RS-002, "PROCESSING APPLICATIONS FOR EARLY SITE PERMITS"

ATTACHMENT 2

2.3.4 SHORT-TERM DISPERSION ESTIMATES FOR ACCIDENTAL ATMOSPHERIC RELEASES

REVIEW RESPONSIBILITIES

Primary - Probabilistic Safety Assessment Branch (SPSB)

Secondary - None

I. AREAS OF REVIEW

This section of the site safety assessment for an early site permit (ESP) application concerns atmospheric dispersion estimates for postulated accidental releases of radioactive effluents to the atmosphere. Section 2.3.4 of this review standard applies to dispersion estimates for radiological releases to the exclusion area boundary and low population zone. Because little detailed design information is likely to be available for a nuclear power plant or plants that might be constructed on the proposed site at the ESP stage, dispersion of airborne radioactive materials to the control room will be evaluated at the combined license (COL) stage. The review covers the following specific areas:

1. Atmospheric transport and diffusion models to calculate relative concentrations for postulated accidental radioactive releases.

2. Meteorological data summaries used as input to diffusion models.

3. Specification of diffusion parameters.

4. Probability distributions of relative concentrations.

5. Determination of relative concentrations used for assessment of consequences of postulated radioactive atmospheric releases from design basis and other accidents.

Potential non-radiological accidents on or in the vicinity of the site that could affect control room habitability (such as toxic chemical releases) are addressed in Section 2.2 of this review standard.

II. ACCEPTANCE CRITERIA

The applicant should provide conservative estimates of atmospheric transport and diffusion conditions at appropriate distances from the source for postulated accidental releases of radioactive materials to the atmosphere.

These estimates are necessary to demonstrate compliance with 10 CFR 100.21 (Ref. 1) with respect to the meteorological considerations used in the evaluation to determine an acceptable

exclusion area and low population zone. Regulatory Guides 1.23[1] and 1.145 (Refs. 2 and 3) provide information, recommendations and guidance, and in general describe methods acceptable to the staff for meeting the requirements of 10 CFR Part 100. For light-water reactors, applicants using the "alternate source term" (AST) may use Regulatory Position 5.3 of Regulatory Guide 1.183 (Ref. 4) as guidance as appropriate. The NRC does not have a similar reference for reactors not cooled and moderated by light water.

The applicant's diffusion estimates should demonstrate that the requirements of 10 CFR Part 52 and 10 CFR Part 100 are met. Specifically, the following information is needed:

1. A description of the atmospheric dispersion models used to calculate relative concentrations (χ/Q values) in air resulting from accidental releases of radioactive material to the atmosphere. The models should be documented in detail and substantiated within the limits of the model so that the staff can evaluate their appropriateness to site characteristics, plant characteristics (to the extent known), and release characteristics.

2. Meteorological data used for the evaluation (as input to the dispersion models) which represent annual cycles of hourly values of wind direction, wind speed, and atmospheric stability for each mode of accidental release.

3. The variation of atmospheric diffusion parameters used to characterize lateral and vertical plume spread (σ_y and σ_z) as a function of distance, topography, and atmospheric conditions, as related to measured meteorological parameters. The methodology for establishing these relationships should be appropriate for estimating the consequences of accidents within the range of distances which are of interest with respect to site characteristics and established regulatory criteria.

4. Cumulative probability distributions of relative concentrations (χ/Q values) describing the probabilities of these χ/Q values being exceeded. These cumulative probability distributions should be presented for appropriate distances (e.g., the exclusion area boundary distance and the outer boundary of the low population zone) and time periods as specified in Section 2.3.4.2 of Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants" (Ref. 5). The methods of generating these distributions should be adequately described.

5. Relative concentrations used for assessment of consequences of atmospheric radioactive releases from design basis and other accidents.

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[1] References in Regulatory Guide 1.23 to Appendix D to 10 CFR Part 50 should be read as references to 10 CFR Part 51. For ESP applications, references in Regulatory Guide 1.23 to 10 CFR 100.10 should be read as references to 10 CFR 100.20.

III. REVIEW PROCEDURES

1. Atmospheric Dispersion Models

The applicant's dispersion models are compared to the general Gaussian models which are contained in Regulatory Guide 1.145 for design basis accidental releases. The models are reviewed for suitability to release characteristics, plant configuration (to the extent known), and site topography. The accidents and release characteristics to be considered are obtained from the reviews of safety assessment Chapter 15. When the models described in Regulatory Guide 1.145 are not applicable (e.g., buoyant gases), other models and techniques used to make estimates are identified and evaluated. Each release should be characterized as either an elevated point source or a ground-level point source. Generally the release point is considered to be elevated if it is at least two-and-one-half times as high as nearby solid structures. Turbulent mixing of the effluent into the wake of plant structures is usually allowed for ground-level releases (if sufficient information is available on the plant design to make this feasible).

