U.S. NUCLEAR REGULATORY COMMISSION

DESIGN-SPECIFIC REVIEW STANDARD FOR mPOWER^{TM} iPWR DESIGN

15.0.3 DESIGN BASIS ACCIDENT RADIOLOGICAL CONSEQUENCE ANALYSES FOR mPower^{TM} iPWR DESIGN

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of design basis accident radiological consequence analyses

Secondary - Organization responsible for the review of meteorology
Organization responsible for the review of post-accident water chemistry

I. AREAS OF REVIEW

Chapter 15 of the Design-Specific Review Standard (DSRS) discusses the analysis of postulated accidents that could affect the safe design and siting of an integral pressurized water reactor (iPWR). The staff reviews information presented by the applicant for a standard design certification (DC), early site permit (ESP), combined operating license (COL), standard design approval, or manufacturing license concerning radiological consequence analyses for postulated design basis accidents (DBAs). This DSRS section applies to reviews performed for each of these types of applications. The review covers the following specific areas:

1. DC or COL Applications. For a DC or COL application, the staff reviews the radiological consequences of potential DBAs in six parts: (1) review of selected bounding DBAs, (2) review of accident source terms, (3) review of the major structures, systems, and components of the facility that are intended to mitigate the radiological consequences of a DBA, (4) review of the characteristics of fission product releases from the proposed site (COL reviews) or reference site (for the DC review) to the environment, (5) review of the meteorological characteristics of the proposed site for the COL review (reference site for DC review), and (6) review of the total calculated radiological consequence dose at the exclusion area boundary (EAB), low population zone (LPZ) and control room from the bounding DBAs. In support of the Standard Review Plan (SRP) Section 13.3 emergency planning review, the staff also reviews the dose analysis performed to demonstrate technical support center (TSC) habitability.

   The application must contain sufficient nuclear plant design information for the staff to review in making a determination regarding the acceptability of the proposed site and/or design using the radiological consequence evaluation factors identified in Title 10 of the *Code of Federal Regulations* (CFR), Section 50.34(a)(1), and/or either 10 CFR 52.47(a)(2) or 10 CFR 52.79(a)(1) as applicable to the licensing action, and General Design Criterion (GDC) 19.

2. ESP Applications that Reference Standard Reactor Designs Certified by the U.S. Nuclear Regulatory Commission (NRC).

ADAMS Accession No. ML12257A226

Standard reactor designs are certified with a postulated set of short-term atmospheric relative concentration (χ/Q) values at an EAB and LPZ in lieu of site-specific meteorological data and actual distances to the EAB and LPZ. The NRC has determined, for purposes of the ESP review, that the certified standard reactor designs meet the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1) and 10 CFR 52.17(a)(1), provided that the site parameters fall within those postulated in the DC.

3. ESP Applications that Use the Plant Parameter Envelope (PPE) Approach. A PPE is a set of plant design parameters that are expected to bound the characteristics of a reactor or reactors that may be constructed at a site, and it serves as a surrogate for actual reactor design information. The PPE values are selected by the applicant to bound a range of possible current and future reactor designs. The PPE values and associated information in the ESP application must contain sufficient information for the staff to make a determination regarding the acceptability of the proposed site using the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1) and 10 CFR 52.17(a)(1).

4. ESP Applications that Neither Reference the Standard Reactor Designs Certified by NRC Nor Use the PPE Approach. Applications may be received that neither reference a certified design nor use the PPE approach. For example, an application may reference a "standard" design that is not yet certified, or a custom design. In such cases, the staff reviews the radiological consequences of potential DBAs in six parts: (1) review of selected bounding DBAs, (2) review of accident source terms, (3) review of the major structures, systems, and components of the facility that bear significantly on the acceptability of the site for mitigating the radiological consequences of a DBA under the radiological consequence evaluation, (4) review of the characteristics of fission product release from the site to the environment, (5) review of the meteorological characteristics of the proposed site, and (6) review of the total calculated radiological consequence dose at the EAB and LPZ from the bounding DBAs.

   The application must contain sufficient nuclear plant design information for the staff to review in making a determination regarding the acceptability of the proposed site using the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1) and 10 CFR 52.17(a)(1).

5. COL Applications that Reference Standard Reactor Designs Certified by NRC and ESP Issued by NRC. Should the site characteristic short-term χ/Q values specified in the ESP fall within the postulated short-term χ/Qs for the chosen certified design, the staff concludes that the COL applicant has satisfied the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1) and 10 CFR 52.79(a)(1). However, the application must contain sufficient information regarding control room habitability for the staff to make a determination regarding the acceptability of the proposed control room design using the radiological dose acceptance criteria specified in GDC 19.

6. COL Applications that Reference an ESP Issued by NRC but not a Certified Standard Reactor Design by NRC. The staff reviews the radiological consequences of potential DBAs in five parts: (1) review of selected bounding DBAs, (2) review of accident source terms, (3) review of the major structures, systems, and components of the facility that bear significantly on the acceptability of the site for mitigating the radiological

consequences of a DBA under the radiological consequence evaluation, (4) review of the characteristics of fission product release from the site to the environment, and (5) review of the total calculated radiological consequence dose at the EAB and LPZ from the bounding DBAs to determine whether the applicable regulations in 10 CFR 50.34(a)(1), 10 CFR 52.79(a)(1), and GDC 19 regarding dose consequence evaluation factors have been met.

