U.S. NUCLEAR REGULATORY COMMISSION

DESIGN-SPECIFIC REVIEW STANDARD FOR mPOWER™ iPWR DESIGN

6.1.2 PROTECTIVE COATING SYSTEMS (PAINTS) - ORGANIC MATERIALS

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of chemical engineering issues and component integrity.

Secondary - None.

I. AREAS OF REVIEW

This review standard addresses the overall quality and safety performance of protective coatings under normal and design-basis accident (DBA) conditions. It also addresses the radiation and chemical effects of DBA conditions on coatings and other organic materials.

The specific areas of review are as follows:

1. The protective coating systems (paints) used inside the containment are evaluated as to suitability for DBA conditions.

2. The stability of materials including protective coatings and organics are examined to determine the potential formation of decomposition products under DBA conditions. Radiation and chemical effects are considered.

3. Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC). For design certification (DC) and combined license (COL) reviews, the staff reviews the applicant's proposed ITAAC associated with the structures, systems, and components (SSCs) related to this design-specific review standard (DSRS) section in accordance with Standard Review Plan (SRP) Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." The staff recognizes that the review of ITAAC cannot be completed until after the rest of this portion of the application has been reviewed against acceptance criteria contained in this DSRS section. Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP and DSRS Sections 14.3, 14.3.2, 14.3.3, 14.3.4, 14.3.7, 14.3.10, and 14.3.11

4. 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.

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Review Interfaces

The review organization as part of its primary review responsibility for DSRS Section 6.5.3 also reviews the deposition of fission products on containment protective coating systems.

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

1. Review of the radiation and chemical environments of equipment under DBA conditions is part of review responsibility for DSRS Section 3.11,"Environmental Qualification of Mechanical and Electrical Equipment."

2. Review of the control of combustible gases that can potentially be generated from the coating systems and organic materials is part of the review responsibility for DSRS Section 6.2.5, “Combustible Gas Control in Containment.

3. Review of the consequences of solid debris, including an assessment for potential loss of long-term cooling capability resulting from loss-of-coolant accident (LOCA)-generated and latent debris, is part of the review responsibility for DSRS Sections 6.2.2, “Containment Heat Removal Systems,” and 6.3, “Emergency Core Cooling System.”

4. Review of the risk significance of both the engineered safety features (ESFs) and regulatory treatment of nonsafety systems (RTNSS) is performed under SRP Section 19.1, “Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities."

II. ACCEPTANCE CRITERIA

Requirements

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

1. Appendix B to Title 10 of the *Code of Federal Regulations* (CFR), Part 50, as it relates to the quality assurance requirements for the design, fabrication and construction of safety-related and risk-significant SSCs.

2. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a facility that incorporates the DC has been constructed and will be operated in conformity with the DC, the provisions of the Atomic Energy Act (AEA), and the U.S. Nuclear Regulatory Commission’s (NRC's) regulations.

3. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the COL, the provisions of the AEA, and the NRC's regulations.

As discussed in Regulatory Guide (RG) 1.54, Revision 2, to the extent that failure of protective coatings could prevent safety related SSCs from fulfilling their safety related function, the

maintenance rule, 10 CFR 50.65, requires that licensees monitor the effectiveness of maintenance for protective coatings, or demonstrate that their performance or condition is being effectively controlled through the performance of appropriate preventative maintenance. Acceptance criteria include verification that coating monitoring and maintenance procedures are capable of ensuring that the coatings will not fail (delaminate from the substrate), and therefore, become a debris source that could prevent the emergency core cooling system from performing its safety related function

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. A coating system to be applied inside a containment is acceptable if it meets the regulatory positions of RG 1.54 and the standards of American Society for Testing and Materials (ASTM) D5144-00 and ASTM D3911-03.

2. 10 CFR 52.47(b)(1) specifies that the application of a DC should contain proposed ITAAC for SSCs necessary and sufficient to assure the plant is built and will operate in accordance with the DC. 10 CFR 52.97(b) specifies that the COL identifies the ITAAC for SSCs necessary and sufficient to assure that the facility has been constructed and will be operated in conformity with the license. SRP Section 14.3 provides guidance for reviewing the ITAAC. The requirements of 10 CFR 52.47(b)(1) and 10 CFR 52.97(b) will be met, in part, by identifying inspections, tests, analyses, and acceptance criteria of the top-level design features of the containment organic materials in the DC application and the COL, respectively.

