curves all bend off so that, if extrapolated to an ordinate of 0.1, the estimated maximum velocities would be upwards of 300 cm. per second (10 feet per second). It is significant that the commercial absorber data indicate an extremely high allowable velocity, even after correcting for the high vapor density.

It may be concluded from the data available that the allowable vapor velocity from the point of view of entrainment is at least 120 cm. per second (4 feet per second) at plate spacings of 30 cm. (12 inches), and probably much higher in commercial columns. It seems probable that in most cases column capacity may be limited by pressure drop or priming, rather than by entrainment. Such a conclusion was, in fact, intimated by Peters (5) in his discussion of the paper by Chillas and Weir.

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# Effect of Entrainment on Plate Efficiency in Rectification

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CERTAIN topics covered in the article which appeared under this title in IND. ENG. CHEM., 26, 1333 (1934), and was later presented as part of this Symposium on Distillation, were discussed so briefly that they are, apparently, not clear.

When both the Murphree efficiency, k, and the entrainment efficiency, k' or $R/[R + E(R + 1)]$, are known, the actual number of plates required to produce, with a given reflux ratio, a product of known composition from a charge of known composition is as follows: Plot the vapor-composition curve and the enrichment line as in the method of McCabe and Thiele. Since the vapor from the kettle will normally be in equilibrium with the liquid in the kettle and will not contain any appreciable amount of entrained liquid, its composition will be represented by the ordinate, y_0, of the point, A, on the vapor-composition curve of which the abscissa, x_0, represents the composition of the charge. With no entrainment from the kettle, the composition of the liquid on the bottom plate will be represented by the abscissa, x_1, of the point on the enrichment line, B, that has the same ordinate as A. The vapor from plate 1 will have the composition represented by y_1, which is the ordinate of point C, which point is so located that $AC/AD = k$. The liquid on plate 2 will have composition x_2, the abscissa of point E, which point is so located that $CE/CF = k'$. Similarly, the vapor from plate 2 will have the composition represented by the ordinate of point H, where $EH/EI = k$; the liquid on plate 3 will have the composition represented by the abscissa of point J, where $HJ/HK = k'$. Thus, to find the number of plates required in the column, we start at point B on the theoretical enrichment line and construct, alternately, vertical and horizontal steps. The length of each vertical step bears the ratio k to the vertical distance between its lower end and the equilibrium vapor-composition curve; the length of each horizontal step bears the ratio k' to the horizontal distance between its left-hand end and the theoretical enrichment line. Successive steps are constructed until a final vapor composition of the required value is reached. The curve joining the upper ends of the vertical steps is the effective vapor-composition curve; the graph joining the right-hand ends of the horizontal steps is the effective enrichment line.
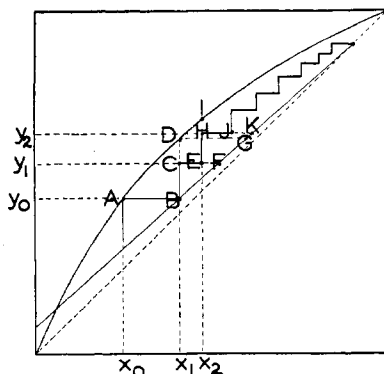
The net efficiency of any of the upper plates in the column is a complex function of the two efficiency factors, k and k'. The net efficiency of the lowest plate, expressed as the ratio of the actual difference between the composition of the liquid on plate 2 and the composition on the liquid on plate 1 to the difference that should exist if there were no entrainment and if perfect equilibrium between liquid and vapor were attained, is simply the product of the two efficiency factors. This may be seen from the accompanying diagram:

$$CF/DG = CB/BD = k$$
$$CE/CF = k'$$
$$CE/DG = (CE/CF) \times (CF/DG) = kk'$$

In evaluating k and k' individually, two or more distillations are made, with the same charge and the same total rate of flow of vapor but with different known reflux ratios. The charge in the kettle, the final product from the top of the column, and the liquids on plate 1 and on plate 2 are analyzed.

From these data and the known vapor-composition relationships for the particular pair of liquids used, the amount of entrainment and the Murphree efficiency may be computed by the method described in the original article.

ERRORS IN THE ORIGINAL ARTICLE

The definition of the Murphree efficiency, as given, is the special definition that applies only in the case of infinite reflux ratio. In the discussion, and in the equations given in the article, the term "Murphree efficiency" was used with its general significance: the ratio of the actual change in composition of the vapor in passing through a plate to the change that should occur if there were perfect equilibrium between the liquid and the outgoing vapor.

On page 1333, just above Equation 2, "$R = 1 + EV_n$" should read "$R + 1 + EV_n$."

In Equations 6 and 7, page 1334, the term "$E/(1 + E)$" should be enclosed in brackets to show that fy_n is not in the denominator.

In the equation at the middle of column 1, page 1334, the expression "$(x_{n+1} - x)_{actual}$" should read "$(x_{n+1} - x_n)_{actual}$."

In the last line of the second table on page 1335, the reflux ratio should be "0.5:1" instead of "5:1."