7. COL Applications that Reference a Certified Standard Reactor Design by NRC but not an ESP Issued by NRC. The staff evaluates the site-specific short-term χ/Qs for the selected site and uses the site-specific χ/Qs and the source term determined in the certified design to determine whether the applicable regulations in 10 CFR 50.34(a)(1) and 10 CFR 52.79(a)(1) regarding dose consequence evaluation factors have been met. The application must contain sufficient information regarding control room habitability for the staff to make a determination regarding the acceptability of the proposed control room design using the radiological dose acceptance criteria specified in GDC 19.

8. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action items and requirements and restrictions (e.g., interface requirements and site parameters).

   For a COL application referencing a DC, a COL applicant must address COL action items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

9. Standard Design Approval and Manufacturing License Applications. Review procedures for standard design approvals and manufacturing license applications are the same as those for DCs, as far as applicable to the scope of the application.

Review Interfaces

Other DSRS or SRP sections interface with this DSRS section as follows:

1. 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 and Chapter 2 of the DCD Tier 2[1] submitted by the applicant is performed under SRP Section 2.0, "Site Characteristics and Site Parameters."

2. Review of the short-term χ/Q values for use in the DBA radiological consequences analyses is performed under SRP Section 2.3.4, "Short-Term Atmospheric Dispersion Estimates for Accident Releases."

3. Review of the coolant radioactivity source terms for non-LOCA accidents is performed under DSRS Section 11.1, "Coolant Source Terms."

4. Review of the provisions for protection of the control room from radiation and habitability during an emergency is performed under DSRS Section 6.4, "Control Room Habitability

[1]Additional supporting information of prior DC rules may be found in DCD Tier 2 Section 14.3.

System." A similar review of TSC habitability is performed in support of SRP Section 13.3, "Emergency Planning."

5. Review of the emergency safety features (ESFs) ventilation and filtration systems that are designed to remove fission products is performed under SRP Section 6.5.1, "ESF Atmosphere Cleanup Systems."

6. Review of the analysis modeling of fission product removal capability for plant systems and structures is performed under SRP Section 6.5.3, "Fission Product Control Systems and Structures."

7. For review of DC applications, and COLs or ESPs referencing the iPWR design, this DSRS section also interfaces with:

   A. DSRS Section 4.2, "Fuel System Design," as it relates to fuel design parameters and reactor operation as input and assumptions for core fission product inventory calculations.

   B. DSRS Section 15.0, "Transient and Accident Analyses," as it applies to the selection of design basis accidents and scenarios.

   C. DSRS Section 15.1.1 – 15.1.4, "Decrease in Feedwater Temperature, Increase in Feedwater Flow, Increase in Steam Flow, and Inadvertent Opening of a Steam Generator Relief or Safety Valve"

   D. DSRS Section 15.1.5, "Steam System Piping Failures Inside and Outside of Containment"

   E. DSRS Section 15.2.1 – 15.2.5, "Loss of External Load; Turbine Trip; Loss of Condenser Vacuum; Closure of Main Steam Isolation Valve; and Steam Pressure Regulator Failure (Closed)"

   F. DSRS Section 15.2.6, "Loss of Nonemergency AC Power to the Station Auxiliaries"

   G. DSRS Section 15.2.7, "Loss of Normal Feedwater Flow"

   H. DSRS Section 15.2.8, "Feedwater System Pipe Break Inside and Outside Containment"

   I. DSRS Section 15.3.1 – 15.3.2, "Loss of Forced Reactor Coolant Flow Including Trips of One or More Pump Motors, Flow Controller Malfunctions, and Flow Blockages"

   J. DSRS Section 15.3.3 – 15.3.4, "Reactor Coolant Pump Rotor Seizure and Reactor Coolant Pump Shaft Seizure and Break Accidents"

   K. DSRS Section 15.4.1, "Uncontrolled Control Rod Assembly Withdrawal from a Subcritical or Low Power Startup Condition"

L. DSRS Section 15.4.2, “Uncontrolled Control Rod Assembly Withdrawal at Power”

M. SRP Section 15.4.3, “Control Rod Misoperation (System Malfunction or Operator Error)”

N. SRP Section 15.4.7, “Inadvertent Loading and Operation of a Fuel Assembly in an Improper Position”

O. DSRS Section 15.5.1 – 15.5.2, “Inadvertent Operation of Emergency Borated Water Tanks (EBTs) and Inadvertent Operation of Reactor Coolant Inventory and Purification System (RCIPS) that Increases Reactor Coolant Inventory”

P. DSRS Section 15.6.1, “Inadvertent Opening of a Pressurizer Pressure Relief Valve”

Q. DSRS Section 15.6.5, “Loss of Coolant Accidents Resulting From Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary”

II. ACCEPTANCE CRITERIA

Requirements

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

1. Section 50.34(a)(1) of 10 CFR Part 50, “Contents of applications; technical information,” as it relates to the evaluation and analysis of the offsite radiological consequences of postulated accidents with fission product release.

2. GDC 19 of Appendix A to 10 CFR Part 50, “Control room,” as it relates to maintaining the control room in a safe condition under accident conditions by providing adequate protection against radiation.

3. Section 52.17(a)(1) of 10 CFR Part 52, “Contents of applications; technical information,” as it relates to the evaluation and analysis of the offsite radiological consequences of postulated accidents with fission product release for ESPs.

4. Section 52.47(a)(2) of 10 CFR Part 52 , “Contents of applications; technical information,” as it relates to the evaluation and analysis of the offsite radiological consequences of postulated accidents with fission product release for Standard DCs.

