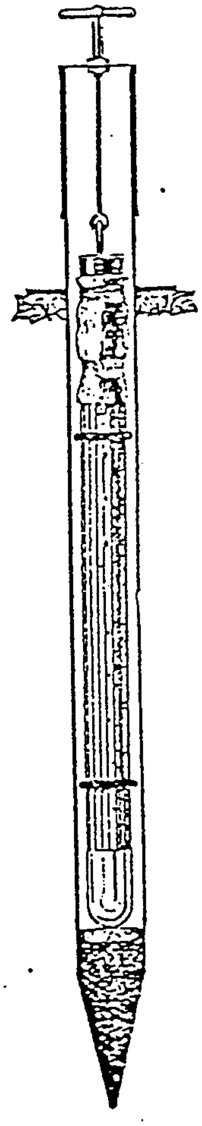


Figure 3.9: 30 cm earth thermometer

3.5.2. Exposure

The thermometers are installed within the instrument enclosure beneath a level piece of bare ground about 0.8 m x 0.8 m square and as typical as possible of the surrounding soil for which information is desired. The positions they occupy are illustrated in the chapter on Exposure.

3.5.3. Installation

5 cm , 10 cm and 20 cm earth thermometers

The thermometers should be installed with particular care as any strain whatever will almost certainly result in a fracture at the right-angle bend. Right-angle thermometers should only be handled by the vertical portion when removing from or replacing in ground. Care should also be taken that soil surrounding the thermometer is disturbed as little as possible, so that the temperature recorded will represent, as closely as possible, the temperature of the undisturbed soil.

Make holes in the ground of rather more than the required depth with a small crow-bar or other suitable tool of a diameter slightly greater than that of the thermometer bulb.

Place a little fine soil at the bottom of the hole when the horizontal part of the stem lies along the surface of the ground.

Carefully fill the hole with fairly fine soil, taking care not to break the bulb.

In locations where there is any possibility of "frost heaving", clear the soil from immediately underneath the horizontal portion of the stem by scraping it out with a knife to leave a clear space of not less than 3mm and not more than 13mm.

The depths of the bulbs of the thermometers are to be indicated by white marker pegs on each of which the appropriate depth is indicated by coloured plastic markers.

30 cm and 1 m earth thermometers

Unless the soil is exceptionally hard, it will be possible to drive the 30 cm tube into the ground by hammering a block of wood placed over the top. It is normally necessary to drill a hole the diameter of which is equal to the tubes diameter using an auger for the lm tube. Ensure the hole is truly vertical. Considerable care is required to avoid distorting the top of the tube and again care is required to avoid disturbing the surrounding soil unnecessarily.

In order to protect the thermometers, four white stakes, measuring about 25 mm x 25 mm x 457 mm long, should driven 150 mm into the ground just outside the corners of the area. A wire can be tied round the top of the stakes thus forming a square of approximately 0.9 m x 0.9 m.

3.5.4. Reading earth thermometers

These are read in the usual way to the nearest tenth of a degree at the main observation hour of 9 am N.Z. local time (i.e. ordinary clock time).

Reading when ground covered with snow

In the event of a snowfall, the snow should be carefully removed for taking the readings, and then replaced to the original depth.

3.5.5. Maintenance of thermometers and earth plot

Maintenance of thermometers

5 cm, 10 cm, and 20 cm earth thermometers

Maintenance of these thermometers is restricted to blackening the graduations. Should the graduations on the scale become indistinct they can be renovated in various ways. The easiest way is to rub a black felt-pen along the thermometer and then wiping off the surplus with a rag moistened with methylated spirits. In either case the horizontal portion of the thermometer must he lightly supported during the operation to avoid breakage.

30 cm and 1 m earth thermometers and tubes

The tubes are not withdrawn for maintenance and are replaced only when penetrated by rust. This condition is normally indicated by the presence of water in the tube. Any such water should be removed

If a tube has to be withdrawn from the ground this is best done by gripping the section of tube about ground level with either a pair of vice-grips or a pipe wrench. Then rotate the tube and at the same time apply a lifting force. By this process the tube can be removed without disturbing the surrounding ground.

The outer glass shield of the thermometer requires periodic cleansing; discolouration may be removed by polishing lightly using a metal polish. The thermometer (with its outer shield) should be replaced if condensation is observed on the inside of the glass.

Maintenance of the earth plot

Any grass encroaching on the plot is to be cut back and any weeds removed. The surface of the plot is to be left otherwise untouched. Where the soil is light, or where the plot is very exposed, the effect of erosion may necessitate the addition of earth to maintain the surface at its original level. The old surface should be broken before the new soil is added then both should be packed down lightly.

If any of the thermometers have sunk, they should be lifted fully, and then re-positioned, after a small amount of soil has been poured into the hole. Extreme care is required, the thermometer being handled by the vertical portion only. If necessary, the ground should be thoroughly soaked before the thermometer is lifted. In such cases the water should be allowed to drain away before the instrument is replaced. A note concerning the action taken is to be entered in the Field Book and Met. 301.

3.6. The helix-type bi-metallic thermograph

This section refers to a number of different makes of thermograph, all made to essentially the same design which incorporates a helical bi-metallic sensing element. They differ from the Lambrecht thermograph, which is described in the next section below.

The bi-metallic thermograph records temperature variations using the principle of differing coefficients of expansion of metals. The temperature element consists of a bimetallic strip, coiled in the form of a helix with the metal of greatest expansion on the outside.

The helix, which is fixed at one end, is free to rotate with changes in temperature and this movement actuates a pen on a chart. This chart is affixed to a drum which revolves about a clock at the rate of one revolution per week.

3.6.1. Installation

The instrument should be exposed in a large thermometer screen on the base board to one side of the thermometers.

On installation it maybe found necessary to adjust the thermograph so that the reading corresponds to the dry bulb temperature in the screen. The fine setting screw located beneath the temperature element is used to make this adjustment. Whilst tapping the case gently with the fingers adjust the setting till the temperature indicated on the chart is the same as the dry bulb temperature. Do not make this adjustment when the temperature is changing rapidly.

3.6.2. Operation at climate stations

Chart changing

The chart is replaced each week at the same time. This should be as soon as practicable after the 9 am thermometer readings, normally on Monday.

Before inserting a new chart on the drum enter the station name and the day, month, and year data (against each day of the week), the time on and corresponding temperature from the dry bulb thermometer.

Wrap the new chart around the drum so that it fulfils the following conditions. (These are absolutely necessary if good and reliable records are to be obtained).

The chart should fit tightly around the drum.

The lines of equal scale value should be parallel to the flange at the bottom of the drum, i.e. corresponding lines on the beginning and end of the chart in the overlap portion should coincide. The bottom of the chart should be as close to the flange as possible and touching it in at least one place. (If the chart is not cut quite correctly it may not be possible for it to touch the flange all the way round and still comply with the other conditions cited.)

The end of the chart should overlap the beginning and not vice versa.

After removing the old chart enter in the appropriate spaces the following data from the field book:

- Time at which time mark made, corresponding dry bulb temperature, maximum and minimum temperatures.

NOTE: The maximum and minimum temperatures are entered to the date to which they refer, i.e. the minimum to the day of observation and the maximum to the previous day.

Clock

The clock should be fully wound when the chart is fitted. The clock has an eight day movement and should only be wound later in the week if it is running slow. In such cases a replacement should be requested. Minor adjustments to the rate of rotation may be made with the regulator (see "Clock and Drum" below).

Pen

Disposable fibre-tipped nibs are used and are replaced as necessary.

Setting

After a new chart is mounted on the drum the pen setting is checked and the clock drum is rotated in the direction of increasing time, i.e. clockwise, and is then turned back until the pen is on the correct time. This operation eliminates backlash in the clock mechanism.

Check that the pen lifting device is clear of the pen arm.

Time marking

Time marking can be done by carefully depressing the pen arm slightly with the finger. As the vertical movement of the pen arm places stress on the linkage, the amount of pressure should be reduced to the minimum necessary to give a clear mark. Time marks should be about 6 mm in length.

3.6.3. Adjustment and maintenance

Adjustment

After the initial adjustment as described above further adjustment of the temperature setting should only be necessary after pen replacement or some similar adjustment.

Maintenance

The record should be examined for evidence of pen wear or excessive friction. The former will be indicated by a faint trace. Excessive friction will be shown by an irregular "stepped" trace and/or a marked variation between the temperature recorded before and after a time-mark.

The friction of the pen against the chart can be reduced by adjusting the angle of the gate suspension towards the upright. This adjustment should not be necessary as the inclination of the gate suspension would not normally alter. However, very slight reductions in friction can be made by raising the rear of the thermograph case by cardboard shims placed under the "feet".

Where the presence of dirt on the pivots is suspected these may be cleaned with a fine brush dipped in white petrol and, when this has dried, a small quantity of good clock oil applied.

The interior and exterior should be kept clean and dusted.

Clock and Drum

Most bimetallic thermographs supplied will use chart Met. 525 (-5/ + 35°C) or No. 526 (-15/+25°C) with an "S" drum (93 mm diameter). The weekly clock (Horstmann) is fixed to the baseboard by three screws. Where the clock regulator is not obvious, it will usually be exposed under the clock when the three retaining screws are removed.

Instrument clocks are not subject to routine overhaul and will be replaced if a defect is noted.

3.6.4. Transport of thermographs

The pen arm is to be attached to the pen-lifter by a paper loop which will allow a limited amount of vertical movement. The loop is formed from a 50 mm length of paper 13 mm - 19 mm in width. Holes are punched in the paper, approximately 13 mm from each and the pen lifter is passed through these so that the section of paper between the holes is over the pen arm.

The clock winding key is to be attached to the outside of the case by some suitable means.

The drum retaining ring is to be checked for tightness to prevent damage to the toothed rings on the under-side of the drum and clock spindle.

The case is to be tied closed with string before packing.

Care should be taken in packing to ensure that the cage protecting the temperature element and the exposed end of the pen arm movement will not be damaged.

The exterior of the package is to be marked with the usual fragile warning.

3.7. The Lambrecht Bi-metallic thermograph

The Lambrecht Bi-metallic Thermograph records temperature variations using the principle of differing coefficients of expansion of metals.

The temperature element consists of a bimetallic ring with the metal of greatest expansion on the outside. The temperature-dependent movements of the bimetallic ring are transmitted to the pen arm by means of a lever gearing.

The temperature values are recorded on a chart affixed to a drum which revolves about a clock at the rate of one revolution per week.

3.7.1. Installation

The instrument should be exposed in a large thermometer screen on the base board to one side of the thermometers.

The spring catch can be released by pulling the catch outwards and the case can then be opened.

Release the pen arm lock by rotating it about the pen lifting arm. Remove the rubber nipple form the nib of the ink cartridge. Remove the cardboard which secures the pen lifting arm.

Adjust the pen pressure on the chart until it just writes, by turning the silver adjusting screw at the base of the pen arm.

On installation it maybe found necessary to adjust the thermograph so that the reading corresponds to the dry bulb temperature in the screen. This can be carried out by turning the red adjusting screw. This is a fairly coarse adjustment and will have to be checked several times to ensure that the correct setting is attained. Do not make this adjustment when the temperature is changing rapidly.

3.7.2. Operation chart changing

The chart is replaced each week at the same time. This should be as soon as practicable after the 9 am thermometer readings, normally on Monday.

Before inserting a new chart on the drum enter the station name and the day, month, and year (against each day of the week), the time on and corresponding temperature from the dry bulb thermometer.

Wrap the new chart round the drum so that it fulfils the following conditions. (These are absolutely necessary if good and reliable records are to be obtained).

(i) The chart should fit tightly round the drum.

(ii) The lines of equal scale value should be parallel to the flange at the bottom of the drum, i.e. corresponding lines on the beginning and end of the chart in the overlap portion should coincide.

(iii) The bottom of the chart should be as close to the flange as possible and touching it in at least one place. (If the chart is not cut quite correctly it may not be possible for it to touch the flange all the way round and still comply with the other conditions cited.)

After removing the old chart enter in the appropriate spaces the following data from the field book:

- Times at which time marks were made, corresponding dry bulb temperatures, maximum and minimum temperatures.

NOTE: The maximum and minimum temperatures are entered to the date to which they refer, i.e. minimum to day of observation and maximum to previous day.

Clock

The clock should be fully wound when the chart is fitted. The clock has an eight day movement and should only be wound later in the week if it is running slow. In such cases a replacement should be requested. Minor adjustments to the rate of rotating may be made with the regulator. (See "Clock and Drum" below).

Pen

This instrument is fitted with a fibre-tipped pen which must be replaced when they run dry. Care should be taken in pulling the pen off the arm to avoid bending the arm. Do not push the new pen on too far or it will be difficult to remove.

Setting

After a new chart is mounted on the drum the pen setting is checked and the clock drum is rotated in the direction of increasing time, i.e. clockwise, and is then turned back until the pen is on the correct time.

This operation eliminates backlash in the clock mechanism. Check the pen lifting device is clear of the pen arm.

Time marking

Time marking can be done by carefully raising the pen arm slightly with the finger. The time marks should be about 6 mm in length.

3.7.3. Adjustment and maintenance

Adjustment

After the initial adjustment as described above, further adjustment of the temperature setting should only be necessary after pen replacement or some similar adjustment.

Maintenance

If the trace is irregularly "stepped" and/or there is a marked variation between the temperature recorded before and after a time mark, then there is too much pen pressure. The method for remedying this is described above.

Where the presence of dirt on the pivots is suspected these maybe cleaned with a fine brush dipped in White Petrol and, when this has dried, a small quantity of good clock oil applied.

At regular intervals, the lacquered and chromium-plated surfaces of the recorder should be cleaned with a soft brush or a piece of damp cloth, as adhering dirt often accelerates corrosion.

Clock and drum

The Lambrecht Thermograph uses chart Met 530 (-15°/ + 35°C) with an "S" type drum (93 mm diameter). The weekly clock is fitted into the drum which fits over a central spindle screwed directly into the instrument base. Access to the regulator is through a small hole in the top diaphragm of the drum. Occasionally, this instrument is modified to allow the installation of a Horstmann clock.

Instrument clocks are not subject to routine overhaul and will be replaced if a defect is noted.

3.7.4. Transport of Lambrecht-thermographs

The nipple should be replaced on the nib and the pen arm attached to the pen-lifter by a paper loop which will allow a limited amount of vertical movement. The loop is formed from a 50 mm length of paper 13 mm - 19 mm in width. Holes are punched in the paper, approximately 13 mm from each end and the pen lifter is passed through these so that the section of paper between the holes is over the pen arm.

The clock winding key is to be attached to the outside of the case by some suitable means.

The drum retaining ring is to be checked for tightness to prevent damage to the toothed rings on the under side of the rim and clock spindle.

The case is to be tied closed with string before packing.

The exterior of the package is to be marked with the usual "Fragile" warning.

3.8. The hair hygrograph

A record of changes in relative humidity can be obtained by magnifying and recording variations in the length of human hair. A change from 0 to 100% in relative humidity will result in hair increasing in length from 2 to 2.5%. Hair hygrographs take advantage of the fact that the change in length corresponds with change in relative humidity - not to variations in actual water vapour content.

3.8.1. Description

Two types of instrument which are all described as "hair" hygrographs have been in use in New Zealand. These are now fitted with a patented synthetic ("Pernix") element in place of human hair. The Pernix element has a more rapid response to change and a greater resistance to stretch. It is indistinguishable from and receives the same treatment as human hair.

The hygrographs in use are:

The "Chimney' type manufactured by Negretti & Zambra. This has a single multi-strand Pernix element suspended vertically. There is a basic, direct, linkage between the element and the pen and the non-linear response of the element to change is evident from the chart. The chart, Met. Form 508, shows the greatest response at low humidity decreasing proportionally to the least response at high humidity.

The "Lambrecht" hygrograph, manufactured by the firm of that name. The element consists of seven multi-strand Pernix elements suspended vertically. There is a basic, indirect, linkage with provision for fine span adjustment. The linkage provides minimum response in the middle of the range. The chart used is Met. Form 500.

Most hygrographs use Horstmann "weekly' clocks and S-type drums. The Lambrecht Hygrograph is usually fitted with a central spindle over which a drum, with a clock unit installed inside, is fitted.

3.8.2. Installation

Hair hygrographs are exposed to the atmosphere in standard double louvered, large thermometer screens located in climatological measurement enclosures.

3.8.3. Operation

Chart changing

Charts are to be replaced as soon as possible after the 9 am climatological observation on Mondays. All details which are known are to be entered on the chart before it is attached. All other details, for which provision is made, are to be entered after the chart is removed.

The new chart is to be attached to the drum so that:

- It is firmly attached with the end overlapping the beginning;
- Lines of equal scale value are parallel to the drum flange and are in line at the overlap;
- The bottom edge of the chart is in contact with the flange (in at least one place).

Chart drive

The clock should be fully wound when the chart is fitted. The clock has an eight-day movement and should only be wound later in the week if it is running slow. In such cases a replacement should be requested.

The clock has to be removed from the hygrograph to permit access to the rate adjustment control which is located in the base.

Pen

A disposable fibre-tipped nib is used.

Calibration

Recently-overhauled instruments will be supplied with zero and/or span adjusting screws capped or otherwise sealed against adjustment. Such instruments will not be reset and will be replaced when adjustment becomes necessary.

Other hygrographs will be reset when required.

Time setting

The procedure followed is that employed with other instruments using similar chart drives. Chart drive backlash is minimised by turning the drum clockwise (i.e. in the direction of increasing time), then anti-clockwise until the pen is at clock time on the chart.

Time marking

The accuracy of the chart drive is to be checked by marking the trace and recording the time at which the mark is made. Where possible, this is to be done at least once each day.

The time mark is to take the form of a vertical mark, of about 5 mm in length, made by a gentle upward or downward movement of the pen-arm. To avoid stretching the element, it is most important that the pen-arm of a Lambrecht hygrograph is moved upward and the pen-arm of the BMO and "chimney" hygrograph is moved downward.

3.8.4. Maintenance

On receipt

Remove the means by which the pen-arm is secured to the pen lifter and check that the linkage has not been displaced while in transit. Particular care is required to ensure that the three-sided-diamond shaped hooks at the top and bottom of the elements on chimney hygrographs are correctly seated.

Check the pen pressure

The pen pressure should be such that it just writes. A stepped trace indicates too much pressure. On the Lambrecht hygrograph this pen pressure can be adjusted by turning the silver adjusting screw at the base of the pen arm. Other hygrographs can have this pressure reduced by adjusting the angle of the gate suspension towards the upright. However, very slight reductions in pressure can be made by raising the rear of the hygrograph case, by placing cardboard shims under the "feet".

Elements

The hair element is to be washed each week. This is to be done in conjunction with chart replacement and also, during the week, after periods when 30%, or less, has been recorded. The washing is to remove impurities from the element and also to revive its response.

The element is washed by brushing it along its length with a camel-hair artist's brush dipped in distilled - or rainwater. This is repeated until the element is saturated and then surplus droplets are brushed off. Both human and synthetic elements receive this treatment.

After washing, hygrographs which are not pre-set are to be adjusted to read 95% (if necessary) after the relative humidity reading is seen to cease increasing.

Elements must not be touched by bare fingers.

Linkage and pivots

These are to be kept clean and lubricated with the minimum amount of light clock.

For despatch

Before packing, remove any ink from the pen. The pen is then secured to the pen lifting arm by a paper loop or in the case of a Lambrecht hygrograph by the clip provided. Suitable precautions are to be taken to protect the glass surfaces before the instrument is packed. It is to be packed in a wooden container marked fragile.

4. Atmospheric pressure

Atmospheric pressure is measured by barometers or barographs. There are three main types of instruments, the mercury barometer which measures the deflection of a mercury column directly caused by changes in pressure, the precision aneroid barometer which has an evacuated pressure chamber, and the barograph which has a similar system amplified onto a chart.

The procedures and standards are set by MetService in their Manuals of Instruction and are traceable to international references.

See the Meteorological Service of New Zealand Ltd Manual of Instructions for further details.

5. Wind

5.1. The electric anemograph

The electric anemograph is used where it is not practicable to have the recorder immediately beneath the anemometer head, or where the sensing elements must be located some distance from the place where the indicators and/or recorder are required.

The system consists of the following units:

Anemometer, cup generator, MKII

Indicator, wind speed, MKII

Wind vane IM144, complete with Niphan plug Indicator, wind direction

Recorder, wind speed and direction

Transformer, 230:50 volt, 100 watt, single phase

Resistance box

The majority of maintenance is to be carried out by NIWA Instrument Systems staff.

What follows are a brief overview of an installation and procedures to be used by the observer operating the station and/or the person inspecting the station.

5.1.1. Description

Anemometer, cup generator, MKII

An a.c. generator driven by a standard British Meterological office three-cup anemometer. Starting speed about 2 to 3 knots and output 26 volts at 1000 rpm. It can operate up to six indicators and one recorder.

No maintenance is to be attempted as it may disturb the calibration. If a unit is suspect it should be changed.

Indicator, wind speed, MKII

This is a d.c. voltmeter with built-in rectifier. If a unit is suspect it should be changed. A zero adjustment is provided.

Wind vane, IM 144

A pinion on top of the wind vane operates a magslip through a lay shaft. It will operate up to six indicators and a recorder. 50 volt a.c. power is required and all units in the system MUST be supplied from the same phase. Precise frequency regulation is not required unless the same power supply is used to drive the chart motor.

Indicator, wind direction

This contains a magslip receiver. No maintenance is to be attempted on stations and if a unit is suspect it should be changed.

Resistance box

The accuracy of the wind speed system depends on the resistance of the circuit having a fixed value. Therefore if the full number of indicators and a recorder are not connected into the circuit the missing units must be replaced by equivalent resistances. The box is fitted with six resistors of 5500 ohms each and one of 2700 ohms together with two sets of clips, one set in circuit and the other set out of circuit. For each speed indicator in the system one 5500 ohm resistor must be transferred to the "dummy" clips, and the 2700 resistor must also be transferred if there is a recorder in the system. If the recorder is withdrawn for any reason the 2700 ohm resistor must be replaced in the circuit. Normally these resistors must not be touched.

Recorder, wind speed and direction

This is a dual unit.

Recorder, wind speed

A recording d.c. voltmeter with built-in rectifier. It is fitted with a zero setting adjustment and a dual range switch to change the range from 0-90 to 0-180 knots. On the higher range the recorder is inaccurate below 20 knots. No maintenance is to be undertaken on this unit, and if it is suspect the complete wind speed and direction recorder must be changed.

Recorder, wind direction

This is in the same outer case as the speed recorder and writes on the other half of the same chart roll. The receiving magslip motor is geared down 1:8 to a pinion.

The mechanism is extremely sensitive to mal-adjustment and should not normally be touched except by an Instrument Systems technician.

The chart drive motor normally operates off 230 volts a.c. but if the frequency is not controlled precisely, spring wound chart motors can be supplied.

Warning

The magslips in the vane, the direction indicators and the recorder all operate off 50 volts a.c. power and the wiring of these must not under any circumstances be touched by persons not in possession of the necessary license under the Electrical Wiring Regulations. Offenders are liable to prosecution.

5.1.2. Recorder and indicator adjustment

The 30degree lock test

Any major discrepancy with the recorder is probably a wiring fault. Most installation now have a 30deg lock setup on the "chocolate block". With these simply lift the clips on the X, Y, 1, 2 and 3 wires and push in the two wired clips. If the setup doesn't have the two wired clips, still lift the X, Y, 1, 2 and 3 clips and connect X to 1 and Y to 2. Alternatively, disconnect the wires on the side of the recorder and connect X to 1 and Y to 2. To make a final adjustment to direction insert a slim screwdriver through the slot in the transparent cover over the magslip and turn the screw. This will rotate the magslip casing and thus vary the recorder direction.

In case a fuse blows replace with a 2 amp fuse.

The indicators can be checked in the same way as the recorder by connecting 1 to X and 2 to Y when it should read 030 degrees (minus any variation set on adjustable indicators). However if there are any discrepancies do not try to make any adjustments. Contact Instrument Systems first. The indicators are likely to need replacing.

5.1.3. Operation

Replacing a chart

Insert date and time off on the old chart.

Release the combined catch and inking arm lifter carefully. If it is handled roughly the pens will be thrown violently upwards.

Swing the chart mechanism out on its hinges.

Wind on the remainder of the old chart by turning the driving wheel spindle by hand.

Raise the detents and remove the take-up roll.

Carefully remove one end of the spool and slide off the chart roll.

Replace the end of the spool.

Check that the spring driving belt is correctly positioned as the spool is re-inserted. Swing detents back into position to secure the spool.

Raise the detents and take out the rear spool.

Carefully remove one end, take off the cardboard tube from the previous roll, slip the new chart on the spindle and replace the end.

Put the rear spool back so that the chart has its round holes on the right and its slots on the left when viewed from in front.

Swing detents back into position to secure the spool.

Bring the free end of the chart up behind the clock housing, over the top plate under the hinged range strip and engage the perforations with the pins on the driving wheels.

Move the chart forward by turning the driving spindle by hand until there is enough chart to be inserted in the slot in the take-up spool.

If the take-up spool is removed to insert the chart into the slot check that the spring driving belt is correctly replaced before the spool is returned.

Swing the chart mechanism back into the position, secure it by lowering the pens on to the chart, move the chart on to the correct time and write the date and time on the chart.

Filling inkwells

Remove inking arms and place with the writing tip upwards.

Remove inkwells, clean if necessary and refill. Do not overfill.

Replace inkwells ensuring that the handles are clear of the pen movements.

Replace inking arms, taking care not to mix them, i.e. the speed arm should be replaced on the speed chart.

Any ink spilled on the recorder should be removed immediately, using a damp cloth or tissues.

Care of inking arms and inkwells

Each inking arm consists of a capillary tube bent at right angles and attached to a knife edge strip which rests in a support attached to the speed or direction movement. One end of the tube dips into the inkwell. The other end is screwed into a small nozzle which rests lightly on the chart and writes on it. Adjustable balance weights are provided so that the pressure can be reduced to the minimum necessary for satisfactory writing. Readjustment is not normally necessary.

To start the flow of ink, or to clear an air bubble in the capillary, place the inking arm in position in its stirrup with its end in the inkwell. Squeeze the rubber bulb of the filer with the fingers of one hand, and with the other hand press the nozzle lightly into the rubber insert in the transparent plastic portion of the filler. Ease the pressure on the rubber bulb and in a few seconds ink should be seen flowing steadily into the clear portion. Remove the filler and allow the nozzle to drop onto the chart.

Care must be taken not to bend the inking arm.

The filler must be washed out with clean water as soon as it has been used.

