CHAPTER 5

TEMPERATURE

5.1 GENERAL. A full description of Thermometers, Psychrometers and associated equipment is given in Instrument Manuals 20 and 30. Therefore the instructions in this chapter are confined mainly to temperature observing procedures.

5.1.1 Definition. The temperature of a body is the condition which determines its ability to communicate heat to other bodies or to receive heat from them. In a system of two bodies, that which loses heat to the other is said to be at the higher temperature.

5.1.2 Reading the Thermometer. The main steps in reading thermometers are given below:

(a) stand as far from the thermometer as is consistent with accurate reading, to prevent body heat from affecting the thermometer.

(b) ensure that the line of sight from the eye to the top of the liquid column makes an angle of 90 with the thermometer tube, to avoid an error due to parallax.

(c) read the thermometer to the nearest tenth of a degree.

(d) recheck the reading to ensure that it was not misread by five or ten degrees.

5.1.2.1 When readings are required from two or more thermometers they shall be observed in the following order:

Dry Bulb

Wet Bulb

Maximum

Minimum

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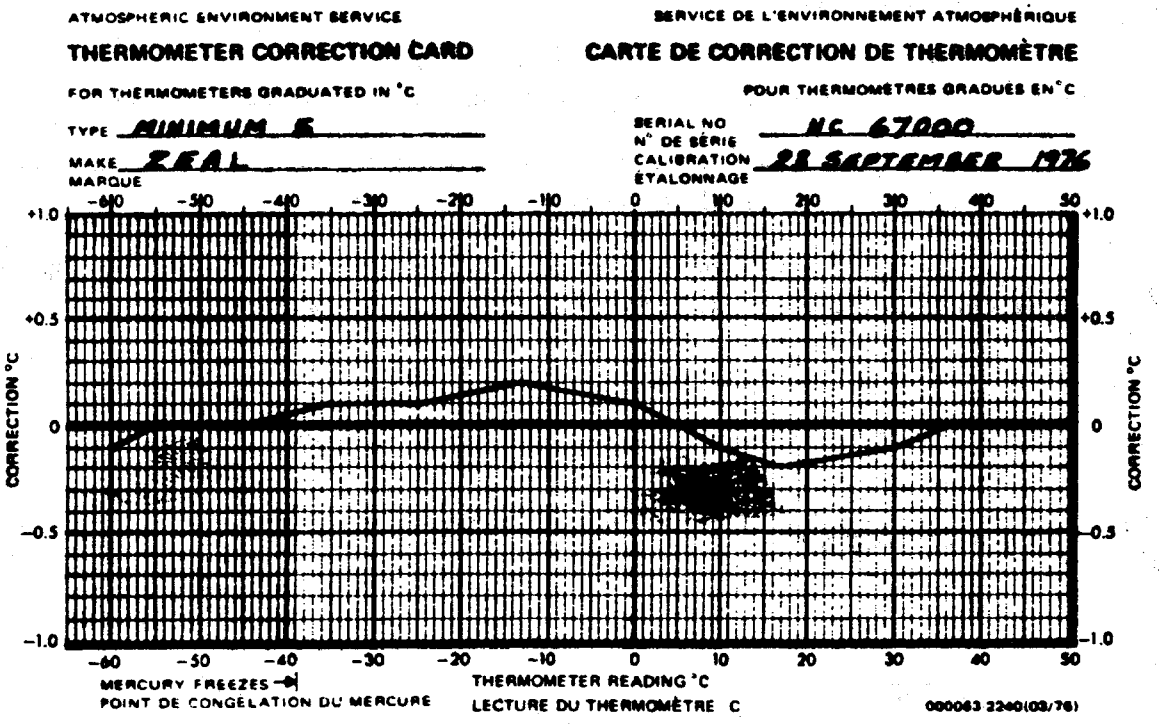
5.1.3 Correction Cards. Thermometer calibrations are given on a correction card supplied with each thermometer. Correction values from this card shall be applied to thermometer readings to obtain the true temperature. (If a correction card is lost or becomes unreadable, a replacement card should be requested from Regional Headquarters. Be sure to use a spare thermometer with its correction card while awaiting the replacement card.)