5. Section 52.79(a)(1) of 10 CFR Part 52, “Contents of applications; technical information in final safety analysis report,” as it relates to the evaluation and analysis of the offsite radiological consequences of postulated accidents with fission product release for COLs.

6. Section 52.137(a)(2) of 10 CFR Part 52, “Contents of applications; technical information,” as it relates to the evaluation and analysis of the offsite radiological consequences of postulated accidents with fission product release for Standard Design Approvals.

7. Section 52.157(d) of 10 CFR Part 52, “Contents of applications; technical information in final safety analysis report,” as it relates to the evaluation and analysis of the offsite radiological consequences of postulated accidents with fission product release for Manufacturing Licenses.

8. Section 100.21 of 10 CFR Part 100, “Non-seismic siting criteria,” as it relates to the evaluation and analysis of the radiological consequences of postulated accidents for the type of facility to be located at the site in support of evaluating the site atmospheric dispersion characteristics.

9. Sections 50.47(b)(8) and (b)(11), “Emergency Plans,” and Paragraph IV.E.8 of Appendix E, to 10 CFR Part 50, “Emergency Planning and Preparedness for Production and Utilization Facilities,” as they relate to adequate provisions for an onsite TSC from which effective direction can be given and effective control can be exercised during an emergency.

DSRS Acceptance Criteria

Specific DSRS acceptance criteria acceptable to meet the relevant requirements of the NRC’s regulations identified above are as follows for review described in this DSRS section. The DSRS is not a substitute for the NRC’s regulations, and compliance with it is not required. Identifying the differences between this DSRS section and the design features, analytical techniques, and procedural measures proposed for the facility, and discussing how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria, is sufficient to meet the intent of 10 CFR 52.47(a)(9), “Contents of applications; technical information.”

1. Offsite Radiological Consequences of Postulated DBAs. The acceptance criteria are based on the requirements of 10 CFR 50.34(a)(1) [as referenced by 10 CFR 100.21, non-seismic siting criteria], and 10 CFR 52.17(a)(1) [ESPs], 10 CFR 52.47(a)(2) [standard DCs], 10 CFR 52.79(a)(1) [COLs], 10 CFR 52.137(a)(2) [standard design approvals], or 10 CFR 52.157(d) [manufacturing licenses], as related to mitigating the radiological consequences of an accident.

   The plant design features intended to mitigate the radiological consequences of accidents, site atmospheric dispersion characteristics and the distances to the EAB and to the LPZ outer boundary are acceptable if the total calculated radiological consequences for the postulated fission product release fall within the following exposure acceptance criteria specified in 10 CFR 50.34(a)(1)(ii)(D):

   A. An individual located at any point on the boundary of the exclusion area for any 2-hour period following the onset of the postulated fission product release, would not receive a radiation dose in excess of 25 rem total effective dose equivalent (TEDE), and

   B. An individual located at any point on the outer boundary of the LPZ, who is exposed to the radioactive cloud resulting from the postulated fission product release (during the entire period of its passage), would not receive a radiation dose in excess of 25 rem TEDE.

These criteria are repeated in the applicable subpart of Part 52 for each of the permits, certifications, approvals, or licenses under consideration.

For DC and COL reviews, the application is acceptable with regard to the radiological consequences of analyzed DBAs if the calculated TEDEs at the EAB and the LPZ outer boundary do not exceed the dose acceptance criteria listed in Table 1 below. Based on the classification of events done in DSRS Section 15.0, for some iPWRs, some accidents in Table 1 may not be applicable to the design or there may be additional accidents that are not listed. To aid in determining the dose acceptance criteria for DBAs not listed below in Table 1, the dose acceptance criterion would decrease stepwise as the likelihood of occurrence of the accident increases, as is done in the SRP for large light water reactors (LWRs). The dose acceptance criterion may be equivalent to the regulatory dose reference value of 25 rem TEDE, well within (25%), or a small fraction (10%) of the regulatory dose reference value.

For ESP applications that neither reference the standard reactor designs certified by NRC nor use the PPE approach, the staff may establish dose acceptance criteria lower than those stated above for certain DBAs based on the probability of occurrence. Examples of such criteria are illustrated in Table 1.

For COL applications using an ESP with a PPE approach, these acceptance criteria may be applied at that time. Such applicants bear the burden of ensuring sufficient margin is provided in the design parameters (for example, PPE values) in the ESP application to compensate for uncertainty in those parameters. The margin should be large enough such that the actual design submitted at the COL stage, coupled with the site characteristics as described in the ESP, will comply with NRC regulations.
The review process discussed in this DSRS section for DC and COL reviews may also be applied to review of applications for standard design approval or manufacturing license, as far as is applicable.

2. Control Room Radiological Habitability. The acceptance criterion is based on the requirements of GDC 19 that mandate a control room design providing adequate radiation protection to permit access and occupancy of the control room under accident conditions for the duration of the accident, without personnel receiving radiation exposures in excess of 5 rem whole body, or its equivalent to any part of the body, for the duration of the accident. These requirements are incorporated by reference in 10 CFR 52.47(a)(3) [standard DCs] and 10 CFR 52.79(a)(4) [COLs]. These requirements are also incorporated by reference in 10 CFR 52.137(a)(3) [standard design approvals] and 10 CFR 52.157 [manufacturing licenses], as far as applicable to the scope of the application.

   The radiation protection design of the control room is acceptable if the total calculated radiological consequences for the postulated fission product release fall within the exposure acceptance criteria specified in GDC 19 of 5 rem TEDE for the duration of the accident.

