

1969

Diffusion Coefficients over Rough and Smooth Boundaries, obtained by Measuring the Concentration-Velocity Covariance

R. S. McQuivey

T. N. Keefer

Follow this and additional works at: <http://scholarsmine.mst.edu/sotil>

 Part of the [Chemical Engineering Commons](#)

Recommended Citation

McQuivey, R. S. and Keefer, T. N., "Diffusion Coefficients over Rough and Smooth Boundaries, obtained by Measuring the Concentration-Velocity Covariance" (1969). *Symposia on Turbulence in Liquids*. 63.
<http://scholarsmine.mst.edu/sotil/63>

This Article - Conference proceedings is brought to you for free and open access by Scholars' Mine. It has been accepted for inclusion in Symposia on Turbulence in Liquids by an authorized administrator of Scholars' Mine. This work is protected by U. S. Copyright Law. Unauthorized use including reproduction for redistribution requires the permission of the copyright holder. For more information, please contact scholarsmine@mst.edu.

DIFFUSION COEFFICIENTS OVER ROUGH
AND SMOOTH BOUNDARIES, OBTAINED BY MEASURING
THE CONCENTRATION-VELOCITY COVARIANCE

R. S. McQuivey and T. N. Keefer¹
U. S. Geological Survey
Fort Collins, Colorado

ABSTRACT

A preliminary investigation of the coefficients of turbulent diffusion in an open channel was conducted by employing: 1) hot-film anemometry to detect the velocity fluctuation, 2) a platinized single-electrode conductivity probe to detect the concentration fluctuations, and 3) a digital computing system to evaluate the covariance and other statistical properties of the two output signals.

Data were collected downstream of a constant-discharge point source of neutrally-bouyant salt solution at stream temperature and velocity. Using current semi-empirical methods diffusion coefficients were obtained in the vertical and lateral directions as well as dispersion coefficients due to convection.

Using the concentration-velocity covariance data the longitudinal diffusion coefficient could be evaluated directly from basic principles. The necessary equation is derived from the conservation of mass and is referred to as the Eulerian diffusion equation,

$$\frac{\partial \bar{c}}{\partial t} + \bar{u}_i \frac{\partial \bar{c}}{\partial x_i} = - \frac{\partial}{\partial x_i} \overline{c' u_i'} \quad (1)$$

A coefficient of turbulent diffusion may then be defined as

$$T_{ij} = \frac{\overline{c' u_i'}}{\bar{u}_j} \quad (2)$$

No simplifying assumptions have been made in these equations and it is thus felt to be a true representation of the diffusion process.

Diffusion coefficients obtained by the direct method are compared with those obtained by the semi-empirical methods. The comparison makes possible the evaluation of the validity of the assumptions made in obtaining diffusion coefficients by earlier methods.

The results also include intensities, autocorrelations and power spectra for the velocity and concentration signals at various selected points in the flow.

An evaluation and description of the equipment along with data reduction procedures are discussed in detail.

ACKNOWLEDGMENT

Publication of this abstract was authorized by the Director of the United States Geological Survey, Washington, D. C..

SYMBOLS

\bar{c}	time average concentration
c'	fluctuating concentration
t	time
u_i'	fluctuating velocity in x_i - direction
\bar{u}_i	time average velocity
x_i, x_j	space coordinates
$\epsilon_{T_{ij}}$	coefficient of turbulent diffusion
$\overline{c' u_i'}$	covariance of concentration and velocity

¹Research Hydraulic Engineers.