

Replacement of the Canadian Standard freeness temperature and consistency correction tables with equations suited to computer use

Christopher J. Biermann and Jerry L. Hull

KEYWORDS: Canadian Standard freeness, computation, computers, consistency, equations, temperature, test methods, standards.

Corrections for Canadian Standard freeness tests that are not run at exactly the assigned conditions of 0.30% consistency and 20°C are customarily made using tables supplied with the test method (1). According to Clark, these tables were worked out by Campbell early in the development of the tester (2). Exactly how these tables were developed is not well documented, but it is believed that they were derived experimentally, using groundwood pulp for the lower freenesses, and sulfite pulp for the higher freenesses as noted in the test method. Considering the importance of these tables, it is surprising that the original data and means of generating them are essentially unknown and the tables have not been verified by any studies in the literature. Our recent work indicates that the corrections may be somewhat low in absolute value for chemical pulps (3).

In this work, empirical equations have been developed that yield correction values very close to those of the tables included with the test method (1). The reason for the form of these equations will not be discussed here, but the form is not quixotic.

Given the capabilities and availability of modern computers and calculators, it is possible to replace these tables with mathematical formulas that calculate the correction factors, given the actual conditions of the test. These formulas can be entered into mill computer systems or common spreadsheet programs, and provide the corrected freeness faster and with less chance for error.

The formulas for the correction to test method consistency and temperature, presented in a format that is compatible with most common spreadsheet programs, are as follows:

$$\text{Consistency correction} = (\text{Cons} - 0.3) * 590 * (1 + (((0.4 - \text{Cons}) / 0.2 * (\text{CSF} / 1000))) * (1 - (((\text{CSF} - 390)^2 / ((\text{CSF}^2 * 87000)))))) \quad (1)$$

$$\text{Temperature correction} = (20 - \text{Temp}) * 4.6 * (1 - (((400 - \text{CSF})^2 / ((\text{CSF}^{25} * 61000)))))) \quad (2)$$

where

cons = actual consistency, %

temperature = actual temperature, °C

CSF = measured CSF or already corrected for one term

As with correction values from the tables, the corrections should be applied sequentially, with the corrected freeness from the first correction used as the measured freeness for the second correction. It should be noted that these formulas are derived solely to duplicate the values from the tables. No theoretical or physical basis for their form is postulated, although some theoretical considerations may be useful in explaining any differences from the actual table values.

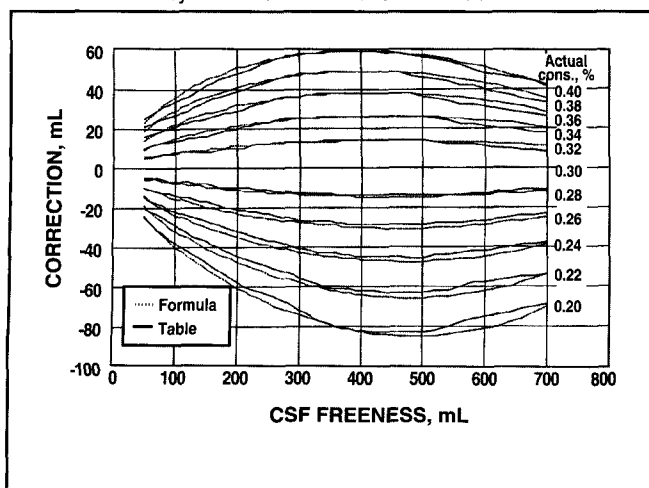
Graphs of the table values compared to the calculated values from the formulas are presented in **Figs. 1 and 2**. The maximum difference between the calculated and table values for a given set of consistency and freeness values occurs at the lowest consistency (0.2%) and measured freenesses of 580–620 mL; the maximum difference is 6. The maximum difference between the calculated and table values for temperature corrections is 4, occurring at the extremes of 10°C and 30°C temperature and at measured freenesses of 130–220 mL.

Earlier researchers (4) have presented an equation that allows freeness to be theoretically derived from initial stock consistency, viscosity of water, and filtration resistance, with filtration resistance assigned a value based on the measured freeness of the stock being tested. Their equation is more complex than those presented here, however, and depends on inputs that are not simple, direct physical measurements. In addition, the maximum differences between the table values and the calculated values using the theoretically derived equation are greater than with the fitted equations presented here.

Examination of the graphs of correction values for consistency from the table shows that these values do not follow particularly smooth curves. Deviation of the formula

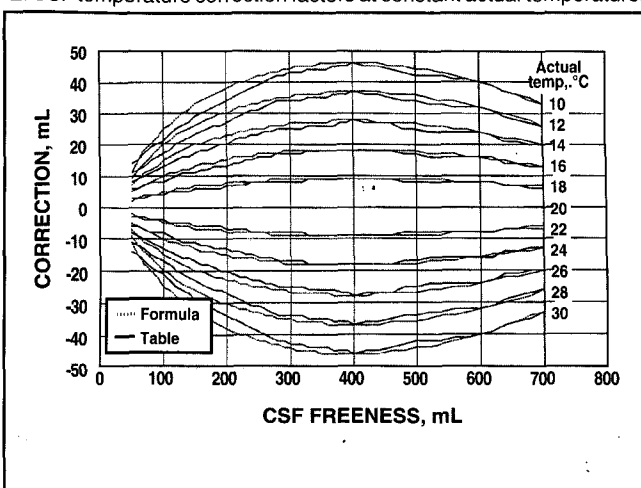
Freeness Measurement

1. CSF consistency correction factors at constant actual consistencies



values from the table values occurs at those points where the table values deviate most from a smooth curve. If, as suggested in the literature, the freeness value is related to physical properties which change uniformly over the considered range, it is reasonable to expect a more uniform change in the actual correction values. Thus, the anomalies in the curve may have come from experimental errors or

2. CSF temperature correction factors at constant actual temperatures



curve-fitting algorithms in the original work that was used to generate the correction tables, and the deviation of the calculated from the table values may be attributed to possible errors in the table values. In short, the equations may be more consistent than the table values.

Maximum deviation from the table values for temperature correction occurs along a relatively smooth portion of the curve, however, and is more likely attributed to imperfect fit of the equation. The fit of the equation in the range of 50–100 ml freeness causes this minor deviation. However, our work shows that temperature correction factors for chemical pulps are low in value in any case (3), so the equations are probably more realistic than the tables for freeness values of chemical pulps above 80 mL. The absolute values of the table of correction values are bilaterally symmetrical about the central temperature, with equal deviations from that central temperature at a given freeness being of the same magnitude whether the measured temperature is higher or lower than the test method. If the freeness is in fact related to the viscosity of water, which does not vary symmetrically about the central temperature, it is not reasonable that the correction would be symmetrical. Our recent work indicates that the temperature correction table, indeed, is not symmetrical (3). **U**

Literature cited

1. TAPPI Method T 227 om-85 "Freeness of pulp."
2. Clark, J. d'A., *Pulp Technology and Treatment for Paper*, Miller Freeman Publications, San Francisco, 1978, p. 510.
3. Biermann, C.J., Sundrani, R., and Hull, J. L., Unpublished data, 1992.
4. El-Hosseiny, F. and Yan, J. F., *Pulp and Paper Canada* 81 (6): 61(1980).

Received for review Feb. 7, 1992.

Accepted April 25, 1992.