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. Appendix B to 10 CFR Part 50 requires a quality assurance program which comprises all those planned and systematic actions necessary to provide adequate confidence that a structure, system, or component will perform satisfactorily in service. It is important to prevent the deterioration of protective coatings by one, all, or a combination of the following conditions: ionizing radiation; contamination by radioactive nuclides and subsequent decontamination processes; chemical and water sprays; high-temperature; high-pressure steam; and abrasion or wear. The protective coatings must be resistant to causing generation of combustible gases like hydrogen and methane and gaseous formation of radioactive organic iodides. If the protective coatings deteriorate by flaking, peeling, etc., they may form solid debris which can reach the containment recirculation sump and have a negative impact on the performance of post-accident cooling safety systems. RG 1.54, Revision 2, describes an acceptable method of complying with the quality assurance requirements in regard to protective coatings applied to ferritic steels, stainless steel, zinc-coated (galvanized) steel, concrete, or masonry surfaces of nuclear facilities. Compliance with Appendix B to 10 CFR Part 50 is important to ensure the

overall quality and safety performance of protective coatings under normal and accident conditions.

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.

In accordance with 10 CFR 52.47(a)(8),(21), and (22), and 10 CFR 52.79(a)(17) and (20), for new reactor license applications submitted under Part 52, the applicant is required to (1) address the proposed technical resolution of unresolved safety issues and medium- and high-priority generic safety issues which are identified in the version of NUREG-0933 current on the date up to 6 months before the docket date of the application and which are technically relevant to the design; (2) demonstrate how the operating experience insights have been incorporated into the plant design; and, (3) provide information necessary to demonstrate compliance with any technically relevant portions of the Three Mile Island requirements set forth in 10 CFR 50.34(f), except paragraphs (f)(1)(xii), (f)(2)(ix), and (f)(3)(v). These cross-cutting review areas should be addressed by the reviewer for each technical subsection and relevant conclusions documented in the corresponding safety evaluation report (SER) section.

The reviewer verifies that the applicant has committed to using protective coating systems which meet the acceptance criteria.

The reviewer determines the types and quantities of radiation and chemical decomposition products that can be produced from all the paints and organic materials which are exposed to the containment atmosphere. The paints and organic materials to be considered include those paints that are specified in the safety analysis report (SAR), unspecified protective coatings on small machinery and equipment, and organic materials such as cable insulation. The determination is based on documented test data provided by the applicant. If test data are unavailable, a conservative analysis is required. The environmental conditions for the test and analysis must be comparable to those specified in Section 3.11 of the SAR. In the absence of test data on specific coating systems and organic materials, the data in Reference 10 may be used to estimate the rates of hydrogen formation from zinc primers and from zinc primers plus topcoats. Cable insulation is assumed to generate hydrogen by radiolysis with a yield comparable to that of polyethylene. Unqualified paints (organic or inorganic), those that do not meet the acceptance criteria of this DSRS section, are assumed to form solid debris under DBA conditions. Unqualified paints that contain only organic materials and that do not meet the acceptance criteria of this DSRS section are assumed to generate hydrogen by radiolytic decomposition with a yield comparable to that of organic polymers as given in Reference 11.

If combustible gases such as hydrogen and methane can be generated, the reviewer notifies the appropriate reviewer if this source is not included in Section 6.2.5 of the SAR. If a system to control combustible vapors is not provided, then the release of volatile alkanes to form organic iodides is of additional concern. The yield of organic iodides relative to the total iodine released after a DBA is estimated using the data of Reference 12 and any applicable experimental results submitted by the applicant. The appropriate interfacing reviewer should be notified of the estimated organic iodide formation.

If solid debris can be produced, the interfacing reviewer responsible for solid debris should be notified of the quantity of debris that can result from decomposition of unqualified materials. The interfacing reviews should determine the effects of the debris on operation of post accident fluid systems.

