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than those on the mean plume axis. Various observations of P/A as a function of distance from the source, the relative level of source and receptor, and the times over which the peak and average concentrations were obtained are discussed in Chap. 4.

In principle the theoretical results of Sec. 3-3.2 on fluctuating plumes and the above paragraphs apply equally to other diffusion conditions and not just to looping. The looping condition, however, makes visually evident the separation between plume spreading and meander.

3-3.5.1.4 Coning. Coning is the straightforward, relatively uncomplicated case of diffusion in a neutral or slightly stable atmosphere and is handled by means of Eq. 3.116, evaluated for the Pasquill type C or D conditions. Figure 3.19 shows an instantaneous photograph and a time exposure of a coning plume.

3-3.5.1.5 Lofting. Since a ground-based inversion prevents material from reaching the surface, lofting is of practical importance largely as the possible precursor of a fumigation. A reasonable scheme for estimating concentrations in the lofting plume might simply be to treat the inversion base as the level z = 0 and to apply Eq. 3.116 (with h = 0 to obtain concentrations along the plume center line) although there are no concentration observations confirming this suggestion.

3-3.5.2 Volume-source Formulas. Because of the possible emission of airborne radioactive material through leaks in a reactor-containment structure, Eq. 3.116 should be modified for the effect of a volume source. In a reactor-hazard analysis, the source generally consists of some fraction of the fission products contained in the reactor core, and the source material is assumed to be distributed uniformly throughout the volume of the building enclosing the reactor. For many power reactors the enclosure is a large pressure-tight dome designed to have, at most, some specified leakage rate under the postulated accident conditions. The source strength, Q', is defined, but the location of the leak and the effect of the building on the source geometry must be determined.

Reasoning that a reactor building must have a turbulent wake in its lee, Fuquay (1960) suggested treating the building effect as an initial dilution factor, D_B,

$$D_B = cA\bar{u} \qquad (3.139)$$

where A is the cross-sectional area of the building normal to the wind. In other words, any material escaping from the containment building is assumed to be dispersed rapidly into a volume equal to c times the building cross-sectional area times the wind speed. The

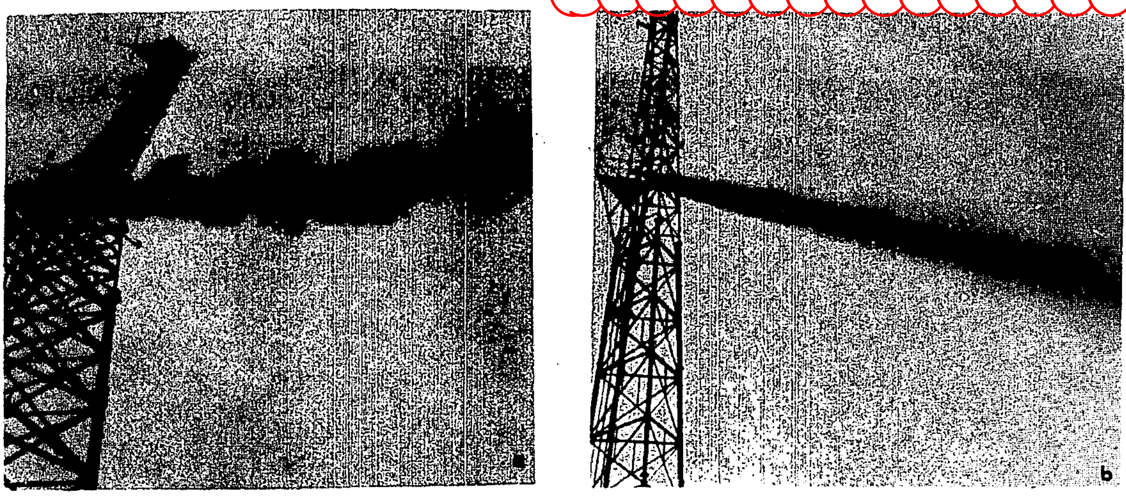

Fig. 3.19—(a) Coning plume using an exposure of 1/25 sec at the meteorological tower of the Big Rock Point reactor site near Charlevoix, Mich. (b) The same coning plume photographed with a time exposure of 5 min. (Courtesy W. M. Culkowski)