5.1.3.1 The following is a copy of a correction card for Minimum Thermometer No. NF 67000:



5.1.3.2 Where the graph is above the 0 reference line the true temperature is warmer than that shown by the thermometer; for example, when this thermometer reads –13.0 it has a correction factor of +0.2, thus the true temperature would be –12.8.

5.1.3.3 Where the graph is below the 0 reference line the true temperature is colder than that shown by the thermometer; for example, when this thermometer reads 17.0, it has a correction factor of –0.2, thus the true temperature would be 16.8.

5.1.4 Freezing of Thermometers. Mercury filled thermometers (ordinary, maximum) freeze at approximately –39 °C, and spirit–filled thermometers (minimum) well below –75 °C. Mercury thermometers shall be moved indoors when the temperature falls to within 2 degrees of their freezing point, –37 °C.

5.1.5 The Stevenson Screen is a louvered wooden box especially designed to shield thermometers from the effects of radiation, while at the same time allowing the free flow of air over the thermometer bulbs. Ordinary, maximum and minimum thermometers are exposed in it. The screen is so located as to have a standard exposure in order that meaningful comparisons of temperature observations may be made between stations.

5.1.6 The Psychrometer. The psychrometer is a device for determining the moisture content of the air. It consists of two "ordinary" thermometers placed side by side, one known as the "dry bulb" and the other as the "wet bulb". The bulb of the "wet bulb" thermometer is covered by a thin wet cloth or with a continuous film of water or ice.

5.1.6.1 In order to obtain representative temperatures the psychrometer requires ventilation. In some cases the natural movement of air is relied upon and the arrangement is known as a "simple" or non–ventilated psychrometer. Artificial ventilation is applied in other types, such as the "sling psychrometer" and the "motor psychrometer" (ventilated psychrometer). A motor psychrometer should be turned on at least two minutes before the thermometers are read to allow equilibrium to be obtained.

5.2 DRY BULB TEMPERATURE is the value obtained after the appropriate thermometer correction has been applied to the observed reading of an "ordinary" thermometer. If any moisture is found on the dry bulb, it shall be wiped off and a short time allowed before reading, to permit the thermometer to reach equilibrium. When the dry bulb has been moved indoors to prevent the mercury freezing (para. 5.1.4) the spirit column of the "minimum" thermometer shall be read to obtain the current dry bulb temperature.

5.2.1 Dry bulb temperatures may be read and recorded directly from the left display of the AES Remote Temperature and Dewpoint (1987) System (RTD–87), at stations so equipped. Operating instructions are found in Section 4 of the Technical Manual TM 02–04–01.

5.3 WET BULB TEMPERATURE is the value obtained after the appropriate correction has been applied to the observed reading of an "ordinary" thermometer whose bulb is covered by a thin film of water or by a thin coating of ice. The wet bulb thermometer is cooled by evaporation of the water or by sublimation of the ice. The wet bulb temperature differs from the dry bulb temperature by an amount dependent on the moisture content of the air and is normally the same as, or lower (colder) than the dry bulb temperature. The difference is called the "depression" of the wet bulb temperature.

5.3.1 Depression of the wet bulb temperature shall be obtained by subtracting the value of the wet bulb temperature from the value of the dry bulb temperature.

5.3.2 Negative Depression. On some occasions the wet bulb temperature will be higher (warmer) than the dry bulb temperature, resulting in a "negative depression". When this occurs, the subtraction of the wet bulb temperature from the dry bulb temperature shall be done algebraically.

Example: Dry Bulb Temperature –3.3°

Wet Bulb Temperature –3.2 °

Depression –0.1 °

5.3.2.1 The depression can be negative only when the wet bulb is actually covered with ice and the humidity is very high. Fog, precipitation or the formation of rime ice is usually present in such cases. When a negative depression is observed, the observer should carefully check the following points:

(a) has too heavy a coating of ice been allowed to accumulate on the wet bulb?

(b) has sufficient time been allowed since wetting the bulb for the temperature to fall to a true wet bulb reading?

(c) have the thermometer corrections been applied?

(d) is there moisture on the dry bulb?

