UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

May 11, 1988

MEMORANDUM

SUBJECT: Stack-Structure Relationships

FROM: Joseph A. Tikvart, Chief Signed
Source Receptor Analysis Branch

TO: Richard L. Daye, Regional Meteorologist
Region VII

In response to your request, the Model Clearinghouse has reviewed the generic question of how close a stack would be, in the crosswind direction, before the wake effects from a building should be considered when modeling with the ISC model. As you note, the ISC Users' Guide only provides general guidance, referring to a distance of 5L, where L is the lesser of the height or the projected width. We agree with you that the 5L distance is too large when the stack is in the vicinity of the structure in the crosswind direction.

Based on his familiarity with the ISC model and with wake effects phenomena, Russ Lee has prepared the attached technical analysis on the appropriate crosswind distance inside of which a stack should be modeled accounting for the wake effects. The analysis supports a crosswind distance of 1/2 L. The Model Clearinghouse agrees with the analysis and recommends that stacks located within a crosswind distance of up to 1/2 L from a building be modeled accounting for the wake effects from the building.

On a related matter, Region V has pointed out that the Clearinghouse had previously agreed that the upwind distance of a stack from a building for which wake effects should be included is 2L. The attachment recognizes that this distance is appropriate. Thus, the Clearinghouse recommends that stacks within 2L in the upwind direction be modeled accounting for the wake effects from the building.

Finally, page 2-38 of the ISC Users' Guide indicates that, for a very squat building (height to width ratio of less than 1 to 5), the area of influence of wake effects may extend out to 2.5L in the crosswind direction. Russ indicates that this distance is not well supported in the literature and believes that 1/2 L is still appropriate. The Clearinghouse agrees with this position.

In summary, the Clearinghouse recommends that the area of influence of a building for wake effects calculations extends 2L in the upwind direction, 5L in the downwind direction, and 1/2 L in the crosswind direction, where L is the lesser of the projected building width and height for that wind direction.

If you have any further questions, please contact Russ Lee (FTS 629-5684).

Attachment

cc: D. deRoeck
A. Huber
W. Keith
W. Laxton
S. Reinders
D. Wilson

ATTACHMENT

The Application of Wake Effects Calculations to Stacks Separated from Buildings

Russell F. Lee

The most recent revision of the Industrial Source Complex Dispersion Model makes use of wind direction dependent building height and width for certain building wake effects calculations. Separate values of building height and width can be input to the model for each wind direction. For cases where a stack is separated from a building causing the wake effects, it is now possible for the model to account for wake effects when the stack is upwind or downwind from the building, and to ignore wake effects when the stack is crosswind from the building. Current guidance specifies that wake effects calculations should be applied when a stack is within 5L of a building, where L is the lesser of the height or the width of the building. For any given wind direction, the "5L rule" for the "region of influence" is appropriate for stacks in the downwind direction. The region of influence in the upwind direction is considered to be 2L as reflected in a memorandum to Michael Koerber from Joseph A. Tikvart dated March 6, 1985. While the building wake does extend in the crosswind direction from the building, its extent is certainly less than 5L. For stacks in the crosswind direction from the building, it is not clear from current guidance at what distances the wake effects calculations should be applied.

Briggs ("Diffusion Estimation for Small Emissions, 1973) recommends using 1/4 L. (Briggs also recommends 3L in the downwind direction.) Hosker ("Flow and Diffusion Near Obstacles", Chapter 7 of Atmospheric Science and Power Production, D. Randerson, Ed., 1984), recommends a more complex formula, for the width of the cavity, which is equivalent to values ranging from about 0.5L to about 0.8L for buildings having width to height ratios ranging between 1/5 and 5.

Page 2-38 of the ISC Users' Guide states that for a building width to height ratio of "greater than 5 and a stack located laterally within about 2.5 [L] of the end of the building, lateral plume spread is affected by the flow around the end of the building." This comment has been carried forward from the original ISC Users' Guide which was published in 1979. This appears to be a suggestion of the original authors of the ISC model. Although it is known that the area of influence to the side of a building will be larger (in terms of L) for very squat buildings, the suggestion of 2.5L does not appear in the literature sited in the ISC Users' Guide. It should, therefore,

be treated as an early suggestion, and that preference be given to the results of the research quoted above.

It is therefore recommended that wake effects calculations be applied when modeling the impact of emissions from a stack that is within 1/2 L of the side of the building in the crosswind direction, provided the stack is also within the 5L distance downwind, or 2L upwind, of the building. This is determined from the projection of the building and stack on a plane perpendicular to the direction of the wind. For example, in Figure 1, wake effects calculations should be applied when modeling the emissions from any stack located within the area circumscribed by the outer lines for the specified wind direction. Of course, any particular stack may be influenced by wake effects for some wind directions and not for others.

This problem has been discussed informally with Alan Huber and he agrees that the "1/2 L rule" as described above is a reasonable approach.

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                    Wind direction
                    --------------->

 ____________________________________________ __
|            ____  _ _ _ _ _ _ _ _ _ _ _ _ _ |  __ 1/2 L
|        ___|  |___                          |
|        |         |                         |
|        |Building|                         |
|        |_____    |                         |
|              |___| _ _ _ _ _ _ _ _ _ _ _ _ |  __
|____________________________________________|  __ 1/2 L

|<--2L->|          |<--------5L------->|
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Figure 1

Plan View of Area of Influence of Building Wake Effects