U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

2.3.4 SHORT-TERM ATMOSPHERIC DISPERSION ESTIMATES FOR ACCIDENT RELEASES

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of short-term atmospheric dispersion estimates for accident releases

Secondary - None

I. AREAS OF REVIEW

Chapter 2 of the SRP discusses the site characteristics that could affect the safe design and siting of the plant. The staff reviews information presented by the applicant for a construction permit (CP), operating license (OL), design certification (DC), early site permit (ESP), or combined license (COL) concerning conservative atmospheric dispersion factor (χ/Q value) estimates (1) at the exclusion area boundary (EAB), the outer boundary of the low population zone (LPZ), and at the control room for postulated design-basis accidental radioactive airborne releases and (2) at the control room from the onsite and/or offsite airborne releases of hazardous materials such as flammable vapor clouds, toxic chemicals, and smoke from fires. This SRP section applies to reviews performed for each of these types of applications. The review covers the following specific areas:

1. Atmospheric dispersion models to calculate atmospheric dispersion factors for postulated accidental radioactive and hazardous airborne releases.

2. Meteorological data and other assumptions used as input to atmospheric dispersion models.

3. Derivation of diffusion parameters (e.g., σ_y and σ_z).

4. Cumulative frequency distributions of χ/Q values.

5. Determination of conservative χ/Q values used to assess the consequences of (1) postulated design-basis atmospheric radioactive releases to the EAB, LPZ, and control room and (2) onsite and offsite hazardous material releases to the control room.

6. Additional Information for 10 CFR Part 52 Applications: Additional information will be presented dependent on the type of application. For a COL application, the additional information is dependent on whether the application references an ESP, a DC, both or neither. Information requirements are prescribed within the "Contents of Application" sections of the applicable Subparts to 10 CFR Part 52.

   The evaluation of the dispersion of airborne radioactive and hazardous materials to the control room is generally evaluated at the COL stage. Control room habitability is not evaluated at the ESP stage because the evaluation of control room habitability satisfies a general design criteria and general design criteria are not typically addressed at the ESP stage. Control room habitability is not evaluated at the DC stage because site information such as meteorological conditions and the locations of hazardous materials onsite and offsite is not available at the DC stage.

   For a design certification review, bounding χ/Q values for design basis radiological releases to the EAB, LPZ, and control room should be in the site parameter envelope specified for the standardized design.

Review Interfaces

The listed SRP sections interface with this section as follows:

1. A review of the definitions of the EAB and LPZ that may be used as input to this SRP section is performed under SRP Section 2.1.1.

2. A review of the identification of onsite and offsite hazardous materials that could threaten control room habitability that may be used as input to this SRP section is performed under SRP Sections 2.2.1-2.2.2 and 2.2.3.

3. A review of local meteorological conditions that could affect the atmospheric dispersion estimates that are reviewed in this SRP section is performed under SRP Section 2.3.2.

4. A review of the onsite meteorological monitoring program and the resulting meteorological database that may be used in this SRP section as input to the atmospheric dispersion estimates is performed under SPR Section 2.3.3.

5. The control room χ/Q values reviewed in this SRP section are provided as input to the review of the adequacy of the design of the control room habitability system that is performed under SRP Section 6.4.

6. The EAB and LPZ χ/Q values reviewed in this SRP section are provided as input to the review of the consequences of a variety of postulated radiological accidents at the EAB and LPZ that is performed under a variety of subsections in SRP Section 15.

7. For DC applications and COL applications referencing a DC rule or DC application, review of the site parameters in the Design Control Document (DCD) Tier 1, Chapter 2 of the DCD Tier 2, and the supporting information in DCD Tier 2 submitted by the applicant is performed under SRP Section 2.0, “Site Characteristics/Site Parameters.”

The specific acceptance criteria and review procedures are contained in the referenced SRP sections.

II. ACCEPTANCE CRITERIA

Requirements

Acceptance criteria are based on meeting the relevant requirements of the following Commission regulations:

1. For CP and OL applications on or after January 10, 1997, 10 CFR 50.34(a)(1)(ii)(D) (Ref. 1) with respect to an assessment of the plant design features intended to mitigate the radiological consequences of accidents, which includes consideration of site meteorology, to evaluate the offsite radiological consequences at the EAB and LPZ.

2. For CP, OL, DC, and COL applications, 10 CFR Part 50, Appendix A, General Design Criterion 19 (GDC 19), "Control Room," with respect to the meteorological considerations used to evaluate the personnel exposures inside the control room during radiological and airborne hazardous material accident conditions.

3. For ESP applications, 10 CFR 52.17(a)(1)(ix) (Ref. 2) with respect to a safety assessment of the site, including consideration of major SSCs of the facility and site meteorology, to evaluate the offsite radiological consequences at the EAB and LPZ.

4. For DC applications, 10 CFR 52.47(a)(2)(iv) with respect to an assessment of the plant design features intended to mitigate the radiological consequences of accidents, which includes consideration of postulated site meteorology, to evaluate the offsite radiological consequences at the EAB and LPZ.

5. For COL applications, 10 CFR 52.79(a)(1)(vi) with respect to a safety assessment of the site, including consideration of major SSCs of the facility and site meteorology, to evaluate the offsite radiological consequences at the EAB and LPZ.

