PRACTICAL USER TIPS FOR ARCON96

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INTRODUCTION

ARCON96 is a NRC-sponsored air dispersion model (Ref. 1) for estimating atmospheric relative concentrations (X/Qs) in building wakes. The revised ARCON96 Rev. 1 code was issued by NRC in 1997. In March 2000, NRC conducted a panel discussion for control room habitability analysis at nuclear power plants. In that panel discussion, comments and questions were raised by technical people from consulting firms and utility companies regarding the functionalities of ARCON96.

NRC requested that the original code developer – Pacific Northwest National Laboratory - revise the code based on recommendations raised in the panel discussion. However, instead of revising the code, NRC issued Regulatory Guide 1,194 (Ref. 2) in 2003 to provide guidance on the proper use of ARCON96.

The purpose of this paper is to provide some practical tips that are not discussed either in the ARCON96 User's Guide (NUREG/CR-6331) or in RG 1.194, so that users may make better use of their time in setting up modeling entry, and avoiding some common mistakes.

AREAS OF INTEREST

Release Mode

ARCON96 offers three possible release modes – ground, vent and stack (elevated). However, NRC at present time does not recognize the vent release mode unless the user provides sound justifications. If a release point is lower than 2.5 times the height of the adjacent structures, it is considered as a ground-level release. Evidently this approach is rather conservative especially if the vent height is only slightly lower than 2.5 times the height of any adjacent structures. Because ARCON96 does not calculate plume rise, treating a vent release with significant plume rise as a ground-level release is typically conservative.

NRC allows users to add an estimated plume rise to be part of the release height. Unless the code is able to calculate hourly plume rise internally, the inclusion of a representative plume rise is not as simple as expected because the user needs to know the specific plume rise associated with the worst case X/Q value.

Consequently, unless the vent release height is relatively high and the plume rise is significant, it is suggested that the vent releases be treated as ground-level releases in the model.

Release Height

ARCON96 calculates a "midpoint height" between the lower and upper wind instrumentation heights. When the release height is below or higher than this midpoint height, X/Q is calculated using the lower or higher wind data, respectively. The applicable wind speed data are extrapolated upward or downward accordingly to be representative of the release height. This approach exists in the code but both RG 1.194 and User's Guide fail to address the issue explicitly. ARCON96 will perform the above approach even if the user intends to model a vent release as a ground-level source as long as the vent release height is above the "midpoint height".

If both the release height and the receptor height are above the ground level, the model will calculate the proper X/Qs if the actual release height and receptor height are entered as input. However, since a vent release could be treated as a ground-level release, the user may inadvertently enter the absolute release height and receptor height instead of the actual heights above grade.

For example, assume that the vent release and the control room air intake heights are 300 ft and 200 ft above grade, respectively. The lower and upper wind instrumentation heights are 33 ft and 197 ft above grade, respectively. ARCON96 will internally calculate an instrument midpoint height of 115 ft. If the user enters the absolute vent release height and intake height as 100 ft and 0 ft, respectively, instead of the actual 300 and 200 ft, the code would not calculate the X/Qs properly. When the user treats the vent release as a ground-level release as suggested by RG 1.194, the user might incorrectly choose to enter the absolute release height (100 ft) and intake heights (0 ft) in this case. Since the actually vent release height is 300 ft, which is greater than the instrumentation midpoint of 115 ft, the code will calculate X/Qs using the upper wind data. Instead, if the user enters an absolute vent release height of 100 ft, the code would end up using the lower wind speed data. Subsequently, the X/Qs would not be calculated correctly.

This kind of error could be avoided if RG 1.194 or the Users Guide explicitly discusses the approach of using the wind instrumentation midpoint to determine the wind speed, especially involving a vent release. To limit uncertainty, it is suggested that users always enter the actual release and receptor heights in ARCON96 modeling.

Wind Direction

Traditionally, north wind (wind coming from north) is recorded as either 0 or 360 degrees. Clam hours may be defined as hours with no wind or when wind speeds lower than the instrument threshold wind speed. During such below-threshold wind speed hours, the wind direction is undefined. In practice, sometimes clam hours are recorded as 0 degree wind direction with zero wind speed. However, the Users Guide does not indicate that 0-degree wind direction is treated as calm. In the ARCON96 computer code, the valid wind directions are within the range of 1 to 360 degrees. Users need to be careful that when running the code, the meteorological input data should not have north wind recorded as 0 degree, but instead 360 degrees.

Building Area

Since the main purpose of ARON96 is to estimate X/Qs within the wake region, a directional-dependent building cross-sectional area which creates the wake impact area should be a crucial input parameter. For simplicity, an actual building vertical cross-sectional area, perpendicular to the wind direction that is expected to have the largest impact on the building wake within the wind direction window, is an input parameter for ARCON96 modeling. This approach is conservative as the smallest wake area would result in higher X/Qs. However, ARCON96 is not particularly sensitive to the building area, especially when the wind speed is low. For example, building areas of 0.01 m^2 and 900 m^2 were used to determine the difference in X/Qs, where 0.01 m^2 is suggested by RG 1.194 if a zero entry is desired. To ensure that the receptor is located within the wake impact region, a short downwind distance of 60 m was selected for the testing. The results indicate that for wind speeds lower than 2m/s, the building area has insignificant impact to calculated X/Qs. The wake-related X/Q values are never higher than 3% of those produced for non-wake scenario. This finding is not surprising because wake effect is more prominent when the wind speed is moderate or high. Past experience has shown that the worst case ARCON96-produced X/Q values usually occur under 3 to 4 m/s winds. The conventional Gaussian dispersion model would produce worst case X/Q when the wind speed is low (e.g., 0.5 m/s or 1 m/s depending on the agency's requirements). Because of the wake models used for ARCON96, users are expect to have wind speeds that are associated with the worst case X/Q to be within the ranges of 3 to 4 m/s. This could be important because some users might wonder why the worst-case X/Q is not associated with the lowest wind speeds.

Wind Speed

As an extension of the above discussion regarding wind speed, for a vent release ARCON96 would determine a midpoint for the wind instrumentation heights, then extrapolate wind speed accordingly based on the release height. This practice is reasonable if the releases are not under the influence of wake. If a vent release height is lower than the cavity height (roughly about 1.5 building height above ground level) (Ref. 3), the effluent would be caught by the wake and re-circulated within the cavity zone.

To access concentrations inside the cavity zone, it is commonly assumed that the effluent is uniformly distributed (Ref. 4). In other words, for approximation purpose, wind velocity inside the wake could be assumed to be constant in estimating concentrations, regardless of the height within the wake zone because the wake region extends all the way to the ground level. However, for a vent release located at a level higher than the instrumentation midpoint, ARCON96 calculates X/Qs based on wind speeds extrapolated to the release height even if the release is within the wake region. This practice implies wind speeds at higher levels within the wake region are higher than those at lower levels. Further research and testing is required to support this approach. Until NRC further clarifies this issue, it is suggest actual release and receptor heights be used in ARCON96 modeling.

SUMMARY

- Always treat vent releases as ground-level releases, unless sound justification could be made;

- Always enter actual above grade heights for the vent release height and receptor height in modeling, instead of entering absolute heights;

- Make sure north winds are recorded as 360 degrees, instead of 0 degree in the input meteorological data set;

- The worst case ARCON96 calculated X/Qs usually occur under 3 to 4 m/s winds;

- ARCON96 is not sensitive to the building area when the wind speeds are low.

REFERENCES

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3. Guideline for Determination of Good Engineering Practice Stack Height, EPA-450/4-80-023, U.S. Environmental Protection Agency, July 1981.

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