ATTACHMENT 2

COMMENTS ON ISSUES DISCUSSED AT MEETING JUNE 8, 1994 AT OAQPS OFFICES AT RESEARCH TRIANGLE PARK

Submitted by

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Criteria for Selecting Equivalent Buildings

We suggest that the criteria for selecting the equivalent building should be that:

a. the equivalent building produces an overall maximum ground-level concentration which exceeds 90% of the overall maximum ground-level concentration observed with the model of the actual site configuration in place; and

b. the equivalent building produces longitudinal maximum ground-level concentrations which exceed at each downwind distance the longitudinal maximum ground-level concentration observed with the model of the actual site configuration in place less 20% of the overall maximum ground-level concentration with the model of the actual site in place.

These criteria shall be applied at all downwind distances *beyond the cavity region of the actual downwash structure.*

A review of selected data from some of our projects suggests that the secondary criteria (b. above) provides an adequate buffer from the vagaries of low concentration data which may be near detection limits in some cases. Including as well the additional restriction that the comparisons would only be made when the concentrations were greater than 30% of the overall maximum would result in little change in outcome for the additional complication of the technique. We feel that the 30% criteria is unnecessary.

Upon reflection, we feel that the cavity region should be excluded from the comparisons for selection of an equivalent building. The equivalent building is intended to provide a wake similar to that for the actual structure. It is not intended to provide a similar cavity region. Our perusal of a sampling of the data suggests that including the cavity region in the comparisons will prevent an equivalent building from being selected in cases which would otherwise provide appropriate concentrations at points downwind of the cavity region.

Rather than simply excluding all points in an assumed cavity region of length $3L_b$, we suggest that all points should nominally be accepted for the comparison except those reflecting high concentrations close to the source (which imply a cavity region phenomena). Exclusion of such points from the comparison would be at the discretion of the analyst on the basis of a qualitative or quantitative demonstration that the points are within the cavity region. Such demonstrations can be accomplished, for example, with long-exposure photographs of smoke released at selected points around the model of the actual building.

Wind Tunnel Configurations for Tests

Wind tunnel tests are to be conducted to characterize the concentrations associated with 1) the actual site configuration and 2) the equivalent building configuration. The tests of the actual site configuration will be conducted with a model of the site on the turntable. The remainder of the tunnel floor will be covered with a uniform density of randomly distributed roughness elements ("uniform roughness") to simulate the actual aerodynamic roughness of the site. Three approaches to configuring the wind tunnel for the simulation of equivalent building flows have been discussed. These include:

- **Removal of selected buildings.** In this approach, the tunnel is configured in the same manner as for the simulation of the actual site except that selected buildings are removed from the model. The intent is to identify for removal buildings which contribute to the downwash condition.
- **Use of a turntable of uniform roughness matching the roughness of the actual site.** In this approach, the aerodynamic roughness of the actual site is documented by velocity profiles downwind of the model of the actual site for a variety of wind directions. A roughness, or set of roughnesses, is then chosen to adequately represent the general aerodynamic roughness of the site. A uniform roughness to match this is installed on the turntable in place of the actual site model. Different roughness distributions may be required for different wind directions.
- **Use of a uniform roughness across the entire tunnel floor.** In this approach, a uniform roughness matching that of the rest of the tunnel is installed on the turntable in place of the actual site model.

  In all of the equivalent building simulations, the tunnel floor (except for the turntable) is covered with the same uniform roughness as used in the simulation of the actual site configuration.

We feel that the best approach is to use the uniform roughness throughout the wind tunnel. It is the most consistent with the "universe" of ISC and avoids significant complications introduced by the other two methods. These complications will increase the time and expense of the studies without significantly improving the results. The approach of removing only "nearby" buildings affecting downwash introduces the following complicating factors:

1) The modeler must determine which buildings to remove. The selection of "nearby" buildings could be based (among other approaches) on the BPIP algorithm, wind tunnel experimentation or the judgement of the modeler.
2) Once the buildings have been removed, there is the issue of whether roughness elements should be placed in the open space to maintain the ambient turbulence of the flow.
3) The buildings that remain during the wind tunnel tests present potential obstacles to placement of the sampling grid which can interfere with the observation of the maximum concentrations.