Any exception to RG 1.54, Revision 2 involving quality assurance and quality control requirements should be referred to the appropriate interfacing reviewer for review and resolution.

Adverse interactions, if any, under DBA conditions, between the potential decomposition products, namely hydrogen and solid debris, and the engineered safety features are evaluated under DSRS Sections 6.2.5 and 6.2.2, respectively.

For review of a DC application, the reviewer should follow the above procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and site parameters), set forth in design control document (DCD). The reviewer should also consider the appropriateness of identified COL action items. The reviewer may identify additional COL action items; however, to ensure these COL action items are addressed during a COL application, they should be added to the DCD.

For review of a COL application, the scope of the review is dependent on whether the COL applicant references a DC, an early site permit or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

For review of both DC and COL applications, SRP Section 14.3 should be followed for the review of ITAAC. The review of ITAAC cannot be completed until after the completion of this section.

IV. EVALUATION FINDINGS

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 SER. The reviewer also states the bases for those conclusions.

1. The staff concludes that the protective coating systems and their applications are acceptable and meet the requirements of Appendix B to 10 CFR Part 50. This conclusion is based on the applicant having met the quality assurance requirements of Appendix B to 10 CFR Part 50 since the coating systems and their applications meet the positions of RG 1.54, Revision 2, "Service Level I, II, and III Protective Coatings Applied to Nuclear Power Plants," and the quality assurance standards of ASTM D5144-08, "Standard Guide for Use of protective Coating Standards in Nuclear Power Plants," and ASTM D3911-08, "Standard Test Method for Evaluating Coatings Used in Light Water Nuclear Power Plants at Simulated Design Basis Accident (DBA)Conditions." Also, the containment coating systems have been evaluated as to their suitability to withstand a postulated DBA environment. The coating systems chosen by the applicant have been qualified under conditions which take into account the postulated DBA conditions.

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.

In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable.

V. IMPLEMENTATION

The staff will use this DSRS section in performing safety evaluations of mPower™-specific design certification (DC), or combined license (COL), 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™ 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 (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™ -specific DC, or COL 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 Standard Review Plan (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 supplement the DSRS section by adding appropriate criteria in order to address new design assumptions. The same approach may be used to meet the requirements of 10 CFR 52.79(a)(41) for COL applications.

VI. REFERENCES

1. 10 CFR Part 50, Appendix B, "Quality Assurance Criteria For Nuclear Power Plants and Fuel Reprocessing Plants."

2. RG 1.54, "Service Level I, II, and III Protective Coatings Applied to Nuclear Power Plants."

3. RG 1.68, "Initial Test Programs for Water-Cooled Nuclear Power Plants."

4. RG 1.160, "Monitoring the Effectiveness of Maintenance."

5. RG 1.182, "Assessing and Managing Risk Before Maintenance Activities of Nuclear Power Plants."

6. RG 1.206. " Combined License Applications for Nuclear Power Plants (LWR Edition."

7. RG 1.215, "Guidance for ITAAC Closure Under 10 CFR Part 52."

8. ASTM D5144-08, "Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants." (with exceptions listed in RG 1.54, Revision 2)

9. ASTM D3911-08, "Standard Test Method for Evaluating Coatings Used in Light Water Nuclear Power Plants at Simulated Design Basis Accident (DBA) Conditions." (with exceptions listed in RG 1.54, Revision 2)

10. H. E. Zittel, "Post-Accident Hydrogen Generation from Protective Coatings in Power Reactors," Nuclear Technology, Volume 17, pp. 143-146.

11. R. O. Bolt and J. G. Carroll, "Radiation Effects on Organic Materials," Academic Press, New York.

12. A. K. Postma and R. W. Zavadoski, "Review of Organic Iodide Formation Under Accident Conditions in Water-Cooled Reactors," WASH-1233 (1972).

13. 10 CFR Part 52, Subpart B, “Standard Design Certifications,” Section 52.47, “Contents of Applications; Technical Information,” and Subpart C, “Combined Licenses,” Section 52.80 “Contents of Applications; Additional Technical Information.”