551·524:551·508·72

ON THE INFLUENCE OF TEMPERATURE ON STANDARD U.S.A. OPEN PAN EVAPORIMETER READINGS

Primault (1961) has drawn attention to the fact that the extent of the drop in level of water due to evaporation will be influenced by the variation of temperature between two consecutive observations on the metallic container and the volume of water in the evaporimeter. This is because of differential expansion of water and the metal. Further while the volume expansion of the metallic container with temperature is linear, the cubical expansion of water is not so. As is well known, the coefficient of expansion of water varies with temperature and is negative below 4°C. Therefore, apart from the change in level associated with loss of water due to evaporation, the level of water will also change depending upon the difference of temperature between the successive measurements.

Let the area of the container be A_0, the coefficient of linear expansion of the metal of the container α and the coefficient of volume expansion of water at T°C β. Then, the increase or decrease in the level of water at temperature $T+1$°C for unit height is given by—

$$\frac{A_0\,(1+\beta)\;-\;A_0\,(1+3\alpha)}{A_0\,(1+2\alpha)} = \frac{\beta-3\alpha}{1+2\alpha}$$

β (Smithsonian Tables 1956) can be accurately determined from the density variations of the water with temperature $\left(\beta = \frac{-1}{\rho_0} \times \frac{d\rho}{dT}\right)$, where ρ_0=density of water at 0°C and $\frac{d\rho}{dT}$ = rate of change of density at T°C.

TABLE 1

Temp. (°C)	Coeff. of cubical expansion of water as calculated from density variation	Rise in level of water in inches/degree rise of temperature due to expansion of water and container		
		Copper	Zinc	Iron
	×10⁻⁵	×10⁻³	×10⁻³	×10⁻³
0	—6·6	—1·045	—1·304	— ·880
2	—3·3	— ·748	—1·007	— ·603
4	—0·1	— ·460	— ·719	— ·295
7	+4·5	— ·046	— ·305	+ ·119
10	+8·7	+ ·332	+ ·073	+ ·497
15	+15·1	+ ·908	+ ·649	+1·073
20	+20·6	+1·403	+1·144	+1·568
25	+25·6	+1·853	+1·594	+2·018
30	+30·3	+2·276	+2·017	+2·441
35	+34·2	+2·627	+2·368	+2·801
40	+38·0	+2·969	+2·710	+3·134

Linear Expansion of Copper $\cdot167\times10^{-4}$,
Linear Expansion of Zinc $\cdot263\times10^{-4}$,
Linear Expansion of Iron $\cdot106\times10^{-4}$

TABLE 2

Temp. (°C)	Correction to be applied per unit rise of temperature for the evaporation in inches between 2 consecutive observations with moving point gauge		
	Copper	Zinc	Iron
	$\times 10^{-3}$	$\times 10^{-3}$	$\times 10^{-3}$
0	—1·121	—1·380	— ·956
2	— ·824	—1·083	— ·679
4	— ·536	— ·795	— ·371
7	— ·122	— ·361	+ ·043
10	+ ·256	— ·003	+ ·421
15	+ ·832	+ ·573	+ ·997
20	+1·327	+1·068	+1·492
25	+1·777	+1·518	+1·942
30	+2·200	+1·941	+2·365
35	+2·551	+2·292	+2·725
40	+2·893	+2·634	+3·058

Correction due to expansion of still well (brass) of height 10″ —·000189″/degree rise of temperature
Correction due to hook gauge (brass) of length 6″ +·000113″/degree rise of temperature

α is a constant for any given metal. The increase or decrease in level of water per unit increase of temperature for pan evaporimeter made of copper, zinc and iron are given in Table 1 for range of temperature from 0° to 40°C assuming that the depth of water in the evaporimeter pan is 9″ (the usual depth). Zinc has been included so as to have a metal with a very high α.

In the case of evaporimeters provided with moving point gauges, when there is an increase in temperature the still well also expands. Consequently the reference point at which the hook gauge is fixed is raised per unit increase of temperature to an extent of $10 \times (1+\alpha_1 \times 1)$ where 10″ is the height of the still well and α_1 is the coefficient of linear expansion of brass, the metal used for making still well. The hook gauge also will expand resulting in lowering the point of hook. These two changes, *viz.*, the expansion of the still well and the depression of the point of the hook are in opposite directions. However since the length of the still well is greater than that of the hook gauge, the net result is an apparent increase in evaporation.

The effect of changes in temperature on the expansion of the scale of the hook gauge has been neglected since evaporation per day even in the tropics hardly exceeds 1/2″.

In the case of evaporimeters fitted with fixed point gauges the increase in length of the pointed brass rod (of length 19 cm or 7·48 inches) due to a rise in water temperature between 2 successive observations tends to give an increased estimation of evaporation.

The net correction, which includes the correction due to (*i*) cubical expansion of water with temperature, (*ii*) volume expansion of the container and (*iii*) linear expansion of still well

TABLE 3

Temp. (°C)	Correction to be applied per unit rise of temperature for the evaporation in inches between 2 consecutive observations with fixed point gauges		
	Copper	Zinc	Iron
	$\times 10^{-3}$	$\times 10^{-3}$	$\times 10^{-3}$
0	—1·186	—1·445	—1·021
2	— ·889	—1·148	— ·744
4	— ·601	— ·860	— ·436
7	— ·187	— ·446	— ·022
10	+ ·191	— ·068	+ ·356
15	+ ·767	+ ·508	+ ·932
20	+1·262	+1·003	+1·427
25	+1·712	+1·453	+1·877
30	+2·135	+1·876	+2·300
35	+2·486	+2·227	+2·660
40	+2·828	+2·569	+2·993

Correction due to expansion of brass rod of length 19 cm or 7·48 inches —·000141″/degree rise of temperature

and hook-gauge or the linear expansion of the pointed rod, to be applied to the standard pan evaporimeter readings recorded with (a) moving point gauges and (b) fixed point gauges, for a unit increase in temperature between 2 consecutive observations for zinc, copper and iron pans from 0° to 40°C are given in Tables 2 and 3 respectively. However, the correction for both types of gauges for many temperature ranges will be practically the same when rounded off to the third place of decimal in view of the fact that the correction due to the cubical expansion of water is the predominant correction. An example is given below—

Let the temperature of water increase in a copper pan evaporimeter from 20°C to 25°C between two observations. The correction to be applied works out to

$$\left(\frac{1\cdot327+1\cdot777}{2}\right) 10^{-3}\times 5 = \cdot0078 = \cdot008'' \text{ in}$$

the case of moving point gauges, and

$$\left(\frac{1\cdot262+1\cdot712}{2}\right) 10^{-3}\times 5 = \cdot0074 = \cdot007'' \text{ in}$$

the case of fixed point gauges.

Thus for a comparative study of the evaporation data the correction due to differences in water temperature at successive measurements has to be evaluated and applied to the readings of evaporation.

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