The approach of replacing the turntable with uniform roughness matching the roughness of the model requires that the aerodynamic roughness of the site model be measured for a variety of wind directions, and that matching uniform roughness be installed. The uniform turntable roughnesses might not be constant with direction. An additional set of equivalent building simulations would be required for each different roughness chosen as representative of a range of wind directions. This approach does avoid the disadvantage of possible interference of the sampling grid layout.

The two more complex configurations for equivalent building simulations will provide concentration data which are closer to what would actually be observed in the real world in the absence of the structures inducing downwash. However, they can not be expected to produce a set of equivalent building dimensions which result in as accurate a set of ISC predictions as the use of the uniform roughness setup. This is primarily because the uniform roughness approach is the most consistent with the universe of ISC (and most other Gaussian models). Again, we recommend the use of the uniform roughness approach as the choice that is most likely to produce the highest quality concentration predictions from ISC (and other Gaussian models) and avoids unproductive complications involved in the alternative approaches.

Flexibility should be included to allow advantage to be taken of improvements in the dispersion models as they become available. It is expected that such improvements might include options to 1) vary surface roughness values with direction and downwind distance and 2) allow the use of building configurations other than 1:2:1. The equivalent building technique should include these options as the model universe is expanded.

Model Design Issues

The model must be designed to provide a good correspondence between the real world air flows and the air flow in the tunnel taking into account the general features of the real air flow and the limitations of the wind tunnel. Assuming that the fluid similarity requirements (Reynolds number, etc.) are satisfied, the primary limitations of the wind tunnel are that the spatial resolution is limited and that air flow at the sides of the tunnel follows the walls. So one must be wary of horizontally convergent or divergent flows such as in narrowing river valleys or around large terrain obstacles. The model must also be large enough that the sampling grid can resolve the spatial peaks in ground-level concentration patterns with sampling grids composed of tubing approximately 1/8 inch in diameter. As a general guideline, we note that in most applications of this type, a well-designed model will include all structures within a 400 m to 1000 m radius of the stack under evaluation and that the model scale reduction will range from 1:200 to 1:1000. The report should discuss the model design, and calculations should be provided to show that the model does not significantly block the flow in the wind tunnel. Additional information regarding these issues is provided below.

Size of the Model. The EPA Fluid Modeling Guideline (Snyder, 1981) suggests that buildings be included in the model whose distance upstream is 20 times the height of the building (for roughly cubical buildings) or 100 times the height of the building (for buildings whose width is much greater than the height). This criteria will require that the scale model typically include buildings within a 400 to 1000 m radius from the stack. It should be noted that this criteria is based on restoring the mean velocity to within 3% of the value without the buildings present. One reason a building could be excluded is that several taller buildings are located between the building and stack. These taller buildings would dominate the flow field and thus make the inclusion of the smaller upwind building unnecessary. The effect of this upwind building could be accounted for in the approach roughness (i.e., urban).

To address this issue, the report should include a map and discussions showing that the criteria has been met, or if it hasn't, provide the rationale for why it is acceptable to violate the criteria in this case. When the model coverage can not be adequately defended, review at a higher level may be advisable.

Model Scale. The EPA Fluid Modeling Guideline (Snyder, 1981) suggests that the length scale reduction for the wind tunnel model should range from 1:200 to 1:1000 for studies involving flow around buildings. This range of scale reductions seems reasonable based on our experience. The report should, however, include some discussion regarding the model scale selection criteria.

Another factor to consider in specifying the model scale is whether the model produces a blockage to the airflow in the wind tunnel. The EPA Fluid Modeling Guideline recommends that blockage be less than 5% (ratio of total crosswind building area to wind tunnel cross sectional area) for tunnels with a fixed roof and 10% for tunnels an adjustable roof. A calculation should be provided in the report showing that the model provides less than 5% blockage (fixed roof tunnel) or 10% blockage (adjustable roof).