factor c represents an estimation of the relation of the cross-sectional area of the building to the size of observed pressure wakes, and its exact numerical value will have to be determined by suitable experiments. Gifford (1960) suggested that, as a reasonable estimate, $\frac{1}{2} \leq c \leq 2$. The reason for choosing these particular bounds, which were actually no more than a guess, was to provide, in the absence of suitable experimental data, usable numbers for concentration estimations. According to Barry (1964), who made an interesting and useful summary of the results of a number of recent experiments, studies with wind-tunnel models have suggested values of c near the lower of these limits, namely, $c = 0.50$ to 0.67. Of course, it is not impossible that larger values of c may be found if suitable full-scale atmospheric experiments are performed, particularly in unstable light-wind conditions. A comprehensive summary of relevant wind-tunnel measurements of building dilution effects is given in Chap. 5. A few atmospheric experiments have been reported by Islitzer (1965) and J. E. Martin (1965). A photograph from Martin's paper, Fig. 3.20, illustrates the building effect on the plume.

The building dilution factor, D_B, is combined with the atmospheric dilution factor, $D_A = Q'/\bar{\chi}$, in a way similar to Fuquay's (1958) handling of stack dilution,

$$D_{total} = D_B + D_A \qquad (3.140)$$

Combining Eqs. 3.116, 3.139, and 3.140, one can reasonably assume that, as suggested by Davidson (1965),

$$\frac{\bar{\chi}}{Q'} = (\pi \Sigma_y \Sigma_z \bar{u})^{-1} \exp\left[-\left(\frac{y^2}{2\Sigma_y^2} + \frac{h^2}{2\Sigma_z^2}\right)\right] \qquad (3.141)$$

where Σ_y and Σ_z are total diffusion factors given by

$$\Sigma_y = (\sigma_y^2 + cA/\pi)^{\frac{1}{2}}$$

$$\Sigma_z = (\sigma_z^2 + cA/\pi)^{\frac{1}{2}} \qquad (3.142)$$

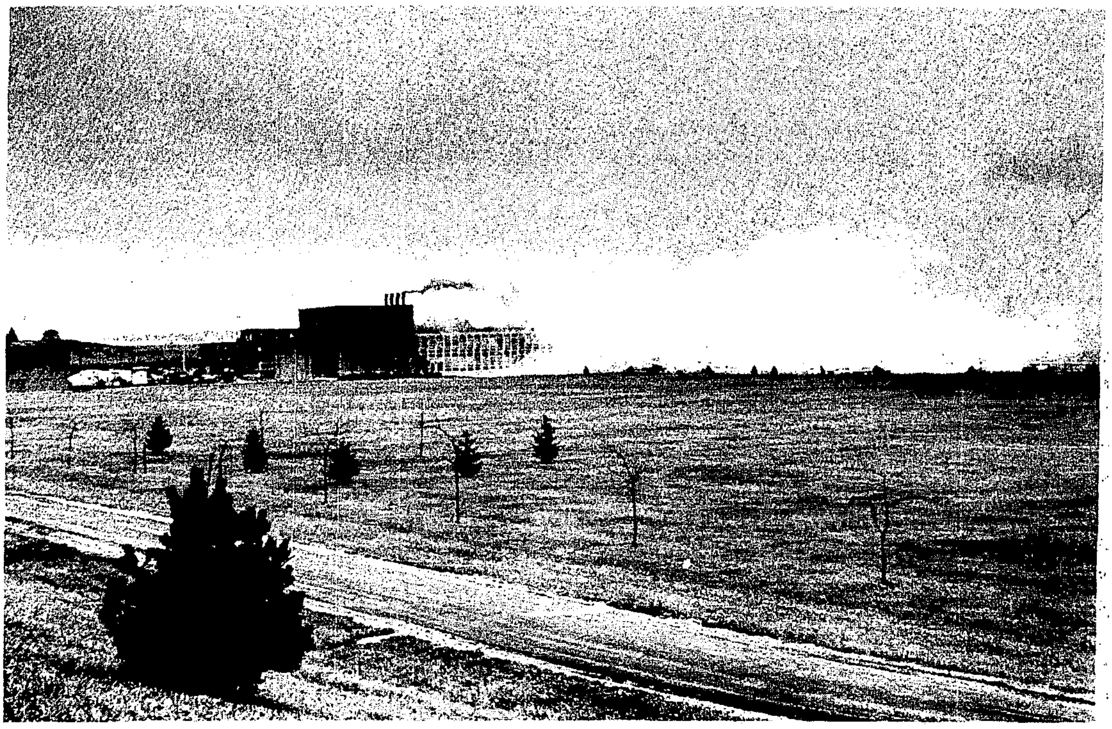

Fig. 3.20—A photograph of a smoke plume released from the top of a building during neutral conditions. (Courtesy J. E. Martin, 1965).