U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

2.3.4 SHORT-TERM DISPERSION ESTIMATES FOR ACCIDENTAL ATMOSPHERIC RELEASES

REVIEW RESPONSIBILITIES

Primary - Accident Evaluation Branch (AEB)

Secondary - None

I. AREAS OF REVIEW

Information is presented by the applicant and reviewed by the staff concerning atmospheric dispersion estimates for postulated accidental releases of effluents to the atmosphere. The review covers the following specific areas:

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

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

3. Derivation of diffusion parameters.

4. Probability distributions of relative concentrations.

5. Determination of relative concentrations used for assessment of consequences of postulated radioactive atmospheric releases for design basis accidents and for other accidents, and of onsite and offsite hazardous airborne releases.

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 and hazardous materials to the atmosphere. The plant should be considered as both a source and a receptor.

The information is necessary to demonstrate compliance with the following regulations:

A. 10 CFR Part 50, Appendix A, General Design Criterion 19, "Control Room" (Ref. 1), with respect to the meteorological considerations used to evaluate the personnel radiation exposures inside the control room during design basis accident conditions.

B. 10 CFR Part 100, §100.11(a) (Ref. 2), with respect to the meteorological considerations used in the evaluation to determine an acceptable exclusion area and low population zone. Regulatory Guides that provide information, recommendations and guidance and in general describe a basis acceptable to the staff to implement the requirements of General Design Criterion 19 and 10 CFR Part 100 include Regulatory Guides 1.5, 1.23, 1.24, 1.25, 1.77, 1.78, 1.95, and 1.145 (Refs. 3, 4, 5, 6, 7, 8, 9, and 10).

The applicant's diffusion estimates should reasonably reflect staff positions and state-of-the-art atmospheric diffusion knowledge. Specifically the following information is required:

1. A description of the atmospheric dispersion models used to calculate relative concentrations in air resulting from accidental releases of radioactive and hazardous gases 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, plant, 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. A discussion of atmospheric diffusion parameters, such as lateral and vertical plume spread (σ_y and σ_z) as a function of distance, topography, and atmospheric conditions should be 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 (X/Q) should be constructed to describe the probabilities of these X/Q values being exceeded. All cumulative probability distributions of X/Q 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 Contents of Safety Analysis Reports for Nuclear Power Plants," (Ref. 11). The methods of generating these distributions should be adequately described.

5. Relative concentrations used for assessment of consequences of atmospheric radioactive releases for design basis and other accidents, and for onsite and offsite releases of hazardous airborne materials.

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, and site topography. The accidents and release characteristics to be considered are obtained from the reviewers of SAR Chapter 15. When the Gaussian assumptions are not applicable (e.g., buoyant gases and close-in estimates made for points among or near buildings), 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 is considered to be elevated if the release point 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. The volumetric correction is based on one-half the minimum cross-sectional area of the structure from which the effluent is released.

Most accidental releases can be considered as continuous releases (i.e., on the order of several minutes or more). However, some releases such as from steam line breaks or of hazardous chemicals may be considered as 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. 12).

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. In the absence of site-specific information concerning the frequency, duration, and directional preference of fumigation conditions, deterministic approaches such as those described in Regulatory Guides 1.5, 1.24, 1.25, and 1.145 may be used.

2. Meteorological Data

The meteorological data used in atmospheric dispersion analyses are reviewed for compatibility with the models, representativeness with respect to airflow characteristics of the site and vicinity, and representation of normal annual distribution of meteorological conditions. If adequate onsite meteorological data are not available, the reviewer must ensure that adequate conservatism is applied. General criteria for onsite data are stated in Regulatory Guide 1.23 and in subsection III.2 of SRP Section 2.3.3. 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

To define atmospheric stability, measurement of vertical temperature gradient (Ref. 4) should be used, particularly during stable conditions accompanied by low wind speeds (i.e., less than 1.5 m/s). Other classification schemes (Refs. 14 and 15) 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.