5.3.2.2 If fog, precipitation, rime, ice, etc., is not occurring when a negative depression is observed, or if any depression is observed which is outside the values listed in the psychrometer tables, a check reading of the wet and dry bulb thermometers shall be made in the period between observations. The muslin or coating of ice shall be removed from the wet bulb and both thermometers operated as a dry bulb. After sufficient time has elapsed, the thermometers shall be read, corrections applied, and the resulting temperatures compared and recorded under notes. If the thermometers differ by more than 0.1 ° in this check, they shall be checked against a spare and the defective thermometer returned for replacement. The above check should also be performed at any time when the psychrometer data appear unreliable.

5.4 OPERATION OF THE WET BULB. To obtain correct results from a psychrometer it is essential that the wet bulb be given frequent and careful attention. Detailed instructions are given below.

5.4.1 Cleanliness. The wet bulb and everything connected with its operation, (wicks, muslin sleeves, water, observers' hands, etc.) shall be kept clean.

5.4.2 Water Supply. Commercial distilled water, if available, should be used but clean rain water (rain collected in cities is not usually clean enough) or clean melted snow is satisfactory. Ordinary tap water or well water shall not be used. Any impurities contained in the water will be left on the muslin and wick as the water evaporates, causing the wet bulb to read higher than it should. The water container shall be kept at least half full and checked frequently.

5.4.3 Muslin Sleeves. Sleeves which fit over the bulb of an ordinary thermometer are supplied. They should be tied to the neck of the thermometer bulb with a piece of fine thread. If the simple psychrometer or motor psychrometer is used, the sleeve should be changed once a week (more often in very dusty locations, as at some airports). If the sling psychrometer is employed, the sleeve should be changed at least once a month.

5.4.4 Wicking. A wick of special rayon yarn, just sufficient for one thermometer is attached to the wet bulb thermometer. The best method of attaching the wick is to make a slipknot in a loop, and pull it tight around the thermometer just above the bulb. If it is immediately wetted it will stay in place. The wick shall run horizontally from the water container to the bulbv and shall not be allowed to fall down over the sides of the bulb. The wick should be changed once a week, the same as the sleeve.

5.4.5 Rayon Tubing. Rayon tubing is also provided which serves as both muslin and wick. One end of a length of tubing (about 20 cm) should be tied to the thermometer bulb, and the remainder should stretch horizontally to the top of the water container.

5.4.5.1 In general, a wick of rayon tubing will be found most practical during the summer months when temperatures are consistently above freezing. However, during the spring and fall when temperatures are likely to fluctuate above and below freezing, it is better to use a wick of rayon yarn together with a muslin sleeve, for reasons given below.

5.4.6 Operation Below Freezing.

5.4.6.1 Removal of Rayon Tubing. Rayon tubing does not make a suitable covering for the wet bulb when the temperature is below freezing because the ice coating formed with it is too thick. The rayon tubing shall be replaced by a muslin without a wick when the wet bulb temperature goes below 0 C.

5.4.6.2 Removal of Yarn Wick. If a simple psychrometer is in use the wick should be removed when the water on it is frozen. Where a motor psychrometer is in use, the wick should be removed when the temperature is expected to go below freezing, lest the thermometer be damaged during the removal of a frozen wick. When the temperature fluctuates above and below freezing, and the wick is removed, the muslin should be left on and the wet bulb wetted before each reading. When not frozen, the wet bulb should be wetted about five minutes before each reading if used in a simple psychrometer; in a motor p sychrometer it should be wetted about two minutes before reading. Experience on the part of the observer will indicate the time required. If not enough time is allowed, the wet bulb will not have reached a steady, equilibrium temperature by the time it is read and the correct wet bulb temperature will not be obtained; below freezing, follow the instructions in para. 5.4.6.3.

5.4.6.3 Removal of Muslin Sleeves. From 0 C down to about –10 C a thin coating of ice on the wet bulb can best be maintained by leaving the muslin on the bulb. However, at lower temperatures the muslin should be removed and a coating of ice formed on the bulb itself. This is a general rule and the stated temperature of –10 C is not intended as a rigid specification. The frequency of observations will influence this operation and the observer should use his own judgment.