3. TSC Radiological Habitability. This acceptance criterion is based on the requirement of Paragraph IV.E.8 of Appendix E to 10 CFR Part 50 to provide an onsite TSC from which effective direction can be given and effective control can be exercised during an emergency. The radiation protection design of the TSC is acceptable if the total

calculated radiological consequences for the postulated fission product release fall within the exposure acceptance criteria specified for the control room of 5 rem TEDE for the duration of the accident.

Table 1
iPWR Accident Dose Criteria

Accident or Case	EAB and LPZ Dose Criteria	Analysis Release Duration
Loss-of-Coolant Accident (LOCA)	25 rem TEDE	30 days for all leakage pathways
Small Line Break Accident	2.5 rem TEDE	Until isolation, if capable, or until cold shutdown is established
Steam Generator Tube Rupture Fuel Damage or Pre-incident Spike Coincident Iodine Spike	 25 rem TEDE 2.5 rem TEDE	Affected SG: time to isolate; Unaffected SG(s): until cold shutdown is established
Main Steam Line Break Fuel Damage or Pre-incident Spike Coincident Iodine Spike	 25 rem TEDE 2.5 rem TEDE	Until cold shutdown is established
Locked Rotor Accident	2.5 rem TEDE	Until cold shutdown is established
Rod Ejection Accident	6.3 rem TEDE	30 days for containment leakage pathway; Until cold shutdown is established for secondary pathway
Fuel Handling Accident or Cask Drop	6.3 rem TEDE	2 hours

Note: For some iPWRs, some accidents may not be applicable or there may be additional accidents that are applicable.

Technical Rationale

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

1. Compliance with 10 CFR 50.34(a)(1), or the applicable subsection of 10 CFR Part 52, ensures that the application includes a description and safety assessment of the standard design, custom design and/or site on which the facility is to be located. The review performed under this DSRS section ensures that the application contains a sufficient description of the DBA radiological consequences analyses that will enable the staff to evaluate the planned site and provide reasonable assurance that plant design and operation will reflect site considerations in a manner adequate to minimize the consequences of an accident.

   The dose acceptance criteria in Table 1 of this DSRS section are fractions of the offsite receptor regulatory dose reference values for accidents other than the LOCA, as has been done historically. For events having a moderate frequency of occurrence, any

release of radioactive material must be such that the calculated offsite doses are a small fraction of the regulatory reference values. A small fraction is defined as less than 10% of the regulatory reference value, or 2.5 rem TEDE. The plant site and dose mitigating engineered safety features are acceptable with respect to the radiological consequences of a postulated control rod ejection accident, fuel handling accident or cask drop accident if the calculated offsite doses are well within the regulatory dose reference. “Well within" is defined as 25% of the reference value, or 6.3 rem TEDE.

2. Compliance with the radiological provision of GDC 19 provides assurance that control of the plant is maintained during emergency operation. The applicant is required to maintain the control room in a safe condition under accident conditions, including LOCAs, and provide adequate radiation protection to permit access and occupancy of the control room under accident conditions for the duration of the accident. The review performed under this DSRS section for DCs and COLs determines if the design of the control room is acceptable with respect to the radiological consequences of DBAs.

3. 10 CFR 100.21 requires that radiological dose consequences of postulated accidents meet the requirements of 10 CFR 50.34(a)(1) for the type of facility proposed to be located at the site. Compliance with 10 CFR Part 100 provides assurance that the consequences of an accident on the proposed site will be within acceptable levels. The review performed under this DSRS section for COLs determines if the site is acceptable with respect to the radiological consequences of DBAs.

4. Paragraph IV.E.8 of Appendix E, to 10 CFR Part 50, requires that onsite emergency facilities be provided, from which effective direction can be given and effective control can be exercised during an emergency. NUREG-0737 III.A.1.2, Emergency Response Facilities, describes requirements for maintaining emergency facilities in a safe, habitable condition under accident conditions by providing adequate protection against radiation and toxic gases. In particular, the TSC should provide the same level of protection against radiation that the control room provides, for the duration of the event. The radiological consequences analysis for the TSC is performed under this DSRS section to support the SRP Section 13.3 review for acceptability of the TSC.

III. REVIEW PROCEDURES

These review procedures are based on the identified DSRS acceptance criteria. For deviations from these 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.

As applicable, reviews of COLs include a determination that the content and intent of technical specifications related to the plant features intended to mitigate the radiological consequences of postulated DBAs are acceptable and consider any identified unique conditions.

1. ESP applications that reference standard reactor designs certified by NRC

   The staff will use the guidance in SRP 15.0.3.

2. ESP applications that use the PPE approach

The staff will use the guidance in SRP 15.0.3.

3. COL applications that reference both an ESP and a standard reactor design certified by NRC

   A. The staff verifies that no changes from the site characteristic short-term χ/Q values specified in the ESP application have occurred due to changes in plant design, plant location on the site, building orientation, or fission product release points or any such variance from the ESP is requested by the COL applicant. Review of site characteristic short-term χ/Q values is coordinated with the review performed under DSRS

   B. Should the site characteristic short-term χ/Q values specified in the ESP fall within the postulated short-term χ/Qs for the chosen certified design, the staff concludes that the COL applicant has satisfied the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1) and 10 CFR 52.79(a)(1).

   C. If the site characteristic short-term χ/Q values do not fall within the postulated short-term χ/Q values for the chosen certified design, the staff reviews the applicant's radiological dose calculations and performs independent confirmatory radiological consequence dose calculations using the site characteristic short-term χ/Q values and the source terms and related DBA accident information provided in the certified reactor design control document or Final Safety Analysis Report (FSAR).