Blockage effects can also be more localized as in the case of a building between the stack and the tunnel side wall. If the building is too close to the wind tunnel side wall, the flow downwind of the building may not be accurately simulated. If a building is more than several building heights from the stack (in the crosswind direction), its effect on plume dispersion is probably insignificant and the building proximity to the tunnel wall is unimportant. If one side of the building is close to the stack (say 1 to 3 building heights), and the other side close to the tunnel wall, the building wake simulation may be flawed. This issue should be addressed in the report. For questionable cases, review at a higher level may be required.

Quality Assurance

We are attaching a set of checklists which we use at CPP as part of our quality assurance plan. These checklists should provide a pretty good idea of what is involved in a well-run test program. The checklists attached include:

Model Information Checklist
Boundary Layer Checklist
Quality Control Checklist (calibrations and certifications)

Standard operating procedures which should typically be incorporated in an acceptable test program include the following:

Calibration Procedures for All Instruments

- Pitot/Static System (calibrated against manometer)
- Hot-Film Anemometers (calibrated using TSI flow calibrator or pitot/static system)
- Flow Meters (calibrated against a Gilibrator or similar bubble meter displacement apparatus)
- Syringe Air Sampling System (system check by sampling a uniform calibration gas in all syringes - sample-to-sample intercomparisons within 3 percent for all samples)
- Gas Chromatograph (linearity checks every 6 months; single-point recalibration using certified gases at the beginning each set of 50 samples)

Data Acquisition Procedures:

- Obtaining Vertical Profiles of Velocity and Turbulence Intensity
- Obtaining Time-Average Concentration Data

Repeatability was discussed as an overall demonstration of the quality control on a project. The same simulation can be run twice to observe the differences from one run to the next. An example of a fairly typical repeatability exercise is included as Figures 1 and 2. Figure 1 is a scatter diagram in which each point represents the concentrations observed for the two runs at a single receptor. The solid line represents a perfect match and the dotted lines show the 10% repeatability limits. Most of the significant data, and all of the high concentration data, fall within the 10 percent repeatability criteria. Those that do not are plotted as open squares to make them easy to see.

Figure 2 shows the sampling grid which produced the data in Figure 1. The source is located at the origin of the plot. The receptor locations which experienced repeatability within 10 percent are plotted as solid squares, those outside the 10 percent range are plotted as open squares. The results are fairly typical in that we experience reduced repeatability at the edges of the plume and close to the source where the variability of the instantaneous concentrations is high. The repeatability could be improved by significantly increasing the sampling time, but no change in the conclusions of study would be expected.

MODEL INFORMATION --- Project No.
Project Manager:
Date:

ITEM	DESCRIPTION	INITIAL & DATE WHEN COMPLETE
A. Model scale		
B. Building to construct		
1.		
2.		
3.		
4.		
5.		
C. Terrain to Construct		
1. Upwind		
2. Downwind		
D. Wind Directions		
E. Source Description		
1. Number of Stacks		
2. Stack Diameters, (in)		
3. Stack Flow Rates,(cm3/s)		
4. Stack Locations.		
5. Trip Required?		
F. Concentration Sampling Grid (Include Sketches)		
1. Ground level		
2. Building Taps		

BOUNDARY LAYER CHECKLIST --PROJECT ____________________
PROJECT MANAGER: ____________________
DATE PREPARED: ____________________

VELOCITY PROFILE	Target	Actual	INITIAL & DATE WHEN COMPLETE
Turbulence Profile	Fit Snyder		
Power law exponent -- attach velocity profiles results			
Surface roughness, zo (cm) -- attach velocity profile results			

TUNNEL SETUP	DESCRIPTION	INITIAL & DATE WHEN COMPLETE
Model type (Flat Terrain, Complex Terrain)		
Reference height, (ft)		
Reference location		
No. of spires		
Spacing of spires, (ft)		
Height of spires, (ft) and spire type		
Height of trip, (in)		
Length of roughness upwind of turntable		
Distance from upwind edge of spire to trip		
Roughness setup		
Other notes		
1.		
2.		
3.		
4.		