Most accidental releases can be considered as continuous releases (i.e., on the order of several minutes or more). However, some releases, such as those resulting from steam line breaks, may be considered instantaneous (puffs). The general Gaussian diffusion model for continuous releases is used to evaluate releases on the order of several minutes or more. For puff releases, instantaneous point-source Gaussian diffusion equations are used with a correction for initial source volume. (Ref. 6)

Other modifications to the atmospheric dispersion model which should be considered include restrictions to horizontal or vertical plume spread (e.g., by narrow deep valleys, channeling of airflow, and by persistent low-level temperature inversions). Fumigation conditions should be considered for elevated releases transported to offsite locations. In the absence of site-specific information concerning the frequency, duration, and directional preference of fumigation conditions, a deterministic approach such as that described in Regulatory Guide 1.145 may be used.

2. Meteorological Data

The meteorological data used in atmospheric dispersion analyses are reviewed for compatibility with the models used. General criteria for onsite data are stated in Regulatory Guide 1.23 and in subsection III.2 of Section 2.3.3 of this review standard. Additional sources of meteorological data for consideration in the description of airflow trajectories from the site may include National Weather Service stations or other meteorological programs that are well maintained and well exposed (e.g., other nuclear facilities, university and private meteorological programs).

3. Atmospheric Diffusion Parameters

Measurement of vertical temperature gradient (Ref. 2) should be used to define atmospheric stability, particularly during stable conditions accompanied by low wind speeds (i.e., less than 1.5 m/s). Other classification schemes (Refs. 7 and 8) may be used to estimate atmospheric stability class or to determine plume spread parameters directly for unstable and neutral conditions, or for wind speeds greater than 1.5 m/s.

Methods for the classification of atmospheric stability, or for direct determination of plume spread parameters, should be adequately described and substantiated for applicability to the site.

Diffusion parameters σ_y and σ_z are reviewed with respect to the characteristics of the accidental release and distances of interest. The curves of σ_y and σ_z as functions of downwind distance and atmospheric stability as presented in References 3, 9, and 10 are acceptable for most sites with the addition of a curve for an extremely stable (Type G) class. For elevated releases (Ref. 11) or for unusual sources, meteorological conditions, or topography (e.g., narrow, deep valleys, channeling of airflow), modification of the σ_y and σ_z curves may be appropriate (Ref. 12). Modified curves that reflect the results of atmospheric tracer tests primarily during stable, light wind conditions may be used with the atmospheric dispersion model described in Regulatory Guide 1.145. Modified curves based on specific studies under conditions similar to those at the proposed site may also be considered for sites in or near unique terrain features such as deserts (Ref. 6) and large bodies of water (Ref. 13). Such specific studies should meet the criteria for the use of site-specific experimental data as outlined in Regulatory Position 7 in Regulatory Guide 1.194, "Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants," (Ref. 14).

For situations where a puff diffusion equation is used, $\sigma_x = \sigma_y$ is usually an acceptable assumption.

4. Cumulative Frequency Distributions of χ/Q Values

The cumulative probability distributions of χ/Q values are reviewed for inclusion of pertinent modes and time periods of release, and adequacy of input data in accordance with the guidelines set forth in Section 2.3.4.2 of the Standard Format (Ref. 5). The methods used to generate these distributions are reviewed for adequacy and conservatism.

An ESP application that references a certified design will need to verify that appropriate site-related meteorological parameters for the proposed site have been used to derive site-specific χ/Q values and that these values are consistent with (or bounded by) those identified in the site parameter envelope for the certified design.

5. Relative Concentrations Used for Accidents

The χ/Q values used for assessment of consequences of atmospheric radioactive releases for design basis accidents and other accidents are reviewed for appropriateness of atmospheric dispersion model assumptions and input data and adequate documentation of this information.

The staff makes an independent evaluation of atmospheric dispersion for pertinent distances, usually the exclusion area boundary and the low population zone outer boundary, using the appropriate meteorological data and dispersion model. Two probabilistic approaches are available for evaluating short-term atmospheric transport and diffusion characteristics.

a. A direction-dependent probabilistic approach using the χ/Q values which are exceeded 0.5% of the time in each of 16 directions from the plant site. This methodology is described in Regulatory Guide 1.145.

b. A direction-independent probabilistic approach using the χ/Q value which is exceeded 5% of the time. This methodology is described in Reference 15.