   D. For each postulated DBA, the calculated doses from all postulated fission product release pathways from the facility are combined and are compared with the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1) and 10 CFR 52.79(a)(1), and the applicable accident-specific dose acceptance criteria stated above in Table 1, at the nearest EAB and LPZ outer boundary.

   E. For each postulated DBA, the calculated doses from all postulated fission product release pathways from the facility, including all sources of radiation exposure to the control room personnel, are combined, and the calculated dose in the control room is compared with the radiological consequence evaluation factors identified in GDC 19.

   F. For each postulated DBA, the calculated doses from all postulated fission product release pathways from the facility, including all sources of radiation exposure to the personnel in the technical support center, are combined, and the calculated dose in the TSC is compared with the radiological consequence evaluation factor of 5 rem TEDE for the duration of the accident.

4. DC applications or COL applications that do not reference a standard reactor design certified by NRC

   A. The staff reviews the sequences of DBA events as described by the applicant to ensure that the spectrum of DBAs includes the bounding DBA with respect to calculated fission product releases. The spectrum of DBAs has generally been assumed to reflect a substantial meltdown of the reactor core (a major reactor

accident) with subsequent release of appreciable quantities of fission products to the environment. Although the LOCA is typically the maximum credible accident associated with the LWR design, the applicant should consider other accident sequences of greater radiological consequence for the specific reactor designs selected by the applicant. This review is coordinated with the review done under DSRS Section 15.0.

B. The staff reviews a spectrum of representative DBAs selected and evaluated by the applicant for determining the bounding DBA radiological consequences. The selected DBA should cover a spectrum of reactor transients and accidents.

C. The applicant's proposed accident source terms are reviewed in the following areas:

i. Fission product inventory in the reactor core operated at the ultimate maximum proposed power level with the limiting conditions which maximizes fission product releases for evaluation of DBAs. Regulatory Guide (RG) 1.183, Rev. 0, Regulatory Position C.3.1 gives guidance on the information needed to evaluate the applicant's calculation of the core isotopic inventory. This guidance is generally acceptable for iPWRs. Although ORIGEN2 is listed as an acceptable isotope generation and depletion code, Oakride National Laboratory (ORNL) no longer supports or maintains the code. Applicants and staff may use the latest version of ORIGEN-ARP, which is part of the most recent version of the SCALE code package, which should be shown to have applicable models for iPWR fuel. Input and assumptions for the core fission product inventory calculation is coordinated with the review for DSRS Section 4.2, as it relates to fuel design parameters and reactor operation.

   The core isotopic inventory is also used as the basis for coolant source terms for non-accident analyses, such as those evaluated by the staff under DSRS 11.2 and 11.3 for radwaste systems and 12.2 for radiation sources used in health physics and shielding reviews. Therefore, the core isotopic inventory should also include values for those isotopes necessary for those non-accident related purposes.

ii. Timing and rate of fission product release from the fuel following selected DBAs. The fission product release rates should be fractions of fission product inventory in the reactor core based on the maximum full power operation.

iii. Review of the primary coolant activity concentration is coordinated with the review performed under DSRS Section 11.1. The non-LOCA DBA primary and secondary coolant source terms are calculated based on the coolant activity concentration adjusted to the TS concentration limits, and include iodine spiking, using the guidance in RG 1.183 as far as applicable to the design.

iv. The isotopic quantities in curies and the chemical forms of fission products released to the containment and to the environment. The staff

reviews the modeling of changes in chemical form as the releases are processed by mitigating systems.

v. Rates of fission product release to the environment from the site during the entire period of the DBA as a function of time.

D. The staff reviews the fission product distribution, transport, removal, and release models within and between the major structures and systems, as well as the engineered safety feature (ESF) components of the facility, that bear significantly on the acceptability of the site with respect to the radiological consequence evaluation factors. The staff reviews the efficiencies of fission product removal by the ESF systems and components, as justified by the applicant. Conditions for credit for fission product removal by ESF systems are discussed in SRP Section 6.5.1 and 6.5.3 and control room habitability systems are discussed in DSRS Section 6.4. The review under this DSRS section should be coordinated with the primary review organization for each of the aforementioned DSRS sections.

Post-accident water chemistry and pH in containment and the related impact on the iodine speciation, transport and removal is coordinated with the organization that reviews post-accident water chemistry.

E. The iPWR reactor design may include unique design features and passive safety systems. The DBA radiological consequences analyses may consider credit for the mitigation capability of the design through natural fission product removal processes such as diffusiophoresis, thermophoresis and gravitational settling. The staff's review of removal through natural fission product removal processes or for unique features of the design will require additional information from the applicant to fully explain the process being credited, the amount of removal being credited (specifically decontamination factors or coefficients and timing), basis for the proposed values and inputs to the dose analysis calculation, and the justification for assuming the removal process is applicable to the design of the plant for the duration of the event. This review may need to be coordinated with the organizations that review containment, ESF systems, post-accident water chemistry, or other subject matter areas. The staff should determine if a technical assistance contract to assist the NRC staff should be placed to verify the applicant's proposed fission product removal credit.

F. The staff reviews the points of fission product release from the major structures and systems, and from the ESF components of the facility.

G. Under SRP Section 2.3.4, the staff reviews the site characteristic short-term χ/Q values determined by the applicant, and performs an independent evaluation as described therein. Review under this DSRS section should be coordinated with the review done in SRP Section 2.3.4, to ensure that the site characteristic short-term χ/Qs are acceptable for use as input to the DBA dose analyses.