6. For reactor applications before January 10, 1997, 10 CFR 100.11(a) (Ref. 3), with respect to the meteorological considerations used in the evaluation to determine an acceptable EAB and LPZ.

7. For reactor applications on or after January 10, 1997, 10 CFR 100.21(c)(2), with respect to the atmospheric dispersion characteristics used in the evaluation of EAB and LPZ radiological dose consequences for postulated accidents.

SRP Acceptance Criteria

Specific SRP acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are as follows for the review described in of this SRP section. The SRP is not a substitute for the NRC's regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical

techniques, and procedural measures proposed for its facility and the SRP acceptance criteria and evaluate how the proposed alternatives to the SRP acceptance criteria provide acceptable methods of compliance with the NRC regulations.

Appropriate sections of the following Regulatory Guides are used by the staff for the identified acceptance criteria.

Regulatory Guide 1.23, “Onsite Meteorological Programs,” (Ref. 4) presents criteria for an acceptable onsite meteorological monitoring program and the resulting meteorological database that may be used in this SRP section as input to the atmospheric dispersion estimates.

Regulatory Guide 1.78, “Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release,” (Ref. 5) presents criteria for characterizing atmospheric dispersion conditions for evaluating the consequences of airborne hazardous material releases to the control room.

Regulatory Guide 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants," (Ref. 6) presents criteria for characterizing atmospheric dispersion conditions for evaluating the consequences of radiological releases to the EAB and LPZ.

Regulatory Guide 1.194, “Atmospheric Relative Concentrations for Control room Radiological Habitability Assessments at Nuclear Power Plants,” (Ref. 7) presents criteria for characterizing atmospheric dispersion conditions for evaluating the consequences of radiological releases to the control room.

Older plants licenced under 10 CFR Part 50 may have also used the following regulatory guides instead of Regulatory Guide 1.145 for characterizing atmospheric dispersion conditions for evaluating the consequences of radiological releases to the EAB and LPZ:

Regulatory Guide 1.3, “Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors” (Ref. 8).

Regulatory Guide 1.4, “Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors” (Ref. 9).

Regulatory Guide 1.5, “Assumptions Used for Evaluating the Potential Radiological Consequences of a Steam Line Break Accident for Boiling Water Reactors” (Ref. 10).

Regulatory Guide 1.24, “Assumptions Used for Evaluating the Potential Radiological Consequences of a Pressurized Water Reactor Radioactive Gas Storage Tank Failure” (Ref. 11).

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” (Ref. 12).

Regulatory Guide 1.77, “Assumptions Used for Evaluating a Control Rod Ejection Accident for Pressurized Water Reactors” (Ref. 13).

Regulatory Guide 1.98, “Assumptions Used for Evaluating the Potential Radiological Consequences of a Radioactive Offgas System Failure in a Boiling Water Reactor” (Ref. 14).

New reactor applicant atmospheric dispersion estimates should reasonably reflect current staff positions and state-of-the-art atmospheric dispersion knowledge. Specifically for CP, OL, COL, or ESP reviews, the following information should be provided:

1. A description of the atmospheric dispersion models used to calculate χ/Q values for accidental releases of radioactive and hazardous materials 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 of use with regards to release characteristics, plant configuration, plume density, meteorological conditions, and site topography.

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. Any dispersion estimates should be calculated from the most representative meteorological data available for the site. Guidance on appropriate onsite meteorological data is provided in Regulatory Guide 1.23. This information is also reviewed in SRP Section 2.3.3.

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 data. 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. Hourly cumulative frequency distributions of χ/Q values from the effluent release point(s) to the EAB and LPZ should be constructed to describe the probabilities of these χ/Q values being exceeded. All cumulative frequency distributions of χ/Q values should be presented for appropriate distances (e.g., the EAB distance and the outer boundary of the LPZ) 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. 15) and Section 2.3.4.2 of RG 1.206, “Combined License Applications for Nuclear Power Plants (LWR Edition)” (Ref. 16). The methods for generating these distributions should be adequately described. Guidance for calculating EAB and LPZ atmospheric dispersion factors is provided in Regulatory Guide 1.145.

5. Atmospheric dispersion factors used for the assessment of consequences related to atmospheric radioactive releases to the control room for design basis, other accidents, and for onsite and offsite releases of hazardous airborne materials should be provided. Guidance for calculating control room χ/Q values for radiological releases and hazardous material releases is provided in Regulatory Guide 1.194 and Regulatory Guide 1.78, respectively.

6. For control room habitability analysis, a site plan drawn to scale should be included showing true North and potential atmospheric accident release pathways, control room intake, and unfiltered inleakage pathways.

Technical Rationale

The technical rationale for application of these acceptence criteria to the areas of review addressed by this SRP section is discussed in the following paragraphs:

1. Compliance with GDC 19 requires that the control room remain functional so that actions can be taken to operate the nuclear power unit safely under normal conditions and maintain the plant in a safe state under accident conditions.

   Adequate radiological and airborne hazardous material protection must be provided to permit access and occupancy of the control room for the duration of accidental conditions. Atmospheric dispersion estimates are significant inputs in assessments performed to demonstrate compliance with GDC 19. Guidance for determining atmospheric dispersion estimates for control room habitability during radiological accidents and hazardous material accidents is provided in Regulatory Guide 1.194 and Regulatory Guide 1.78, respectively.