Lateral and vertical plume spread parameters, σ_y and σ_z, as functions of meteorological conditions and topography, are reviewed with respect to the characteristics of the accidental release and distances of interest. For stability typing schemes, the curves of σ_y and σ_z as functions of downwind distance and atmospheric stability as presented in reference 16 are acceptable for most sites with the addition of an extremely stable (Type G) class. For elevated releases (Ref. 17) or unusual source, meteorological conditions, or topography (e.g., narrow, deep valleys, channeling of airflow), modification of the σ_y and σ_z curves may be appropriate (see Ref. 18). Modifications to these curves which reflect recent atmospheric tracer tests primarily during stable, light wind conditions may be used with the atmospheric dispersion model described in Regulatory Guide 1.145. Modifications based on specific studies under similar conditions may also be considered to better represent plume spread over unique terrain features such as deserts (Ref. 12) and large bodies of water (Ref. 19).

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

4. Cumulative Frequency Distributions of X/Q

The cumulative probability distributions of X/Q 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. 11). The methods used to generate these distributions are reviewed for adequacy and conservatism.

5. Relative Concentrations Used for Accidents

The X/Q values used for assessment of consequences of atmospheric radioactive releases for design basis accidents and other accidents, and for onsite and offsite releases of hazardous airborne gases 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 atmospheric transport and diffusion characteristics.

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

b. A direction-independent probabilistic approach using the X/Q value which is exceeded 5 percent of the time. This methodology is described in Reference 13.

These values are assumed to represent conditions for a two-hour period. X/Q values for time periods greater than two hours are estimated for the LPZ distance by assuming a logarithmic relationship between the "two-hour" value and the annual average value.

These values of X/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.

X/Q values based on site-specific meteorological data are calculated, as needed, for control room dose calculations and onsite and offsite releases of hazardous airborne materials. These estimates are made on a case-by-case basis since the mode of release and, therefore, the dispersion models vary.

IV. EVALUATION FINDINGS

The reviewer verifies that adequately conservative atmospheric dispersion models, with adequate onsite meteorological data as input to the models, have been used to calculate relative concentrations at appropriate distances and directions from postulated release points during accidental airborne releases of potentially hazardous materials. If adequate onsite meteorological data are not available for the construction permit review, the reviewer must assure that adequate conservatism has been applied to the calculated relative concentrations for accidental airborne effluent releases based on available data.

The reviewer's evaluation must support the following type of concluding statement, to be used in the staff's safety evaluation report:

The staff concludes that atmospheric dispersion estimates are acceptable and meet the relevant requirements of General Design Criterion 19 and 10 CFR Part 100. This conclusion is based on the conservative assessments of postaccident atmospheric dispersion conditions that have been made by the applicant and the staff from the applicant's meteorological data and appropriate diffusion models.

These atmospheric dispersion estimates are appropriate for the assessment of consequences from (1) radioactive releases for design basis accidents in accordance with 10 CFR Part 100, §100.11 and (2) onsite and offsite releases of hazardous materials in accordance with General Design Criterion 19.

In the determination of the atmospheric dispersion estimates, the applicant has followed the guidelines of Regulatory Guides 1.5, 1.23, 1.24, 1.25, 1.77, 1.78, 1.95 and 1.145 (as appropriate).

The input to the safety evaluation report will also include a brief summary of the relative concentrations (X/Q) calculated by the staff, reference to dispersion models used, and a comparison between the values computed by the staff and the applicant.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

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 Part 50, Appendix A, General Design Criteria 19, "Control Room."

2. 10 CFR Part 100, Section 100.11(a), "Determination of exclusion area, low population zone, and population center distance."

3. Regulatory Guide 1.5, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Steam Line Break Accident for Boiling Water Reactors."

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

5. Regulatory Guide 1.24, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Pressurized Water Reactor Radioactive Gas Storage Tank Failure."

6. Regulatory Guide 1.25, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors."

7. Regulatory Guide 1.77, "Assumptions Used for Evaluating a Control Rod Ejection Accident for Pressurized Water Reactors."

8. Regulatory Guide 1.78, "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release."

9. Regulatory Guide 1.95, "Protection of Nuclear Power Plant Control Room Operators Against an Accidental Chlorine Release."

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

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

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

13. 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).

14. 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).

15. Hoffman, F. O., "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).

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

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

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

19. 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).