H. The staff performs an independent confirmatory radiological consequence analysis using pertinent information in the application to determine whether the proposed site meets the radiological consequence evaluation factors identified in

10 CFR 50.34(a)(1) and/or applicable subparts to 10 CFR Part 52. For applications other than an ESP, the staff also determines if the requirements of GDC 19 for maintaining the control room in a safe condition are met. The staff will evaluate the reasonableness of the licensee's analysis model and results, and will do so by performing an independent confirmatory calculation.

I. For each postulated accident, the calculated doses from all postulated fission product release pathways from the site are combined, and the calculated doses are compared with the radiological consequence evaluation factors identified in Part 52 and/or 10 CFR Part 50.34(a)(1) at the nearest EAB and LPZ outer boundary stated in the application.

J. For each postulated accident, the calculated doses from all postulated fission product release pathways from the site, including all sources of radiation exposure to the control room personnel, are combined, and the calculated dose in the control room is compared with the radiological consequence evaluation factors identified in GDC 19.

K. For each postulated accident, the calculated doses from all postulated fission product release pathways from the site, including all sources of radiation exposure to the personnel in the technical support center, are combined, and the calculated dose in the TSC is compared with the radiological consequence evaluation factors identified for the control room of 5 rem TEDE for the duration of the accident.

L. For the methodology and assumptions for calculating the radiological consequences, the staff will use the regulatory positions stated in RG 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors," as applicable to the plant design. Additional information on the progression and assumptions for the failure of small lines carrying coolant outside containment can be found in SRP Section 15.6.2, if applicable to the iPWR design.

5. Review Procedures Specific to 10 CFR Part 52 Application Type

A. ESP 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.

In the absence of certain circumstances, such as 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 ESP 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 of the ESP.

B. Standard DC 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. Site parameters associated with this DSRS section are reviewed, as applicable, to verify that:

a. The postulated site parameters are representative of a reasonable number of sites that have been or may be considered for a COL application;

ii. The appropriate site parameters are included as Tier 1 information. This convention has been used by previous DC applicants. Additional guidance on site parameters is provided in SRP Section 2.0;

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

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

C. COL Reviews: For a COL application referencing a certified standard design, the NRC staff reviews that application to ensure that sufficient information is 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 provides sufficient information to demonstrate that the design of the facility falls within the site characteristics and design parameters specified in the ESP as applicable to this DSRS section. In accordance with 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 10 CFR 52.39 and 10 CFR 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. In the absence of certain circumstances, such as 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 ESP at the COL stage. Consequently, a COL application referencing an ESP need 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 Final Safety Evaluation Report (FSER) to ensure that any ESP conditions, restrictions to the DC, or COL action items identified in the FSERs are appropriately handled in the COL application.

IV. EVALUATION FINDINGS

The review should document the staff's evaluation of the applicant's DBA radiological consequences analyses against the relevant regulatory criteria. The evaluation should support the staff's conclusions as to whether the regulations are met. The reviewer should state what was done to evaluate the applicant's submittal. The staff's evaluation may include verification that the applicant followed applicable regulatory guidance, performance of independent calculations, and/or validation that the appropriate assumptions were made. 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 acceptance and 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.

A conclusion of the following type for the radiological consequence analyses will be included in Section 15 of the site safety evaluation, standard design safety evaluation, or COL safety evaluation:

1. ESP application.

   Refer to SRP 15.0.3.

2. Standard reactor DC application. As set forth above, the applicant has selected and analyzed the bounding DBAs and has determined that the total radiological consequences of such accidents meet the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1), 10 CFR 52.47(a)(2) and GDC 19 for the standard reactor design, considering a reference site. The results of the applicant's radiological consequence dose calculation are provided in Table [ ].

   The staff reviewed the radiological consequence analyses provided by the applicant and has performed an independent analysis of the radiological consequences of each DBA considered in the application using the design reference site parameter χ/Q values at the EAB, LPZ, and control room proposed in the application. The staff finds that its results are also within the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1), 10 CFR 52.47(a)(2) and GDC 19. Although the staff performed an independent radiological consequence dose calculation as a means of confirming the licensee's results, the staff's approval of the standard design is based on the applicant's analyses. Details of the staff's analyses are presented in Section [ ] of this safety evaluation report and the results are listed in Table [ ].

The staff performed a similar review of the applicant's evaluation of the DBA radiological consequences in the TSC in support of the emergency planning review. The staff has reasonable assurance that the dose in the TSC will be within 5 rem TEDE. The details of the staff's analysis is presented in Section [ ] of this safety evaluation report, and the results are listed in Table [ ].

Therefore, the staff concludes that the plant features intended to mitigate the radiological consequences of postulated DBAs, in conjunction with the source term and the fission product release rates from the site to the environment provided by the applicant, are sufficient to provide reasonable assurance that the total radiological consequences of the DBAs will be within the dose evaluation factors set forth at 10 CFR 50.34(a)(1), 10 CFR 52.47(a)(2),GDC 19 and the regulatory requirements for TSC radiological habitability. This conclusion is based on the staff review of the applicant's analysis and on the staff's independent analysis, which confirms that the calculated total doses are within the dose evaluation factors set forth at 10 CFR 50.34(a)(1), 10 CFR 52.47(a)(2) and GDC 19.