   Meeting the requirements of this criterion provides assurance that those personnel needed to monitor and control an accident will be able to function effectively.

2. 10 CFR 100.11(a) specifies for reactor applications before January 10, 1997, that determination of an EAB, LPZ, and population center distance be based on a set of assumptions involving the release of fission products from the reactor core, an expected leak rate from containment, and pertinent meteorological conditions.

   Identification of an EAB, LPZ, and population center distance is an integral aspect of the siting criteria for a new nuclear power plant. Specified radiation dose guidelines are associated with the EAB and LPZ. Verification that the proposed nuclear plant design meets these radiation dose guidelines is accomplished by calculating expected offsite radiation doses using (a) an assumed inventory of fission products available for release from the containment building, (b) the expected containment leak rate, and (c) site atmospheric dispersion characteristics. Atmospheric dispersion characteristics are determined from meteorological measurements taken at the proposed plant site. Guidance on the onsite meteorological program needed to obtain meteorologicaldata is provided in Regulatory Guide 1.23, and models for calculating the atmospheric dispersion for the EAB and LPZ are provided in Regulatory Guide 1.145.

3. Compliance with 10 CFR 50.34(a)(1)(ii)(D) (for CP and OL applications on or after January 10, 1997), 10 CFR 52.17(a)(1)(ix) (for ESP applications), 10 CFR 52.47(a)(2)(iv) (for DC applications), 10 CFR 52.79(a)(1)(vi) (for COL applications), and 10 CFR 100.21(c)(2) (for reactor applications on or after January 10, 1997) requires an assessment demonstrating that the safety features that are to be engineered into the facility, including the plant design features intended to mitigate the radiological consequences of accidents, are adequate to ensure that the offsite radiological consequences of accidents meet specified radiation dose guidelines for the EAB and LPZ.

   Verification that the major SSCs of the facility that bear significantly on the acceptability of the proposed facility on the site are adequate to meet EAB and LPZ dose criteria under accident conditions is accomplished by calculating expected offsite radiation doses using (a) an assumed inventory of fission products available for release from the containment building, (b) the expected containment leak rate, and (c) site atmospheric dispersion characteristics. Atmospheric dispersion characteristics are determined from meteorological measurements taken at the proposed plant site. Guidance on the onsite

meteorological program needed to obtain meteorological data is provided in Regulatory Guide 1.23, and models for calculating the atmospheric dispersion for the EAB and LPZ are provided in Regulatory Guide 1.145.

III. REVIEW PROCEDURES

The reviewer will select and emphasize material from the procedures described below, as may be appropriate for a particular case.

The procedures outlined below are used to review CP applications, ESP applications, and COL applications that do not reference an ESP to determine whether appropriate atmospheric dispersion models, with adequate onsite meteorological data as input to the models, have been used to calculate atmospheric dispersion factors at appropriate locations from postulated release points during accidental airborne radiological and hazardous material releases. For reviews of OL applications, these procedures are used to verify that the data and analyses remain valid and that the facility's design specifications are consistent with these data. As applicable, reviews of OLs and COLs include a determination on whether the content of technical specifications related to short term atmospheric dispersion estimates is acceptable and whether the technical specifications reflect consideration of any identified unique conditions.

These review procedures are based on identified SRP acceptance criteria. For deviations from these specific acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

1. Atmospheric Dispersion Models

The reviewer verifies that adequately conservative atmospheric dispersion models, with adequate onsite meteorological data as input to the models, have been used to calculate χ/Q values at appropriate distances and directions from postulated release points during design-basis radiological and hazardous material releases. If adequate onsite meteorological data are not available for the CP review, the reviewer should ensure that adequate conservatism has been applied to the calculated relative concentrations for accidental airborne effluent releases based on available data.

The applicant's atmospheric dispersion models used to evaluate design-basis accident releases are compared to the general Gaussian models contained in (1) Regulatory Guide 1.145 for radiological releases to the EAB and LPZ, (2) Regulatory Guide 1.194 for radiological releases to the control room, and (3) Regulatory Guide 1.78 for airborne hazardous material releases to the control room. Use of the PAVAN computer code (Ref. 17) is an acceptable approach for implementing the dispersion algorithms discussed in Regulatory Guide 1.145 for evaluating the consequences of airborne radiological releases to the EAB and LPZ. Use of the ARCON96 computer code (Ref. 18) is an acceptable approach for implementing some of the Regulatory Guide 1.194 criteria for evaluating the consequences of airborne radiological releases to the control room. In addition, use of the EXTRAN module (Ref. 19) of the HABIT computer code (Refs. 20-21) under certain circumstances (e.g., neutrally buoyant releases) is an acceptable approach for determining χ/Q values for evaluating the consequences of airborne hazardous releases to the control room.