5.4.6.4 Formation of Ice Coating. A fresh coating of ice shall be formed on the wet bulb before each reading in sufficient time to allow equilibrium to be reached before the time of reading; fifteen minutes or more are usually required. If hourly observations are being taken, it will usually be adequate to form a new ice film on the bulb after each observation so that it will be ready for the next. To form a fresh coating of ice, the bulb shall be dipped in pure water until the indicated temperature rises to a few degrees above freezing; this ensures that all the old ice is removed. Then withdraw the bulb from the water, hold the thermometer in a position nearly horizontal, and rotate it slowly until the water coating turns to ice. This method produces an even coating of fresh ice on the bulb, with or without muslin covering, and prevents the formation of an ice button on the bulb.

5.4.6.4.1 The wet bulb of the sling psychrometer should be wetted immediately before it is used.

5.4.6.4.2 If, in freezing weather, the thermometer is watched after it has been moistened, it will be seen to fall to slightly below 0°C, and then suddenly rise to 0°C remaining at that temperature for about a minute until all the water is frozen; then it will descend to its proper wet bulb temperature. If the temperature falls straight to its final reading, with no pause at 0°C, it is highly probable that the water has not frozen on the bulb (water can exist in a supercooled state at temperatures several degrees below the freezing point). It can usually be determined from the appearance of the bulb whether it is covered with ice or water, but if there is any doubt, freezing can generally be initiated by touching the bulb with a fragment of ice or snow. As the water freezes, the temperature will rise toward 0°C, and then fall again.

5.4.6.4.3 Numerous coatings of ice shall not be allowed to accumulate on the wet bulb, as correct results will not be obtained because of the poor thermal conductivity of the ice, and the thermometer may be broken during removal from the psychrometer duct.

5.5 MAXIMUM TEMPERATURE

5.5.1 This is the highest temperature reached during the interval under consideration. Maximum temperatures may be read and recorded directly from the left display of the AES Remote Temperature and Dewpoint (1987) System (RTD–87), at stations so equipped. Operating instructions are found in Section 4 of the Technical Manual TM 02–04–01. At stations not equipped with the RTD–87, the maximum temperature is the highest of the following values:

(a) The value obtained after the appropriate correction has been applied to the observed reading of the maximum thermometer, or

(b) The highest corrected dry bulb temperature during the period under consideration provided that readings were taken at hourly intervals, or

(c) The highest temperature observed from hourly readings of the spirit column of the minimum thermometer, when the maximum thermometer is out of service or cannot be used due to low temperatures (below –37 C).

5.5.2 At stations which operate during part of the day, seven days a week, but do not take an observation at 0600Z, the thermograph chart in conjunction with the maximum thermometer may be used to obtain maximum temperature data. (para 10.4.4.1 and para. 13.3.4.1).

5.5.2.1 At such stations, if collocated with an automatic station, maximum temperature data may be obtained from the automatic station (para. 10.4.4.4 and para. 13.3.4.4).

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Dec. 1991

5.6 MINIMUM TEMPERATURE

5.6.1 This is the lowest temperature reached during the interval under consideration. Minimum temperatures may be read and recorded directly from the right display of the AES Remote Temperature and Dewpoint (1987) System (RTD–87), at stations so equipped. Operating instructions are found in Section 4 of the Technical Manual TM 02–04–01. At stations not equipped with the RTD–87, the minimum temperature is the lower of the following values:

(a) The value obtained after the appropriate correction has been applied to the observed reading of the minimum thermometer, or

(b) The lowest corrected dry bulb temperature during the period under consideration provided that readings were taken at hourly intervals.

5.6.1.1 If the minimum thermometer is out of service, the lowest corrected dry bulb reading shall be recorded as the minimum temperature provided that readings were taken at hourly intervals.

5.6.2 At stations which operate during part of the day, seven days a week, but do not take an observation at 0600Z, the thermograph chart in conjunction with the minimum thermometer may be used to obtain minimum temperature data (para. 10.4.5.1 and 13.3.6.1).

5.6.2.1 At such stations, if collocated with an automatic station, minimum temperature data may be obtained from the automatic station (para. 10.4.5.4 and para. 13.3.6.4)

5.7 RESETTING AND CHECK READINGS – MAXIMUM AND MINIMUM THERMOMETERS

5.7.1 The maximum thermometer shall be reset after the reading. To reset,remove the thermometer from its supports*, grasp it firmly at the end opposite the bulb and hold it with the bulb down. Allow the mercury to come into contact with the constriction before starting the reset motion. Swing the thermometer, briskly, through an arc that prevents the bulb from rising above the horizontal.This is to prevent damage to the thermometer.