The inkwells should be removed every six months and cleaned thoroughly of all sediment which could block the inking arm. They are cleaned by flushing out with warm water. If necessary the top is removed by levering it up at the small hole near the circumference.

If the inking arm filler will not draw ink through, remove the inking arm. Hold it by the flanged end and the knife-edged cross-piece to avoid bending it. Unscrew the nozzle, wash it with water and clean it with the wire cleaner supplied. If this is lost another should be requisitioned, but in emergency 42 s.w.g. (0.004" diameter) nichrome resistance wire can be used. If it is nipped off with wire cutters the flattened end must be removed before it will enter the hole. If the ink has solidified it should be soaked in methylated spirits until it softens.

If the trouble is not a blocked nozzle the pen arm must be cleaned using the syringe provided.

Charge the syringe with methylated spirits or a solution of one part glycerine to ten parts warm water. Holding the unit by the knife-edged cross-piece, press the inkwell end of the inking arm into the rubber adaptor of the syringe and force the solution through the arm.

When this is clear, replace the writing nozzle and force more solution through the whole unit. Both will then be thoroughly cleaned and can be replaced. When they are refilled as described above any cleaning solution still in the inking arm will be drawn out ahead of the ink.

The syringe must then be thoroughly washed out with clear water.

Chart winding mechanism

The friction spring drive for winding the chart is adjusted before dispatch and should not require attention. Should the used chart tend to sag on the rewind roller due to stretching of the spring belt, the latter can be tightened by cutting off a few turns and rejoining it. On the other hand, if the chart tends to run off the driving sprockets it is usually a sign that the driving belt is too tight and should be stretched very slightly.

If the chart stops moving though the chart motor continues to run see that the retaining strips are clear of the paper and that the ends of the chart spools are pressed firmly in. If the strips are not clear, loosen the screws which hold them, adjust and re-tighten. Alternatively the inking arm lifter may swing so far over that the end of the arm will foul the gasket at the bottom of the case.

When the cover is closed the arm is then pressed against the chart and can stop it from moving. Do not force the catch too far over.

Double range switch

It is most important that if this switch is used the time of changing to the 0-180 knot position and the time of return to normal are written on the chart and a firm red line drawn above the speed trace throughout the duration of the change. The return to normal should be made as soon as speeds in excess of 90 knots are no longer likely as the recorder is inaccurate below 20 knots when on the 0-180 knot range.

5.1.4. Maintenance

The following maintenance is to be carried out on a routine basis by the observer. These procedures are to be checked during the annual inspection.

Daily

Time mark at about the same time each day by gently swinging the speed nozzle sideways. Write the time alongside and either add the date or, preferably, add a date stamp.

Fortnightly

Refill inkwells. (First remove inking arms and put in a safe place.)

Monthly

Change chart roll.

Six-monthly

Wash out inkwells and refill.

5.1.5. Faults

Generator

Cups or arms accidentally bent:

- Contact Instrument Systems, the unit needs replacing.

Cups stiff to turn

- Contact Instrument Systems, the unit needs replacing.

No indication

- Contact Instrument Systems.

Vane

Physical damage

- Contact Instrument Systems, the unit needs replacing.

Stiff

- Contact Instrument Systems, the unit needs replacing.

Magslip noisy or running hot

- Contact Instrument Systems, the unit needs replacing.

Speed indicator

Error

- Disconnect one wire or wait for a calm day when the cups are stationary and adjust.

  NOTE: This is the only case where the wiring can be touched by someone not in possession of a wireman's licence.

No indication

- Contact Instrument Systems, the unit needs replacing.

Stiff movement

- Contact Instrument Systems, the unit needs replacing.

Disagrees with other indicators or recorder

- Contact Instrument Systems, the unit may need replacing.

All units apparently reading low

- Check generator for physical damage or stiff spindle. Contact Instrument Systems, the unit may need replacing.

Direction Indicator

Noisy

- A slight hum is quite normal but if it becomes loud the indicator can be changed.

Sticking or sluggish

- Contact Instrument Systems, the unit may need replacing.

Indicator dead

- Probably a fuse or line fault.

Indicator showing wrong direction or moving in wrong sense (i.e. clockwise when vane moves anti-clockwise and vice versa)

- Contact Instrument Systems. Probably a reversed connection. Have technician check connections and circuits. 1, 2 and 3 wires must have the same resistance (1 ohm) and not exceed 20 ohms each. An error of 180 degrees probably indicates reversed X and Y connections somewhere in the system. An error of a multiple of 30 degrees probably indicates wrong connections in the 1, 2 and 3 circuits.

Speed recorder zero error

- Check that inking arm knife edge is correctly seated in its stirrup without side play. If necessary bend sides of stirrup together slightly. Have technician disconnect circuit or wait for a calm day (when cups can be seen to be stationary) and adjust.

Continuous zero

- Contact Instrument Systems.

Stiff movement

- Contact Instrument Systems, the unit needs replacing.

Disagrees with indicator

- Contact Instrument Systems, the unit needs replacing.

Chart stopped

- If chart motor continues to run, see above. Contact Instrument Systems, the unit needs replacing. If necessary request replacement chart drive unit.

Direction recorder

Chart stopped

- See above.

Inking arm not following vane

- First check visually that vane is moving. Fault is probably failure of slotted block to engaged actuating pin. Rotate inking arm stirrup by hand until the block engages with a pin. If the block is engaged already the fault is probably power off or an open circuit. Contact Instrument Systems, the unit needs replacing.
- If the fault was failure of the block to engage a pin and if it is an isolated occurrence no further action need be taken. If it recurs the actuating weights probably require adjustment. Switch off the power supply to the transformer and rotate the direction inking arm stirrup until the pen is on north. The screws for adjusting the stops for the centring device are accessible through holes in the top of the anemometer between the two transparent plastic cover plates. Either a very short screwdriver or one with a flexible shaft is needed for the

rear screw. Using a torch for illumination, adjust these until the centring levers can be seen just to touch the block. This should correct the fault which can be checked by rotating the inking arm stirrup GENTLY until the pen reaches the edge of the chart and the slotted block disengages after which it should return by itself to the central position and engage the next pin. Repeat at the other edge of the chart and then line up the inking arm with the approximate wind direction before switching on power to the transformer.

- Incorrect adjustment of the actuating weights gives the characteristic trace shown in figure ***. It is, however, possible for a bevelled side of the slotted block to rest on the actuating pin and be carried to and fro even though not engaging correctly. This gives a trace which appears normal but is displaced in direction. A light touch on the inking arm stirrup will engage the pin. A check should be made that the slotted block moves freely on its pivots. If it does, the pressure on the pin should be reduced slightly by loosening the lock nut and screwing down slightly the stop at the end of the arm which actuates the direction recorder. Then retighten the lock nut.

Magslip humming or running at more than blood heat

- Contact Instrument Systems.

Inking arm sluggish or sticking

- If the nozzle is sluggish at low speeds and returns to zero only if the recorder is tapped check the balance of the inking arm. It should be such that the nozzle only just returns to the chart when lifted slightly.

- Contact Instrument Systems.

Recording wrong direction

- If a slight constant error, check that inking arm knife edge is correctly seated in its stirrup without side play. If necessary bend sides of stirrup together slightly.

5.2. The Lambrecht mechanical anemograph

The anemograph is a self-contained instrument, only requiring the clock to be wound and the chart to be changed periodically once it is installed. The monthly clock spring and the monthly chart length make the instrument ideal for remote locations.

Wind direction, as determined by a wind vane, is recorded against time on a strip chart, as is wind run (in kilometres) from the rotations of three hemispherical cups. The record of wind run does not provide a direct reference to wind speed but mean wind speeds can be evaluated.

5.2.1. Description

The anemograph consists of a cylindrical body, housing the recording mechanism surmounted by the two sensing elements. The instrument is mounted on a mast with the cups 6.1 metres above ground level.

The wind vane and cup anemometer are geared at the lower end of their coaxial shafts, just beneath the housing top cover, to the recording rollers. The recording rollers are aligned next to each other on their respective 32 mm sections of the pressure-sensitive strip chart. Traces are etched on the strip chart at the point where the embossed rib of the recording roller bears on the chart. The 32 mm length of the recording roller is completed in one revolution by the embossed rib on its outer surface. A pressure of approximately 20 g is required for tracking, this is derived by mounting the recording rollers at the end of a pivoted cage, which forms a counter-balance arm, and adjusting the position of the counter-weights at the opposite end of the cage.

The clock and chart drive mechanism is mounted directly below the recording rollers, the chart is divided into two separate 32 mm sections with a 6 mm space between, the left section records direction and the right, wind run.

The gear ratio between wind vane and recorder roller is 1:1 giving corresponding positions for wind vane, and trace on the 360^0 strip.

The gear ratio for the cup anemometer is 7..440:1 which produces a single traverse of the 32 mm graduated wind run chart, for a nominal 10 000 metres of wind-run.

By use of the wind speed evaluation rule, which is based on the chart speed of 10 mm per hour the mean speed maybe evaluated from the strip chart for any desired time interval. The speed range is from 0-60 m/s (0-116.5 knots) and the starting speed of both elements is under 0.6 m/s (1.2 knots).

Instantaneous wind speed including gusts cannot be ascertained with this instrument,

5.2.2. Operation

Wind and start the clock; the winding square is positioned to the right of the strip chart, beneath which an interruption lever is provided for starting (green) and stopping (red) the clock. The lever positions are colour marked as indicated.

The caged recording rollers are lowered on to the strip chart by backing off the knurled thumb-nut located top centre of the anemograph opening. This nut releases the tension on the spring which secures the recording rollers during shipping and chart changing.

A knurled wheel is located at the right centre of the strip chart mechanism for setting the strip chart to the correct time. As the actual strip chart position being traced by the recording roller is inaccessible, adjustment is affected at a pointer provided for this purpose marked "-4^{h}" and positioned on the right chart guide-plate at an accessible section of the strip chart. This position is exactly four hours ahead in time of the actual recording position, i.e., actual recording position time 0900, pointed "-4^{h}" indicates time 0500. Draw a line on the chart at this position using the pointer as a rule and enter the time on the chart. When entering time marks the back lash in the gears must be taken up by turning the chart backwards, after which any slackness in the chart is to be taken up on the lower take-up spool.

Time-marks are made on the strip chart by rotating the wind vane a complete revolution by hand; the time is then entered on the chart as above. Note: the difference in time, between the entered time, and the traced time-mark, must be allowed for when completed strip charts are later evaluated.

Close and secure the door.

The clock should be wound and the chart changed at least every month. No other maintenance should be required.

5.2.3. Chart changing

Time mark the completed chart then raise the recording rollers with the knurled thumb-nut located at the top of the anemograph door opening. Free the strip chart from the guide-plates by opening the guide-plates outwards. Raise the take-up spool securing levers and remove the spooled chart. The completed strip chart can now be taken off the take-up spool by removing the right limit disc from the spool. Enter the name of the station, the date and time on and off on each chart.

The new chart is now fitted by first unwinding about 25 cm, then releasing the two securing hooks at the top of the recording pad and allowing the complete mechanism to hinge forward. The chart is slipped on to the spool, located in its clips and the mechanism is repositioned by securing hooks. The loose end of the chart is fixed to the bottom spool which is in turn relocated by its securing levers at the bottom of the mechanism. Align the sprocket drive with the chart perforations and close the guide-plates. Lower the recording rollers, set the chart to the correct time, and time mark the chart.

The only maintenance recommended by the manufacturers is to have the instrument checked and re-oiled every three years.

5.2.4. Tabulations of hourly winds from Lambrecht anemograph charts

Checking of record

Before data can be extracted from an anemogram it is essential to examine the entire record to ensure that the background scale is correctly positioned with respect to the speed and direction helices. Corrections to the scaled values of wind direction are to be applied as necessary.

Time marks must also be examined and any necessary adjustments to the time scale made.

5.2.5. Evaluation of charts

Wind direction

The mean wind direction over each hour is obtained by drawing, in imagination, a line through the middle of the direction trace so that, where the trace is fluctuating, the areas enclosed by the trace on either side of the line are equal. The direction is estimated from the trace to the nearest 10 degrees. A small plastic sheet with a line inscribed on it is useful for this.

If there is a sudden change of direction so that for part of an hour the wind is from one direction and for the rest of the hour from a substantially different direction, the value tabulated for that hour should be the direction which lasted for the greater period.

If the wind is calm for only part of the hour, the mean wind direction for the remainder of the period is taken to apply to the whole hour even if it covers less than half of the period.

Wind speed

Scales

Three scales are provided to obtain wind speeds from the anemogram.

On scale I, sloping lines labelled in knots may be compared with the slope of the recorder trace. This scale is suitable for wind speeds up to 10 knots.

Scale II is used to obtain average wind speeds over intervals of one hour. There are two models of Scale II. one for speeds up to 30 knots and a second for speeds from 30 knots up to 55 knots.

NOTE: Incorporated in these scales is a calibration correction of approximately + 0.8 knots in near clam conditions rising to + 1.4 knots for speeds from about 10 to 25 knots. Above about 40 knots it begins to decrease again, reaching zero at about 80 knots.

Average wind speeds over intervals of one hour are found with the use of scale II. Count on the chart the number of separate traces occurring in the hour being scaled. (The trace need not extend completely across the chart.) The number of traces is then used to select the corresponding index marked along the bottom of scale II. The selected index on the scale is set against the point "A" where the trace intersects the initial hour line and the mean wind speed, in knots, is read off the top scale at "B" where the trace intersects the next hour line.

Table

An alternative method of obtaining wind speeds from Lambrecht anemograms is to use a special table instead of the plastic overlay scale.

Average wind speeds over intervals of one hour are obtained by counting the number of complete traverses and tenths of a traverse. Commence counting the traverses at the point on the trace where it intersects the initial hour line and terminate the count where the trace intersects the second hour line.

Using the values so obtained refer to the special table for the wind speeds.

Wind run

Wind run (uncorrected) in any interval may be evaluated directly from the chart, one complete traverse representing a nominal 10 km, i.e. 5.40 nautical miles.

5.3. Compilation of data on Met Form 319

The mean hourly values are to be recorded on Met Form 319. The direction is to be entered in tens of degrees; e.g. a direction of 20 degrees is entered as 02; 100 degrees is entered as 10. Wind speeds of less than 10 should be entered using two digits; e.g. a speed of 4 is to be entered as 04. When the wind is calm the figures 000 are to be written in the direction and speed columns. If there has been loss of record the appropriate hourly columns are to be left blank.

NOTE: The mean hourly values of wind direction and speed to be entered in each column of Met. Form 319, are the values obtained in the 60 minutes following the hour value shown at the head of each column, i.e. 00 NZST shows the means of the directions and speeds between 0000 and 0100 hours

6. Solar radiation

6.1. General

Solar radiation is an important parameter in indicating cloudiness, for the purposes of studying climate change and analysing data for industries such as agriculture, horticulture, tourism, and the construction industry.

There are two main aspects to the measurement of solar radiation:

6.1.1. Sunshine

The hours of sunshine are of importance to many activities, notably tourism. Measurements of the hourly or daily totals are made with sunshine recorders. However there are four possible recording methods, so the World Meteorological Organisation (WMO) has adopted the Campbell Stokes recorder as the reference standard in order to reduce the differences.

The standard unit is tenths of an hour of sunshine at intensity as determined by the Campbell Stokes recorder.

6.1.2. Solar radiation

As short-wave radiation from the sun passes through the earth's atmosphere, it is modified by the following processes:

- absorption, scattering and reflection by cloud
- absorption, by atmospheric gases, particularly oxygen, ozone, carbon dioxide and water vapour
- scattering and diffuse reflection from particles (e.g. dust and smoke) of a size comparable with, or larger than, the wavelength of light
- scattering by molecules of air and particles smaller than the wavelength of light.

As a result of the scattering processes, the solar radiation received on a horizontal surface comprises a direct component and a diffuse component which, when measured together, are referred to as the global solar radiation.

In New Zealand we operate two main radiation networks, primary and secondary.

The primary network uses Eppley instruments and measures direct, diffuse and global radiation. The secondary network uses Licor instruments and measures global solar radiation.

6.2. Sunshine recorders

6.2.1. General

Description

NIWA uses sunshine recorders of Campbell-Stokes pattern, as shown in Figures 6.1, 6.2, 6.3 and 6.4. The glass sphere is mounted concentrically so that the sun ray's are always in focus on the card held inside the bowl.

Different shaped cards are used in their respective grooves, according to the season. (summer, winter or equinoctial). The total duration of bright sunshine is found by comparing the total length of line charred by the direct rays of the sun with the time scale on the card.

More detail is available in the British Meteorological Office Handbook of Meteorological Instruments, Volume 6.

Types of recorders

Variations of recorder are used for three different ranges of latitude. In the case of `universal' model, illustrated in Figure 6.4, the range is indicated by a letter A, B or C for low, mid or high latitudes respectively. Non-universal types (figures 6.1 to 6.3) may be distinguished as follows:

	Low latitude	**Mid latitude**	**High latitude**
Approximate latitude	0-40°	35-45°	45-60°
Sphere support	Two opposite mountings		Single pedestal mounting
Card bowl end (shape of cut)	Part diagonal part right angle	Single diagonal cut	Single diagonal cut

6.2.2. Installation

Exposure

So that no record may be lost due to obstructions, the site selected for a sunshine recorder should have:

- a free horizon between about northeast and southeast on the east side;
- a free horizon between about northwest and southwest on the west side;
- no obstruction to the north which is at an elevation angle greater than the sun at mid-winter;
- obstructions to the south are of no consequence.

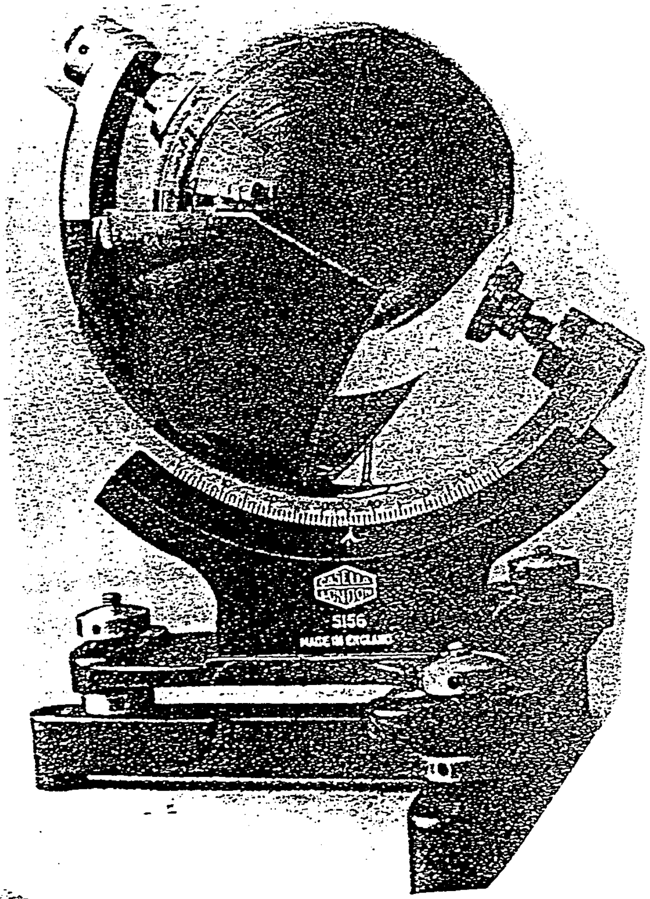


Figure 6.1 Low latitude

Figure 6.2 Mid latitude

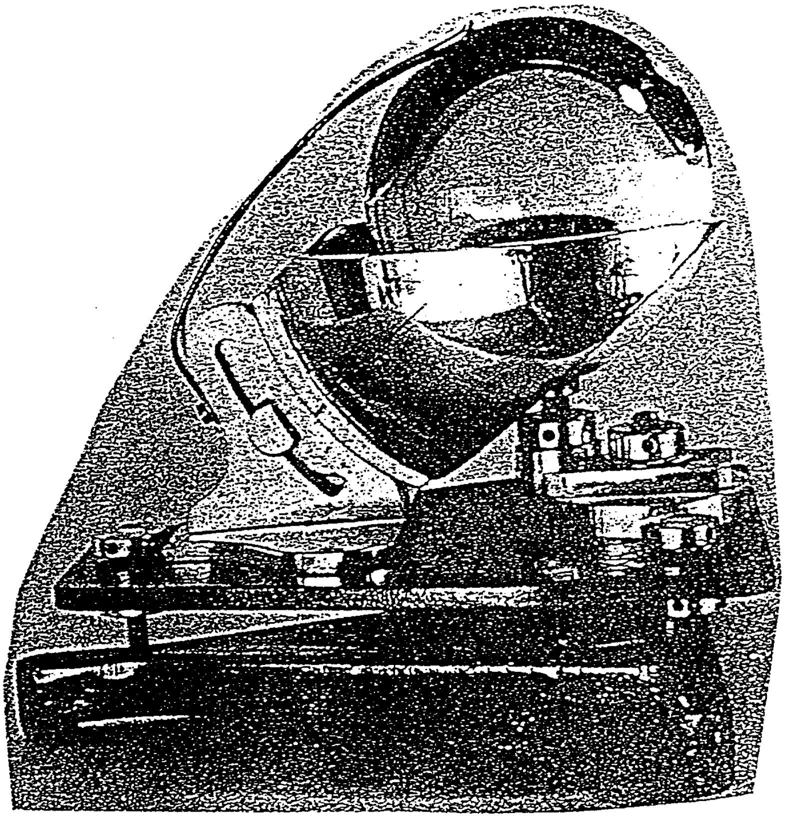


Figure 6.3 High latitude

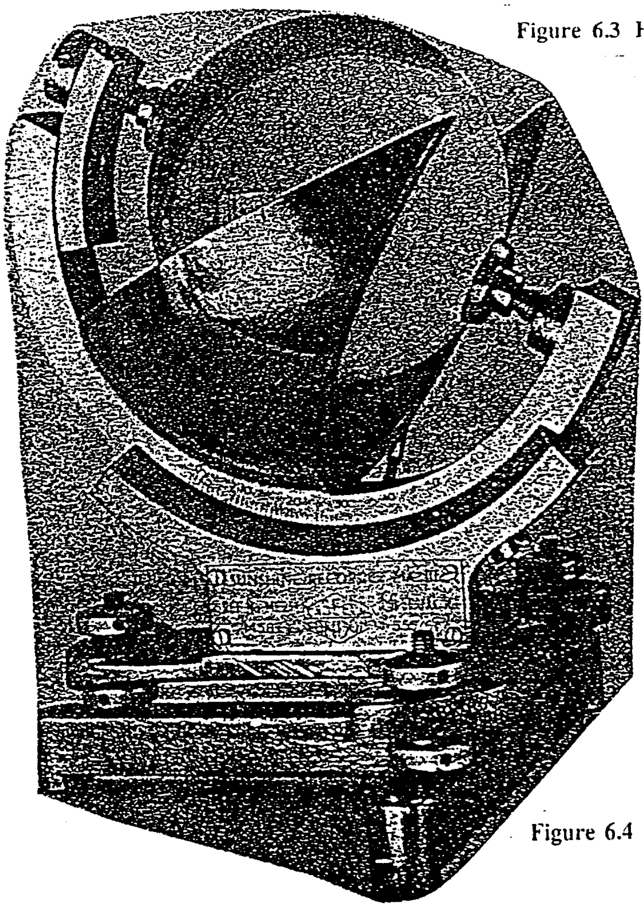


Figure 6.4 Universal

A prerequisite to siting a sunshine recorder is the completion of a horizon profile on form Met. 306 for appraisal by the Climate Databank.

The elevation of the sun at all times of the day is shown on the form for the equinoxes and the summer and winter solstices at latitudes 35°S and 45°S.

Mounting

The recorder is usually packed for shipment with the sphere separate. If the recorder is one with two retaining screws, the lower one will be locked in place. Only the upper screw may be moved. This should clamp the sphere positively but not with such force that it cannot be rotated or so as to risk chipping the sphere. The type with a single support has a retaining clip to prevent the sphere being dislodged.

The support on which the recorder is placed should be rigid and not liable to warp or otherwise be affected by the weather. It should be easy of access so that the cards can be changed each day without difficulty. To avoid obstructions, it is often necessary to install the recorder on the roof of a building, in which case particular care must be taken to provide safe and easy access.

The recorder is mounted on the level support facing True North with the front pair of screws on an east-west line and the third screw to the south. Use brass or stain-less steel countersunk head screws at least 40 mm long.

6.2.3. Adjustment concentricity

The centre of the glass sphere must coincide with the centre of the bowl. This adjustment is made by the use of a special gauge and the lower support locked in the correct position. This support must not be moved.

Latitude

The recorder is set to the latitude of the site by loosening the clamp at the back of the bowl and sliding the bowl until the arrowhead is opposite a point on the scale corresponding to the latitude of the site. Once set, the clamp must be tightened again firmly.

Level

Level the sub-base using a spirit level placed parallel to the front edge and then at a right angle to it. The first (E-W) is particularly critical. For older instruments with solid bases, it is necessary to adjust the level with brass shims or washers under the corners of the base. A bridge designed to fit over the sphere is used to check the E-W level, once the recorder is correctly orientated. Also check the N-S level.

Orientation

The recorder must face true north. This may be set by turning the recorder as a whole until the sun's image on the card is exactly on the 12 mark at the times appropriate to the longitude of the station. See 6.1.3 for compilation of table.

The differences between noon standard time and the time the sun is due north of the station are equally applicable to any other hour of the day. For example if the sun's image should be on the 12-hour line at 1225 NZST, then it should be on the 10-hour line at 1025 NZST, the 11-hour line at 1125 NZST, etc.

It should be remembered that during Daylight Saving that an one hour correction should be applied to NZDT to bring it back to NZST, i.e. at 1325 NZDT it is equal to 1225 NZST.

NOTE: To install and/or check the orientation obviously the sun must be shining brightly and the card installed correctly.

New Zealand stations

For each new station, use the tables below to compile a table of the times when the sun is due north (360° True).