The applicant's use of dispersion models is reviewed for suitability to release

characteristics, plant configuration, plume density, meteorological conditions, and site topography. The accidents and release characteristics to be considered are obtained from the reviews of safety analysis report (SAR) Chapter 2.2.1-2.2.2 and 2.2.3 for airborne hazardous material releases and Chapter 15 for radiological releases. When the Gaussian assumptions are not applicable (e.g., dense or buoyant hazardous material releases), 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 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. Additional guidance on the criteria for classifying releases as either ground or elevated, which applies to both site boundary χ/Q calculations and control room χ/Q calculations, is provided in Position 3.2.2 of Regulatory Guide 1.194. Turbulent mixing of the effluent into the wake of plant structures is usually allowed for ground-level releases. Dispersion models used for radiological control room χ/Q estimates will be compared against ARCON96, which is described in Regulatory Guide 1.194.

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 materials 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, either instantaneous point-source Gaussian diffusion equations with a correction for initial source volume (Ref. 22) or hemispheric cloud configuration assumptions with the cloud traveling slowly downwind (e.g., at approximately 1 m/sec) can be used.

Although the model implemented in ARCON96 is a general code for assessing atmospheric dispersion in building wakes under a wide range of situations, there may be atmospheric dispersion scenarios and source-receptor geometries for which the model would be inappropriate, e.g., control room outside air intakes located close to the base of tall elevated stacks, extremely short duration releases, or receptor distances shorter than about 10 meters. Section C.3.2.2 of Regulatory Guide 1.194 discusses an appropriate procedure for generating χ/Q values for those situations where the control room intake is located close to the base of a tall elevated stack. Extremely short duration (puff) releases can be modeled using the criteria discussed in the previous paragraph of this SRP section.

Facility design and operation should attempt to maintain some minimal distance of separation (e.g., more than 10 meters) between postulated sources and control room receptors. However, if the distance to the receptor is less than about 10 meters, the ARCON96 code should not be used to assess χ/Q values. An acceptable alternative approach would be to define the 0-8 hour χ/Q value as 1/F where F is the higher value of the volumetric flow rate at either the release point (e.g., a vent or stack flow rate) or the intake point (e.g., an air intake flow rate). The χ/Q values for other time intervals can be obtained by adjusting the 0-8 hour χ/Q value for long-term meteorological averaging of wind direction. This can be accomplished by multiplying the 0-8 hour time interval χ/Q value by 0.88 for the 8-24 hour time interval, 0.75 for the 1-4 day time interval, and 0.50 for the 4-30 day time interval. Use of this volumetric flow rate methodology should factor in possible decreases in the flow rate (e.g., due to loss of offsite power or other single failure). In addition, unfiltered inleakage should be considered independently of the control room air intake flow rate.

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 to the EAB and LPZ. 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 Guide 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 meteorological monitoring programs are stated in Regulatory Guide 1.23 and 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 as described in Regulatory Guide 1.23 should be used. Other classification schemes (Refs. 23 and 24) may be used to estimate atmospheric stability but the use of alternative methods to classify atmospheric stability may require modifications to the models described in Regulatory Guides 1.145 and 1.194. 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 elevated releases or unusual source, meteorological conditions, or topography (e.g., narrow, deep valleys, channeling of airflow), modification of the σ_y and σ_z parameters discussed in Regulatory Guide 1.145 may be appropriate (Ref. 18). Modifications based on specific studies under similar conditions may be considered to better represent plume spread over unique terrain features such as deserts (Ref. 22) and large bodies of water (Ref. 26). Such specific studies should meet the criteria for the use of site-specific experimental data is outlined in Regulatory Position 7 in Regulatory Guide 1.194.

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

4. Cumulative Frequency Distributions of χ/Q Values

The cumulative frequency distributions of EAB and LPZ 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 Regulatory Guide 1.70 and Section 2.3.4.2 of RG 1.206. The methods used to generate these distributions are reviewed for adequacy and conservatism.

5. Atmospheric Dispersion Factors Used for Accidents

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

The staff makes an independent evaluation of atmospheric dispersion for pertinent distances, usually the EAB and the LPZ outer boundary, using the appropriate meteorological data and dispersion model. The definitions for the EAB and LPZ are reviewed in SRP section 2.1.1. Two probabilistic approaches as described in Regulatory Guide 1.145 are available for evaluating atmospheric dispersion characteristics and the more conservative approach is used.

a. A direction-dependent probabilistic approach which uses the highest χ/Q value which is exceeded 0.5% of the time in each of 16 compass directions from the plant.

b. A direction-independent probabilistic approach which uses the χ/Q value which is exceeded 5% of the time independent of direction.

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 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. 18). 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 SRP Chapter 15 for dose assessment of design basis accidents.

ARCON96 is used to estimate the level of control room exposure during postulated accidents, as documented in Regulatory Guide 1.194. Interpretation of results from ARCON96 should take into account control room inflow from dual air intake valves as discussed in Regulatory Guide 1.194.

6. Review Procedures Specific to 10 CFR 52 Application Type

a. Early Site Permit Reviews

Subpart A to 10 CFR Part 52 specifies the requirements and procedures applicable to the Commission’s review of an ESP application for approval of a proposed site. Information required in an ESP application includes a description of the site characteristics and design parameters of the proposed site. The scope and level of detail of review of data parallel that used for a CP review.