These values are assumed to represent conditions for a 2-hour period. χ/Q values for time periods greater than two hours are estimated for the low population zone (LPZ) distance by assuming either a logarithmic relationship between the "2-hour" value and the annual average value or a "sliding window" approach using hourly meteorological data. As applied herein, the term "sliding window" refers to the calculation of running mean χ/Q values for time periods varying from 1 to 720 hours in duration, using an averaging method similar to that used for control room χ/Q values as calculated by the ARCON96 computer code referenced in Regulatory Guide 1.194. The methodology is described in Sections 3.6, 3.7, and 3.8 of NUREG/CR-6331, Rev.1, "Atmospheric Relative Concentrations in Building Wakes" (Ref. 16). Any similar methodology that is applied to LPZ calculations should be made on a direction-dependent basis, analogous to that presented in Regulatory Guide 1.145.

These values of χ/Q based on appropriate models for appropriate time intervals and distances are used in the analyses presented in Chapter 15 for dose assessment of design basis accidents.

IV. EVALUATION FINDINGS

The reviewer verifies that adequately conservative atmospheric dispersion models and appropriate meteorological data have been used to calculate relative concentrations for appropriate distances and directions from postulated release points for accidental airborne releases of radioactive materials.

The reviewer's evaluation should support the following type of concluding statement, to be used in the staff's safety evaluation report (conclusions regarding the control room are not necessary for the ESP review):

As set forth above, the applicant has made conservative assessments of post-accident atmospheric dispersion conditions from the applicant's meteorological data and appropriate diffusion models. These atmospheric dispersion estimates are appropriate for the assessment of consequences from radioactive releases for design basis accidents in accordance with 10 CFR 100.21(c).

[For an ESP application referencing a certified standard design:] The applicant has used appropriate site-related meteorological parameters for the proposed site to derive site-specific χ/Q values, and these values are consistent with [or bounded by] those identified in the site parameter envelope for the certified design.

Based on these considerations, the staff concludes that atmospheric dispersion estimates are acceptable and meet the relevant requirements of 10 CFR Part 100.

Atmospheric dispersion estimates for the control room from radioactive releases will be addressed in the review of the combined license (COL) application.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants regarding the NRC staff's plans for using this section of this review standard.

This section will be used by the staff when performing safety evaluations of ESP applications submitted by applicants pursuant to 10 CFR Part 52. Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

VI. REFERENCES

1. 10 CFR 100.21, "Non-Seismic Siting Criteria."

2. Regulatory Guide 1.23, "Onsite Meteorological Programs."

3. Regulatory Guide 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants."

4. Regulatory Guide 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors."

5. Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants."

6. G. R. Yanskey, E. H. Markee, and A. P. Richter, "Climatography of the National Reactor Testing Station," IDO-12048, Idaho Operations Office, USAEC (1966).

7. Hanna, S. R., G. A. Briggs, J. Deardorff, B. A. Egan, F. A. Gifford, and F. Pasquill, "AMS Workshop on Stability Classification Schemes and Sigma Curves-Summary of Recommendations," Bulletin of the American Meteorological Society, Vol. 58, No. 12 (December 1977).

8. Hoffman, F. 0., "Proceedings of a Workshop on the Evaluation of Models Used for the Environmental Assessment of Radionuclide Releases," CONF-770901, Oak Ridge National Laboratory (April 1978).

9. D. H. Slade (ed.), "Meteorology and Atomic Energy - 1968," TID-24190, Division of Technical Information, USAEC (1968).

10. Darryl Randerson (ed.), “Atmospheric Science and Power Production,” DOE/TIC-27601, U.S. Department of Energy (1984).

11. Singer, I. A. and M. E. Smith, "Atmospheric Diffusion at Brookhaven National Laboratory," Int. J. Air and Water Pollution, 10, 125-135 (1966).

12. Weber, A. H. "Atmospheric Dispersion Parameters in Gaussian Plume Modeling," EPA-600/4-76-030a, U.S. Environmental Protection Agency (July 1976).

13. R. P. Hosker, Jr., "A Comparison of Estimation Procedures for Over-Water Plume Dispersion," paper presented at the Symposium on Atmospheric Diffusion and Air Pollution in Santa Barbara, Calif., American Meteorological Society (September 9-13, 1974).

14. Regulatory Guide 1.194, “Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants.”

15. J. F. Sagendorf, "A Program for Evaluating Atmospheric Dispersion From A Nuclear Power Station," Technical Memorandum ERL ARL-42, National Oceanic and Atmospheric Administration (1974).

16. NUREG/CR-6331, “Atmospheric Relative Concentrations in Building Wake,” Revision 1 (May 1997).