Time, New Zealand Standard Time when sun is on meridian at longitude 175°E

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	12.23	12.34	12.32	12.24	12.17	12.17	12.23	12.26	12.20	12.10	12.04	12.09
4	12.25	12.34	12.32	12.23	12.17	12.18	12.24	12.26	12.19	12.09	12.04	12.10
7	12.26	12.34	12.31	12.22	12.17	12.18	12.25	12.26	12.18	12.08	12.04	12.11
10	12.27	12.34	12.31	12.22	12.16	12.19	12.25	12.25	12.17	12.07	12.04	12.12
13	12.28	12.34	12.30	12.21	12.16	12.20	12.25	12.25	12.16	12.07	12.04	12.14
16	12.30	12.34	12.29	12.20	12.16	12.20	12.26	12.24	12.15	12.06	12.05	12.15
19	12.31	12.34	12.28	12.19	12.16	12.21	12.26	12.24	12.14	12.05	12.05	12.17
22	12.31	12.34	12.27	12.19	12.16	12.22	12.26	12.23	12.13	12.05	12.06	12.18
25	12.32	12.33	12.26	12.18	12.17	12.22	12.26	12.22	12.11	12.04	12.07	12.20
28	12.33	12.33	12.25	12.18	12.17	12.23	12.26	12.21	12.10	12.04	12.08	12.21
31	12.33	-	12.25	-	12.17	-	12.26	12.21	-	12.04	12.-	12.23

To determine the time that the sun is due north (on the meridian) at other longitudes:

ADD 4 minutes to above table for each whole degree station is WEST of 175°E (ie., from 175°E to 168°E, etc).

SUBTRACT 4 minutes to above table for each whole degree station is EAST of 175° (ie., 175°E to 180°E, etc).

A copy of any table prepared should be forwarded to the Climate Databank, together with particulars of longitude, latitude etc. See Figure 6.5 for an example of a complete table.

For further details on compilation of tables refer to the British Meteorological Office Handbook of Meteorological Instruments Volume 6.

Tropical stations

In the topics (22° 27'S South or less) the sun will be on the meridian at the times stated but will be either overhead or due south during a period centred on the summer solstice. The instructions are not materially affected, even though the sun may be to the south of the station. Tables for tropical stations should be headed

"time ……… sun is on the meridian at …………..(longitude).

Island stations not using New Zealand Standard Time should make appropriate adjustments, and in every case the time standard used should be clearly indicated.

Tables for the Islands will be compiled by the Databank with reference to the British Meteorological Handbook of Meteorological Instruments Volume 6.

Example of use

The instrument is to be set up, or the setting checked on 16 July. From the table note that on 16 July the sun is true north at 1233 NZ Standard Time. Therefore, at 1233 observe the position of the sun's image or "burn" on the card and turn the recorder until the "burn" is exactly on the 12 mark.

Station Located at: Nelson , Aerodrome

Table showing the time, NZ Standard Time, when the sun is due north of Longitude 173° 13.5' E

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1230	1241	1239	1231	1224	1224	1230	1233	1227	1217	1211	1216
4	1232	1241	1239	1230	1224	1225	1231	1233	1226	1216	1211	1217
7	1233	1241	1238	1229	1224	1225	1232	1233	1225	1215	1211	1218
10	1234	1241	1238	1229	1223	1226	1232	1232	1224	1214	1211	1219
13	1235	1241	1237	1228	1223	1227	1232	1232	1223	1214	1211	1221
16	1237	1241	1236	1227	1223	1227	1233	1231	1222	1213	1212	1222
19	1238	1241	1235	1226	1223	1228	1233	1231	1221	122	1212	1224
22	1238	1241	1234	1226	1223	1229	1233	1230	1220	1212	1213	12225
25	1239	1240	1233	1225	1224	1229	1233	1229	1218	1211	1214	1227
28	1240	1240	1232	1225	1224	1230	1233	1228	1217	1211	1215	1228
31	1240	-	1232	-	1224	-	1233	1228	-	1211	-	1230

Figure 6.5: Example of completed meridian time table.

Checking adjustments:

Figure 6.6 maybe used to make a preliminary check on the adjustment to ensure that the sun's trace will not fall on the flanges at any time of the year. It will indicate any error in the north-south levelling.

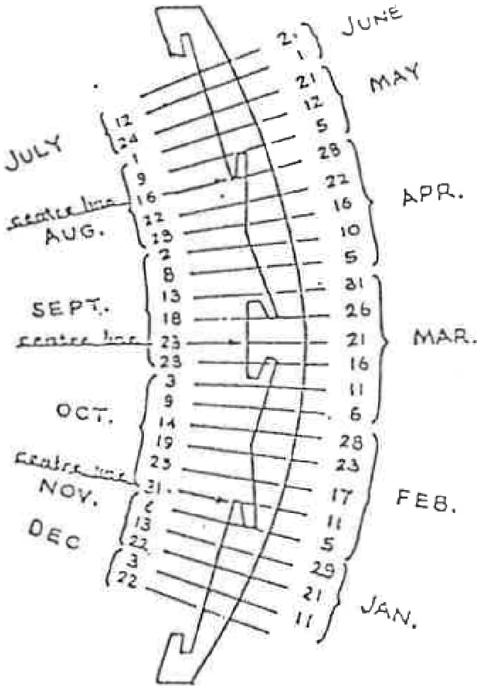


Figure 6.6: Position on the bowl the sun's trace should occupy at any time of the year

If all adjustments have been correctly made, the trace should be parallel to the edge of the card. If not, further alterations may be made by trial and error. Only a very small change should be made at a time and this should be checked on a day of fairly continuous sunshine before any further alteration is made.

NOTE: The sphere clamping screws must not be touched.

When adjustments are completed and the instrument is recording correctly, check again that it is rigid to prevent its being displaced when changing the cards.

6.2.4. Faulty adjustment

If the recorder is out of adjustment, this will be shown by the trace not being parallel to the edge of the card or approaching it very closely.

Before making any adjustment, the mounting of the recorder should be checked and the cause of any movement remedied. When it is clear that distortion or movement of the platform has been prevented, the recorder should be adjusted, using the following table as a guide.

Fault correction table

Fault	Cause	Action required
Trace slopes upwards from am to pm	Recorder facing W of true N or W side higher than E	Check orientation and, if correct lower West side and/or raise East side in small increments. Correct orientation if necessary.
Trace slopes downward from am to pm	Recorder facing E of true N or E side higher than W side	Check orientation and, if correct, raise W side and /or lower E side in small increments. Correct orientation if necessary.
Trace lowest around noon	Latitude setting too high or N-S level too high at S end	Check latitude setting, if correct, lower S end in small increments. Correct latitude if necessary.
Trace highest around noon	Latitude setting too low or N-S level too high at N end	Check latitude setting, if correct, lower N end in small increments. Correct latitude if necessary

NOTE:

1. The latitude once set will not normally change. However, this possible fault should be eliminated before other action is taken.

2 Gross errors of level are checked by spirit level and final adjustment by small daily increments. It is, therefore, preferable to eliminate errors in orientation, and then correct level.

6.2.5. Operation

Changing cards

The appropriate grooves for the different cards are indicated in Figure 6.7 which is a cross-section through the bowl which holds the cards.

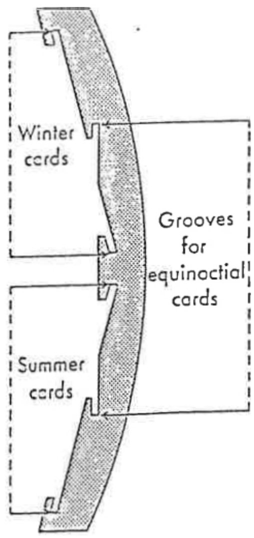


Figure 6.7: Cross-section of sunshine recorder bowl

If possible, the cards should be changed after sunset each day. Where this is impracticable, they may be changed at the normal time for the other daily observations, 0900 NZDT. The aim is to change them at as near the same time each day as possible so as to avoid errors due to overlapping of the burns. If the sun is shining when changing cards, the recorder should be shaded so that it does not make a false scorch mark. **A pencil line should be made to show the centre of the initial burn.**

A new card should be inserted every day, even if no sunshine has been recorded. A blank card affords evidence that the sun has been obscured by cloud. Immediately a card has been removed, write the name of the station and current day on the back. If the card is changed during daylight hours, so that parts of two days' records are represented, both the previous days and the current date should be entered. When inserting the card, care must be taken to see that the **'12' line on it coincides with the noon mark on the centre of the bowl**. A clamping screw is some-times provided to ensure that the card is firmly held.

The glass sphere should be cleaned as required. Great care must be taken not to use anything that would scratch the glass. If snow or hoar frost settles on the sphere, the deposit should be removed at the first opportunity. Use a warm damp cloth.

6.2.5 Scaling of suncards

The suncards are evaluated to determine the duration of bright sunshine using the transparent scale, as shown in Figure 6.8.

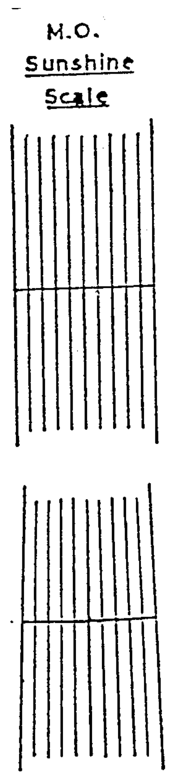


Figure 6.8: Sunshine scale

On initial inspection of the card ensure that the burn is parallel to the edge of the sun card, and that all details are entered on the back of the sun card and haven't been burnt out. If they have been burnt, re-enter them elsewhere on the back of the sun card.

Care must be taken not to over-estimate the length of burn, particularly when the sun has been shining brightly but intermittently.

The correct method of allowing for the tendency of a burn to spread out is to measure only up to the centre of the semi-circular end of each burn and not to the extreme end. It is easier to read off the scale if you have pencilled in the ends of the burns. However near sunrise and sunset or when the sun is shining through thin cloud or haze, the scorch is faint. In this case, the whole of the burn as far as it can be seen is measured.

Careful examination of the trace will show whether or not the sun has been intermittent. A smooth edge means the sun's rays have been uninterrupted and a serrated edge indicates intermittent cloud cover.

Dots or a series of dots should be disregarded altogether.

The transparent scale is placed over the card so that the horizontal line lies over the white crosses printed on the centre line of the card. If summer cards are in use, invert the scale.

Move the scale sideways so that the outer lines of the grid lie over the two adjacent hour lines on the scale.

Then move the scale sideways to the pencil lines and read off the duration in tenths off the scale and write this figure in the appropriate hour division on the sun card.

The values are totalled and entered on the back of the sun card. See Figure 6.9 for examples of scaled charts.

6.2.6. Sun cards changed during daylight

If it is not practical to change the sun cards after sunset, the next best option is to change the card at the time of the 0900 climate observation.

If the sun card is to be changed during daylight hours it is very important that it is changed at the same time each day. This is to avoid errors with overlapping burns.

Scaling of sun cards is the same as in section 6.1.6, but as there is sunshine from two days on each card it is important to distinguish between the two totals. To do this the following procedures are to be followed:

When changing the sun card:

* enter the time on and off on the back of the sun cards in the appropriate positions,

* if the sun is burning a trace on the card mark the card with a pen or pencil at the time of changing. This shows which is today's sunshine and which is tomorrows sunshine.

After scaling the sun cards:

* enter the totals for the two periods onto the back of the sun card in the appropriate positions.

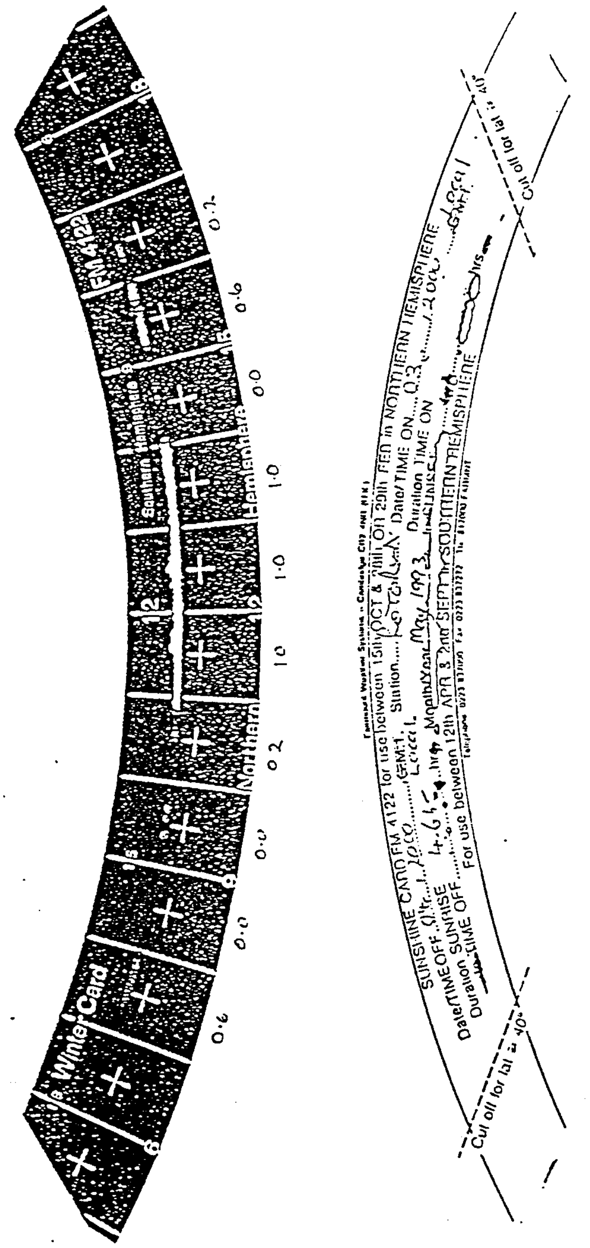


Figure 6.9: Example sun cards

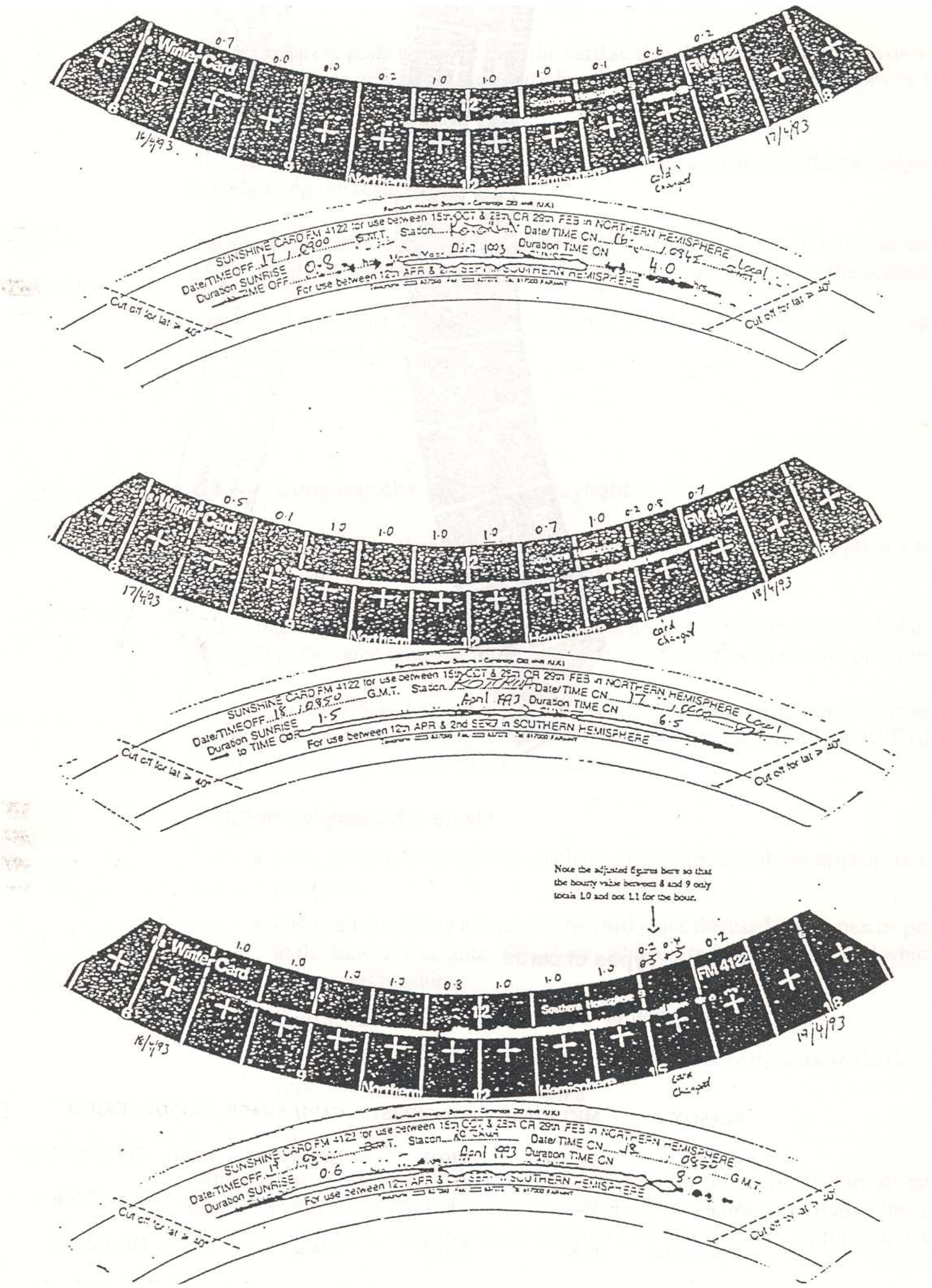


Figure 6.10: Example sun cards changed during daylight.

When determining the total sunshine for *any* given day, remember that in any given hour there can be no more than 1.0 hours of sunshine. If for some reason the total comes to 1.1 or 1.2, scale the values down to 1.0. See Figure 6.10 for examples.

6.2.7. Types of cards

Description of cards

Season	BMO Metform	Our stock list	Care Shape	Flange	Period
Summer	6730	0.1080	Long, curved	Bottom	Oct 15-Feb 28/29
Winter	6731	0.1081	Short, curved	Top	Apr 12-Sep 2
Equinoctial	6732	0.1082	Straight	Centre	Mar 1-Apr 11 Sep 3-Oct 14

All cards are inserted so that the edge with the hour figures is uppermost in the appropriate flange.

Some users will be required to trim sections from the cards they receive. Stations located at or north of latitude 25° South will be required to trim the summer card Metform 6730 along the lines marked on the card. Stations located at or south of latitude 40° South will be required to trim the winter card Met Form 6731 along the lines marked on the card. <u>Failure to carry out this action could result in the loss of record near sunrise and sunset.</u>

6.3. Radiation

6.3.1. Introduction

This section defines the components of solar radiation that are measured, the instruments that are used, and the units of measurement and the process of standardising the measurements.

6.3.2. Types of measurement

There are several different components of solar and terrestrial radiation although we are mostly concerned with only three:

GLOBAL SOLAR RADIATION. This is the total radiation received on a horizontal surface. It comprises the direct component from the sun and the diffuse component which results from scattering and reflection as the solar radiation traverses the atmosphere. The global radiation is measured by a pyranometer.

DIRECT SOLAR RADIATION. The direct component is that radiation from the sun's disc received on a surface normal to the direct ray from the sun. It is measured by a pyrheliometer.

DIFFUSE RADIATION. The diffuse or sky radiation component is that part received on a horizontal surface from the atmosphere alone. It is measured by a pyranometer which is shaded from the direct radiation of the sun.

OTHER COMPONENTS. In addition, we occasionally refer to "net radiation", "total radiation" and "terrestrial radiation".

TERRESTRIAL RADIATION. This is the radiation re-radiated by the ground, measured through a horizontal surface, while total radiation is the sum of the global solar radiation and the terrestrial radiation. Net radiation equals global radiation minus terrestrial radiation. It is important to note that until quite recently global solar radiation was called total radiation.

6.3.3. Instruments

A radiometer is simply a calibrated radiation measuring device. The following descriptions refer to instruments specifically used to measure components of solar radiation in New Zealand.

Pyrheliometer

This is an instrument for measuring the intensity of direct solar radiation at normal incidence, i.e. the measuring surface is set normal (at right angles) to the direct rays from the sun. The highest precision "absolute" pyrheliometers are used as primary standards to establish the WMO world reference and regional references for solar radiation measurement. Secondary standard instruments are used to calibrate other network pyrheliometers and standard pyranometers.

Pyranometer

A pyranometer is a radiometer for the measurement of global solar or diffuse radiation. The World Meteorological Organization (WMO) has defined three classes of pyranometer on the basis of their accuracy and overall performance. In New Zealand, First Class (Eppley PSP thermopile) and Second Class (Li-Cor LI-200SB silicon cell) pyranometers are used in the primary and secondary radiation monitoring networks respectively. Secondary Standard pyranometers are used for routinely calibrating network instruments.

Other radiometers

Other radiometers and photometers are used in research programmes for measuring particular spectral components, e.g. ultra-violet wavebands, or long-wave terrestrial radiation. Sun photometers measure solar radiation in several narrow wavebands to determine the optical depth of the atmosphere for air pollution monitoring.

6.3.4. Units of measurement

There are a number of units which can be used for radiation measurements.

Radiant Exposure is the quantity of energy transferred as radiation per unit area incident upon a surface.

Irradiance is the rate of transfer of radiant energy per unit area incident upon a surface.

Early measurements

Prior to the adoption of SI metric units the unit used in New Zealand was langleys and langleys per minute as the units of radiant exposure and irradiance respectively, where:

1 langley	= 1 calorie per square cm
	= 4.186 x 104 Jm ^{2}, and
1 langley/minute	= 697.7 Wm.

A langley is a (gram) calorie per square centimetre (gm cal cm^{-2}) and so for gradation intensity, a langley per minute is a (gram) calorie per square centimetre per minute (gm cal cm` min^{-1}). One calorie is the amount of heat required to raise the temperature of one gram of water by one degree Celsius. Applying this to radiation measurement, a Langley is the amount of radiation falling on an area of one square centimetre that would raise the temperature of one gram of water by one degree Celsius. The term "gram calorie" is often shortened to "calorie".

Example: If a constant level of radiation falling on a square centimetre was sufficient to increase the temperature of one gram of water by one degree Celsius in one minute, then the amount of radiation measured in an hour would be 60 Langleys and the intensity would be one Langley per minute.

Note that in International System (S.I.) metric units

1 langley = 4.186 x 10^4 J m ^{2} as 1 calorie = 4.186 joules (J) and the unit of area is a metre.

Also 1 langley per minute = 6.97 x 10^2 J m"2s ^{1} as a factor of 1/60 is introduced in converting to seconds.

SI units

In the Systeme Internationale (SI), the units of measurement for radiant exposure and irradiance are joules per square meter (J/m^2) and watts per square metre (W/m^2) respectively.

Each radiometer has a calibration constant which is provided, firstly by the manufacturer, and then by NIWA Instrument Systems following calibration by NZ MetService. It gives the output of the instrument in millivolts when the radiation is 1.0 kilowatt per square metre.

For example: If a pyranometer has a calibration constant of 8.50 millivolts per kW/m^2 then, when the radiation input is 1.0 kW/m^2, the pyranometer output is 8.5 millivolts.

6.4. Radiation sensors and recorders

6.4.1. Radiation sensors (pyranometers)

Two types pyranometer are in use, the Eppley Precision Spectral Pyranometer (P.S.P) and the Kipp and Zonen CM Pyranometer. Both have ± 1% accuracy.

Both instruments operate on the principle of a differential thermopile with the hot-junction receivers blackened and the cold-junction receivers whitened. The surfaces are protected by precision-ground optical glass covers and the instrument has built-in temperature compensation. The output of the thermopile is a millivoltage which is a measure of the intensity of the incident radiation.

The primary stations in the radiation network are equipped with an Eppley pyranometer, the output from which is recorded on a datalogger. The datalogger gives a value for the radiation measured each hour.

6.4.2. The Eppley shading ring

The four primary network stations measure diffuse radiation as well as global solar radiation. The diffuse radiation pyranometer is shaded from direct radiation by means of a shadow band. The shadow band is a strip of metal approximately three inches wide and arranged in a semi-circle around the pyranometer. With the shading ring assembly orientated due north and set for latitude the only adjustment required is a weekly re-setting of the shadow band to compensate for changing solar declination. With this adjustment the diffuse pyranometer should always be shaded from direct radiation. The whole assembly is painted with "Parsons optical black lacquer".

6.5. Installation of radiation instruments

6.5.1. Pyranometer

The pyranometer is to be located on the top of a pillar or platform which is constructed so as to minimise the possibility of a change occurring to the level of the instrument. The instrument is placed on the mounting so that the cable socket points south (in the southern hemisphere). The pyranometer is then levelled by centring the bubble of the spirit level on the base plate and then secured by three brass wood or machine-screws. Care must be taken not to over tighten the base plate securing screws as this can cause distortion.

6.5.2. Eppley shading ring

This is mounted on a pillar and orientated due north. The pillar must be sufficiently robust and stable to prevent *any change* in level occurring and also allow for slight orientation adjustments to be made. The pyranometer is mounted on the pedestal of the shading ring assembly in accordance with the instructions in 3.1.

After checking the orientation and that the base plate is level, the two wing nuts carrying the shadow band are loosened and each bar reset so that the 0° mark of the declination scale, engraved on the bar, is opposite the index engraved on the plate with the latitude scale. Both wing nuts are then tightened. The latitude of the station is now set. Next, the pedestal height is set so that the pyranometer sensor and the two sighting holes in the shadow band are in a straight line. The pedestal is now locked in this position and the pyranometer level checked. The only adjustment now required is a weekly resetting of the shadow band along the polar axis with changing solar declination. Declination settings and dates can be provided by Instrument Systems.

6.6. Maintenance

6.6.1. Pyranometer

Once a week or more often if necessary, wipe any dust, salt spray, etc. from the pyranometer bulb. In addition, remove any leaves or ice from the bulb whenever necessary. Ice is to be removed carefully with a warm cloth.

Check the level of the pyranometer each week. Make any adjustment necessary to level the pyranometer.

If the pyranometer has a desiccant container that screws into the side of the instrument this is to be checked once a month. The desiccant is to be bright orange in colour. When it becomes pale, or green, it must be replaced.

6.6.2. Calibration

Each station is visited annually by a NIWA Instrument Systems technician for calibration and servicing.

6.6.3. Pyranometer(s)

The PSP sensors are exchanged annually and the LiCor sensors are exchanged every two years on the above servicing visit.

The removed sensors are then serviced and sent to NZ MetService for calibration.

6.7. Li-COR radiation and monitor equipment

This section covers both installation and operation procedures. Several sections can be used as an excerpt to form an "OPERATIONS" manual for use by NIWA staff and climatological observers.

These self contained LI-COR pyranometer and sensor installations used in New Zealand and the Pacific complement the primary network of Eppley pyranometers and the secondary network of Licor pyranometers on the AWS and EWS.

6.7.1. Equipment

The pyranometer sensor and calconnector

The LI-COR LI 200SB Pyranometer is an instrument for measuring solar radiation received on a horizontal surface. The whole sky hemisphere is viewed and the pyranometer measures the total contributions of the whole sky and the direct solar radiation. This total is usually called `Global Radiation'.