The applicant’s ESP site characteristics should include EAB and LPZ atmospheric dispersion factors calculated as described previously in this SRP

section. If the exact plant configuration and location is not known at the ESP stage, the EAB and LPZ χ/Q values should be calculated using the shortest distances between the ESP plant envelope boundary and the EAB and LPZ distances in each downwind sector. Conservative assumptions for the minimum building cross-sectional area and height values should be used to determine building wake effects.

The calculation of control room χ/Q values is not typically completed at the ESP stage because the evaluation of control room habitability satisfies a general design criteria and general design criteria are not typically addressed at the ESP stage. In this situation, the staff should issue a COL Action Item stating that a COL or CP applicant should assess the dispersion of airborne radioactive materials to the control room at the COL stage.

In the absence of a compliance or adequate protection issue, 10 CFR 52.39 precludes the staff from imposing new site characteristics, design parameters, or terms and conditions on the early site permit at the COL stage. Accordingly, the reviewer should ensure that all physical attributes of the site that could affect the design basis of SSCs important to safety are reflected in the site characteristics, design parameters, or terms and conditions on the early site permit.

b. Standard Design Certification Reviews

DC applications do not contain general descriptions of site characteristics because this information is site-specific and will be addressed by the COL applicant. However, pursuant to 10 CFR 52.47(a)(1), a DC applicant must provide site parameters postulated for the design. The reviewer verifies that for the applicable site parameter:

1. The postulated site parameters are representative of a reasonable number of sites that may be considered within a COL application; e.g., the site parameter values should be reasonable as compared to site characteristics listed in previously docketed ESP applications;

2. The appropriate site parameters are included as Tier 1 information. This convention has been used by previous DC applicants. Site parameters are addressed in SRP Section 2.0;

3. Pertinent parameters are stated in a site parameters summary table; and

4. The applicant has provided a technical basis for each of the site parameters.

The staff should ensure that the DC applicant has included EAB, LPZ, and control room atmospheric dispersion factors for the appropriate time periods in the list of site parameters. The DC application should also contain figures and tables showing the design features that would be used by the COL applicant to generate control room χ/Q values (e.g., intake heights, release heights, building cross-sectional areas, distance to receptors). If any straight-line horizontal distances of less than 10 meters from a release location to the environment to a receptor have been proposed, the staff should attempt to impress upon the applicant that it is good engineering practice to design and maintain some distance of separation

(e.g., more than 10 meters) between potential release pathways and potential intake pathways to the control room.

c. Combined License Reviews

For a COL application referencing a certified standard design, NRC staff reviews that application to ensure sufficient information was presented to demonstrate that the characteristics of the site fall within the site parameters specified in the DC rule. Should the actual site characteristics not fall within the certified standard design site parameters, the COL applicant will need to demonstrate by some other means that the proposed facility is acceptable at the proposed site. This might be done by re-analyzing or redesigning the proposed facility.

For a COL application referencing an ESP, NRC staff reviews the application to ensure the applicant provided sufficient information to demonstrate that the design of the facility falls within the site characteristics and design parameters specified in the early site permit as applicable to this SRP section. Per 10 CFR 52.79(b)(2), should the design of the facility not fall within the site characteristics and design parameters, the application shall include a request for a variance from the ESP that complies with the requirements of §§ 52.39 and 52.93.

In addition, long-term environmental changes and changes to the region resulting from human or natural causes may have introduced changes to the site characteristics that could be relevant to the design basis. The requirements of 10 CFR 52.39 preclude the Commission from changing or imposing new site characteristics, design parameters, or terms and conditions on an ESP, unless the change is necessary to assure adequate protection of the public health and safety or to bring the permit or site into compliance with the Commission's regulatory requirements in effect when the permit was issued. Consequently, the staff's review of a COL application referencing an ESP should not include a re-investigation of the site characteristics that have previously been accepted in the referenced ESP. However, in accordance with 10 CFR 52.6, "Completeness and Accuracy of Information," the applicant or licensee is responsible for identifying changes of which it is aware, that would satisfy the criteria specified in 10 CFR 52.39. Information provided by the applicant in accordance with 10 CFR 52.6(b) will be addressed by the staff during the review of a COL application referencing an ESP or a DC.

For a COL application referencing either an ESP or DC or both, the staff should review the corresponding sections of the ESP and DC FSER to ensure that any unresolved items, commitments, assumptions, and deferred issues identified in the FSERs are appropriately handled in the COL application.

IV. EVALUATION FINDINGS

The review should document the staff's evaluation that appropriate atmospheric dispersion models, with adequate onsite meteorological data as input to the models, have been used to calculate conservative estimates of atmospheric dispersion conditions at appropriate locations during postulated accidental releases of radioactive and hazardous materials to the atmosphere. The reviewer should state what was done to evaluate the applicant's safety analysis report. The staff's evaluation may include verification that the applicant followed applicable regulatory

guidance, performance of independent calculations, and/or validation of appropriate assumptions. The reviewer may state that certain information provided by the applicant was not considered essential to the staff's review and was not reviewed by the staff. While the reviewer may summarize or quote the information offered by the applicant in support of its application, the reviewer should clearly articulate the bases for the staff's conclusions.

The reviewer verifies that the applicant has provided sufficient information and that the review and calculations (if applicable) support conclusions of the following type to be included in the staff's safety evaluation report. The reviewer also states the bases for those conclusions.