3. COL application without ESP or certified standard reactor design. As set forth above, the applicant has selected and analyzed the bounding DBAs and has determined that the total radiological consequences of such accidents meet the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1), 10 CFR 52.79(a)(1), GDC 19 and the regulatory requirements for TSC radiological habitability. The results of the applicant's radiological consequence dose calculation are provided in Table [ ].

The staff reviewed the radiological consequence analyses provided by the applicant and has performed an independent analysis of the radiological consequences of each DBA considered in the application using the site characteristic χ/Q values at the EAB, LPZ and control room proposed in the COL application. The staff finds that its results are also within the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1), 10 CFR 52.79(a)(1) and GDC 19. Although the staff performed an independent radiological consequence dose calculation as a means of confirming the licensee's results, the staff's approval of the COL is based on the applicant's analyses. Details of the staff's analyses are presented in Section [ ] of this safety evaluation report, and the results are listed in Table [ ].

The staff performed a similar review of the applicant's evaluation of the DBA radiological consequences in the TSC in support of the emergency planning review. The staff has reasonable assurance that the dose in the TSC will be within 5 rem TEDE. The details of the staff's analysis is presented in Section [ ] of this safety evaluation report, and the results are listed in Table [ ].

Therefore, the staff concludes that the distances to the EAB and the LPZ outer boundary of the [site name] site and plant features intended to mitigate the radiological consequences of postulated DBAs, in conjunction with the source term and the fission product release rates from the site to the environment provided by the applicant, are sufficient to provide reasonable assurance that the total radiological consequences of the DBAs will be within the dose evaluation factors set forth at 10 CFR 50.34(a)(1), 10 CFR 52.79(a)(1),GDC 19 and also meet the regulatory requirements for TSC radiological habitability. This conclusion is based on the staff review of the applicant's analysis and on the staff's independent analysis, which confirms that the calculated total

doses are within the dose evaluation factors set forth at 10 CFR 50.34(a)(1), 10 CFR 52.79(a)(1) and GDC 19.

4. COL application with certified standard reactor design. As set forth above, the staff has reviewed the site characteristic short-term atmospheric dispersion (χ/Q) values at the EAB, at the boundary of the LPZ, in the TSC and in the control room for the proposed site in the COL application and has verified that they are within the design reference set of site parameter χ/Q values specified in the [name of certified reactor design] design control document.

   Therefore, the staff concludes that the distance to the EAB and to the LPZ boundary of the [name] site and plant features intended to mitigate the radiological consequences of postulated DBAs, in conjunction with the engineered safety features as described in the [name] certified standard design, are sufficient to provide reasonable assurance that the total radiological consequences of the DBAs considered in the [name] certified design will be within the radiological consequence evaluation factors of 10 CFR 50.34(a)(1), 10 CFR 52.79(a)(1) and GDC 19 and also meet the regulatory requirements for TSC radiological habitability.

   [or :]

   As set forth above, the staff has reviewed the site characteristic short-term χ/Q values at the EAB, at the boundary of the LPZ, in the TSC and in the control room for the proposed site in the COL application and found that [name the χ/Q receptors that are not within the DCD] exceed the design reference set of site parameter χ/Q values specified in the [name of certified reactor design] design control document. However, the staff has verified that the applicant has demonstrated that the radiological consequences associated with the bounding DBAs using its site characteristic χ/Q values meet the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1), 10 CFR 52.79(a)(1) and GDC 19.

   The staff performed a similar review of the applicant's evaluation of the DBA radiological consequences in the TSC in support of the emergency planning review. The staff has reasonable assurance that the dose in the TSC will be within 5 rem TEDE. The details of the staff's analysis is presented in Section [ ] of this safety evaluation report, and the results are listed in Table [ ].

   Therefore, the staff concludes that the distance to the EAB and to the LPZ boundary of the [site name] site and plant features intended to mitigate the radiological consequences of postulated DBAs, in conjunction with the engineered safety features as described in the [name] certified standard design, are sufficient to provide reasonable assurance that the total radiological consequences of the DBAs considered in the [name] certified design will be within the radiological consequence evaluation factors of 10 CFR 50.34(a)(1), 10 CFR 52.79(a)(1) and GDC 19 and also meet the regulatory requirements for TSC radiological habitability.

5. COL application with both ESP and certified standard reactor design. As set forth above, the staff has verified that the site characteristic short-term atmospheric dispersion (χ/Q) values at the EAB and at the boundary of the LPZ for the proposed site in the ESP and that the site characteristic short-term χ/Q values for the control room and TSC are

within the design reference set of site parameter χ/Q values specified in the [name of certified reactor design] design control document. Therefore, the applicant has demonstrated that the radiological consequences associated with the bounding DBAs using its site characteristic χ/Q values meet the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1), 10 CFR 52.79(a)(1) and GDC 19 and also meet the regulatory requirements for TSC radiological habitability.

Therefore, the staff concludes that the distance to the EAB and to the LPZ boundary of the [site name] site and plant features intended to mitigate the radiological consequences of postulated DBAs, in conjunction with the engineered safety features as described in the [name] certified standard design, are sufficient to provide reasonable assurance that the total radiological consequences of the DBAs considered in the [name] certified design will be within the radiological consequence evaluation factors of 10 CFR 50.34(a)(1), 10 CFR 52.79(a)(1) and GDC 19 and also meet the regulatory requirements for TSC radiological habitability.