The sensor is a silicon photodiode. It is sensitive to a limited wavelength region of about 400 nm to 1100 nm rather than the full spectrum. However, this limited sensitivity does not cause errors of more than 5 percent.

A current signal (microamps) is generated by the sensor in direct proportion to the radiation intensity and fed to the monitor via the calconnector. The calconnector, which contains the calibration resistances for the particular sensor in use, ensures that the solar radiation results displayed by the monitor are in the required scientific units.

The sensor is classified by WMO as a second class pyranometer, its overall accuracy being about 10 percent.

The monitor

The LI-COR LI 1776 Solar Monitor is a microprocessor-controlled meter/integrator. Both instantaneous and integrated (totalised input from the sensor over a pre-selected period of time) measurements can be taken. In the New Zealand network the daily integrated data is manually transferred from the monitor to data sheets.

The instantaneous output is called the `solar irradiance' and is displayed by the monitor in units of Watts per square meter ($W/m^2$). The integrated totals are called `solar irradiation' and are displayed in Joules or megajoules per square metre (MJ/m^2).

The monitor's liquid crystal display can be switched to display, firstly, the instantaneous irradiance, secondly the present partially completed integral, and thirdly, the preceding completed daily integrals.

The results can alternatively be displayed in the old units of Langleys and Langleys per minute respectively.

The LI 1776 monitor has a standard 9 volt internal battery which provides short term (about 40 hours maximum) power back up in case of external power failure.

Power

Power to the LI 1776 monitor will be normally provided by a solar power system consisting of a solar panel which charges a 12 volt gel-cell battery that is enclosed with the necessary electronics in an alloy box (solar power module).

In a very few cases, the power may be supplied to the monitor from the mains via a DAVRED PU 35 rectified step down transformer.

The mounting system

There are many advantages of having this equipment in a `stand-alone' form so the LI-1776 monitor and solar power supply module are housed in a weatherproof polyester cabinet which is secured to a galvanised water pipe post (Field Mount). The LI 200 SB sensor is fitted to the top of the post. The solar panel is attached to a perpendicular outrigger.

All signal and power wiring is internal to the Field Mount and cabinet.

6.7.2. Site selection

Because the characteristics of sites vary so widely, it is not possible to set a uniform specification for the location of equipment. This section specifies the ideal siting requirements which are, briefly, good sensor exposure and good access to the sensor. At some sites compromises will have to be made.

6.7.3. Sensor location/exposure

So that no radiation record is affected by obstructions or reflections the site selected for the LI-COR LI-200SB pyranometer sensor should have:

- no obstructions greater than 5 degrees in altitude between the northeast and southeast sunrise positions and between the northwest and southwest sunset positions.

- no obstruction or surface that will reflect solar radiation on to the sensor especially from the south.

- no obstruction of any bulk or height in close proximity that would shade the sensor for an appreciable time or reduce the viewed hemisphere to any significant extent.

- no adjacent strong artificial lighting at any time. (e.g. runway/taxiway lights).

- unobstructed access for daily visual inspection and cleaning.

NOTE: A prerequisite to siting the pyranometer is a site report including a horizon profile on form MET 306, taken from the proposed sensor site. This should be submitted to the Climate Databank for approval.

6.7.4. Calibration

The LI-COR LI-1776 monitor and the LI-200SB pyranometer sensor are calibrated and tested by the manufacturer and by NIWA Instrument Systems biennially. NO ADJUSTMENTS are to be made to the monitor or sensor other than those outlined in this manual.

6.7.5. Instructing operator

Full instruction should be given to the people who are to operate the solar monitor.

The operating manual shall be explained with the aid of practical exercises using the monitor. Operation shall be demonstrated as fully and as clearly as possible (for examples use integration periods of 12 minutes as a simulation of the required 24 hour integral).

6.7.6. Documentation

An installation summary shall be written and forwarded to the Climate Databank. This summary should include:

- instrument serial numbers
- any departures from planned installation
- photographs of the completed installation (preferably of the whole enclosure from 2 different perspectives)

6.7.7. Setting up the LICOR LI 1776 solar monitor

Before mounting the monitor and connecting the unit to the sensor, ensure that the switch marked "Internal Battery" is off.

The sequence of set-up is:

- integration period (i.e. the period over which the monitor will collect and total data; for most stations this period is 24 hours)
- the time of day
- data collection mode
- reading the collected data

NOTE Before starting with the set-up read the following instructions carefully as in two instances a response is necessary within 5 seconds.

Integration period

- mount the monitor unit on the back plate
- connect the plug from the sensor to the monitor sensor marked "input"
- put the MODE switch in the MEMORY position
- put the INTERNAL BATTERY switch in the ON position
- the display should read "P..." (note that you then have 5 seconds in which to begin the following procedure)
- press the switch marked MEMORY to ADVANCE position (this is a momentary contact one and will return to the DATA position when released)
- the display will show "00.12". Repeat pressing the MEMORY switch as above until the display shows the required integration period (e.g. 00.25 for quarter hour, 00.50 for half hour, etc up to 24.00 for a total every 24 hours)

Once the desired period has been reached, leave the MODE switch in the MEMORY position and the MEMORY switch in the DATA position. After 5 seconds the display will go blank for 5 seconds; during this time the time of day can be set as below.

Time of day setting

The time of day is set by using the MEMORY switch (as above). Every time it is pressed, the display will advance by 7 minutes. Alternatively, hold it down and the display will advance in 7 minute intervals.

Using this procedure, advance the display until the correct time of day is reached (using NZST).

Data collection mode

To set the monitor up for data collection,

- Put the MODE switch to the INST position (which shows the instantaneous radiation value 0000 to 1000 W/m^2) or into the CURRENT INTEGRATION position (which will show the "running total" e.g. 01.82 MJ/m^2 for the time interval selected as above)

NOTE: If the display comes up with HELP, then turn the monitor off and repeat the procedure.

- ensure that the UNITS switch is in the NORMAL position, MJ/m^2
- connect the plug from the external battery into the socket marked "Ext. Power Supply"

- put the switch marked INTERNAL BATTERY in the OFF position.

If at any time during the above steps the display shows the wrong information or other problems develop, turn off the monitor (by disconnecting the plug from the "Ext" socket) and start again. A common problem can be needing more than 5 seconds to respond when setting up the integration period or the time of day.

Following the above steps the monitor is set up for data collection. If, for example, the steps above were done at 1100 hrs and a 24-hour integration period was set, then the first integration period will be from 1100 to midnight, and then from midnight to midnight.

Reading the collected data

- To display the collected data, place the MODE switch into the MEMORY position. The display will show the last 24-hour total (if that is what was selected for the integration period)

- By pressing the MEMORY switch you can step back in time; press the MEMORY switch once (the display will read -0002), then release the switch and the 24-hour total of 2 days ago will be displayed. Press and release the MEMORY switch again and the display will show the 24-hour total for the collected data of 3 days ago, etc.

- Return the MODE switch to INST or CURRENT INTEGRATION as in the data collection mode step above.

6.7.8. Routine operation of solar monitor

The INTERNAL BATTERY switch should always be in the OFF position on solar powered installations.

The UNITS switch should always be left in the NORMAL position. This means that the instantaneous readings will be in Watts per square metre ($Wm^{2)}$ and the integrated daily (or other integration period) totals will be in units of megajoules per square metre (MJm^2).

The OPTIONAL position of the UNITS switch gives a display readout in Langleys. A Langley is a unit of energy per square centimetre and has been used in the past as a measure of irradiance and solar irradiation. This unit has now been replaced by the WMO standard SI unit of Watts per square metre.

CONVERSIONS; 100 Langleys = 4.186 MJ

A rate 1 Langley per minute = 698 $Wm\text{-}^2$

NOTE: For NIWA purposes, data must always be recorded in Normal units (MJ/m).

Neither the external power supply plug nor the calconnector and/or sensor lead should be removed unless instructed otherwise.

The output socket on the monitor is not used and it should not be interfered with in any way.

6.7.9. Periodic maintenance

Whenever possible, check the following:

- that all switches are in their correct positions (see above)
- that there is no LOW BATTERY indication

A low battery installation on a mains-powered system means that the internal battery should be replaced as soon as possible

A low battery indication when the internal battery switch is in the OFF position means that the battery in the solar power module is flat and/or that the solar charger is malfunctioning. In this case Instrument Systems should be notified immediately.

- Check the sensor for obstructions, blow off any water from the white diffuser disc and the surrounding channel. This check shall preferably be made at sunrise or as soon as possible thereafter.
- Clean the sensor with a soft cloth but do not remove any grease from the screws on the base plate. Take care not to get grease on the white diffuser.

NOTE: The edges of the diffuser disc must be kept clean to maintain accurate readings. .

- Check the sensor level and adjust if necessary by slackening the securing screws and adjusting the level screws so that the bubble in the level on the base plate is within the centre circle of the level.
- Check the integral and instantaneous readings, if possible, while it is still dark (during the early morning) to ensure there are no erroneous data being logged. Both readings should be zero if no irradiation has been incident on the sensor.
- Check that the drain hole in the Field Mount water pipe post is clear.

Longer-term attention

The internal backup battery gives between 20 and 40 hours of useful life. Battery replacement will be done by Instrument Systems.

6.8. Radiation reference standards

6.8.1. Standardisation of measurement

The accuracy of practical radiation measurements is determined by a series of calibrations against a hierarchy of particular reference instruments and procedures. Thus measurements made in New Zealand are in theory traceable in their accuracy to the World Standard.

The World Radiometric Reference

The WMO adopted a new radiation scale in 1979 which is called the World Radiometric Reference (WRR). This reference represents the physical units of total irradiance to an accuracy of better than ± 0.3 per cent.

The WRR replaced the International Pyrheliometric Scale of 1956 (IPS). The IPS can be transferred into the WRR by using this equation:

WRR/(IPS 1956) = 1.022

This means that measurements of solar radiation made in langleys before 1979 must be increased by 2.2% when converting to megajoules per square metre.

i.e. 1 langley (before 1979) = 1.022 x 0.04186 MJm^{-}2 = 0.04278 MJm ^{2} in current values

The WRR is maintained by a group of at least four selected absolute pyrheliometers called the World Standard Group (WSG), which are intercompared at least once a year. The value of the WRR is transferred to national standards by means of inter-comparisons at WMO Regional Radiation Centres.

6.8.2. The New Zealand meteorological standard pyrheliometer

All calibrations of solar radiation instruments are traceable to this instrument through procedures laid down in MetService Manual Volume No 1. Our standard instrument is of the class of Secondary Standard pyrheliometers which have a precision over one year of better than ±0.5%. It is of the type known as an Angstrom compensation pyrheliometer made by the Eppley company.

The calibration constant of our reference is obtained by a series of comparisons carried out every five years with the WMO Region V standard group of radiometers which are maintained by the Bureau of Meteorology, Australia. The quality of the Regional Standard Group of instruments is maintained by comparisons with the World Standard Group at least every five years, and by local inter-comparisons to check the stability of the individual instruments.

7. Evaporation

The measurement of evaporation is of great importance in agricultural and hydro-meteorological studies, and in the design and operation of reservoirs and irrigation and field drainage systems. It is more difficult to measure than rainfall, and reliable absolute values of the loss of water by evaporation from the surface of the earth over areas of any appreciable size have not yet been obtained. The following factors affect the rate of evaporation from any body or surface:

- total radiation, solar and terrestrial
- temperature, both of the air and the evaporating surface
- wind speed at the surface
- humidity at the surface
- amount of moisture in the surface available for evaporation
- nature of the surface (e.g. roughness).

The standard unit of measurement is millimetres of water evaporated from a free water surface, in a standard evaporation pan which is exposed under standard conditions (see Chapter 2).

7.1. The raised pan evaporimeter

7.1.1. Description

The raised pan evaporimeter used by NIWA is identical with the United States Weather Bureau Class A pan evaporimeter. This type was recommended by the World Meteorological Organisation in 1957 for use as a standard.

The pan is a cylindrical tank of 1207 mm inside diameter and 254 mm inside depth, mounted on a wooden stand approximately 20 cm high. The pan is constructed from stainless steel. The pan is to be left unpainted.

The evaporation is expressed as the depth of water lost from the pan. This is measured by a fixed point gauge in which the quantity of water required to restore the water surface to a fixed level is measured.

The gauge is mounted in a stilling well so that the water surface is not disturbed during measurement. The water surface being measured varies about a level of 6.4 cm below the rim of the pan.

7.1.2. Exposure

The site chosen for the evaporimeter should be reasonably flat, turfed, and free from obstructions such as trees, shrubs and buildings. No obstruction should be closer to the evaporimeter than twice, or preferably four times, the height of the obstruction. Inside an instrument enclosure the evaporimeter should be installed to the north of the screen and other obstructions to avoid any extensive shadows being cast on the evaporimeter.

7.1.3. Installation

The pan should be supported on a stand made of 100mm x 50mm timber suitably treated. The top of the stand should be level and earth fill tamped around the stand to anchor it. The fill should be pressed firmly below the top members, thus leaving an air space between the bottom of the pan and the fill to retard corrosion and to facilitate inspection of the pan for leaks while it is in use.

An adequate fence should be provided to prevent animals drinking the water from the tank. However, the top of the tank must not be covered in any way, for instance with wire netting, etc., as this would seriously affect the wind flow across the surface.

7.1.4. Operation

At the time of observation (0900 NZDT) add or remove water from the pan till the tip of the fixed point coincides with the surface of the water in the stilling well. As the water approaches the tip of the point, pour slowly to prevent overfilling. Adequate time must be allowed for the water for flow from the pan into the stilling well.

To calculate the water removed:

Use the measuring can provided. When adding water to the pan fill the measuring can to the top. Add as many full cans as required. At the final filling, pour into the pan as much water as is required to bring the level up to the fixed point. Insert the dipstick into the residual water remaining in the measuring can; the dipstick is marked in millimetres 0 at the top and 2.0 at the bottom, so that it measures the number of millimetres poured from a full can into the pan. The measuring can is 12.07 cm internal diameter and 20 cm deep (inside) so that each can-full is equivalent to 2 mm of evaporation from the pan. Each 0.1mm evaporation is marked on the dipstick. Enter the depth of water added to the evaporimeter pan to the appropriate day against "Water added (b)" in Met.303 or Met.371.

EXAMPLE:

Full cans added	3 corresponding to a depth of 6 mm
Dipstick reading	1.2 corresponding to a depth of 1.2 mm
Depth of water to be entered against "Water added (b)".	7.2mm

When water has to be removed from the tank remove as many full cans as necessary. After removing the final can the point should be above the surface of the water. Sufficient water should then be poured back from the can into the pan to bring the level up to the fixed point. Pour carefully, to avoid overfilling.

To calculate the water removed:

(i) multiply number of full cans removed by 2 mm;

(ii) read dipstick measurement in final can;

(iii) subtract ii from (i).

EXAMPLE:

Full cans removed (including final one)	4
Dipstick reading after pouring from final full can back into evaporimeter pan	0.7
Therefore water removed	8.0 - 0.7 = 7.3 mm

The water removed is entered against (c) in Met.303 or Met.371.

Enter against (a) the rainfall in millimetres and tenths, measured in the adjacent 5 inch manual raingauge, for the 24-hour period under consideration.

Calculate the evaporation as a + b - c and enter against "Evap. (a + b - c)".

Note that a "Trace" of rain is entered but counts as nil.

EXAMPLES

	(1)	(2)	(3)	(4)
Rainfall (a)	…	T	1.4	2.5
Water added (b)	3.2	3.2	2.3	…
Water removed (c)	…	…	…	2.4
Evaporation (a+b) or (d-c)	3.2	3.2	3.7	0.1

7.1.5. Maintenance

Remove any leaves, dirt, etc., from the surface of the water. If necessary a wire gauze skimmer may be used for this purpose.

Clean the stilling well as often as necessary and remove any sediment.

Inspect the tank for leaks at least once a month. Also check that the pan remains level and that there is no buckling of the bottom.

Whenever necessary empty the can and clean out any sediment. Fill the tank with clean water up the level of the fixed point. Add one bottle of algae inhibitor to the fresh water and repeat the dose as often as required.

7.1.6. Control of algae

Algae inhibitor is to be used to restrict the growth of algae in the pan or tank (note that the material supplied will restrict growth <u>but will not remove existing growth).</u>

When received, the bottles of inhibitor are to be assembled in batches of six. The first bottle will be used when the tank or pan is refilled after cleaning. Thereafter the content of a bottle is to be emptied into the evaporimeter (and the event recorded in the Field Book) whenever an increase is noted in the growth of algae until the six bottles of a batch have been used. When a further increase in growth is noted the pan or tank is to be emptied and cleaned. **No more than six bottles of inhibitor may be used between cleanings of the tank or pan and no more than one bottle is to be emptied into the tank at the one time.** This requirement is dictated by the necessity for keeping the inhibitor in the water below a concentration which might effect evaporation.

The bottle must be shaken thoroughly before its contents are emptied. It is then to be refilled with water from the pan, shaken and again emptied. The bottle is not returnable.

The algae inhibitor is a fungicide with a trade name of Phygon-XL and is a chemical 2 3 dichloro-1, 4-napthtoquinone. Although it qualifies as a poison, it has a low order of toxicity to man. It can be an irritant to the skin in warm conditions and care should be taken when using it to avoid excessive contact with the solution.

8. Quality assurance

The quality assurance programme aims to provide users of the information collected with the confidence that this information is accurate and reliable. This is a crucial objective of NIWA's work.

Quality assurance begins prior to any measurements being made (with calibration of the measuring instruments) and continues throughout all measuring and recording procedures to the data reduction and checking. This chapter covers the procedures designed to check and record these.

- measurements are made to the required standards of accuracy
- work practices conform to the highest international standards
- personnel have the necessary skills and knowledge

The quality assurance tools used include:

- formal inspections of the stations operated by voluntary or paid observers, according to defined procedures, with written reports being sent to the Climate Databank for quality control action
- inspections, as above, for NIWA operated stations
- formal inspections of the field practice and knowledge of the NIWA staff, to ensure the standardisation of procedures, siting and instrumentation
- calibration of all measuring equipment
- testing and checking of instruments and equipment prior to installation.

8.1. Inspections of rainfall and climatological stations

8.1.1. Objectives

The main objectives during an inspection are to:

- ensure uniform exposure of instruments and methods of observing
- instruct and advise observers on observing procedure
- test, overhaul and adjust instruments
- make personal contact with observers and interest them in the work. Inspecting Officers should approach their work, not in the manner of one who is out to find fault, but rather to help and advise. As most of the observing is done voluntarily, good public relations are essential and, while observers need

to realise that accurate and reliable observations are necessary, it should be borne in mind that their services are to a large extent irreplaceable.

8.1.2. Pre-inspection procedures

After planning your inspection programme contact the Climate Databank to advise of the inspection trip. They will then advise you of any problems or things to look for while at the station. In particular check for missing returns, instrument faults and general observation procedures that may show up on the returns.

If applicable, advise the observer that you propose to visit them and give a time and date if possible. Assemble the station record sheets, blank inspection sheets and maps for each station. Assemble spare instruments and forms.

8.1.3. Inspection procedures – general

The annual procedures are outlined on the Form CI – Climate Inspection (Appendix E) for climate stations and the Form RI (Rainfall Inspection) (Appendix F) for rainfall stations, which shall be used to record all the details of the inspection.

Ascertain how the climatological programme at each station is functioning, to see if there is anything that can be done to improve the exposure of the instruments, the quality of the observations, or further good relations between NIWA and the persons doing the observations.

Work through the inspection form systematically, in much the same order as set out. The inspection form should be completed at the time of the visit. The form is self explanatory and all sections should be completed where appropriate.

The following sections give descriptions, followed by a summary of common instrument faults, incorrect management, incorrect observing procedures, etc., that should be checked during an inspection. Some of the material contained here is also included in other chapters and inspecting personnel should be fully conversant with all sections.

For further detail on the various instruments refer to the relevant chapter in this manual.

8.1.4. Raingauges - 5" Manual

Check the condition of the metalwork for corrosion and cuts in the outer can and funnel. Sometimes the outer cans are so badly dented that difficulty is experienced in removing and replacing the inner cans. Examine the condition of the solder on all visible seams,

Check for water in the outer can. If there is, determine whether water is due to condensation, overflow from inner can, or leaks in outer or inner cans. The most common place for leaks in the outer can is around the seam where the splayed base is joined to the cylindrical section, and in the case of the inner can, around the seam where the base is attached. Impress on observers the need to keep the inside of the outer can clean and dry at all times, for if this is done, immediately even a small leak starts it is readily detected.

Check for leaks in the funnel by stopping up the funnel outlet and filling the funnel with water. It may also be checked by inverting the funnel and filling the space between the outer cylindrical part and funnel itself.

Before testing inner or outer cans for leaks by filling with water, it is most helpful to clean them thoroughly so that the leaks show up more quickly.

Check condition of the rim. It should be sharp and perfectly circular. Any burrs can be filed off. The rim should be level and 30.5 cm above ground. Where new raingauges are installed, advise observers to keep checking the level of the rim with a spirit level till the soil consolidates. Some observers do not push the funnel as far down and over the outer can as they are made to go. Advise them to do so.

Measure the internal diameter of the rim using a registered set of calipers or calibrated tape. Two diameters should be taken, at right angles to one another. If either rim diameter error is ± 5 mm or greater from 127.0 mm (5.00 inches) or the mean error is ± 3 mm or greater, the raingauge should be replaced. However, if the general appearance is good, a slightly distorted rim can sometimes be adjusted by gentle pressure from inside the rim.

Note where raingauges have been set up by observers on posts, fences, buildings, etc., with the rims at much greater heights above ground level than the standard height set by NIWA. Whenever a raingauge is found exposed in this way, endeavour to locate another site which, of course, must be acceptable to the observer as well as fulfilling exposure requirements. At some rainfall stations it is not always possible to locate a better raingauge site. Where non-standard exposures cannot be improved on, as detailed a report as possible should be prepared on the exposure and noted on the station record sheets.

Check that the grass is being kept cut as short as possible around the raingauge. This is a common fault at many stations.

Check that the rainfall measure is free from cracks and chipping; also that it is clean and the scale easy to read. Old measures become very dirty inside but few observers take the trouble to clean them. The flat based measures used in the 4" plastic raingauges are particularly prone to becoming dirty, and thus require regular cleaning.

The 10 mm glass measures used in the manual raingauge network are to be calibrated against a registered pipette.

Two points are to be checked, 2mm and 10mm. (10 mm and 50 mm for the 50 mm glass measures)

Pour in 25.34 from the pipette into the glass measure. This should correspond to 2 mm. (126.7 m1 for 10mm)

Empty the glass measure and pour in 126.7m1 from the pipette. This should correspond to 10mm. (633.5ml or 50mm)

Check that both values are within ±3%; i.e., ±0.06 mm and ±0.3 mm respectively. (0.3 mm and 1.5 mm for the 50 mm measure)

Replace glass measure if outside of tolerances.

Ensure the registration number of the glass measure/s, and dipsticks where used, are noted on the Station record sheets.

Check the observer's procedure for reading the rainfall measure.

Ask to have a look at the Form 302 in use at the time of the inspection, and tactfully show where mistakes, if any, are being made or how the record can be improved.

In those places where very heavy falls of rain are likely, ensure observers know the correct procedure when (a) more than 10 mm of rainfall occurs and (b) when the inner can overflows.

In those parts of the country where hail or snow occurs ensure observers know how to obtain the correct measurement.

Impress upon observers the importance of recording on the Form 302 the times that observations are made. Obviously it is impossible for all observers to read the raingauge at the standard time every day. Likewise, it is often impossible to read the rainfall every day, and when this happens it is of the utmost importance that the observers know what to do when more than one day's rainfall accumulates in the raingauge. Where it is impossible to avoid the accumulation of rainfall over several days, point out how this should be avoided if possible at the end of the month, in order to obtain actual monthly totals. Failure by rainfall observers to record accurately the actual days when rain fell and the days when the raingauge was read, leads to more confusion in the interpretation of the rainfall records than any other single factor; even failure to set the daily values back a day.

Stress the importance of posting the monthly rainfall returns as soon as possible after the beginning of each month to the Climate Databank where they should arrive not later than the 10th of the month as a considerable amount of processing work has to be done.

Report on any changes in exposure due to growth or removal of trees, erection or removal of buildings, etc., since the last inspection. If the exposure does not meet the required standard, re-site if possible the raingauge in a position where the standard exposure requirements are met. Provide with the report a complete and accurate sketch map of the new site, plus photos if possible.

Summary: Inspection of rainfall stations

1. Check condition of metal for corrosion, holes, etc.
2. Check cleanliness of raingauge, then for leaks.
3. Condition of rim.
4. Test diameter of rim.
5. Height of rim above ground.
6. Height of grass around raingauge.
7. Condition and cleanliness of rainfall measure.
8. Procedure for reading rainfall measure.
9. Is the Met 302 filled in correctly?
10. Knowledge of what to do during heavy rains, hail and snow, and when several days of rainfall accumulates in the raingauge.
11. Early posting of monthly returns.
12. Check on changes of exposure.

8.1.5. Raingauges - Tilting Siphon

Check the condition of all metal parts for corrosion, also condition of rim, window, hinges, hasp, etc.

Check cleanliness of filler tube, filter and siphon mechanism. If dirty, wash the mechanism. Some observers make no attempt whatsoever to clean the enclosed section of the raingauge. Show how easily this is done. Most of the faults which develop in an automatic raingauge are usually due to lack of cleaning, not only of the mechanism but of the frame also.

Dismantling and cleaning of the siphoning mechanism is essential. Where observers are sufficiently interested and appear reliable the opportunity should be taken to show them how to dismantle, clean and re-assemble the mechanism correctly. Finally, show how both the pen on the float rod and trigger are correctly adjusted. The demonstration of the pen and trigger adjustment is an important one. This adjustment is really very simple but few observers are capable of doing it correctly, consequently the records from some stations are spoilt needlessly.

At those stations subject to frosts, it is essential that the observers know how to dismantle and re-assemble the siphoning mechanism and to make pen and trigger adjustments following the application of "Kilfrost" paste to float and float chamber.

Important notes

- The sub-base must be level
- There must not be any friction between the float rod and the chamber lid.
- The pen arm must be straight and able to swing freely in its gimbals.
- Check the condition of the nib.

Where it is necessary to investigate faults, check recent daily charts.

Check that observers are heading up their charts correctly. Common omissions are days of the week, and the times on and off not recorded to the nearest minute. Also, some observers write up an entire month's charts with the same time on, and then put the chart on at a different time to that written on the chart. This is to be discouraged.

If times as recorded on charts appear unreliable, note the speed of clock and adjust regulator if required.