1. Construction Permit, Operating License, and Combined License Reviews

The following statements should be preceded by a summary of the short-term (post-accident) atmospheric dispersion estimates used for the plant:

> The staff concludes that the applicant's atmospheric dispersion estimates are acceptable and meet the relevant requirements of 10 CFR 100.11(a) [or 10 CFR 100.21(c)(2)]. This conclusion is based on the conservative assessments of post-accident 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 50.34(a)(1)(ii)(D) [for CP or OL reactor applications on or after January 10, 1997], 10 CFR 52.79(a)(1)(vi) [for COL applications], 10 CFR Part 100.11(a) [or 10 CFR 100.21(c)(2)] and (2) onsite and offsite releases of radiological and hazardous materials in accordance with General Design Criterion 19.

2. Early Site Permit Reviews

The following statements should be preceded by a summary of the short-term (post-accident) atmospheric dispersion site characteristics to be included in any ESP that might be issued for the ESP site:

> As set forth above, the applicant has presented and substantiated information to establish short-term (post-accident) atmospheric dispersion site characteristics. The staff has reviewed the information provided and, for the reasons given above, concludes that the applicant has established site characteristics and design parameters acceptable to meet the requirements of 10 CFR 52.17(a)(1)(ix) and 10 CFR 100.21(c)(2).

3. Design Certification Reviews

The following statement should be preceded by a list of the applicable short-term (post-accident) site parameters used for the plant:

> The applicant has selected the short-term (post-accident) site parameters referenced above for plant design inputs (a subset of which is included as Tier 1 information), but does not claim that they are representative of any particular percentile of possible sites in the United States, and does not assert the

acceptability of the basis for the choice of values with respect to siting. The short-term atmospheric dispersion characteristics for accidental release are site-specific and will be addressed by the COL applicant. This should include the provision of information sufficient to demonstrate that the design of the plant falls within the values of the actual site characteristics specified in a COL or CP application.

V. IMPLEMENTATION

The staff will use this SRP section in performing safety evaluations of DC applications and licence applications submitted by applicants pursuant to 10 CFR Part 50 or 10 CFR Part 52. Except when the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the staff will use the method described herein to evaluate conformance with Commission regulations.

The provisions of this SRP section apply to reviews of applications docketed six months or more after the date of issuance of this SRP section, unless superseded by a later revision.

VI. REFERENCES

1. 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities."

2. 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."

3. 10 CFR Part 100,"Reactor Site Criteria."

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

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

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

7. Regulatory Guide 1.194, "Atmospheric Relative Concentrations for Control room Radiological Habitability Assessments at Nuclear Power Plants."

8. Regulatory Guide 1.3, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors."

9. Regulatory Guide 1.4, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors."

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

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

12. 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.”

13. Regulatory Guide 1.77, “Assumptions Used for Evaluating a Control Rod Ejection Accident for Pressurized Water Reactors.”

14. Regulatory Guide 1.98, “Assumptions Used for Evaluating the Potential Radiological Consequences of a Radioactive Offgas System Failure in a Boiling Water Reactor.”

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

16. Regulatory Guide RG 1.206, “ Combined License Applications for Nuclear Power Plants (LWR Edition).”

17. NUREG/CR-2858, “PAVAN: An Atmospheric Dispersion Program for Evaluating Design Basis Accidental Releases of Radioactive Materials from Nuclear Power Plants” (November 1982).

18. NUREG/CR-6331, Rev. 1, “Atmospheric Relative Concentrations in Building Wakes” (May 1997).

19. NUREG/CR-5656, “EXTRAN: A Computer Code for Estimating Concentrations of Toxic Substances at Control Room Air Intakes” (March 1991).

20. NUREG/CR-6210, “Computer Codes for Evaluation of Control Room Habitability (HABIT)” (June 1996).

21. NUREG/CR-6210, Supp. 1, “Computer Codes for Evaluation of Control Room Habitability (HABIT V1.1)” (October 1998).

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

23. 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).

24. 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).

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

26. 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).

SRP Section 2.3.4
Description of Changes

This SRP section affirms the technical accuracy and adequacy of the guidance previously provided in Draft Revision 2, dated April 1996, of this SRP. See ADAMS accession number ML052070235.

In addition this SRP section was administratively updated in accordance with NRR Office Instruction, LIC-200, Revision 1, "Standard Review Plan (SRP) Process." The revision also adds standard paragraphs to extend application of the updated SRP section to prospective submittals by applicants pursuant to 10 CFR Part 52.

The technical changes are incorporated in Revision 3, dated [Month] 2007.

Review Responsibilities - Reflects changes in review branches resulting from reorganization and branch consolidation. Change is reflected throughout the SRP.

