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Concentration and Velocity Structure of Self-Preserving Steady Round Buoyant Turbulent Plumes in Crossflow FRANCISCO J. DIEZ, LUIS P. BERNAL, GERARD M. FAETH, University of Michigan — The structure of self-preserving steady round buoyant turbulent plumes in uniform crossflows were studied. The experiments involved a round salt-containing (sodium phosphate) water source jet injected into an ethyl-alcohol/water crossflow to match the refractive indices of the two flows in a water channel. Planar-Laser-Induced Fluorescence (PLIF) was used to measure mean and rms fluctuating concentrations of source fluid whereas Particle-Image-Velocimetry (PIV) was used to measure mean and rms fluctuating velocities, both over cross-sections of the flow. Self-preserving behavior was reached when the plumes were deflected into nearly the crossflow direction, yielding counter-rotating vortex systems similar to self-preserving line thermals. As a result, achieving self-preservation was strongly affected by the source/crossflow velocity ratio, e.g., the self-preserving region was observed for $(x_c\text{-}x_{os})/d$ greater than the following values: 25 (u_o/v_∞=5), 110 (u_o/v_∞=50) and 170 (u_o/v_∞=100). At self-preserving conditions, it was possible to construct contour plots of concentration and velocity properties over the flow cross section using scaled self-preserving variables. Another interesting property of these flows is their surprisingly rapid mixing; this was indicated by a flow width for plumes in crossflows that was 2.7 times larger than that of plumes in still surroundings.

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