Report on changes in exposure, also whether or not the drainage from raingauge is satisfactory.

Where electric lights are fitted for frost protection purposes, check that the electrical installation is in good order.

Ensure power is off before testing the raingauge with water

Check observers know what to do during severe frosts to protect the siphoning mechanism.

See the Tilting Siphon Raingauge section of Chapter 1 for further detail, particularly the maintenance section.

Details of the pre- and post-overhaul checks and the results are to be noted.

Summary: Inspection dines tilting siphon raingauge

1. Condition of metal for corrosion, damage, etc.
2. Cleanliness of all parts including interior of float chamber.
3. Instruction on dismantling, cleaning and re-assembly of siphoning mechanism, and adjustment of pen and trigger.
4. Overhaul.
5. Condition of float and rod.
6. Condition of pen arm, nib and pen lifting arm.

7. Examine recent daily charts for instrument faults.

8. Charts headed correctly.

9. Report on changes in exposure and whether drainage satisfactory.

10. Check condition of frost protection lights, where fitted.

11. Does observer know procedure for protection of siphoning mechanism during severe frosts?

8.1.6. Raingauges-tipping bucket

Check the following:

General condition of gauge for signs of corrosion.

The reading interval coincides with the Form SHR.

Logbooks regularly filled in and details entered correctly.

Orifice height, diameter, and level. Measure and confirm. Accuracy of recorder.

Type of check gauge (see 8.1.4 for checks to make on check gauges) Are housings weatherproof and is security adequate.

Wiring between sensor and recorder in good condition.

Power supply, test voltage during a reading. Is wiring tidy?

The batteries have the date of entry into service on them. There should be a record of charging, discharge testing , conditioning, etc., as appropriate for the type and duty of battery.

Provide comment on the apparent accuracy of the data being collected at present, and any other factor not so far covered which would have a bearing on the accuracy of data during the period since last inspection.

In particular, investigate the differences between the recorder rainfall and the check gauge rainfall. If the difference exceeds 10% of the check gauge catch for more than 50% of readings, or more than 20% for any reading, then re-check gauge calibrations.

Details of the pre- and post-overhaul checks and the results are to be noted.

8.1.7. Thermometer screen

Check the cleanliness. The screen must be kept perfectly clean and the paintwork as white as possible. At industrial locations and sea-side stations frequent washing of the screen, both inside and outside, must be done by the observers. Also many insects like to build their nests in screens and need to be removed.

Check the condition of the paintwork. Where the paint is in poor condition, action can be taken as follows:

(1) If the station maintenance is the responsibility of the Local Body or person operating the station, they can be requested to arrange for sanding and painting of the screen (both inside and outside) and the legs.

(2) If the station maintenance is the responsibility of NIWA and the observer is co-operative, they may be willing to do the work, in which case supply the paint which shall be "White, High Gloss Acrylic".

(3) Alternatively, if the observer is unwilling to do this work, do it as part of the inspection.

Check for signs of dry rot, especially just below ground level and on wooden roofs of small thermometer screens, and also for insect infestation in the woodwork.

Ensure that screens are securely screwed to the stand and that there is no possibility of screen movement on the stand during strong winds. This may cause thermometer faults as described in Chapter 3.

Ensure that the soil is firmly packed around the legs of the stand. During very dry weather, some soils "shrink" away from the legs enabling the screen and stand to move in strong winds. This may also cause thermometer faults.

Check that the screen is level. Often during periods of very wet weather when some soils are water-logged, strong winds will dislodge the screen and stand from the vertical, thereby altering the correct slope of the thermometers. If the tilt is such as to raise the bulb end of the thermometers then broken columns may occur in ordinary thermometers and "creeping" may occur in the maximum thermometers.

Check condition of screen door hinges, door chain plus door hasp and staple.

Ensure there is a good stand of grass growing underneath the screen and that this grass is kept cut short; also check that a hollow has not been formed in the ground in front of the screen where observers stand to make their thermometer readings. If the grass underneath the screen has died, replace with new turf. Likewise, a hollow in front of a screen must be filled with new turf and the ground made level with the surrounding surface.

Note changes in exposure since last inspection.

Summary: Inspection thermometer screens

1. Cleanliness - wash if required.
2. Paintwork - arrange to repaint if required.
3. Check for dry rot and insect infestation.
4. Screen secure in stand.
5. Stand firm in ground.
6. Screen is level.
7. Hinges, door chain, roof etc
8. Condition of turf underneath and in front of screen.
9. Note changes in exposure.

8.1.8. Thermometers (in screen)

All thermometers should be clean. If dirty, wash or wipe clean.

Ensure that maximum and minimum thermometers are correctly aligned, i.e., the clip at the bulb end shall be 6 mm lower than the clip at the opposite end or, expressed another way, there must be a 2° angle to the horizontal with the bulbs at the lower end.

NOTE: Where dry and wet bulb thermometers are mounted in a small thermometer screen, both these thermometers will have the same slope as the maximum and minimum thermometers. Only when dry and wet bulb thermometers are mounted in a large or marine thermometer screen are they mounted vertically.

Check that all clips holding the thermometers, especially the maximum and minimum thermometers, have a reasonably firm grip on the thermometer to prevent them "shaking" in strong winds. If not, bend the clips slightly to ensure this. This fault frequently causes broken columns in ordinary thermometers and "retreater" and "creeper" faults in maximum thermometers.

Check that the muslin and wicks are being changed regularly; also that they are fitted correctly. Common faults are: 2 muslin discs used; 1, 3 or 4 strands of cotton used (instead of 2); muslin not smoothly wrapped around bulb (i.e. large creases in muslin or not covering bulb completely); water bottle placed too near or too far from bulb of wet bulb thermometer; wicks allowed to hang in a large loop.

Check that the water used with the wet bulb thermometer is obtained from an acceptable source. Impress on observers the need to clean out the water bottle at regular intervals in order to avoid a "dirty" supply accumulating in the water bottle. (Many observers never clean the water bottle.)

Where a lime or salt deposit on the bulb under the muslin is noticeable, clean off, by scraping with a coin etc.

Check ordinary (both wet and dry bulb) thermometers for breaks in their mercury columns. With thermometers still mounted in the screen warm the bulbs with the fingers until the thermometers read 20 or 30°C, then withdraw the fingers and watch that the mercury columns retreat without breaking to the bulb end. A common point for the mercury to break is near where the capillary tube is joined to the bulb. Whenever ordinary thermometers with broken columns are found they should be replaced.

Test the maximum thermometer for "retreater" and "creeper" faults as described in Chapter 3.

Visually check minimum thermometers for bubbles in the stem, or drops of spirit in the upper portion of the capillary tube or expansion chamber.

All thermometers, including grass and earth thermometers, shall be calibrated against a 0.1 degree divided certified reference thermometer with checks at ambient and ice point.

If readings vary by more than 1% do another set of checks.

Ambient check

The simplest method here is to use a water bath.

All thermometers, including the reference thermometer, shall be placed in a fairly deep vessel of water. The inner can from the 5" manual raingauge is suitable. The thermometers should be immersed in the water at least to the top of the mercury or spirit columns.

The temperature of this water should be as near as possible to that of the air. This helps to keep it stable. The calibration should be conducted away from sources of direct heat or bright sunlight.

All thermometers should be allowed to stand in the bath for approximately ten minutes before taking comparative readings. The water should be stirred frequently during this time. Test each thermometer, one at a time, against the reference thermometer, hold them with their bulbs close together, move them backwards and forwards through the water a few times, then read them with their bulbs still well in the water. Particular care should be taken to avoid errors of parallax; if the thermometers can be arranged so that the ends of the columns of spirit or mercury are opposite to one another, without the bulbs being far apart, the chances of errors from this source will be reduced. Observe the difference between the readings several times before making an entry on the report form, in order to make sure that a sudden variation of the temperature of the water has not caused a temporary difference due to the inequality of lag in the two thermometers as may easily happen. Test all thermometers in turn in the same way.

When testing a maximum thermometer, care must be taken that the mercury column has been properly shaken down to the temperature of the bath. A simple and effective method of ensuring this is to immerse the bulb of the maximum thermometer in the bath for a minute or two, then remove the thermometer from the bath and holding it at arm's length swing it vigorously, at the same time shaking the mercury as far down the capillary tube as it will go. This swinging will ventilate the maximum thermometer similarly to a wet bulb thermometer, thereby reducing its temperature below that of the bath. Then place the maximum thermometer in the bath again, and notice that the mercury initially rises and when it becomes steady, then take the comparison readings.

If a spirit thermometer reads too low, examine it carefully for detached drops of spirit in the upper part of the tube and expansion chamber. If it reads high, check for a break low down in the spirit column. Often, such an examination reveals no visible condensation of spirit Jr, after shaking and allowing the thermometer spirit to drain down the tube, there will still be an appreciable negative error. If the error is still outside the prescribed limits, replace or arrange to have the faulty minimum thermometer replaced.

The mean difference between each of the thermometers and the inspector's reference thermometer must not exceed plus or minus 0.3°C. Replace it if it does.

Ice point

The ice point is the equilibrium between ice and air-saturated water. Whether the accuracy required is 100°C or 0.1°C the ice point is an invaluable aid in ensuring that a thermometer is functioning correctly. Its limitations should however be recognised. Although an ice point apparatus can be made to achieve an accuracy of better **than** 0.01°C, it has to be very carefully constructed to do so.

The ice point procedure given below is suitable for a secondary reference standard. A thermometer check at 0°C is a very convenient way to see if the thermometer is performing correctly and that the calibration certificate is still valid. If there is a discrepancy at 0°C some remedial action can be taken. For liquid-in-glass thermometers, this means adjusting the certificate correction terms.

An ice point apparatus can be easily assembled and consists of a container, a siphon tube, ice, and distilled water. See Figure 8.1. A Dewar flask, approximately 36cm deep and 8cm in diameter, can serve as a container for the ice. A vessel of this type is preferable, since the melting of the ice is retarded by the insulating properties of the Dewar flask. A siphon is placed in the flask to enable excess water to be removed as the ice melts. The clear or transparent portion of commercially purchased ice, or ice made from distilled water, can be used. The ice is shaved or crushed into small chips measuring 2-5mm. The flask is one-third filled with distilled water and the shaved ice is added. This mixture is compressed to form a tightly packed slush and any excess water is siphoned off. Before the bath is used, adequate time (15-30 min) should be given for the mixture to reach a constant temperature through out.

Ideally, there should be as much ice packed into the flask as possible, so that the small spaces between the chips contain mainly distilled water with a little air to ensure the water is air-saturated. It will be necessary periodically to add ice and to remove the excess water while the bath is being used to maintain this ideal consistency. If care is taken to prevent contamination of the ice and water, the ice point can be realised to better than 0.01°C.

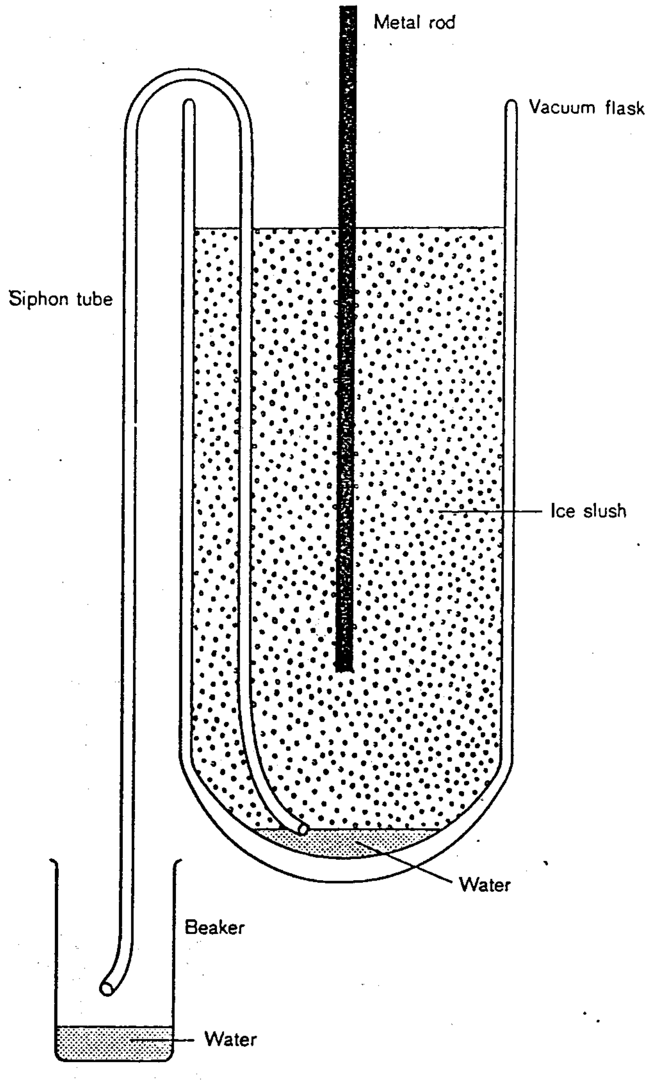


Figure 8.1: Ice point apparatus for calibrating thermometers

Some notes on the above procedure are given below.

(1) Distilled water

Good clean tap water is often sufficient. Contamination by salts or organic solvents should be avoided by good housekeeping procedures.

(2) Dewar flask

The length given is to cater for a wide range of thermometers, obviously shorter ones can be used for smaller thermometers. For metal temperature probes, an adequate immersion depth is essential. (A Dewar flask is a scientific name for the vacuum flasks commonly used for keeping tea, coffee, soup, etc., hot).

(3) Excess water

Some of the depth is required to take up the melted ice. If the depth is not sufficient, siphoning procedures will need to be frequent. The water level should not rise to the thermometer.

(4) Ice

See comments on distilled water. Many commercial ice-making machines purify the water by the freezing process and thus can serve as a satisfactory source of ice.

(5) Shaved or crushed

The ice can be crushed with a mallet or hammer after putting it inside a protective bag. A more satisfactory method is to use a mechanical ice shaver or grinder. Some ice-making machines may produce small enough ice particles.

(6) Tightly packed

It is essential to tightly pack the ice to achieve good thermal contact between it and the thermometer. Lack of this thermal contact can be the main source of error in using an ice point. A clean metal rod (preferably aluminium or stainless steel) can be used to form a hole in the tightly packed ice. After the thermometer is inserted the ice should be pressed tightly around it.

(7) Slush

When ice is frozen its temperature is usually lower than 0°C. For the ice point all the ice needs to be at 0°C; this is one of the reasons for shaving it into small pieces. Crushed ice lower than 0°C will appear white due to frosting on its surface. Formation of the slush is to ensure all the ice is at 0°C, i.e., just on the point of melting; hence it will appear clear.

- Check that observers know how to recognise faults in the ordinary thermometers-
- Breaks in mercury columns (wet and dry bulb).
- Faults in fitting muslin and wicks and the water supply of wet bulb thermometers.
- "Retreater" and "Creeper" faults in maximum thermometers
- In minimum thermometers, bubbles in the stem and detached drops of spirit in the upper portion of the capillary tube or the expansion chamber.

Check that observers know how to remedy these faults and when this is not possible, what action to take. Also check that they know what to record in the Field Books and Met 301, when these faults are detected. This latter point is most important, as it is surprising how many observers will, on detecting faults, correct them but record the faulty readings as though they were the correct ones and never record a remark that a fault had been found or that it had been corrected.

Check the procedures of observers when reading thermometers.

Common faults are:

- Not reading to nearest tenth of a degree.
- 1°, 5°, or 10° errors in reading.
- Taking too long to read thermometers or leaving the screen door open too long before taking the readings.
- Not reading dry bulb thermometer before the wet bulb.
- Standing too close to thermometers or breathing over them while making readings.
- Topping up water in water bottle before taking wet bulb reading.
- Errors of parallax.

Resetting faults are:

- Handling thermometers by their bulbs.
- On sunny days keeping thermometers in direct sunlight for longer than need be, thereby allowing solar warming of the thermometers to take place.
- Not swinging the maximum thermometer in the way recommended. Some observers develop ways of swinging the maximum thermometer which are not very effective or are dangerous, e.g., standing with their backs to the screen while swinging.
- Too **much** haste by some observers when resetting the minimum and in so doing not allowing the index to come to rest exactly at the end of the spirit column.
- Point out how, if the maximum and minimum thermometers are reset correctly, the reset readings of both thermometers should be reasonably close (approx 0.5°C) to that of the dry bulb thermometer, and that all observers should make this check on completion of every resetting of the maximum and minimum thermometers.
- In those parts of the country where the wet bulb is likely to become frozen, ensure that observers know the correct procedure in order to obtain a true

wet bulb reading. Some observers think they do, but in practice they do not know the correct procedure.

Ensure that the serial numbers of the thermometers are logged on the Station record sheets and that the Calibration certificates are placed on the station files as part of the record sheets.

Summary: Inspection of thermometers (in screen)

(1) Cleanliness of thermometers.

(2) Thermometers aligned correctly.

(3) Clips adjusted for firmness.

(4) Muslin and wicks fitted properly.

(5) Water supply satisfactory.

(6) Faults: ordinary - broken column
maximum – creeper and retreater
minimum - bubbles and detached drops of spirit.

(7) Check-calibrate thermometers against a traceably-calibrated reference thermometer.

(8) Check procedure of observers when reading and resetting thermometers, recognition of faults, and knowledge of how to correct faults, also what to do when wet bulb is frozen.

8.1.9. Earth thermometers

Ensure that the scales engraved on 5 cm, 10 cm and 20 cm earth thermometers are easily read. If not, blacken the scale.

Watch for dirt deposited inside the capillary tube, particularly in right angle earth thermometers, at about 5-15°C. Thermometers showing this should be replaced. This can occur in old thermometers.

Check outer glass shield of 30 cm and 100 cm thermometers for discolouration and clean if necessary, using soap and water or polishing lightly using a metal polish.

If condensation is observed inside the outer glass shield of the 30 cm and 100 cm thermometers, the thermometer should be replaced.

Check that there are no breaks in the mercury columns of the 5 cm, 10 cm and 20 cm thermometers. Often these breaks occur near the right angle bend.

Ensure there are no leaks in the iron tubes. If a thermometer is wet when withdrawn from a tube endeavour to determine from the appearance of the water on the thermometer whether or not this is due to condensation or a leak in the tube. If a leak is suspected, the tube should be replaced.

Inspect the caps of the tubes for cracks or leaks. Cracked caps should be replaced. Ensure the flange of the caps fit properly over the tube.

Check the length of chain to ensure the centre of the thermometer bulb is the correct distance from ground level. Old earth thermometer chains often break and when observers mend them they do not always make the chain the correct length. The thermometer should just rest on the rubber bung at the bottom of the tube.

Check that the soil in the earth thermometer plot is free from weeds. Often after a number of years, constant weeding causes hollows to form in the plot, thus allowing water to "pool" around the thermometers. Where this fault is found, surface soil must be obtained from nearby the earth thermometer plot, and used to build up the level of the plot and then tramped down, till it is flush with the ground surrounding the plot and of similar texture.

The 30 cm and 100 cm earth thermometers should be tested in the same way as the screen thermometers. Remember, when tests of Symons-pattern thermometers are made, there will be a greater lag in the response of these thermometers to a change in temperature than is the case with the screen thermometers.

A special inspector's earth test thermometer is required to test the index errors of 5 cm, 10 cm, and 20 cm earth thermometers; they are tested as follows:

The thermometers to be tested are not to be removed from the ground. The special inspectors test probe is inserted in the ground near to the thermometers being tested. (A steel pin is provided for the test thermometer). The test probe should be pushed carefully and vertically into the holes made in the ground by the steel pin. These holes should be about one inch away from the thermometers to be tested in order to avoid striking the earth thermometer bulbs.

Push the test thermometer into the ground to the required depth. Water at a temperature midway between the two - if water at that temperature can be obtained - should be poured gently so that it will run into the ground along the thermometer stems. When enough water has been poured to make the temperature conditions steady, the inspector's thermometer and the thermometer should be read after about 10 minutes. Take two or three such comparison readings. If the apparent index error of a thermometer exceeds ±0.3 °C, the thermometer should be removed from the ground and tested in water as directed in "Screen Thermometers".

In those parts of the country where snow is likely to occur, ensure that observers know how to go about reading the earth thermometers when snow covers the ground.

Check that the 30 cm and 100 cm earth thermometer tubes and 5 cm, 10 cm and 20 cm thermometer stems are vertical in the ground also that the tube flanges are flush with the surface of the ground. In frost prone areas the horizontal stems of the 5 cm, 10 cm and 20 cm thermometers should have a shallow trench 3 - 13 mm scraped from under them.

Ensure that the serial numbers of the thermometers are logged on the Station record sheets and that the Calibration certificates are placed on the station files as part of the record sheets.

Summary: Inspection of earth thermometers

(1) Scales easily read.

(2) Dirt deposit inside capillary tubes.

(3) Cleanliness 30 cm and 100 cm thermometers.

(4) Condensation inside outer glass shield 30 cm and 100 cm.

(5) Broken columns 5 cm, 10 cm and 20 cm.

(6) Leaks in 30 cm and 100 cm tubes.

(7) Leaks in tube caps.

(8) Chain lengths correct.

(9) Plot free from weeds, also free from hollows in soil.

(10) Test thermometers.

(11) Procedure when snow covers the ground.

(12) Check that 30 cm, 100 cm and the stems of 5 cm, 10 cm and 20 cm thermometers are vertical.

(13) Are all thermometer bulbs at correct depth?

8.1.10. Grass minimum thermometer

Check that the thermometer is mounted correctly. The most common fault is the bulb touching the grass.

Visually check the grass minimum thermometer for "bubbles in the stem" and "detached drops of spirit in the upper portion of the capillary tube or expansion chamber". To make sure this check is complete, it is essential to remove the shield.

Test this thermometer in the same way as the thermometers from the screen.

Check that observers know how to visually recognise the faults noted above; also that they know how to correct these faults and what should be recorded in the field book and Met 301.

In those parts of the country where snow is likely to occur, it is important to ensure that observers know how to go about adjusting the height of the grass minimum thermometer above the snow surface in order to obtain the correct minimum temperature.

Summary: Inspection of grass minimum thermometers

(1) Exposed correctly.

(2) Faults - bubbles or detached drops spirit.

(3) Test.

(4) Check procedure when reading, resetting, also recognition of faults (both in the thermometer and its exposure, e.g., touching grass), and how to remedy them.

(5) Observer's knowledge of procedure when snow covers the ground or the thermometer.

Ensure that the serial numbers of the thermometers are logged on the Station record sheets and that the Calibration certificates are placed on the station files as part of the record sheets.

8.1.11. Sunshine recorders

Inspect the metal parts of the recorder for corrosion, and that the glass sphere has not been scratched or chipped; chipping often occurs around the sphere supports. Check that the card grooves are clear of obstructions, and that the sphere is kept clean.

Check that the latitude setting is correct, that the recorder is level, the sphere is centred and all adjustment screws are tight. The best means of determining if the orientation is correct is to check that the traces burnt on the cards are parallel with the edges of the cards.

Check the condition of the mounting on which the recorder is set. Check the condition of the ladder and handrail (where these are fitted). These should all be in good condition, and in the case of the access ladder, this should be safe to use at all times. Correct any looseness in the support, corrosion of metal, dry rot in timber, or any need for cleaning and painting.

A point which should be noted by persons not familiar with locating the cause of faults in the setting of sunshine recorders, e.g. not level or oriented correctly, is that these faults are often not due to the recorder settings, but to unstable mountings. For example, if mounted on a pole, the pole moves under the weight of a person on the access ladder, or the pole moves in strong winds.

All stations with a sunshine recorder (and in fact all climatological stations) should have a horizon profile prepared. This should be checked at each inspection. Use horizon profile form Met 306. Indicate clearly where observations are taken from (normally they should be observed from the position of the recorder sphere, (or radiation sensor) or screen if there is no sunshine recorder. Indicate how far away from the recorder the various obstructions are. Name the obstructions. Where low cloud or any other phenomena obscure the true horizon at the time of observing profiles, the profile should not be completed.

Summary: Inspection of sunshine recorder

(1) Inspect the condition of metal parts and sphere, also cleanliness of instrument.

(2) Check the latitude setting, sphere is centred, the recorder level and oriented correctly, and the tightness of all adjusting screws.

(3) Check the condition of mounting, ladder, etc.

(4) Compile the horizon profile when required.

8.1.12. Cup anemometers (cup counters)

Visually check the condition of all external metal parts of the anemometer unit mounted on the mast for corrosion, also that cups are securely fixed to their arms and note their condition in the report.

Rotate the cups by hand to ensure that they are turning freely. Listen for any noises, indicating damaged or worn bearings.

Check condition of mast, guy-wires, ladder, and outrigger arm - where fitted. These should all be in good condition at all times. Looseness in any of these components should be corrected. Where corrosion of metal, dry rot in wood, or need for cleaning and painting are noted, these should be corrected.

If it is necessary to check a cup counter for friction, the anemometer should be placed on a horizontal surface indoors in a place free from draughts and the cups rotated by hand at a rate of 1 rev/sec in the same direction as the wind would turn them. The time taken for the cups to come to rest after being released at this rate should not be less than 60 seconds. Repeat this test several times and note results in report.

Check that there is no moisture entering the case of the cup counter anemometer. On some old pattern cup counter anemometers this often occurs and evidence of the presence of moisture is seen on the glass of the counter window. When this fault is observed, report it to Instrument Systems.

Report any changes in exposure due to growth or removal of trees, erection or removal of buildings, etc., since last inspection.

Note that all cup counter anemometers are to be exchanged at four-yearly intervals.

Summary: Inspection of cup anemometers

(1) Check the external condition of the unit on the mast.

(2) Check for friction. Test if required.

(3) Inspect the condition of mast, ladder, etc.

(4) Check for moisture in some old type cup counter anemometers.

(5) Lubricate if required.

(6) Check on changes of exposure.

8.1.13. Wind vanes

Visually check the condition of all external metal parts of the wind vane for corrosion. The mast, guy-wires, ladder, and outrigger arm - where fitted - should all be in good condition at all times. Looseness in any of these components should be corrected. Where corrosion of metal, dry rot in wood, or need for cleaning and painting are noted, these should be reported.

Check the orientation of the Cardinal arms. Ensure that these always indicate true directions on both ordinary and remote indicating wind vanes. This check is done by standing some distance from the mast and directly in line with the cardinal arms and taking a bearing using a reliable compass. Alternatively if it is on record that one or more of the cardinal arms point towards a prominent object that happens to be exactly true N, S, E or W of the wind vane, check the orientation by sighting along the arm to the object.