I. AREAS OF REVIEW

a. Added design certification (DC) as a type of licensing action covered by this SRP section.

b. Clarified that this SRP section includes reviewing conservative atmospheric dispersion factor (χ/Q value) estimates (1) at the EAB and LPZ for postulated design-basis accidental radioactive airborne releases and (2) at the control room from the onsite and/or offsite airborne releases of hazardous materials (e.g., flammable vapor clouds, toxic chemicals, and smoke from fires).

c. Expanded the scope of this SRP section to include the review of conservative atmospheric factor (χ/Q value) estimates at the control room for postulated design-basis accidental radioactive airborne releases.

d. Changed the term "atmospheric transport and diffusion models" to "atmospheric dispersion models" throughout the document.

e. Changed the term "relative concentrations" to "atmospheric dispersion factors" and/or "χ/Q values" throughout the document.

f. Expanded the areas of review to include other assumptions (beyond the meteorological data) used as input to the atmospheric dispersion models.

g. Changed the term "probability distributions" to "cumulative frequency distributions" throughout the document.

h. Added a paragraph describing the evaluation of dispersion estimates for control room habitability, which is only addressed at the COL stage.

i. Added a paragraph describing the requirements for a DC review of χ/Q values.

j. Expanded the subsection on "Review Interfaces."

II. ACCEPTANCE CRITERIA

a. Added the following appropriate regulations:

- **10 CFR 50.34(a)(1)(ii)(D)** - For assessments of the plant design features intended to mitigate the radiological consequences of accidents for CP and OL applications on or after January 10, 1997.

- **10 CFR 53.17(a)(1)(ix)** - For ESP applications with respect to a safety assessment for consideration of major SSCs to evaluate offsite radiological consequences at the EAB and LPZ.

- **10 CFR 52.47(a)(2)(iv)** - For DC applications with respect to an assessment of the plant design features intended to mitigate the radiological consequences of accidents at the EAB and LPZ.

- **10 CFR 52.79(a)(1)(vi)** - For COL applications with respect to a safety assessment for consideration of major SSCs to evaluate offsite radiological consequences at the EAB and LPZ.

- **10 CFR 100.21(c)(2)** - For reactor applications on or after January 10, 1997 with respect to the atmospheric dispersion characteristics use in the evaluation of dose consequences.

b. Clarified the RGs that are applicable for new reactor licensing (i.e., RGs 1.23, 1.78, 1.145), deleted reference to RG 1.95 (which has been withdrawn) and added reference to RG 1.194.

c. Clarified the RGs that may have been used to license older plants under 10 CFR Part 50 (prior to issuing RG 1.145), including adding RGs 1.3, 1.4, 1.5, 1.24, 1.25, 1.77, and 1.98.

d. Added plant configuration, plume density, meteorological conditions, and site topography to the list of model evaluation criteria.

e. Noted that any dispersion estimates should be calculated from the most representative meteorological data available for the site. Added that guidance on appropriate onsite meteorological data is provided in RG 1.23 and that the resulting data base is reviewed in SRP section 2.3.3.

f. Changed the term “measured meteorological parameters” to “measured meteorological data” throughout the document.

g. Added that cumulative frequency distributions of χ/Q values should be hourly and calculated from the effluent release point(s) to the EAB and LPZ.

h. Added RG 1.206 as a reference for the time periods to be evaluated for EAB and LPZ evaluations.

i. Added that guidance for calculating EAB and LPZ atmospheric dispersion factors is provided in RG 1.145.

j. Added that guidance for calculating control room χ/Q values for radiological releases and hazardous material releases is provided in RG 1.194 and RG 1.78, respectively.

k. Added a paragraph describing the type of information that should be evaluated for control room habitability analyses.

Technical Rationale

l. Revised the discussion concerning compliance with GDC 19 to be more generic by reference the requirements to protect against both radiological and airborne hazardous materials. Added that guidance for determining atmospheric dispersion estimates for control room habitability during radiological accidents is provided in RG 1.194.

m. Added a discussion concerning the technical rational for the application of acceptance criteria to demonstrate compliance with 10 CFR 50.34(a)(1)(ii)(D), 10 CFR 52.17(a)(1)(ix), 10 CFR 52.47(a)(2)(iv), 10 CFR 52.79(a)(1)(vi), and 10 CFR 100.21(c)(2).

III. REVIEW PROCEDURES

a. Added an introduction paragraph to clarify the use of the procedures presented in this SRP section for review of CP, ESP, COL, and OL applications.

Atmospheric Disperion Models

b. Added that the applicant's atmospheric dispersion models used to evaluate design-basis accident releases should be compared against the appropriate regulatory guide criteria (i.e., RG 1.145 for radiological releases to the EAB and LPZ, RG 1.194 for radiological releases to the control room, and RG 1.78 for hazardous material releases to the control room). Also added a list of the atmospheric dispersion computer codes used by the staff to perform its atmospheric dispersion analyses. These models include PAVAN, ARCON96, and HABIT.

c. Added "plume density" and "meteorological conditions" to the list of review parameters for the applicant's use of dispersion models.

d. Added references to SAR Chapters 2.2.1-2.2.2 and 2.2.3 for airborne hazardous material releases.

e. Added a reference to RG 1.194 for additional guidance on the criteria for classifying releases as either ground-level or elevated.

f. Removed the sentence "The volumetric correction is based on one-half the minimum cross-sectional area of the structure from which the effluent is released" and replaced it with references to RG 1.194 and the ARCON96 atmospheric dispersion model.

g. Added that for puff releases a hemispheric cloud configuration assumption can be used.

h. Added a discussion on the limitations of using ARCON96 to model radiological releases to the control room. Encouraged facility designers to maintain a minimal distance of separation (e.g., more than 10 meters) between postulated sources and control room receptors as good engineering practice and provided a new methodology for determining control room χ/Q values when the source-to-receptor distance is less than 10 meters. NOTE: The factors presented to convert the 0-8 hour χ/Q values to other time periods is based on Column 1 of Table 3 to RG 1.194.

i. Deleted references to RG 1.5, 1.24, and 1.25 as sources for deterministic approaches concerning the frequency, duration, and directional preference of fumigation conditions. This same information is presented in RG 1.145.