5.7.1.1 Re–check the reading after resetting. This is to ensure the reset value is representative of the ambient temperature.

5.7.2 The minimum thermometer shall be reset after reading. To reset, remove the bulb end from its support and raise it until the index slides down and rests against the meniscus. The bulb end shall then be carefully returned to its support.

*Note: The maximum thermometer is positioned horizontally in the Stevenson Screen, BELOW the minimum thermometer. Its bulb should be slightly lower than the opposite end.

5.7.3 Check readings of maximum and minimum thermometers shall be made after each resetting. This is done to check for the occurence of breaks or bubbles in the column and to ensure that the thermometers are reset correctly.

Note: Maximum thermometers manufactured by the JUMO company may appear to have a short break in the mercury column in the area of the constriction. This break is caused by a small glass rod inside the bore of the thermometer. No attempt to re–unite the column in this area should be made after the thermometer has been reset to the current air temperature.

5.8 GRASS MINIMUM TEMPERATURE

5.8.1 The grass minimum temperature is used mostly to provide information on "ground frosts" at night. It is obtained from a minimum thermometer exposed horizontally over short grass (about 8 cm high) with the bulb of the thermometer just touching the tips of the blades of grass.

5.9 THERMOGRAPHS

5.9.1 Many stations are equipped with thermographs from which a continuous record of temperature against time may be obtained. Refer to Manuals 21 and 22. Although the thermograph is not regarded as a primary standard, it may be used as a reference for temperature data (maximum and/or minimum for 6, 12, or 18 hours, temperature 12 hours ago, etc.) which occurred during periods when the weather watch was not continuous.

5.9.2 When temperature data, required in the completion of Form 63–2322, are not available from maximum, minimum or dry bulb thermometers, the thermograph may be used to obtain CORRECTED temperatures provided that the following procedures (additional to those in Manuals 21 and 22) are observed:

(a) The thermograph shall be housed in a thermometer shelter located no farther than necessary from the one which contains the dry bulb thermometer. It may be possible in some cases to locate the thermograph and the thermometer in the same shelter.

(b) At each time of chart change:

  (i) adjust the thermograph so that the temperature indicated by the beginning of the trace on the new chart agrees with the dry bulb temperature at the time of chart change.

  (ii) enter the dry bulb temperature to the nearest degree just above the end of the temperature trace on the chart just completed.

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(c) At the time of each main synoptic observation:

(i) make a time check mark across the trace by raising and lowering the pen the width of two printed temperature intervals.

(ii) enter above each time check mark the difference (in whole degrees with proper algebraic sign) between the thermograph reading and the corresponding dry bulb temperature.

For example:

Thermograph Reading	Dry Bulb Reading	Difference (correction)
14	15	+1
21	19	–2
–4	–3	+1
+1	–1	–2
10	10	0

(d) Adjust the thermograph promptly, if at any time, the recorder trace is in error by more than 1.5 C.

(e) Except for reading and routine maintenance, the thermograph shall be keè pt in the appropriate screen.

5.10 WATER TEMPERATURE

5.10.1 Designated stations are required to measure water temperature. Special instructions on the use of the thermometers and other special equipment are given in Instrument Manual 20.

5.11 COMPUTER GENERATED TEMPERATURES, DEWPOINTS AND HUMIDITIES

5.11.1 These instructions are for use by sites that are equipped with software which will apply corrections to readings of ordinary, maximum, and minimum thermometers, will calculate dew point and relative humidity, and will select maximum and minimum temperatures for the various synoptic hours based on up to the previous 30 hours of temperature data.

5.11.1.1 Enter all temperatures directly as read, to the nearest tenth of a degree Celsius, on the data input screen. Depending on station equipment, readings may be derived from dry and/or wet bulb thermometers, maximum and minimum thermometers, the AES Dewcel, a Remote Temperature Indicator, or the AES Remote Temperature and Dewpoint (1987) System (RTD–87).

5.11.1.2 Although observing and recording procedures are simplified, no change is made to station operating procedures with regard to the operation and routine maintenance of the dewcel, wet bulb, maximum and minimum thermometers and other temperature/humidity sensors.