NOTE: Remote indicating wind vanes are normally set up with an orientation peg that will be exactly true N, S, E, or W. Remote direction indicators for Aviation and Marine use may be offset from True by the Magnetic Variation, e.g. 20^0 East.

Degrees Magnetic = Degrees True - Magnetic Variation e.g., 340°M = 360°T - 20° Variation.

Ascertain from observers if they check that the orientation of the cardinal arms has not altered; also that they check wind directions as indicated by remote indicating wind vanes against their own visual estimates of wind directions. Very few observers make these checks.

Report on changes in exposure due to growth or removal of trees, erection or removal of buildings, etc., since last inspection.

Summary: Inspection of wind vanes

(1) Check condition of wind vane, mast, ladder, etc.

(2) Check for friction. Where possible lubricate ordinary wind vanes.

(3) Check orientation of the cardinal arms.

(4) Record changes in exposure.

(5) Ascertain whether observers check that the orientation of cardinal arms has not altered, and that the remote indicating vanes indicate the wind directions correctly.

8.1.14. Evaporimeter

Check cleanliness of water in the tank. Empty tank, clean and refill if required.

Check that the holes in the stilling well are clean and unobstructed.

Check the procedure for measuring water-level in the tank and the method of computing evaporation. Ensure that observers have a thorough understanding how to go about adding water or removing water from the tank and when this is done that they make no mistakes in their evaporation computations. This is a very common fault.

Ensure that the serial number of the dipstick is recorded on the record sheets.

Summary: Inspection of tank evaporimeters

(1) Cleanliness both of tank and water.

(2) Condition of tank - in particular cracks in seams.

(3) Stilling well clear of obstructions.

(4) Check procedure for measuring water level, computing evaporation, also procedure for adding or removing water from tank.

8.1.15. Autographic Instruments

These are the barograph, thermograph and hygrograph.

Check that the instrument case is kept clean and free from ink stains. If need be, wipe with soft cloth. The metal cases of thermographs and hygrographs are best cleaned with a wet cloth.

Check condition of the linkage systems for friction. In particular the bearings should be clean. If dirty, clean with fine brush dipped in white petrol and when this has dried, oil sparingly with commercial spray lubricant.

Visually examine the appearance of the meteorological elements, aneroid cells, bimetallic coil and hair element. Report any signs of corrosion on metal parts and if there are any broken or loose hairs in the hair element.

Check that the pen arm is straight, and that the arm swings freely in the gate. Check that the pen lifting arm is lifting the arm correctly. Note that the trace recorded by the pen is as neat as possible. Check friction of nib on the chart, and if necessary adjust the inclination of the pen arm gate suspension to obtain mini-mum pen pressure on the chart and a good trace. Sometimes excess friction of the pen on the chart is caused through the instrument case not being level. Check for this fault, and if necessary re-level by placing cardboard shims under the instrument case "feet".

Examine recent charts to ensure that the observers are heading them correctly, and entering the required "on" and "off" data - too many observers omit this. If time marks are made, ensure that the correct times to the nearest minute are being recorded in the field books.

Ensure that the observers thoroughly understand the correct procedure for changing the charts, and making the necessary adjustments to the instrument pen setting. In some cases no adjustments are made to the pen setting when a new chart is put on.

Is the exposure correct? This mainly concerns barographs, as thermographs and hygrographs are nearly always exposed in a screen. The points to watch for with barographs are: that the barograph has not been shifted (usually unknown to Met Service) from the position where it was installed or alterations have been made to the room which no longer make the position suitable for the barograph e.g. now in direct sunlight or some other source of heat, or now subject to draughts or mechanical vibration. If need be re-site the barograph.

Check that the correct type of chart is being fitted to the instrument in use. This is not a common fault, however occasionally a new observer will often find a stock of obsolete charts and will commence using them. Where any obsolete charts are found during an inspection, these should be withdrawn or destroyed.

Inspect the outward appearance of the clock and drum for any signs of corrosion. Examine time marks on recent charts to determine if the speed regulator is correctly set, if not then adjust regulator accordingly. Make sure the clock (in some cases the fixed spindle) is tightly fixed to the instrument base, and that the drum turns satisfactorily on the spindle without any excess sideways movement.

Summary: Inspection of autographic instruments - barograph, thermograph and hygrograph

(1) Condition of instrument and case.

(2) Friction in linkage system.

(3) Condition of meteorological elements.

(4) Pen arm, pen lifting arm and nib.

(5) Charts headed correctly.

(6) Charts changing procedure.

(7) Exposure.

(8) Correct charts in use - check for obsolete charts.

(9) Condition of clock and drum, and is speed correct?

8.1.16. Electric anemograph

Ensure that the instrument case is kept clean and free from ink stains. It is best cleaned with a wet cloth or tissues. It is most important that no ink is spilt onto the magslips beneath the ink reservoirs. The ink wells should be placed so that they are clear of all pen arm movements. Periodically the wells should be removed and cleaned thoroughly in warm water or methylated spirits. Similarly if blockages exist in either of the pen arms, these can be cleared by flushing warm water or methylated spirits through, using the syringe included with the anemograph accessory pack. When replacing the pen arms care should be taken to reinstall them in the correct position - i.e., the speed arm should be replaced on the speed chart.

To check setting of direction recorder and indicators, carry out the 030° Electrical Lock check:

(1) Remove 50 volt fuses.

(2) Lift Klippon Jumpers X, Y, 1, 2 and 3.

(3) Push in the two Electrical Lock Klippon Jumpers (Usually painted red).

(4) Position Recorder Pen arm to approximately 030°.

(5) Replace fuses and check that pen arm is located exactly on the 030° line of the direction chart, and direction needle reads exactly on the 030° marking of the dial. If discrepancies exist, see next section for remedial action.

(6) Note all recorder adjustments on charts: Degrees adjusted, suspected fault period, etc.

(7) To return to Vane reading, remove fuses and Lift Electrical Lock Klippon Jumpers.

(8) Push in Klippon Jumpers X, Y, 1, 2 and 3.

(9) Position Recorder pen arm to approximate wind direction.

(10) Replace 50 volt fuses.

If no Klippon Jumpers exist in the connection box, follow this procedure: Remove 50 volt fuses.

(1) Disconnect wires labelled Y, X, 1, 2 and 3.

(2) Connect wire X to wire 1, and wire Y to wire 2.

(4) Carry out 4, 5 and 6 as above.

(5) To return to Vane reading, reconnect wires Y, X, 1 2 and 3, then replace the 50 volt fuses.

Adjustment of direction recorder and dial reading

If a discrepancy exists once the 030° Electrical Lock Test has been performed, adjustment of the direction pen arm on the chart is made by turning the screw below the transparent cover beside the direction ink well.

To adjust the reading of the needle on the direction dial it will be necessary to remove the dial cover, and physically readjust the needle to read 030°. Special care should be taken when removing the needle, as damage can be done if excess pressure is exerted.

Remember to advise the Control Tower if these checks are being carried out at an Aerodrome.

NOTE: Wire colours and position are as follows:

Red Y

Black X

Space

White 1

Blue 2

Green 3

i

To check the setting of the speed recorder and indicator follow these procedures.

(1) Disconnect the Red Y wire to stop power generation.

(2) Turn the chart drive off. (This is only necessary if a long delay is expected whilst tests are being carried out - otherwise the chart can be left running)

(3) Check to see that the speed pen arm sits exactly on the zero line of the chart roll. If a discrepancy exists, adjustment is made by turning the "zero set" screw, located on the lower right hand side of the recorder.

(4) Re-connect the Red Y wire.

(5) The reading of the speed needle on the indicator dial can be checked by disconnecting either of the wires leading into the indicator from below. The, needle should read exactly on the zero marking of the dial. If a discrepancy exists adjust the needle as per adjustment of the direction needle, again taking care not to damage it when removing.

Summary: Inspection Electric Anemograph

(1) Condition of Instrument and case.

(2) Recorder/Dial reading checks.

(3) Inking arms clear and set correctly.

(4) Chart Rolls headed correctly.

(5) Chart Roll changing procedures.

(6) Time marking procedures.

(7) Clock timing.

Lambrecht anemograph

The procedure for inspection of a Lambrecht anemograph in the field is as follows:

(1) Check condition of Instrument and case, as well as mounting pole.

(2) Check orientation of instrument.

(3) Ensure cups turn freely, and check that no excessive movement in the bearings exists.

(4) The recording rollers should be in the lowered position, and the clock timing should be correct - Remember that the pointer indicates clock time, minus 4 hours.

(5) Check time-making, chart changing and heading procedures.

8.1.17. Licor solar radiation sensor

Check whether the instrument is clean and installed as described in section 6.8, and the following:

(1) Check that there is no LOW BATTERY indication on the display on the monitor display.

(2) Check the sensor for obstructions, blow off any water from the white diffuser disc and the surrounding channel. This check shall preferably be made daily at

sunrise or as soon as possible thereafter. Ensure observers are aware of this instruction.

(3) Clean the sensor with a soft cloth but do not remove any grease from the screws on the base plate. Take care not to get grease on the white diffuser.

(4) Check the sensor level and adjust if necessary by slackening the securing screws and adjusting the level screws so that the bubble in the level on the base plate is within the centre circle of the level.

(5) Check that the drain hole in the field mount water pipe post is clear.

(6) Spray a moderate quantity of residual type insect killer/repellent into the two ventilation holes from within the cabinet.

(7) Regular calibrations of the sensor will be carried out by NIWA - Instrument Systems on an exchange basis. Stations will be advised when instrument exchanges are to occur.

(8) Record the serial numbers of the cal-connector, sensor and monitor.

8.1.18. Visual observations

Wind direction and force

Ensure that observers understand the correct use of the Beaufort Wind Scale. Also that they know the true bearings of selected reference points at their station in order to determine true wind directions. It frequently happens that when observers are changed, information on reference points is not passed on to the new observer or the new observer gets the information confused.

There should be a note on these reference points, usually on the visibility or height table. Make sure that the estimating of the peaks of the gusts is not confused with the average speed of the wind for reporting purposes also that gusts and squalls are not confused and on rare occasions that wind directions reported are not 180^0 in error, e.g. reporting the direction towards which the wind is blowing.

Visibility

Check that there is a table available to all observers giving the true bearings and distances from the station of selected visibility reference points. If the visibility table is in poor condition, compile a new one. At some stations there are two groups of people doing reporting and it often happens that only one group will have a visibility and height table. In these cases ensure both groups have all they require for doing weather observations. Ensure that all the reference points are still visible - often after such a table has been prepared, some reference points are removed, or are obscured from sight by erection of buildings, growth of trees etc. Check that the observer's method of estimating visibility is correct. A common fault is reporting the average visibility around a station. Ensure that when transient phenomena (passing showers) are present in the neighbourhood, visibility is correctly reported.

Cloud amount

Ensure that they are not overestimating cloud amounts - this is a common tendency particularly with clouds near the horizon, whereas when clouds are overhead the tendency is to underestimate the amount.

Weather phenomena and remarks

Many observers never make any remarks and these people should be encouraged to do so, while on the other hand some observers write too much. Often most of the remarks from such observers are worthless, and in these cases an inspector should tactfully show the type of remark which is worthwhile and that which is not.

Discuss with observers the recognition of ground fog, fog, mist, haze etc. Show observers where in the instructional material on issue to their station, all this information is set out. It is often surprising how few observers know where to find information of this nature. Impress on observers the need to occasionally read or browse through the instructional material on issue, in order to keep them well informed on all aspects of observing practices, also the care and maintenance of meteorological instruments.

Climatological forms

Ensure that the station has an adequate supply of forms, and that those on issue are of the correct type.

Remove any old or excessive supplies of forms.

All climatological and rainfall stations in New Zealand are sent an annual supply of forms, charts etc., and consumables, e.g., muslins and wicks, sun cards, etc., in July and December respectively.

DLYCLI (Daily Climatological Observation)

Before visiting a DLYCLI station contact the Databank to ascertain any repeated errors the observers are making at this type of station. During the visit explain fully how to correctly code a DLYCLI message.

Instruments: Care, management and maintenance

Comment on the overall attitude of the observers towards this aspect of their duties.

Sketch and photographs of site

Ensure the sketch of the enclosure is still current - all heights of trees, building etc., noted. Any additions should be noted. If major changes have been made, re-draw the sketch.

Photographs should be updated approximately every four years. At a climate site they are taken looking North, South, East and West, with the enclosure in the foreground. More than one photo in each direction may be needed - see example.

General impressions of the station and ability of the observer

From your observations of the site, condition of instruments and discussions with the observer or observers, what standard do you consider the observations to be? Is the observer interested or disinterested in his/her work, conscientious or otherwise?

Recommendation

Recommendations and reasons for them should be clearly stated; make them the subject of a separate memo if necessary.

8.2. Compiling station record sheets

A vital part of the quality assurance system is the record of each station's history on the Climate Station Record sheets (Form CSR) or Rainfall Station History (FormSHR).

It is important that all station record sheets be accurately compiled as they form a ready source of information and are the only condensed record available giving information for the site, observing programme and instruments in use.

The record sheets are to remain on top of the station files and are to be kept up to date at all times.

These instructions are intended as a guide to compiling station record sheets and apply to Climate and Rainfall Stations.

The following points should be noted:

Station name

This is the official NIWA name and is allocated by the Project Manager – Climate Data Acquisition.

Map reference (metric)

These are obtained from the NZMS 260 series maps.

Rainfall and climatological station network numbers

These are allocated by the Project Manager – Climate Data Acquisition only. Do not enter the number unless it has been confirmed by the Project Manager – Climate Data Acquisition.

Latitude, longitude

Obtained from a large scale map of the district, usually the NZMS 260 series. Give coordinates to nearest 0.1 minutes of arc, and note which map was used. Extra care should be taken to ensure this is obtained correctly. These are to be in NZGD49.

If a GPS is available this should also be used also using the NZGD49 datum. Coordinates are to be degrees decimal and a note to be that coordinates have been made by GPS.

Height above MSL

Obtain the height at the 5" manual raingauge off a large scale map, if there is no accurate survey height for the station. Elevations from GPS units do not yet seem to be as accurate as they should be and are not to be used for determining elevation.

Date station established

Record the date on which readings commenced.

Observers

Where only one or two persons are involved, then the names of these persons should be recorded, as is also the case for a station operated by a private individual, otherwise the organisation name will suffice.

Enclosure provided (or maintained) by

The full official title of the authority or person must be entered here, e.g., Town Clerk, etc.

Address for general correspondence and supplies

Note the postal address of the observer or observers responsible.

Remarks

For example: "Rainfall readings commenced ………" ; "station changed from rainfall to climate on…….. " ; etc.

Instructions for locating the station by road

Enter clear and concise directions on how to reach the station from some clearly defined landmark, e.g., Post office, major intersection, bridge etc.

Returns furnished

List all summaries, field books, charts, etc., returned monthly to the Climate Databank.

Annual supplies

Complete list of all forms, envelopes, etc., supplied yearly.

Non-instrumental equipment

All publications, instruction, wall charts, scales, etc., on issue to the station should be shown in this section. NOTE: Be constantly alert for out-of-date publications or instructions, and where any are found, withdraw or destroy.

Instrument ownership

It is important to note whose property the instrument is, if it is not NIWA's (to determine who is responsible for supplying and paying for charts, consumables and the repair of the instrument). Enter the name of the organisation who owns the instrument in the remarks section of individual instruments.

Raingauges (manual)

Most of the manual gauges in use are standard 5" copper or stainless steel gauges. Any non-standard or unusual gauges encountered should be adequately described.

Note the reference number of the glass measure.

Raingauges (automatic)

Most will either be Dines tilting siphon or Ota tipping bucket. Ensure the serial number of the gauge is recorded, not the reference number. Record the value of the tip of the Ota, i.e. 0.2 or 0.5 mm.

Instrument screens

The following types of instrument screens are in use:

Large Stevenson screen

Small Stevenson screen

Marine thermometer screen

Forestry screen

The forestry screen is peculiar to the old Forest Service and is still in use at some of their stations.

Full details should also be given on the type of stand or support in use.

Thermometers

The types and descriptions of the various thermometers in use are as follows:

Sheathed - ordinary, maximum and minimum.

These thermometers are made to British Standard Specification 692 and this reference BSS 692 is usually etched on the back of the thermometer stem.

Sheathed minimum with shield

This is a sheathed minimum thermometer with a black shield about 60mm long over the expansion chamber and is used as a grass minimum.

Earth, Symons pattern

This has a bulb encased in wax in glass sheath - used for 30cm and 100cm thermometers

Earth, Right Angle, Solid Stem, 5 cm, 10 cm, and 20 cm thermometers. Other types - These must be described in full.

It should also be stated whether screen thermometers are vertically or horizontally mounted.

Ensure the serial numbers of thermometers are recorded and that the calibration certificates are on the station file.

Barometers

It is important to state type, maker and number, e.g., Kew, Darton, No 4740/54.

The gravity value at most New Zealand stations has been computed and is available at MetService. Information as to whether the barometer has been calibrated under new or old conventions is also available. Heights for barometer cisterns are obtained by survey.

Show correction card numbers and description, e.g., No IA, MSL pressure or No 1 Cistern Level pressure and No 2 MSL pressure.

Autographic Instruments (barograph, thermograph, hygrograph)

Give full particulars including chart numbers and types of clocks in use. For identification of clocks and drums, also refer appropriate sections in the same Manual for full details relating to the correct name of each type of autographic instrument. Give all instrument serial numbers (some have more than one serial number), maker's name, and "Mark" numbers, whenever these are shown.

Sunshine recorders

Sunshine recorders are divided into low, middle and high latitude, and universal models. All later models are fitted with adjustable sub-bases but some of the older ones have non-adjustable, cast iron or slate bases. Particulars of the bases should always be given, ie., "levelling" or "fixed".

Solar radiation recorder

Sometimes called Global or Total Radiation.

Horizon profiles

Form Met 306 is used for compiling sunshine and solar radiation recorder horizon profiles and all bearings on this form are True. The various portions of the horizon should be labelled, e.g., distant hills, trees, buildings 200 m etc. The observation point is the radiation recorder site (e.g., atop sunshine recorder mast) or screen if no radiation recording equipment installed. (Not required for synoptic or rainfall stations.)

Evaporimeters

Describe the type of evaporimeter in use, and means of measurement. The standard pan now is the stainless steel raised pan.

Record the reference number of the dipstick in use.

Anemometers and wind vanes

Show particulars as required. Indicate whether any are set to read true or magnetic bearings. Ensure the instrument number is recorded but note that this is not the reference number of the instrument.

General exposure of station/exposure of climatological enclosure

This must be as detailed as possible, the general aim being to paint a word picture that will enable users of the data to assess the representativeness of the observations. For climatological stations more detail should be given of the immediate surroundings of the site, all obstructions such as trees, hedges, buildings, etc., that could possibly affect the observations being fully described. NOTE although the minimum clearance of any obstructions from a climatological station is usually given as twice the height, the optimum clearance is at least five times the height of the obstruction.

Enclose copies of the NZMS 260 map showing the location of the station to give a good indication of surrounding terrain.

Local effect

Note any topographical features or nearby buildings etc., that may influence conditions at the site.

Plan of enclosure and layout of instruments.

This should be drawn to scale and the scale used indicated (not required for rainfall, only stations).

Sketch and photograph

Where possible obtain large scale maps or plans of the area surrounding the station. Alternatively, make a freehand sketch of the layout around the station. For clarity these sketches may be coloured-in. Make amendments if required to any maps, plans or sketches held by NIWA. Take photographs, showing the exposure of the instruments in relation to their surroundings. In the case of climate stations the instrument enclosure is to be photographed in the four cardinal directions, etc. Take the photos some 20-30 metres, or as far as local conditions will permit, from the instrument enclosure, and looking across the enclosure in each cardinal direction. Note the directions and the date when the photographs were taken. Good photographs can often convey a far better description of the site than can words.

It is very important to show the date when photos are taken and plans/sketches drawn.

Tables of visibility marks and heights of hills

Use maps to compile adequate tables for these references. Objects should be clearly described and true bearings shown to assist in identification. Describe where bearings and distances were observed from, also how they were obtained.

Circulation of record sheets

Any new record sheets are to be sent to the Project Manager – Climate Data Acquisition along with the Inspection or Station Record Amendment forms where applicable. See next two sections for procedures.

8.3. Procedures for circulation of inspection reports

Upon completion of the Inspection Report the forms are to be sent to the Project Manager – Climate Data Acquisition within 30 days of the station being inspected.

The Project Manager – Climate Data Acquisition will then record the month and year of inspection on the spreadsheet maintained by Project Manager – Climate Data Acquisition.

The Project Manager – Climate Data Acquisition will then check the Inspection Report for any instrument, procedural problems or other issues. The site changes screen of Land Station Maintenance on CLIDB is to be updated following a site visit or inspection.

If necessary a JIRA issue will be created if more follow up work is required.

The forms are then returned to the relevant NIWA Team.

The Climate Databank will then take any action necessary. These procedures are detailed in the Climate Databank Operations manual.

8.4. Amending climate station information

The Climate Databank contains station information tables which enable users to be provided with relevant information on details of the stations and changes to them. Changes in all aspects related to instrumentation, observer, exposure, etc. need to be updated to the Databank. The main means of initiating and documenting these data is by means of the Station Record Amendment form (Form SRA).

The form is to be used for all new and closed sites as well as any amendments to current station details.

8.4.1. Procedures

The forms are to be filled out whenever there has been a change, no matter how minor, to the details of a site. The forms are largely self-explanatory with a range of possible changes.

The changes may be detected during a site inspection or a visit, or may be passed on to the team by the observer, the Project Manager – Climate Data Acquisition or the Climate Databank.

The form is to be filled out <u>in red with only the changes entered.</u>

Following compilation by the team, the form shall be sent to the Project Manager – Climate Data Acquisition for entry onto the Climate Databank via the Land Station Maintenance screen. Once Project Manager – Climate Data Acquisition and Databank have finished with the forms they will be sent back to the teams where they are to be retained on the station file.

8.5. Instrument testing on receipt

8.5.1. General

On receipt of instruments, the team shall, if at all practicable, run the instruments to check their calibration and suitability for deployment in the field. The objective is to ensure as far as is practical that all instruments are able to perform reliably and to specification at the time of deployment and beyond.

Instruments received from NIWA - Instrument Systems will have had more exhaustive testing prior to despatch, but vibration and possible impacts during shipping require that further testing be done on receipt.

Likewise, the normal practice of carrying spares in vehicles for extensive periods also requires that bench-testing be done to verify that spare instruments are indeed operational.

Consequently, each team shall bench-test all instruments upon receipt, and all instruments regularly carried in vehicles should be tested each fortnight.

8.5.2. Clocks

Where possible, clocks for climate instruments should be set up in their instrument with charts and run to check the timekeeping. A bare clock may be tested with a simple device made from a piece of wood with a "spike" (paper clip) locked in place to check the rotary movement over time.

8.5.3. Corrective action

Any instrumentation found not to perform reliably and/or to standard shall be returned to its supplier (e.g. Instrument Systems) along with the evidence of malfunction (i.e. the faulty data) with a request for repair, replacement or re-calibration as applicable.

8.6. Assessment of field practice

The technical knowledge and work practices of team members are tested annually using Form FPA and the procedure detailed in the Hydrologists' Field Manual. This includes a section on rainfall and raingauges.

The technical knowledge and work practices of staff carrying out inspections of climatological ………..

8.7. Data quality control

In the Climate Databank, technical staff monitor the quality of the reports and data received from rainfall and climate stations. When a station apparently has malfunctioning instruments or faulty procedures, or is filling in forms or field books incorrectly, sending in returns late, etc., the apparent fault is written into the "Late Returns and Observing Errors" log.

A Form QF.07 will also be filled out by the Databank and dispatched to teams for corrective action. In urgent cases the team will be contacted by telephone, but the form will still be sent.

Teams shall, within two weeks of receipt, investigate the apparent non-conformance, take any corrective action required, and reply to the Databank by means of the same Form QF.07.

8.8. Corrective action

Any areas which are noted as not conforming to standards or standard practices shall be corrected as follows:

- Where the non-conformance is noted by the team and relates to standard practices or equipment, the team shall be responsible to rectify it immediately or to add it to their list of tasks for next visit and/or next quarter's objectives.

- Where the non-conformances are likely to have affected data quality, the team informs the CSU via the inspection forms if applicable, or in writing.

- If not able to be rectified immediately, so that the task is noted on the inspection form as being required, the completion shall be notified to the CSU.

- Any non-conformances detected by the CSU shall be registered as a non-conformance using Form NCF, and followed up for satisfactory completion.

- Where the non-conformances are likely to have affected data quality, the CSU provides the Databanks with details on Form QF.07.

- Where alterations appear to be required to standard procedures, work instructions, forms, manuals or any part of the documentation included in the quality system, the QA/SD Unit shall be informed in writing. That unit then has the responsibility to take the appropriate corrective action.

- All non-conformances are to be separately recorded, for statistical and system improvement purposes, on the quarterly non-conformance report Form NCC.

9. Supplies

9.1. Introduction

Supplies of replacement instruments, various consumable items and forms are required by the network stations in order for them to carry out the required observing programme.

The supply system described in this chapter aims to:

- provide a timely and economical supply of materials to stations
- be as simple as possible to operate and understand.

9.1.1. Definitions

Supplies is an overall term to describe all replacement instruments, stationery, forms and other consumable items.

Instruments refer to all measuring instruments including thermometers, recorders, sensors, etc.

Forms are the numbered forms which are required for recording, managing or processing data by observers or NIWA personnel. They may also be charts, and may be on paper, card or in books or pads. The NIWA forms for climatological and rainfall stations are listed in Appendix A.

Consumables refer to items which are used up over time by the operation of the programme (e.g. charts, muslin and wicks, algae inhibitor, etc., but excluding forms). Consumables are listed in Appendix B.

9.1.2. Methods

Forms and consumables shall be sent to climate and rainfall station observers annually, to ensure that all stations are supplied. Standard quantities will be sent by post.

Climate and rainfall stations shall be treated separately:

- Supplies to climate stations will be sent centrally from the CSU for all of New Zealand, each July/August
- Supplies to rainfall stations shall be sent by the Publication and Communication group, each December.

Replacement instruments and other items required between the annual resupplies shall be provided by the teams. They will source them in the first instance from their own stocks (to reduce missing record and demonstrate timeliness to the observer) and replenish these from Instrument Systems as required.

9.2. Annual resupply – rainfall stations

9.2.1. Requirements

Daily rainfall station supplies are the same for every station, each year. The supplies are sent with a NIWA calendar along with a letter to thank the observers for their contribution during the past year.