[or:]

As set forth above, the staff has reviewed the site characteristic short-term χ/Q values at the EAB and at the boundary of the LPZ for the proposed site in the ESP and the site characteristic short-term χ/Q values for the control room and the TSC and has found that [name the χ/Q receptors that are not within the DCD] exceed the design reference set of site parameter χ/Q values specified in the [name of certified reactor design] design control document. However, the staff has verified that the applicant has demonstrated that the radiological consequences associated with the bounding DBAs using its site-specific χ/Q values meet the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1), 10 CFR 52.79(a)(1) and GDC 19 and also meet the regulatory requirements for TSC radiological habitability.

Therefore, the staff concludes that the distance to the EAB and to the LPZ boundary of the [name] site, in conjunction with the engineered safety features as described in the [name] certified standard design, are sufficient to provide reasonable assurance that the total radiological consequences of the DBAs considered in the [name] certified design will be within the radiological consequence evaluation factors of 10 CFR 50.34(a)(1), 10 CFR 52.79(a)(1) and GDC 19 and also meet the regulatory requirements for TSC radiological habitability.

6. COL application with ESP only. As set forth above, the applicant has selected and analyzed the bounding DBAs using the site characteristic short-term atmospheric dispersion (χ/Q) values at the EAB and at the boundary of the LPZ for the proposed site in the ESP, as well as site characteristic short-term χ/Q values for the control room and TSC, and has determined that the total radiological consequence of such accidents meets the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1), 10 CFR 52.79(a)(1) and GDC 19, and also meet the regulatory requirements for TSC radiological habitability. The results of the applicant's radiological consequence dose calculation are provided in Table [ ].

The staff reviewed the radiological consequence analyses provided by the applicant and has performed an independent analysis of the radiological consequences of each DBA in the application using the EAB and LPZ χ/Q values from the ESP and site-specific χ/Q

values at the control room proposed in the COL application. The staff finds that its results are also within the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1), 10 CFR 52.79(a)(1) and GDC 19. Although the staff performed its independent radiological consequence dose calculation as a means of confirming the licensee's results, the staff's approval of the COL is based on the applicant's analyses. Details of the staff's analyses are presented in Section [ ] of this safety evaluation report, and the results are listed in Table [ ].

The staff performed a similar review of the applicant's evaluation of the DBA radiological consequences in the TSC in support of the emergency planning review. The staff has reasonable assurance that the dose in the TSC will be within 5 rem TEDE. The details of the staff's analysis is presented in Section [ ] of this safety evaluation report, and the results are listed in Table [ ].

Therefore, the staff concludes that the distances to the EAB and the LPZ outer boundary of the [site name] site and plant features intended to mitigate the radiological consequences of postulated DBAs, in conjunction with the source term and the fission product release rates from the site to the environment provided by the applicant, are sufficient to provide reasonable assurance that the total radiological consequences of the DBAs will be within the dose evaluation factors set forth at 10 CFR 50.34(a)(1), 10 CFR 52.79(a)(1) and GDC 19, and also meet the regulatory requirements for TSC radiological habitability. This conclusion is based on the staff review of the applicant's analysis and on the staff's independent analysis, which confirms that the calculated total doses are within the dose evaluation factors set forth at 10 CFR 50.34(a)(1), 10 CFR 52.79(a)(1) and GDC 19.

For DC and COL reviews, the findings will also summarize the staff's evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action items relevant to this DSRS section.

V. IMPLEMENTATION

The staff will use this DSRS section in performing safety evaluations of mPower^{TM}-specific DC, COL, or ESP applications submitted by applicants pursuant to 10 CFR Part 52. The staff will use the method described herein to evaluate conformance with Commission regulations.

Because of the numerous design differences between the mPower^{TM} and large light-water nuclear reactor power plants, and in accordance with the direction given by the Commission in SRM- COMGBJ-10-0004/COMGEA-10-0001, "Use of Risk Insights to Enhance the Safety Focus of Small Modular Reactor Reviews," dated August 31, 2010 (Agencywide Documents Access and Management System Accession No. ML102510405), to develop risk-informed licensing review plans for each of the small modular reactor (SMR) reviews including the associated pre-application activities, the staff has developed the content of this DSRS section as an alternative method for mPower^{TM}-specific DC, COL, or ESP applications submitted pursuant to 10 CFR Part 52 to comply with 10 CFR 52.47(a)(9), "Contents of applications; technical information."

This regulation states, in part, that the application must contain "an evaluation of the standard plant design against the SRP revision in effect 6 months before the docket date of the application." The content of this DSRS section has been accepted as an alternative method for

complying with 10 CFR 52.47(a)(9) as long as the mPower™ DCD FSAR does not deviate significantly from the design assumptions made by the NRC staff while preparing this DSRS section. The application must identify and describe all differences between the standard plant design and this DSRS section, and discuss how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria. If the design assumptions in the DC application deviate significantly from the DSRS, the staff will use the SRP as specified in 10 CFR 52.47 (a)(9). Alternatively, the staff may revise the DSRS section in order to address new design assumptions. The same approach may be used to meet the requirements of 10 CFR 52.17 (a)(1)(xii) and 10 CFR 52.79 (a)(41), for ESP and COL applications, respectively.

VI. REFERENCES

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

2. 10 CFR 50.34, “Contents of applications; technical information”

3. 10 CFR 50, Appendix A, “General Design Criteria for Nuclear Power Plants”

4. 10 CFR 50, Appendix E, “Emergency Planning and Preparedness for Production and Utilization Facilities”

5. 10 CFR Part 52, “Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants”

6. 10 CFR Part 100, “Reactor Site Criteria”

7. Regulatory Guide 1.183, “Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors”.

8. NUREG-0737, Supplement 1, “Clarification of TMI Action Plan Requirements,” January 1983.