A Computational Fluid Dynamic (CFD) Evaluation of a Proposed Model for Determining the Fraction of a Release Recirculated in a Building Wake

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Louis Restrepo and Kyle Ross
OMICRON Safety & Risk Tech., Inc.
(505) 883-0553

Turbulent flow patterns and recirculation cavities created near buildings can significantly effect the downwind transport and dispersion of hazardous materials and the associated dose to individuals. Concentrations and related doses are proportional to the fraction of the material release that is trapped (recirculated) in the building wake cavity.

The evaluation of the fraction of released material that is trapped by the building wake cavity is extremely important in determining the potential doses to individuals located within the building wake as well as to individual further downwind (within about 5km).

The model proposed most recently for estimating the fraction of a release from the top of a building that would be captured (recirculated) in the building wake was developed analytically by integrating the Gaussian dispersion that would occur between the plume centerline height and the ground [Wilson, 1995]. That is:

$$f_c = \frac{1}{2}\left[1 + erf\left(\frac{H_b - h_c}{\sqrt{2s'_z}}\right)\right]$$

Where, f_c is the fraction of the plume or release segment that is captured or trapped by the building wake cavity; erf is the error function; h_c is the plume centerline height, and s'_z is the vertical dispersion parameter (m) characterized by the correlation:

$$s'_z = 0.21R^{1/4}\left(x_b + L_R\right)^{3/4}$$

where R is the building scaling length (a function of the building dimensions, m), X_b is the downwind distance from the source to the building edge (m), and L_R is the length of the recirculation cavity.

This model is correlated to the dimensions of the building and the wake cavity. Preliminary analyses using Computational Fluid Dynamics (CFD) computer codes such as FLOW3D® clearly show that capture fraction is also a function of the atmospheric conditions (e.g., wind speed) at the time of the release.

Results of CFD simulations of f_c, in which wind speed, release height, and stability conditions (turbulence intensity) are varied will be presented and discussed. The impact of stability conditions will be approximated by variations of the diffusion properties of the material being released. This paper will discuss the modeling and results of such analyses based on the CFD results.

Reference:

[Wilson 1995] Wilson, D.J., *Numerical Modeling of Dispersion from Short Stacks*, Seminar 14: Accuracy and Realism of ASHRAE Handbook Estimates of Exhaust Gas Contamination of Nearby Air Intakes, American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc., Atlanta, GA, 1995.