9.2.2. Items

The items required are:

12	Met 201	Envelopes (pre-addressed and pre-paid)
12	Met 302	Rainfall observation forms (pre-stamped with station number)
1	Met 330	Annual Rainfall form (for observer to retain)

9.2.3. Procedure

(1) Teams request the required number of Met 201 envelopes and Met 330 forms from CSU by 30 September.

(2) CSU arranges printing, and for printer to deliver envelopes directly to the teams by 15 November.

(3) Teams copy Met 302's from their master copy, and collate and send forms and envelopes to observers.

9.3. Annual resupply – climate stations

9.3.1. Requirements

Climate stations require supplies of various consumables and forms according to the range of instruments they are equipped.

All annual supplies are to be sent from Client Services Unit in July of each year to coincide with the MetService supply.

9.3.2. Procedure

(1) By 31 May, team managers provide the CSU with a list of all forms and consumables required by each station.

(2) CSU requests a bulk supply of consumables from Instrument Systems by 15 June, and the breakdown of charging to each team.

(3) CSU arranges printing of forms as required

(4) Instrument Systems dispatches the ordered consumables to CSU by 1 July

(5) CSU collates all forms and consumables into station lots and dispatches to observers by 31 July

Areas of responsibility are:

Team Managers

- Ensure lists of requirements are up to date. This is done from the station inspections and the station record sheets. This task is on-going.
- Notify Client Services Unit of all supplies required and addresses supplies are to be sent to by 31 May.

Client Services Unit

- Ensures sufficient and current supplies are on hand. This is on-going.
- Advises Instrument Systems of bulk requirements and breakdown for charging to the teams by 15 June. (Form costs will be covered by CSU as the only charge is in the printing.)
- Arranges for contract worker and ensures supplies are sent to observers by end of July.

Instrument Systems

- Ensures sufficient supplies are on hand. This is on-going and in consultation with Client Services Unit.
- Despatches bulk items to Client Services Unit by 1 July.

9.4. Periodic supply and replacement

There is a requirement for the teams to hold a small supply of replacement and spare materials to enable them to readily respond to any requests or non-conformance to minimise any possible missing record.

All requests for replacement or spares are to he actioned by the teams. The main
1 reason is to ensure a minimum amount of missing record but also to ensure as much
single point contact between the teams and observers as possible.

Requests may come directly from the observer, or may be passed on by the Databank as per the Climate Databank Operations Manual.

All teams are to hold a stock of spare instruments and consumables. These are available from Instrument Systems and are listed in Appendix B. Recommended quantities are given in Appendix C. A six-monthly stocktake and replenishment shall be undertaken by each team.

9.4.1. Instruments

Teams are responsible for rectifying all non-conformances at stations.

When sending thermometers by post, ensure they are extremely well packed so that breakage is virtually impossible. Nevertheless, they must also be well-sealed in a polythene bag so that if a breakage occurs the mercury cannot escape. Include the instruction sheets for that particular thermometer. -

9.4.2. Forms

Teams are responsible for actioning any requests for forms. Spare forms shall be held as per the list in Appendices A and C, and a six-monthly stock-take and replenishment shall be undertaken.

Occasionally requests for forms supplied by MetService are received. These are listed in Appendix D. The Auckland, CSU and Christchurch teams may have supplies, otherwise contact the Client Services Unit.

9.4.3. Areas of responsibility

Databank

- Pass on any requests for supplies to the teams.
- Notify teams of any suspect instruments that may need replacing as detailed in the Climate Databank Operations Manual.

Team Managers

- Ensure sufficient stocks are on hand.
- Action any requests made by Databank, Observer or Client Services Unit. - replace any defective equipment at sites noticed during inspection.

- Install replacement instrument or equipment if on-site, or post out replacement.

Client Services Unit

- Ensure sufficient and current forms are available.

Instrument Systems

- ensure sufficient materials are available.

10. Guide to making climatological observations

10.1. Introduction

To obtain reliable information about the climate of New Zealand, that is the average (and extreme) values of temperature, rainfall, sunshine, number of gales, frosts, etc. that can be expected in any district, it is necessary to set up observing stations at selected points throughout the country. At these stations instruments are carefully installed in fenced enclosures selected so that the instruments will record as closely as possible conditions fairly representative of the area or town in which they are sited. As the weather fluctuates considerably from year to year it is important that observations should continue from the same site and under same conditions for a long period of years.

For a variety of reasons the number of manual climate stations in New Zealand has steadily declined in recent years. The observations are made by local bodies such as City Councils, other Government Organisations such as MetService, and interested private individuals. The work done by these people is of great value to NIWA and without their co-operation it would be much more difficult to compile the valuable climatological data required for research, commerce, industry, agricultural research, etc.

10.1.1. Time of observation

The standard time for making these observations in New Zealand is 9 am. It is most important that the readings be taken as close as possible to this time each morning. The term "time of observation" when applied to a climatological observation is defined as being the time of observing the last element necessary to complete the whole observation.

If the climatological observation is made at any time other than 9 am , then this time (the time the report was completed) must be recorded on both the Field Book and Climatological Form (Met. 301).

Normally 10 minutes should suffice for the completion of an observation at a full climatological station.

10.1.2. Observing routine

Observers should get into the habit of making the observations in a fixed sequence every day. To guide them in this work a list is given below of the various steps in making a full set of climatological observations. Not all stations are equipped with such instruments as evaporimeters, sunshine recorders, thermographs, recording raingauges, etc. as these instruments are restricted to a few key locations, but the general procedure is the same at all stations.

Preparation for climatological observation

Items required for routine daily climatological observation:

- Climatological Field Book (Met. 303 or Met. 371), Synoptic Field Book (Met. 801).
- Where applicable, sun card, daily autographic charts for automatic raingauge.
- On Mondays autographic charts for weekly thermographs, hygrographs and barographs.
- Muslin and wicks required at least once a week.

Observing procedure

Climatological observers should commence their observation by recording those elements which do not change rapidly. These are:

- Amount of Cloud
- Visibility
- Present and past weather
- Wind direction and force (at stations without an anemometer). Where an anemograph is installed the wind direction and speed should be read from this instrument but visual estimation made to check for any obvious inaccuracies in the instrument.
- Remarks

These are recorded in the appropriate spaces in the Field Book (Met. 303, Met. 371 or Met. 801) <u>to the day of observation.</u>

More detailed instructions for making visual observations are contained in Section 10.2.

On completing the visual section of the climatological observation it is recommended that the instruments be attended where possible in the following order:

- Raingauge (manual and automatic)
- Thermometers in the screen
- Thermograph hygrograph
- Grass minimum thermometer
- Earth thermometers and earth thermograph
- Tank evaporimeter

- Sunshine recorder
- Cup counter anemometer
- Anemograph (where in use).
- Barometer
- Barograph

All the instrument readings are recorded in the appropriate spaces in the Field Book (Met. 303, Met.371 or Met. 801) to the day of observation.

More detailed instructions for making instrument observations are contained in section 10.3.

10.2. Visual observations

10.2.1. Amount of cloud

The amount of sky obscured by cloud is estimated in eighths. When there is no cloud present, "nil" is to be recorded in the Field Book. When the sky is obscured because of fog etc., "9" is to be recorded.

0 to 9 are the only applicable code figures for this parameter.

10.2.2. Visibility

Visibility is the relative transparency of the atmosphere. It is measured as the distance of the farthest objects which the observer can recognize clearly from the station. For example, if conspicuous objects are recognisable (not merely "looming") as far away as 8 kilometres the visibility is stated to be 8 kilometres.

If the horizontal visibility differs in different directions the minimum distance is reported, provided that the sector or sectors of reduced visibility occupy at least one quarter of the horizon circle. However, small sectors of the horizon in which transient or local phenomena reduce the visibility are disregarded. In these cases the visibility is reported as if such phenomena were not present. Examples of phenomena referred to here would be showers, fog patches adjacent to the station or smoke from a local fire, but not a general deterioration in visibility due to a major outbreak of fire.

When passing showers or other transient phenomena are present in the neighbourhood but not actually at the station, the visibility observation should be made as far as possible using marks which are not obscured by the showers or other phenomena.

Visibility is reported by means of a scale graduated from 0 to 9, known as the "International Scale of Visibility". A copy of this visibility scale is printed on the back of the Field Books Met. 303 and Met. 371. See Figure 10.1 for this table.

Distance at which standard object is visible	Code number
Less than 50 metres	0
50 metres but not 200 metres	1
200 metres but not 500 metres	2
500 metres but not 1 kilometre	3
1 kilometre but not 2 kilometres	4
2 kilometres but not 4 kilometres	5
4 kilometres but not 10 kilometres	6
10 kilometres but not 20 kilometres	7
20 kilometres but not 50 kilometres	8
50 kilometres or more	9

Figure 10.1: Table of visibility

At all stations there should be available to the observer a table setting out the directions and distances of selected prominent objects from the station.

10.2.3. Wind direction

When surface wind direction is reported in a climatological observation, the mean direction is recorded to the nearest ten degrees, (36, 01, 02 etc) as shown in Figure 10.2.

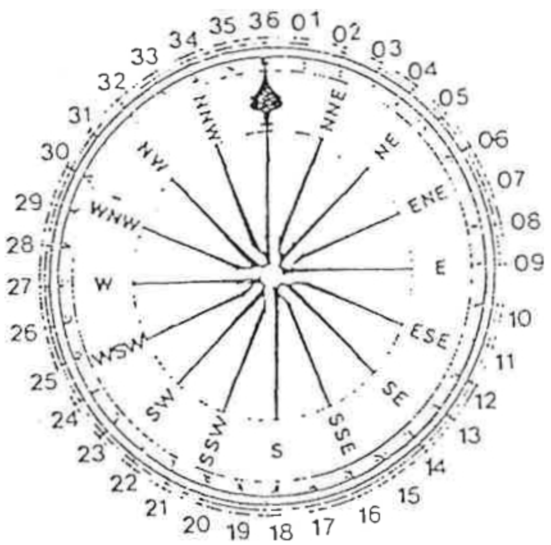


Figure 10.2: Compass rose for reporting wind directions in climatological observations in tens of degrees.

The direction reported is that from which the wind is blowing. All wind directions reported must be <u>true directions,</u> never magnetic directions.

Only code figures from 00 to 36 are applicable for this parameter.

Before an observer can report wind direction by visual estimation, it is of course necessary to know the bearing of TRUE NORTH (360 degrees), as well as the bearings of several conspicuous objects from some given point. At most climatological stations the given point is usually somewhere within the enclosure, e.g., the thermometer screen, or some place near the enclosure from which a good outlook is obtained. At all stations there should be available to the observer a table setting out the true bearings of prominent objects from the station.

In observing surface wind visually, there are a number of ways in which its direction can be ascertained such as by direct observation of the wind on the face and body, or by watching a wind vane, the movement of smoke from neighbouring chimneys, and direction of flags, or the direction in which trees or shrubs are bending.

Such objects as buildings or trees cause considerable deflection to the wind, and accordingly due allowance must be made for the effects of these obstructions on the direction obtained It would obviously be useless to report the wind direction from, say, a wind vane if it were surrounded by buildings. The wind vane should not in these circumstances be used, but recourse taken to other more suitable objects. Also, at most stations the wind direction will swing over an appreciable number of compass points, particularly in light winds and in these circumstances the direction to be reported is the MEAN direction. It is pointed out to all observers that in order to obtain a reliable wind direction, it is often necessary to observe the wind effects for several minutes before deciding on a direction which is truly representative of conditions at the time of observation.

It should be realised that the direction of movement of the cloud is often different from the direction of the surface wind, and accordingly surface wind direction should be ascertained quite independently of the cloud movement.

NOTE: Where ordinary wind vanes are used, observers should frequently check that the orientation of the cardinal arms is correct. It is possible during a strong wind the cardinal arms may be turned slightly, and if this fault goes unnoticed, obviously the wind directions reported will be incorrect.

10.2.4. Wind force

Where the force of the surface wind is estimated visually for climatological reporting purposes, it is necessary to refer to the Beaufort wind scale. Observers are reminded that a copy of this wind scale is printed on the inside of the cover of the field book.

0 to 12 are the only applicable figures for this parameter.

When the scale is studied, it will be seen that it is a scale of the effects of wind, and that each set of effects has been given a code number as well as the mean wind speed in knots applicable to each force code number.

In making visual observations of wind force, it is necessary to note the MEAN effect of the wind over a period of several minutes, on a number of objects such as those on the face and body, inland waters, movement of smoke from neighbouring chimneys, also the movement of flags, trees, and shrubs. Referring to the Beaufort scale, select the description which fits most closely those pertaining at the time of observation and record in the climatological field book the force number applicable to this description.

Remember, the object in reporting wind force is to select a force code number which gives a good representation of the general current of air over the surface of the earth in the vicinity of the climatological station. Unfortunately this is not always possible in built up areas, and the observer should therefore make some allowance for the sheltering effect of surrounding buildings, trees, etc. and endeavour to estimate the wind from the effects in the open.

Observers should thoroughly understand the difference between gusts and squalls. Gusts are variations in the force of the wind lasting not more than a few seconds, and are due to eddies in the atmosphere. They are more conspicuous in built up areas than in open spaces. Squalls, on the other hand, are definite fluctuations in the wind force, or in force and direction, and last for an appreciable number of minutes and do not normally occur more than once or twice an hour. They are usually accompanied by changes in temperature, barometric pressure, cloud types and by precipitation.

NOTE: At those stations equipped with an anemograph the wind direction and speed will be read from this instrument. Visual estimates of wind direction and force should be made in order to keep a check on the accuracy of the anemograph record.

10.2.5. Definitions of weather phenomena

Differentiating between certain weather phenomena may sometimes present difficulties. A special study should be made of the definitions given below.

Lightning is a brilliant momentary discharge between two electrified clouds or between such a cloud and the ground. When a lightening discharge is entirely within a cloud, or hidden from view by intervening clouds, it may be seen only as a diffuse reflection (sometimes referred to as sheet lightning).

Thunder is the sound caused by the atmospheric disturbance created by a lightning discharge and is audible at distances up to about 16 kilometres from the source.

A thunderstorm is reported any time thunder is heard, with or without precipitation and/or lightning. When thunder is heard, and the disturbance is not occurring immediately overhead, the phenomena is still to be regarded as occurring "at the station".

Mist is physically the same as fog, i.e., it is composed of numerous microscopic water droplets suspended in the atmosphere. Mist will be reported when an atmospheric obscurity consisting of suspended water droplets produces a visibility of 1000 metres or greater.

Fog is composed of numerous microscopic water droplets suspended in the atmosphere which restrict visibility to less than 1000 metres at the usual place of observation. Fogs vary greatly in depth most are of the order of 15 metres to 90 metres, but on extreme occasions a fog layer may be upwards of 180 metres to 300 metres deep. Fogs may occur in small patches or they may extend over wide areas. Shallow layers of fog less than 2 metres, known as ground fog, may develop in moist, sheltered localities, usually around sunset and during night hours where there is little or no wind. Ground fogs are entered in the remarks section of the field book and Met. 301. They are not to be counted an occurrence of fog in the Weather Phenomena summary.

Haze differs from fog and mist in that the obscurity is caused by dry particles of dust, smoke, or salt particles from sea spray, instead of water droplets. The particles of haze are much too small to be seen individually but their effect on the visibility and colouring of distant objects is quite marked. Haze gives the air an opalescent appearance, but does not necessarily reduce visibility. If the object is dark, it appears as if viewed through a pale blue veil whereas if it is white, the veil seems yellowish.

Dew is moisture condensed from the atmosphere on exposed surfaces, e.g. grass, shrubs etc. It is deposited from air cooled below the dew point by contact with surfaces which have lost heat by nocturnal radiation to the sky, and is therefore a common phenomenon at night or early morning with calm air and a clear sky.

Hoar-frost is a crystalline icy deposit formed in the same manner as dew when the air and/or ground temperature is below freezing point.

A squall is a strong wind that rises suddenly, lasts for a few minutes then dies away. Squalls are a definite fluctuation in wind force, or in force and direction, not normally occurring more than once or twice an hour. They are usually accompanied by changes in the air temperature, barometric pressure, cloud types, and by precipitation. They are often associated with the passage of cumulonimbus clouds, thunderstorms and frontal systems.

A gale is a wind whose mean speed equals or exceeds Beaufort Force 8 (34 knots or more) for a period of 10 minutes or more.

Snow Lying is recorded when one half or more of the ground representative of the station is covered with snow (fresh and/or accumulated) at the time of observation. (Not at other times of the day and not including ground covered with hail.)

Drizzle consists of tiny water droplets which appear almost to float in the air. The criterion for drizzle is the fineness of the drops, not the amount. Drizzle frequently occurs in association with mist or fog, and may produce low visibility in other-wise clear air. Drizzle falls from layer type clouds, e.g., stratus, nimbostratus or stratocumulus, in the form of either continuous or intermittent precipitation. Estimate the intensity of drizzle on the following basis:

(a) Slight drizzle can readily be detected on the face, but produces very little run-off from road surfaces and roofs. Visibility 1000 metres or more.

(b) Moderate drizzle causes windows and road surfaces to stream with moisture. Visibility 500 metres but not 1000 metres.

(c) Heavy or thick drizzle reduces visibility to less than 500 metres.

Rain is precipitation in the form of water drops of appreciable size. Rain may fall from either layer type clouds, e.g. nimbostratus, in which case the precipitation will be either continuous or intermittent, or it may fall from cumulus type clouds, e.g. cumulonimbus or well developed (towering) cumulus. When rain falls from the latter cloud types it will be in the form of showers. The intensity of rainfall is described as follows:

SLIGHT Individual drops are easily identifiable. Spray does not form above hard surfaces. Puddles form only very slowly. An appreciable time (possibly 5 min.) is required to wet dry surfaces.

MODERATE Individual drops are not easily identifiable. Spray may be formed just above hard surfaces. Puddles form rather rapidly.

HEAVY Rain appears to fall in sheets and individual drops are not clearly identifiable. Heavy spray up to the height of several centimetres is formed over hard surfaces. Puddles form very rapidly.

Snow consists of crystals of white ice, apparently opaque, generally in flakes of light feathery structure. Snow flakes consist of tangled aggregates of ice crystals. Snow may fall from either layer type clouds, e.g. nimbostratus, or cumulus type clouds, e.g. cumulonimbus. Whenever snow falls from nimbostratus the precipitation will be in the form of either continuous or intermittent precipitation. On the other hand when snow falls from cumulonimbus clouds it will usually be in the form of showers.

Rain and snow falling together or snow melting as it falls (sleet). Sleet may fall as intermittent or continuous type precipitation from layer type clouds, e.g., nimbostratus clouds, or a showery type of precipitation from cumulonimbus clouds.

Hail or rather hailstones are composed almost exclusively of transparent ice, or of a series of transparent layers of ice, alternating with translucent layers. The size of hailstones varies from a 5 millimetres in diameter to stones the size of baseballs. Hail falls only from cumulonimbus clouds. Stones smaller than 5 millimetres in diameter are called Ice Pellets, but are recorded as Hail on the climate form.

10.2.6. Forms of precipitation – intermittent, continuous or showers

There is no definite rule stating when precipitation should be termed intermittent or when it should be termed continuous; in each case the observer is guided by the character of the precipitation during the period since it began.

(a) Continuous precipitation falls from layer type clouds, e.g. stratus, stratocumulus, nimbostratus or altostratus, which usually form a dense and fairly uniform layer covering the whole sky. The base of the cloud is sometimes clearly defined, but if so it does not usually show distinct variations in the amount of light which diffuses through, nor in the height of the base.

(b) Intermittent precipitation also falls from the same layer type clouds which may or may not cover the whole sky. There may be considerable variations in the density and opacity of the layer. Occasional brightening or change in the colouration of the sky, with or without a definite break in the cloud, is not unusual, and lifting of the cloud base may occur at times. Because of these variations in the density of a cloud layer or the height of its base above the ground, well defined variations or breaks will occur in the way the precipitation is falling.

(c) Showers always fall from cumulus type clouds, e.g., cumulonimbus or well developed (towering) cumulus. Showers are characterised not only by the rapid beginning and cessation of precipitation, and its widely varying intensity, but also primarily by the appearance of the sky - rapid alternation between dark, threatening cloud and short bright periods (except when perhaps the breaks between the shower clouds are covered by cloud of another layer). The precipitation itself may consist of rain, snow, sleet, hail or a combination of any of these phenomena It is rare for a true shower to take the form of drizzle.

NOTE: It should be noted that there are instances when precipitation, beginning without doubt as a shower, later develops into either intermittent or continuous precipitation or vice versa.

10.2.7. Weather phenomena

The occurrence, if any, of the following weather phenomena is also to be recorded in the Weather Phenomena section by inserting an `X' in the appropriate space:

Gales	Lightning
Snow	Thunder
Fog (but not ground fog)	Hail
Dew	

10.2.8. Remarks

In the "Remarks" sections of the field books and the climatological forms, concise notes should be recorded on the observation of phenomena for which no provision is made elsewhere or to elaborate on phenomena already recorded.

The following will give some indication of what is required:

(a) The times, even if only approximate, of the beginning and ending of unusually heavy falls of rain, snow, etc., periods of fogs, gales, thunderstorms, etc., time of significant changes in weather - both deteriorations and improvements.

(b) If certain significant phenomena are not occurring at the station give the direction and distance if possible from the station of the phenomena.

(c) Significant differences of visibility in different directions, e.g. at coastal stations marked differences in visibility often occur between seaward and landward.

(d) When unusually heavy falls of rain occur it is often useful to make a special measurement of the amount of rainfall that falls on these occasions and to record the rainfall amount and the times of its commencement and cessation.

(e) Always record the depth of snow whenever it covers the ground at the station. Take care to distinguish the depths, e.g. fresh snow depth as opposed to the depth of snow that has accumulated over a number of days.

(f) Optical phenomena, e.g. halo, corona, mirage, etc.

(g) Earthquakes and aurora.

(h) Included in the remarks should be notes on defective instruments, doubtful observations and missing observations (especially instrumental).

(i) A note should always be made if the grass minimum thermometer and/or earth thermometers were buried in snow when the climatological observation was made.

(j) Record when any new instrument is installed or an old one withdrawn from service. Also note when any instruments are shifted to a new site.

(k) Dates when instruments are overhauled or repaired in any way must be noted, together with details of the actual work done.

(l) Dates when muslin and wicks changed.

10.3. Instrumental observations

10.3.1. Raingauges

See the section on rainfall elsewhere in this manual for further detail.

It is the reading from the manual gauge that is used for the official records. Read the manual gauge to the nearest tenth of a millimetre. When recording the reading in the

Field Book it is most important to insert the decimal point this is to avoid confusion, for example between 2.0 and 0.2mm.

Change the chart on automatic raingauge. Ensure that all the required details are entered in the appropriate spaces at the head of each chart, especially the times on and off. These must be shown to the nearest minute in order to obtain a reliable check on the times indicated by the trace. Inspect rainfall trace on the chart that is removed for any instrument faults, e.g. blocked funnel, etc. Check that there are no marked discrepancies between the total rainfall recorded on the chart and the total measured from the manual raingauge. If any fault is detected the fault should, where possible, be corrected without delay.

10.3.2. Reading screen thermometers

See the section on temperature elsewhere is this manual for further detail.

Open screen door and read all thermometers to the nearest degree and tenth of a degree in the following order:- dry bulb, wet bulb, maximum and minimum. Record the readings in the field book then recheck all thermometer readings for possible reading errors. It is very easy to read a thermometer 1, 5 or 10 degrees in error.

Under normal conditions the screen minimum thermometer reading will be higher than the grass minimum thermometer reading. There are however occasions when the reverse situation occurs. It is therefore important that on such occasions care is taken to ensure that both readings are genuine and not the result of an incorrect reading or a fault in either thermometer. Neither thermometer is to he reset until both have been read and compared for this anomaly. If it is found, then recheck both thermometers for reading errors and instrument faults. If the anomaly is con-firmed, please show the following abbreviated note in the "Remarks" section of both the field book and climatological form "Min. temps re-checked" . This note is of great assistance to the Climate Databank when summarising monthly records.

Before resetting the maximum and minimum thermometers, carefully inspect both thermometers for faults. Faults can develop at any time, and it is most important that observers can visually recognise these faults as soon as they occur. It is equally important that observers know how to correct these faults and how to record the appropriate entries in the field book and climatological forms when they occur.

Maximum thermometer faults

See the section on maximum thermometers in the temperature chapter for further detail.

Minimum thermometer faults

See the section on minimum thermometers in the temperature chapter for further detail.

Breaks or bubbles often form in the spirit column or drops of spirit will form in the upper portion of the capillary tube, or in the expansion chamber at the top of the capillary tube.

NOTE; Whenever a new screen or grass minimum thermometer is received through the post it will almost certainly have bubbles, breaks or drops of spirits in the capillary tube due to the shaking received while the thermometer was in the post. Therefore do not put a new minimum thermometer into use until it has been cleared of the faults described.

If a fault does occur the temperatures indicated will be incorrect. Therefore record the indicated temperature in the appropriate spaces for before setting, and draw a circle around it thus 9.8. Record the reason for this doubtful reading in the "Remarks" section of the field book and climatological form for the day(s) concerned.

If no faults are found then reset the maximum and minimum thermometers and record these reset readings in the field book. If the thermometers are reset properly, the reset readings should he either the same as or within half a degree of the dry bulb thermometer reading at the moment of resetting, Where the differences between the reset values and the dry bulb thermometer are greater than one degree, observers should carefully check that their resetting procedures agree with those recommended. If there are still problems contact your nearest NIWA branch office.

Wet bulb thermometer

See section on wet bulb thermometers in temperature chapter for further details.

Check water level in water bottle and "top up" if required. Never allow the water level to fall below the half full mark, Always "top up" the water bottle after reading the thermometers - never before.

Check that the muslin on the wet bulb thermometer appears reasonably saturated Sometimes insufficient water reaches the muslin due to; the water level in the water bottle being too low; dirty muslin and wicks; water bottle set too far from thermometer (correct distance about 2.5-4.0 cm; loop forms in wicks allowing siphoning; muslin not fitted around bulb properly or the incorrect number of strands of cotton between bottle and muslin (should be 4 strands).

At least once every week replace the muslin and wicks. This should always be done after the wet and dry bulb thermometers have been read. Once a week it is a good practice to clean out the water bottle and refill with clean water.

Should the water in the water bottle and/or on the muslin and wicks be frozen at the time of observation, instructions for overcoming this problem are contained in the temperature chap ter.

If an observer is unable to obtain a true wet bulb temperature when the air temperature and/or wet bulb temperature are below freezing, record in the field book and climatological form the indicated wet bulb reading and draw a circle round it thus - 3.2. Then give the reason for this doubtful reading in the "Remarks" section.