Atmospheric Diffusion Parameters

j. Deleted the statements that (1) the measurement of vertical temperature gradient should be used particularly during stable conditions accompanied by low wind speeds to define atmospheric stability and (2) other classification schemes 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. Replaced these statements with the statements that (1) the measurement of vertical temperature gradient as described in RG 1.23 should be used to define atmospheric stability and (2) the use of alternative methods to classify atmospheric stability may require modifications to the models described in RGs 1.145 and 1.194. BASIS: Vertical temperature gradient is an effective indicator for the worst case stability conditions and the models described in RG 1.145 and RG 1.194 are based on empirically derived plume meander factors derived from field tracer studies that used vertical temperature gradient to classify atmospheric stability.

k. Deleted the sentence “For stability typing schemes, the curves of σ_y and σ_z as functions of downwind distance and atmospheric stability as presented in “Meteorology and Atomic Energy - 1968" are acceptable for most sites with the addition of an extremely stable (Type G) class.” BASIS: Each atmospheric dispersion RG presents its own curves of σ_y and σ_z as functions of downwind distance and atmospheric stability.

l. Deleted the sentence “Modifications to [the Meteorology and Atomic Energy - 1968] curves which reflect recent atmospheric tracer tests primarily during stable, light wind conditions may be used with the atmospheric dispersion model described in RG 1.145.” BASIS: RG 1.145 already contains plume meander adjustments for stable, light wind conditions.

m. Added that modifications of the σ_y and σ_z parameters based on specific studies should meet the criteria for the use of site-specific experimental data as outlined in Regulatory Position 7 in RG 1.194.

Cumulative Frequency Distributions of χ/Q Values

n. Added RG 1.206 as a reference for the time periods to be evaluated for EAB and LPZ evaluations.

o. Deleted two paragraphs concerning reviewer responsibilities for DC reviewers. This information is now discussed in separate subsections under "Review Procedures."

Atmospheric Dispersion Factors Used for Accidents

p. Added the sentence "The definitions for the EAB and LPZ are reviewed in SRP section 2.2.1."

q. Added the use of a "sliding window" as an alternative method for calculating LPZ χ/Q values for time periods greater than 2 hours. BASIS: This is the same approach used by the ARCON96 atmospheric dispersion model to calculating control room χ/Q values for time periods greater than 2 hours.

r. Clarified that ARCON96 is used to estimate control room χ/Q values as documented in RG 1.194 and that the interpretation of ARCON96 results should take unto account control room inflow from dual air intakes as discussed in RG 1.194.

Early Site Permit Reviews

s. Added a new subsection applicable to ESP reviews.

Design Certification Reviews

t. Added a new subsection applicable to DC reviews.

COL and CP Applications Referencing an ESP and/or a DC

u. Added a new subsection applicable to reviews of COL and CP applications referencing an ESP and/or a DC.

IV. EVALUATION FINDINGS

a. Updated the references to specific regulations and provided separate evaluation finding statements for ESP and DC reviews.

b. Removed a reference to ITAAC, including DAC.

V. IMPLEMENTATION

a. Added a reference to CP, OL, ESP, DC, and COL applications.

b. Removed the following sentence: "The provisions of this SRP section apply to reviews of applications docketed six months or more after the date of issuance of this SRP section."

VI. REFERENCES

a. Added the following references:

- RG 1.194, “Atmospheric Relative Concentrations for Control room Radiological Habitability Assessments at Nuclear Power Plants.”

- RG 1.3, “Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors.”

- RG 1.4, “Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors.”

- RG 1.98, “Assumptions Used for Evaluating the Potential Radiological Consequences of a Radioactive Offgas System Failure in a Boiling Water Reactor.”

- RG 1.206, “ Combined License Applications for Nuclear Power Plants (LWR Edition).”

- NUREG/CR-2858, “PAVAN: An Atmospheric Dispersion Program for Evaluating Design Basis Accidental Releases of Radioactive Materials from Nuclear Power Plants” (November 1982).

- NUREG/CR-6331, Rev. 1, “Atmospheric Relative Concentrations in Building Wakes” (May 1997).

- NUREG/CR-5656, “EXTRAN: A Computer Code for Estimating Concentrations of Toxic Substances at Control Room Air Intakes” (March 1991).

- NUREG/CR-6210, “Computer Codes for Evaluation of Control Room Habitability (HABIT)” (June 1996).

- NUREG/CR-6210, Supp. 1, “Computer Codes for Evaluation of Control Room Habitability (HABIT V1.1)” (October 1998).

b. Removed the following references:

- RG 1.95, "Protection of Nuclear Power Plant Control Room Operators Against an Accidental Chlorine Release."

- 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).

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

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