metric data also. All differences were small and the variations between the three types of L-J parameters could not be deemed significant.

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An Observation Concerning Pulse Testing of Flow Systems

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Several authors (*1* to *4*) have listed the advantages of the pulse testing technique over those of other similar methods for experimentally determining the residence time distribution and dynamic response of a flow system. One advantage often mentioned is that when one uses the pulse testing technique, measurements of the tracer concentration are made at two points instead of one, and the shape of the input pulse is not assumed. Another advantage which results from using two measurement points, and which to our knowledge has not been previously pointed out, is described below.

Consider the case where an experiment is to be carried out to determine the residence time distribution $E(\theta)$ of a flow system by injecting a unit impulse (or delta function) input of tracer at the inlet of the system and then measuring the outlet tracer concentration as a function of time. The final recorded trace of the outlet concentration will actually be the combined responses of the flow system and the measurement and recording system.

In Laplace transform notation, what one wishes to find is $\overline{E}(s)$; what one actually gets is $\overline{E}'(s) = \overline{E}(s)\overline{M}(s)$. Here $\overline{E}(s)$ is the Laplace transform of the residence time distribution or, equivalently, the transfer function of the flow system, and $\overline{M}(s)$ is the transfer function of the measuring device and the recorder. In this case, the only way to eliminate the influence of instrument dynamics, represented here by $\overline{M}(s)$, is to make a separate experimental measurement of those dynamics and then divide the transformed impulse response curve $\overline{E}'(s)$ by the measured transfer function of the instruments.

Consider now the case where $\overline{E}(s)$ is to be determined with the pulse testing technique. $\overline{E}(s)$ is given by

$$\overline{E}(s) = \frac{\overline{Y}(s)}{\overline{X}(s)} \qquad (1)$$

where $\overline{X}(s)$ and $\overline{Y}(s)$ are the Laplace transforms of the input and output pulses, respectively. In this case, one wants $\overline{X}(s)$ and $\overline{Y}(s)$, but one gets $\overline{X}'(s)$ and $\overline{Y}'(s)$ where

$$\overline{X}'(s) = \overline{X}(s)\overline{M}_1(s) \qquad (2)$$

and

$$\overline{Y}'(s) = \overline{Y}(s)\overline{M}_2(s) \qquad (3)$$

$\overline{M}_1(s)$ and $\overline{M}_2(s)$ are the transfer functions of the instruments. Hence instead of $\overline{E}(s)$ one actually gets $\overline{E}'(s)$ where

$$\overline{E}'(s) = \frac{\overline{Y}'(s)}{\overline{X}'(s)} = \frac{\overline{Y}(s)}{\overline{X}(s)}\,\frac{\overline{M}_2(s)}{\overline{M}_1(s)} = \overline{E}(s)\,\frac{\overline{M}_2(s)}{\overline{M}_1(s)} \qquad (4)$$

The advantage of the pulse testing technique that we wish to emphasize is that one can take steps to insure that

$$\frac{\overline{M}_2(s)}{\overline{M}_1(s)} = 1 \qquad (5)$$

This makes it unnecessary to make corrections in the observed response of the system. Even if $\overline{M}_1(s)$ and $\overline{M}_2(s)$ are slightly different, their presence as a ratio in Equation (4) nearly always produces sufficient tendency toward cancellation, so that a separate experiment to evaluate and compensate for instrument dynamics is unnecessary. In our work (5), in which the pulse testing technique with radioactive P-32 as a tracer was used to investigate liquid mixing on distillation trays, it was found that off-the-shelf scintillation probes and rate meters satisfied Equation (5) without modification.

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