10.3.3. Grass minimum thermometers

See the section on grass minimum thermometers in the temperature chapter for further detail.

Read the grass minimum thermometer to nearest degree and tenth of a degree and record the reading in the field book.

Check for possible reading errors. If any readings are suspect record the temperature indicated in the space for "grass minimum before setting" and draw a circle around it thus 7.6. Record the reason for doubtful grass minimum temperature reading in the "Remarks" section orate field book and climatological form for the day(s) concerned.

Do not reset this thermometer until after the screen minimum has been read or vice. versa.

Each time the grass minimum thermometer is replaced on its supports after resetting, ensure that it is supported 2.5 cm (1 inch) above the grass. If not, then trim the grass until the minimum clearance is obtained.

10.3.4. Earth thermometers

Refer the section on earth thermometers in the temperature chapter for more detail.

Read earth thermometers to the nearest degree and tenth of a degree and record the readings in the appropriate spaces of the field book.

1n the event of snowfall, the snow should be carefully removed for taking the readings, and then replaced to the original depth. A note to this effect should be shown in the "Remarks" section of field book and climatological form.

During winter at those locations where "frost heaving" is a problem, check that the soil immediately underneath the horizontal stems of the 5 cm, 10 cm and 20 cm earth thermometers is not in contact with the stems.

Check that there are no breaks in the mercury columns of the right angle 5cm, 10cm and 20cm thermometers. Breaks often occur in the mercury column near the right angle bend of the stem.

If any water is found in the earth thermometer tubes this must be dried out.

10.3.5. Barometer

See the chapter on barometers for further detail.

Where a mercurial barometer is in use, it must be the last instrument to be read, and it should be read as close as possible to the scheduled time of the climatological observation. The barometer is read to the nearest and tenth of a hectopascal and the reading entered in the appropriate space in the field book together with the corrections and calculations of the cistern level and/or mean sea level pressures.

On completion of reading a mercurial barometer always check that the pressure has not been read 1, 5 or 10 hectopascals in error. Then recheck all corrections and calculations. Where a barograph is in use, the pressure recorded by this instrument affords a cross-check on the barometer reading.

10.3.6. Sunshine recorder

See the section on sunshine in the solar radiation chapter for further detail.

Change sun card. Whenever possible sun cards should be changed after sunset or before sunrise. Where cards are changed at the Climatological observation time 9 am, care should be taken to enter the date and time the card is put on and the date and time the card is removed from the recorder. Also if the sun is shining when a card is changed always mark the end of the burn with a pencil.

NOTE: This applies to both the card which is being taken off and the card being put on.

Unless the record is marked thus it is not possible to measure the daily duration of sunshine accurately. Separate totals of sunshine duration for each date should be clearly recorded on the backs of all cards.

Ensure the station name is on the back of each card.

10.3.7. Solar radiation recorders

See the section on radiation in the solar radiation chapter for further detail.

Where a long period type solar radiation recorder (Eppley) is in use, it should be time marked as close as possible to the standard time of observation. The time to the nearest minute must be written alongside the time mark.

Check that the glass shield that covers the radiation element is clean.

Check the radiation record for the previous 24 hours for possible instrument faults. If any are found they must, where possible, be corrected without delay.

10.3.8. Cup counter anemometer

Read cup counter anemometer to whole kilometres only and calculate the kilometres run each day by subtracting yesterday's reading from today's reading in the appropriate space in the field book.

10.3.9. Anemometer or anemograph

See the chapter on wind for further detail.

Where a remote indicating wind vane and/or a cup generator anemometer is in use, the indicator dials should be observed for upwards of 2 to 4 minutes and the mean direction and speed assessed.

If an anemograph (daily or monthly) is in use the mean wind direction and speed should be assessed over the period of about 10 minutes immediately preceding the time of observation.

When reading either of these instruments for a climatological observation the mean direction (true) is read to the nearest 10 degrees (36, 01, 02, 03, etc) and a Beaufort Force number is selected which is applicable to the mean speed.

The anemograph should be examined to obtain the 24-hour maximum gust and the occurrence of gales.

Where a monthly anemograph is in use, the record must be time marked daily by swinging the speed pen sideways. Record the date and time to the nearest minute alongside the time mark. Add ink to the reservoirs if required.

Check the previous 24 hours record for any faults. Visually check that all mechanical and/or electrical parts of the instrument are functioning properly.

10.3.10. Pan evaporimeters

See chapter on evaporation for further detail.

Read tank evaporimeter and calculate the evaporation by adding rainfall, if any, today's total, then subtract yesterday's total form this in the appropriate section in the field book.

During winter the water in the evaporimeter tank may freeze or may be covered by snow. In either case it may be impossible to obtain a reliable measurement of the water level. On these occasions record either "frozen" or "snow" in the section for evaporation in the field book. In the climatological form please enter a dash for the day(s) concerned.

At other times it may be possible to obtain a satisfactory reading by breaking the ice (providing it is not too thick) into small pieces. Care should be taken not to splash water out of the tank or to leave any ice adhering to the tank walls. In order to measure the water level any ice and/or snow in the stilling well must be removed and placed in the tank. Where this procedure is used to obtain a measurement, a note to this effect should be shown in the "Remarks" section of the field book.

Occasionally tank evaporation daily measurements show a "gain" instead of the usual "loss" of water from the evaporimeter. Under some circumstances a tank may collect more rainwater than does a raingauge. If it does, remeasure the water removed. For this to be possible, any water that it removed should always be retained in a bucket rather than be thrown away. If this is done then it is possible to recheck measurements when this anomaly occurs. If the anomaly is confirmed, then show the following note in the "remarks" section of the field book and climatological form "Evap. rechecked" . Also enter the word "missing" in the space for the daily evaporation in the field book, but on climatological Form 301 record a "dash" for the days concerned.

10.3.11. Thermograph and Hygrograph

See temperature chapter for further detail.

Time mark both instruments by depressing the pen arm slightly. Record the time of time marking (to the nearest minute) in the appropriate spaces in the field book.

On Mondays when the charts of these instruments are changed, ensure that all the necessary details are written on each chart e.g., station name, dates times on and off (to the nearest minute) and control readings - dry bulb temperatures on and off and relative humidity off.

The clock of both instruments should be fully wound and the pens inked at the beginning of each week's record.

The thermograph pen should be set to read the same as the dry bulb thermometer at the time of starting the record.

During the winter months (May to September) at those stations where air temperatures are likely to fall below -5°C., but not lower than -15°C, the following action is to be taken in order to avoid loss of record due to the pen "going off the bottom of the chart".

(a) Change from thermograph chart Met. 525 (temperature scale -5°C to 35°C) to thermograph chart Met. 526 (scale -15°C to 25°C) and adjust pen. to read correctly for the new scale,

or

(b) At those stations where thermographs charts Met. 526 are not available, the temperature scale on thermograph chart Met. 525 should be amended to read -15°C to 25°C and the pen adjusted to read correctly for the new scale.

After making these changes observers should check the temperature record each day, and if the tendency is such that there is a risk of the pen "going off the bottom of the chart" then the pen should be raised 5°C and the scale amended to read -20°C to 20°C from the time of change.

The pen of the hygrograph must be readjusted to read 95%. This is done by wetting the hair element with distilled or rain water using a camel hair brush. Once the hairs are saturated, remove superfluous drops, then adjust the pen by altering the setting screw on top of the hair guard on the "chimney" pattern hygrographs or the thumb screw extending from the guard cage of the compensated pattern hygrographs, until the pen reads 95%.

10.3.12. Earth thermograph

Where Earth Thermographs are in use, the record should be time marked immediately after reading the earth thermometers and the time to the nearest minute recorded in the space provided in the field books.

On Monday mornings, the earth thermograph chart should be changed, and the clock wound. Ensure that all the required details are written on the chart including the times on and off which should be recorded to the nearest minute. The earth thermograph should be set to the same readings as the appropriate earth thermometer temperatures.

10.3.13. Barograph

See chapter on pressure for further detail.

Where a barograph is in use at a climatological station the only requirement is that it be time marked. This is done by depressing the pen slightly (not more than 5 mm) and recording the time to the nearest minute in the appropriate space in the field book.

On Monday mornings the barograph chart should be changed, ink added to the pen and the clock wound. Ensure that all the required details including the appropriate pressure settings on and off are written on the chart in the spaces provided. The times on and off should be recorded to the nearest minute.

At the beginning of each record adjust the pen to read either cistern level pressure or mean sea level pressure as obtained from the mercury barometer. Stations that are less than 60 metres (200 ft) above mean sea level will set their barograph to read "mean sea level pressure". Stations at elevations 60 metres (200 feet) or more above mean sea level will set their barographs to read "cistern level pressure".

10.4. Calculations

- Calculate relative humidity using Relative Humidity Table (Met. 325). Instructions for use of this table are printed on the front page of the table. See temperature chapter for further detail. This calculation is done automatically by the Database and this instruction is intended for those who wish to calculate humidity for their own use.

- When calculating "kilometres run "ensure there are no errors when 9999 is passed.

- Ensure that when rainfall occurs it is included in the calculation of tank evaporation.

- Where the sun cards are changed at 9am ensure that the daily sunshine total is obtained from the correct two cards.

10.5. Completion of climatological form (Met 301)

The information in this Form (Figures 1.3a and 1.3b) will be entered into a computer, and it is essential that all figures be made neat and legible, and that entries be made in accordance with the Instruction as detailed below.

National Institute of Water and Atmospheric Research Ltd

MET. 301
Ed 3 (1993)

Daily Climatological Observations at 0900 Hr

Instrument Readings

Station Christchurch Aero Lat 43° 29' S Long 172° 32' E Year 1993 Month May

STATION No.	YEAR	MONTH
H32451	93	05

NOTES: 1. For details on how to complete this form refer to the Manual of Instructions.
2. Rainfall, maximum temperature, wind run and evaporation read at 0900 Hr (i.e. the local clock time) must be entered to PREVIOUS day.
3. All columns should be added and the totals entered in the next to last row.

DAY	RAINFALL 0.1 mm	TEMPERATURES 0.1 C									PRESS. 0.1 hPa	SUN 0.1 hr	RAD. 0.1 MJ/m²	WIND km	WIND 10° kt	EVAP. 0.1 mm
	Manual Rainguage	Dry Bulb	Wet Bulb	Maximum	Minimum	Grass Min	10cm Earth	20cm Earth	30cm Earth	100cm Earth	Mean Sea Level		Eppley	Total Run	Max Gust 0000–2400 Hr	Raised Pan
01		075	070	124	067	060	089	097	105	120	264	044	079		2210	013
02		079	063	135	058	031	079	094	105	120	175	095	101		0616	017
03		038	033	128	-006	-032	054	075	094	120	127	093	100		0719	012
04		066	065	180	021	003	061	077	092	118	054	065	083		0518	020
05		092	088	146	066	070	095	100	104	115	055	073	089		2313	018
06		110	098	119	047	030	091	099	106	116	099	005	040		1826	010
07		077	071	106	064	036	086	092	102	117	265	000	036		0718	008
08		063	053	133	054	033	077	099	100	117	260	090	091		0820	013
09	0015	087	084	189	052	023	080	089	099	116	198	023	051		2224	015
10		088	085	135	088	084	096	100	105	115	287	047	074		0614	015
11		108	100	205	082	060	098	100	106	116	215	003	036		0722	020
12		160	117	205	105	087	106	109	111	116	093	037	061		0122	023
13		072	058	139	046	023	072	089	103	117	240	037	084		0624	015
14	0004	032	029	170	002	-017	057	077	094	117	176	082	085		0613	010
15	0089	137	112	152	030	023	090	091	096	114	026	000	025		2325	000
16	0272	077	074	095	076	073	087	092	100	115	093	000	015		2221	000
17	0230	072	067	080	070	067	082	089	098	113	977	000	013		2836	030
18	0003	074	072	113	063	063	075	089	089	110	029	049	061		2529	009
19		039	037	110	020	000	060	074	087	109	993	031	046		2219	004
20		051	046	118	025	-001	056	069	082	107	062	060	069		2027	000
21		000	-004	131	-011	-040	035	055	074	106	171	083	073		0310	022
22		029	019	170	000	-017	031	052	068	103	231	090	071		0914	011
23		052	041	163	011	-017	045	061	074	100	249	090	072		2412	011
24		027	021	141	-004	-026	042	057	072	099	225	077	071		2015	009
25		083	075	124	026	000	051	060	072	098	213	016	047		0922	006
26	0007	085	071	115	066	053	071	074	079	096	155	002	025		2211	001
27	0062	061	058	091	028	000	062	069	078	097	103	027	035		1935	000
28		-002	-010	150	-017	-046	028	047	065	097	163	076	069		2315	023
29		078	052	145	-013	-039	023	044	060	094	101	044	053		2017	010
30		030	026	139	004	-026	031	046	062	092	149	076	069		0717	010
31		049	046	182	000	-022	037	052	064	090	151	014	040		3025	020
Sum	0692	2059	1817	4333	1120	536	2052	2400	2746	3380	6604	1479	1870		470 609	375
Mean		6.7	5.9	14.0	3.6	1.7	6.6	7.7	8.9	10.9	1014.9		6.0			

Signatures: D Jones Observer .... Data Checker .... Edit Checker

Figure 10.3a: Form Met. 301 (instrument readings)

NIWA
Taihoro Nukurangi

National Institute of Water and Atmospheric Research Ltd

MET. 301
Ed 3 (1993)

Daily Climatological Observations at 0900 Hr

Visual Observations

Station: Christchurch Aero   Lat: 43° 29' S   Long: 172° 32' E   Year: 1993   Month: May

STATION No.	YEAR	MONTH
H32451	93	05

NOTES:
1. For details on how to complete this form refer to the Manual of Instructions.
2. Columns should be added where possible and the totals entered in the last row.
3. "Hr" refers to local clock time.

DAY	CLO	VIS	WIND 10°		DAYS OF OCCURRENCES							SNOW cm		WEATHER SEQUENCE					REMARKS
	Eighths	Code	Direction	Beaufort	Gale	Hail	Lightning	Thunder	Fog	Dew	Snow	Fresh	Total	0900 Hr	0000–0600 Hr	0600–1200 Hr	1200–1800 Hr	1800–2400 Hr	
01	7	9	23	1															
02	1	9	05	2															
03	1	9	00	0															
04	3	3	06	1															
05	7	8	24	2															
06	7	8	20	4															
07	7	8	00	0															
08	1	8	04	1															
09	7	9	07	1															
10	7	8	29	1															
11	7	8	06	4															
12	4	9	01	2															
13	1	8	05	2															
14	5	9	34	1															
15	7	9	07	2															
16	8	6	25	4															
17	8	6	27	6															
18	8	5	24	5															
19	1	9	27	1															
20	2	8	29	2															
21	3	9	00	0															
22	1	9	25	1															
23	6	9	22	2															
24	1	9	28	1															
25	7	9	06	2															
26	7	9	24	2															
27	8	6	21	6															
28	2	9	00	0															
29	6	9	28	3															
30	5	8	30	1															
31	3	8	03	2															
Sum	148	250	742	62															

The completion of this side of the form is optional

44753F—2,000/7 93 MK

Figure 10.3b: Form Met.301 (visual observations)

10.5.1. Form identification

Enter the Station Name, Station Number, Latitude, Longitude, Month, and Year, in the spaces provided at the top of the form.

Each Station is allocated a Climatological Station Number based on its Latitude/Longitude.

10.5.2. Entry of data

Transfer the readings from the Field Book to the Met. 301 as per following instructions.

The following, where applicable are required to be entered onto the Met. 301:

Element	**Entry procedure**
Rainfall	Enter in millimetres and tenths. NIL rainfall leave blank or enter as four dots. Rainfall less than 0.05 mm, enter the word TRACE Accumulated rainfall. Indicate by bracketing days of accumulation. Enter all high order zeros. e.g. rainfall of 52.3 is entered as 052.3 rainfall of 0.2 is entered as 000.2 **NOTE:** enter
Temperature (dry bulb, wet bulb, maximum, minimum, grass minimum, 10 cm, 20 cm, 30 cm, 100 cm (Earth temps.)	Enter a degrees and tenths Celsius. Enter a minus sign in the column provided to indicate negative temperatures. Enter all high order zeros. e.g. a temperature of 10.2 is entered as 10.2 a temperature of 7.3 is entered as 073 a temperature of 0.1 is entered as 001 a temperature of -1.4 is entered as -014 **NOTE**: Enter Maximum Temperature read at 9 am to previous day. All other temperatures entered to day of observation.
Earth Temperature (5 cm)	Enter in spare column provided after column 75. Head column “EARTH TEMP. 5 cm”.
MSL Pressure	Enter the last 3 digits of pressure values. e.g. a pressure of 1012.8 is entered as 128 a pressure of 1000.0 is entered as 000 a pressure of 986.5 is entered as 865
Sunshine as evaluated	Enter in hours and tenths in column provided. Enter all high order zeros. e.g. 3.1 hours is entered as 0.31 nil is entered as 000. **NOTE**: Enter sunshine to previous day, i.e. the day it occurred.

Element	Entry procedure
Radiation	Enter data from the evaluated record. Enter in tenths of Megajoules, with high order zeros. e.g. a value of 72 is entered as 072.
Wind daily run	Enter in whole kilometres with high order zeros. e.g. a value of 95 is entered as 095 and 1035 is entered as 1035 **NOTE**: Enter 9 am value to previous day
Maximum gust	Enter direction in tens of degrees with high order zero. Enter force (kt) in units with high order zero. e.g. Direction 080° speed 9° knots entered as 08 09 If speed greater than 99 knots enter value as 3 digits.
Evaporation	Enter in millimetres and tenths, with high order zeros entered. e.g. a value of 0.9 mm is entered as 009. **NOTE:** Enter 9 am values for previous day.

The following are optional and are entered on the reverse side of the Met. 301, if desired:

Element	Entry procedure
Cloud amount	Enter amount in digits 0 to 9
Visibility	Enter code in digits 0 to 9. If unknown leave blank.
Wind direction	Enter in tens of degrees. Enter high order zeros where applicable. e.g. Direction of 90 degrees is entered as 09. If CALM enter 00 If VARIBLE enter 99.
Wind force	Enter Beaufort Force Number in digits 0 to 12.
Days of occurrences	Enter an X to indicate any occurrence during the day. If no occurrence leave appropriate column blank.
Snow depth	Enter in centimetres, with high order zeros. e.g. a depth of 5 centimetres is entered as 05

10.5.3. Completion of Met 301 at end of month

To complete the climatological form (Met. 301) at the end of the month the Rain-fall, Evaporation Maximum Temperature, and Wind Kilometres as read at 9 am on the 1st of the following month are needed. All these readings should also be entered in the special space provided on the last page of the Field Books.

Procedures for completion

Sums: Add all data columns and enter the sums in the spaces provided. Totals are used as a check on data transfer to the computer.

NOTES

(a) Totals are not required for snow depth.

(b) In Cloud Amount total, do not add 9's (sky obscured, cloud amount unable to be observed).

(c) Sums of MSL Pressure. When forming totals it is essential that correct account be taken of pressures less than 1000.0 hpa. It is not possible to obtain a correct total first by accumulating these values in the normal way. The procedure to be followed in this case is to add the pressure values and then for each value of 1000.0 hpa or more add 100 to the total. After dividing the Total by the number of observations it will then be necessary to add 900.0 hpa to obtain a correct mean pressure.

For example: pressure values	02.2
	90.1
	18.4
Sum =	110.7
2 values greater than 1000.0, therefore +	200.0
	310.7
Mean = 310.73	= 103.6
	+ 900.0
	= 1003.6

Means

Calculate the means by dividing the totals by the number of observations and enter in the spaces provided.

NOTES:

(a) Calculate all means correct to 1 decimal place except for Radiation and Wind Run which are to be meaned to the nearest whole number.

(b) All means are to be rounded up e.g. A total of 307.5 with 30 observations gives a mean of 10.25, and this is to be entered to 1 decimal place as 10.3.

(c) Do not compute means for Rainfall, Sunshine, Maximum Gusts, Evaporation, Visibility, Wind Direction and Force, Days of Occurrences, and Snow Depth.

Missing or doubtful values

(a) Where the daily values in any column to be summarised are doubtful (denoted by a circle drawn around them) they are not to be included in the total or the computation of the mean.

(b) Where any wet bulb temperature is missing or doubtful e.g. "frozen", then the dry bulb temperature for the same day must also be omitted when totalling the dry bulb column and in the computation of the mean.

(c) Where either eleven or more individual or five or more consecutive daily values in any column to be summarised are missing or doubtful, no attempt is to be made to obtain a total or compute a mean for such a column.

10.6. Returning climatological records

After the Met. 301 has been completed it is posted together with the Field book and any charts in the prepaid envelopes supplied by NIWA. It is essential that the sun card and the raingauge chart removed on the 1St of the month is included.

10.7. Supply of forms, envelopes, etc.

These are sent out to all stations once a year usually about July.

If stocks of forms are insufficient, additional stocks may be ordered at any time from your nearest NIWA branch office.

National Institute of Water and Atmospheric Research Ltd

MET. 301
Ed 3 (1993)

Daily Climatological Observations at 0900 Hr

Instrument Readings

Station: Christchurch Aero Lat: 43° 29' S Long: 172° 32' E Year: 1993 Month: May

STATION No.	YEAR	MONTH
H32451	93	05

NOTES: 1. For details on how to complete this form refer to the Manual of Instructions.
2. Rainfall, maximum temperature, wind run and evaporation read at 0900 Hr (i.e. the local clock time) must be entered to PREVIOUS day.
3. All columns should be added and the totals entered in the next to last row.

DAY	RAINFALL 0.1 mm	TEMPERATURES 0.1 C									PRESS. 0.1 hPa	SUN 0.1 hr	RAD. 0.1 MJ/m²	WIND			EVAP. 0.1 mm
	Manual Rainguage	Dry Bulb	Wet Bulb	Maximum	Minimum	Grass Min	10cm Earth	20cm Earth	30cm Earth	100cm Earth	Mean Sea Level		Epplay	Total Run km	Max Gust 0000–2400 Hr Dir (10²)	kt	Raised Pan
01		075	070	124	067	060	089	097	105	120	264	044	079		22	10	013
02		079	063	135	058	031	079	094	105	120	175	095	101		06	16	017
03		038	033	128	-006	-032	054	075	094	120	127	093	100		07	19	012
04		066	065	180	021	003	061	077	092	118	054	065	083		05	18	020
05		092	088	146	066	070	095	100	104	115	055	073	089		23	13	018
06		110	098	119	047	030	091	099	106	116	099	005	040		18	26	010
07		077	071	106	064	036	086	092	102	117	265	000	036		07	18	008
08		063	053	133	054	033	077	099	100	117	260	090	091		08	20	013
09	0015	087	084	189	052	023	080	089	099	116	198	023	051		22	24	015
10		088	085	135	088	084	096	100	105	115	287	047	074		06	14	015
11		108	100	205	082	069	098	109	106	116	215	003	036		07	22	020
12		160	117	205	105	087	106	109	111	116	093	037	061		01	22	023
13		072	058	139	046	023	072	089	103	117	240	087	084		06	24	015
14	0004	032	029	170	002	-017	057	077	094	117	176	082	085		06	13	010
15	0089	137	112	152	030	023	090	091	096	114	026	000	025		23	25	000
16	0272	077	074	095	076	073	087	092	100	115	093	000	015		22	21	000
17	0230	072	067	080	070	067	082	089	098	113	977	000	013		28	36	030
18	0003	074	072	113	063	063	075	080	089	110	029	049	061		25	29	009
19		039	037	110	020	000	060	074	087	109	993	031	046		22	19	004
20		051	046	118	025	-001	056	069	082	107	062	060	069		20	27	000
21		000	-004	131	-011	-040	035	055	074	106	171	083	073		03	10	022
22		029	019	170	000	-017	031	052	068	103	231	090	071		09	14	011
23		052	041	163	011	-017	045	061	074	100	249	090	072		24	12	011
24		027	021	141	-004	-026	042	057	072	099	225	077	071		20	15	009
25		083	075	124	026	000	051	060	072	098	218	016	047		09	22	006
26	0007	085	071	115	066	053	071	074	079	096	155	002	025		22	11	001
27	0062	061	058	091	028	000	062	069	078	097	103	027	035		19	35	000
28		-002	-010	150	-017	-046	028	047	065	097	163	076	069		23	15	023
29		078	052	145	-013	-039	023	044	060	094	101	044	053		20	17	010
30		030	026	139	004	-026	031	046	062	092	149	076	069		07	17	010
31		049	046	182	000	-022	037	052	064	090	151	014	040		30	25	020
Sum	0682	2089	1817	4333	1120	536	2052	2400	2746	3380	6604	1479	1870		470	609	375
Mean		6.7	5.9	14.0	3.6	1.7	6.6	7.7	8.9	10.9	1014.9		6.0				

Signatures: D Jones Observer .... Data Checker .... Edit Checker

National Institute of Water and Atmospheric Research Ltd

MET. 301
Ed 3 (1993)

Daily Climatological Observations at 0900 Hr

Visual Observations

Station: Christchurch Aero Lat. 43° 29' S Long. 172° 32' E Year 1993 Month May

STATION No.	YEAR	MONTH
H32451	93	05

NOTES: 1. For details on how to complete this form refer to the Manual of Instructions.
2. Columns should be added where possible and the totals entered in the last row.
3. "Hr" refers to local clock time.

DAY	CLD Eighths	VIS Code	WIND 10° Direction	WIND Beaufort	Gale	Hail	Lightning	Thunder	Fog	Dew	Snow	SNOW cm Fresh	SNOW cm Total	WEATHER SEQUENCE 0900 Hr	0000–0600 Hr	0600–1200 Hr	1200–1800 Hr	1800–2400 Hr	REMARKS
01	7	9	23	1															
02	1	9	05	2															
03	1	9	00	0															
04	3	3	06	1															
05	7	8	24	2															
06	7	8	20	4															
07	7	8	00	0															
08	1	8	04	1															
09	7	9	07	1															
10	7	8	29	1															
11	7	8	06	4															
12	4	9	01	2															
13	1	8	05	2															
14	5	9	34	1															
15	7	9	07	2															
16	8	6	25	4															
17	8	6	27	6															
18	8	5	24	5															
19	1	9	27	1															
20	2	8	29	2															
21	3	9	00	0															
22	1	9	25	1															
23	6	9	22	2															
24	1	9	28	1															
25	7	9	06	2															
26	7	9	24	2															
27	8	6	21	6															
28	2	9	00	0															
29	6	9	28	3															
30	5	8	30	1															
31	3	8	03	2															
Sum	148	250	74	62															

The completion of this side of the form is optional

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