Quality Control Check List -- Project No: Project Manager: Date:		
Item	Date Completed	Initial
1. GC Calibration. Take multipoint calibration at least once every two months. Attach copy for project file.		
2. Sampling System Check. Perform at least every two months. Attack copy for project file.		
3. Sampling Tube Inlet Flow Check. Check 10 points every 6 months and attach results.		
4. Volume Flow Calibrations. Calibrate flow rator for all new gas mixtures and every 6 mo for old mixtures. Insure backpressure effects are accounted for.		
5. Reference Velocity Calibration. Check DM against pitot once a day. Attach summary of cks.		
6. Velocity Traverse System. Calibrate once every 6 months. Attach results.		
7. Velocity Calibrations for Profiles. Attach.		
8. Check the scale of the model by measuring dimensions on the model and comparing to full scale. Attach results.		
9. Calibrate pressure transducer every 3 mo. Attach results.		
10. Attach certifications for source and calibration gas mixtures.		

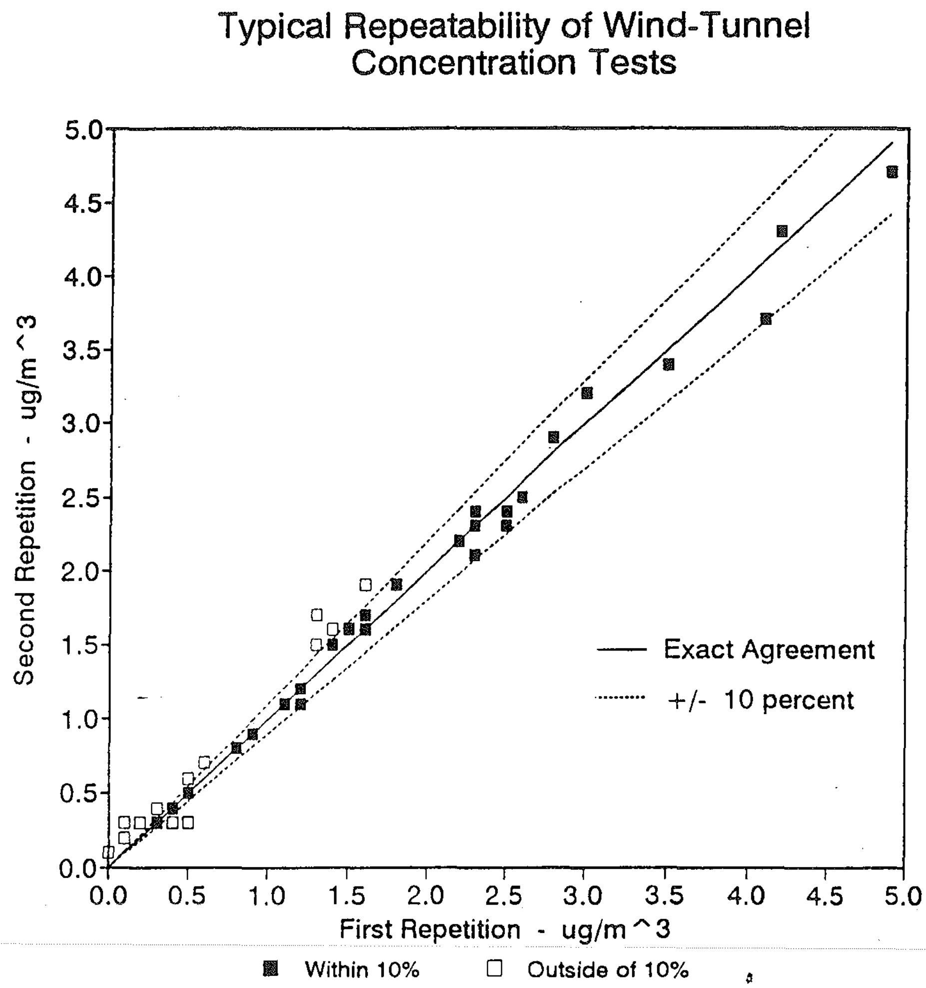

Figure 1. Repeatability Scatter Diagram

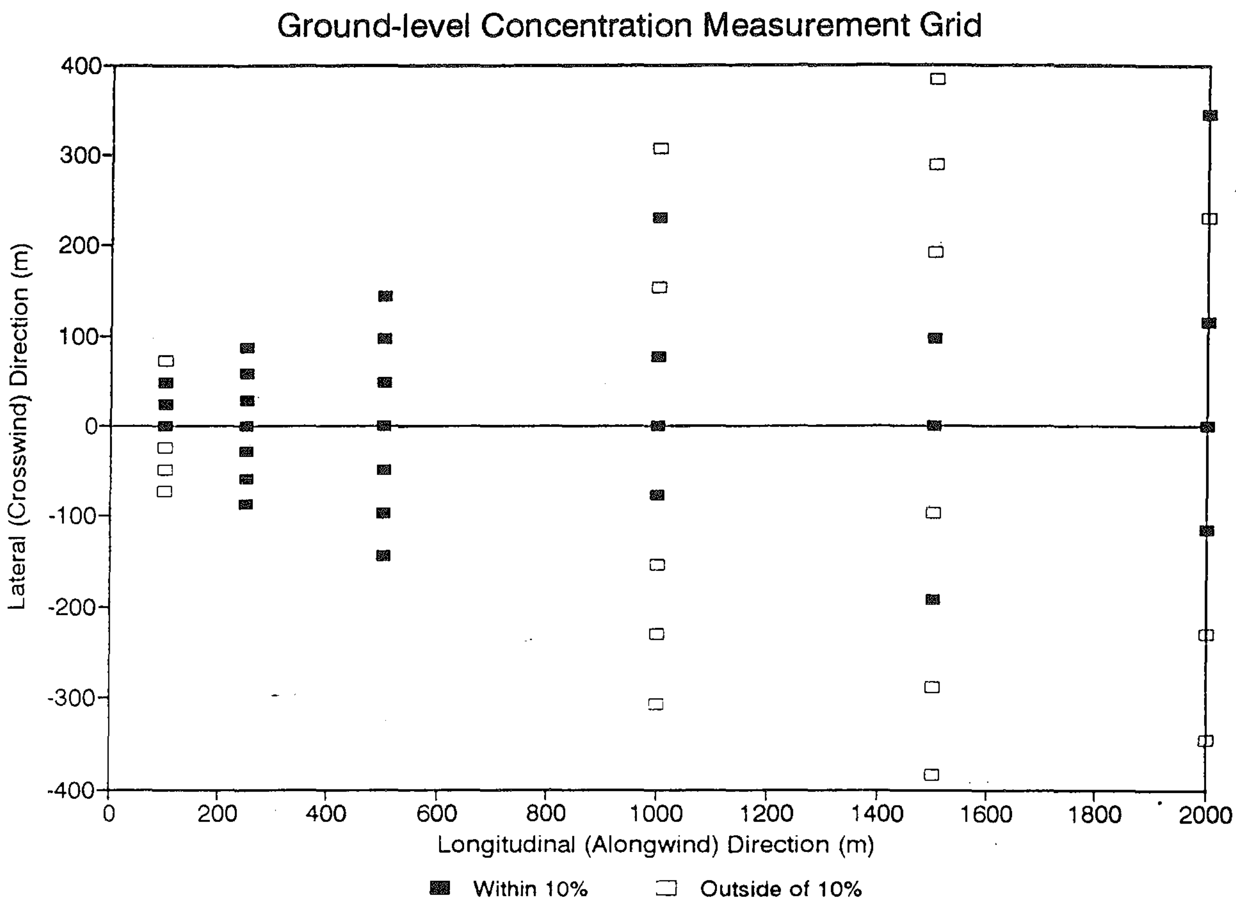

Figure 2. Receptor Locations