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REGULATORY GUIDE

REGULATORY GUIDE 1.54

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SERVICE LEVEL I, II, III, AND IN-SCOPE LICENSE RENEWAL PROTECTIVE COATINGS APPLIED TO NUCLEAR POWER PLANTS

A. INTRODUCTION

Purpose

This regulatory guide (RG) describes a method the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable for the selection, application, qualification, inspection, and maintenance of protective coatings applied to nuclear power plants (NPPs).

Applicability

This RG applies to applicants and licensees subject to Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, "Domestic Licensing of Production and Utilization Facilities" (10 CFR Part 50), Appendix A, "General Design Criteria for Nuclear Power Plants," (Ref. 1), all applicants and licensees for a power reactor combined license under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants" (Ref. 2) and all applicants and licensees for a renewed operating license under 10 CFR Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants" (Ref. 3).

Applicable Regulations

- 10 CFR Part 50, Appendix A, General Design Criterion (GDC) 1, "Quality Standards and Records," requires, in part, that structures, systems, and components (SSCs) important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. GDC 1 also requires licensees to establish and implement a quality assurance (QA) program to provide adequate assurance that these SSCs will satisfactorily perform their safety functions.

- 10 CFR Part 50, Appendix A, GDC 4, "Environmental and Dynamic Effects Design Bases," requires, in part, that SSCs important to safety be designed for compatibility with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents.

Written suggestions regarding this guide or development of new guides may be submitted through the NRC's public Web site under the RGs document collection of the NRC Library at http://www.nrc.gov/reading-rm/doc-collections/reg-guides/contactus.html.

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- 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," establishes QA program requirements for the design, fabrication, construction, and testing of safety-related SSCs in NPPs.

- 10 CFR 50.65, "Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," includes safety-related SSCs that are relied on to remain functional during and following design-basis events with respect to specified functions and nonsafety-related SSCs. To the extent that protective coatings meet these criteria, these coatings are within the scope of the maintenance rule.

- 10 CFR 52.47, "Contents of Applications; Technical Information," requires, in part, that applications for standard design certification rules under 10 CFR Part 52 to comply with the principal design criteria in Appendix A to 10 CFR Part 50.

- 10 CFR 52.79, "Contents of applications; technical information in final safety analysis report," requires, in part, that applications for combined licenses under 10 CFR Part 52 comply with the principal design criteria in Appendix A to 10 CFR Part 50.

- 10 CFR 52.137, "Contents of applications; technical information," requires, in part, that applications for standard design approvals for nuclear power plants under 10 CFR Part 52 comply with the principal design criteria in Appendix A to 10 CFR Part 50, to the extent they are applicable to the scope of the design approval.

- 10 CFR 52.157, "Contents of applications; technical information in final safety analysis report," requires that applications for manufacturing licenses for nuclear power plants under 10 CFR Part 52 comply with the principal design criteria in Appendix A to 10 CFR Part 50.

- 10 CFR Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants," establish requirements for obtaining a renewed license for operation beyond its initial 40 year operating license.

Related Guidance

- RG 1.160, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," (Ref. 4) provides further guidance on the maintenance rule and its requirement for each licensee to monitor the effectiveness of maintenance for protective coatings within its scope (as discrete systems or components or as part of any SSC) or to demonstrate that the performance or condition of these coatings is being effectively controlled through the performance of appropriate preventive maintenance, in accordance with 10 CFR 50.65(a)(1) or 10 CFR 50.65(a)(2), as appropriate.

- NUREG-1801, "Generic Aging Lessons Learned (GALL) Report," (Ref. 5) and/or NUREG-2191, "Generic Aging Lessons Learned for Subsequent License Renewal (GALL-SLR) Report," (Ref. 6) describes the aging management programs (AMPs) to be developed by a licensee and submitted as part of an application for license renewal. The AMP should describe how the aging effects associated with: (1) coatings installed on the inside of containments (i.e., Service Level I), and (2) coatings whose degradation could prevent an in-scope component's or downstream in-scope component's ability to perform its intended function(s) identified under 10 CFR Part 54 are managed such that the component's intended function will be met during periods of extended operation.

Purpose of Regulatory Guides

The NRC issues RGs to describe to the public methods that the staff considers acceptable for use in implementing specific parts of the agency's regulations, to explain techniques that the staff uses in evaluating specific problems or postulated events, and to provide guidance to applicants. Regulatory guides are not substitutes for regulations and compliance with them is not required. Methods and solutions that differ from those set forth in RGs will be deemed acceptable if they provide a basis for the findings required for the issuance or continuance of a permit or license by the Commission.

Paperwork Reduction Act

This RG contains and references information collections covered by 10 CFR Parts 50, 52, and Part 54 that are subject to the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et. seq.). These information collections were approved by the Office of Management and Budget (OMB), under control numbers 3150-0011, 3150–0151, and 3150-0155 respectively.

Public Protection Notification

The NRC may not conduct nor sponsor, and a person is not required to respond to, a request for information or an information collection requirement unless the requesting document displays a currently valid OMB control number.

B. DISCUSSION

Reason for Revision

This revision (Revision 3) of RG 1.54 endorses, with certain clarifications and exceptions, the use of American Society for Testing and Materials (ASTM International) Standard D 5144-08 (2016), "Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants," (Ref. 7), and multiple sub-tier ASTM International standards as identified in Figure 1 and described below. ASTM International, standard D 5144-08 (2016) was issued in 2008 and reapproved in 2016. It provides a common basis on which protective coatings for the surfaces of nuclear power generating facilities may be qualified and selected through reproducible evaluation tests. This revision also expands the scope of this RG to address aging management of internal coatings and linings on components within the scope of license renewal under 10 CFR Part 54.

Background

The NRC developed this RG using definitions and insights from operating reactors. New reactor designs might use design features that are different from the operating reactors that formed the basis for this RG. Consequently, it may be necessary to adjust the guidance in this RG to apply to new reactor designs because these facilities might use design features that are different from the operating reactors that formed the basis for this RG. For example, a plant with passive containment cooling features might have different requirements for protective coatings on containment surfaces, or a plant might rely on the density of failed protective coating particles inside containment which would limit their transport to the emergency core cooling system (ECCS). Therefore, this RG provides guidance for new reactor designs with the recognition that the licensee or applicant may need to adjust some features based on the particular plant design.

Nuclear power plants use protective coatings to protect the surfaces of facilities and equipment against corrosion and contamination from radionuclides. For plants with a design basis that includes a commitment to a previous revision of RG 1.54, the regulations cited above require that protective coatings be qualified and capable of surviving a Design-Basis Accident (DBA) without impairing the safety-related SSCs needed to mitigate the event.

The NRC issued Rev. 0 of RG 1.54, "Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants," (Ref. 8) to provide an acceptable method for complying with NRC QA requirements for protective coatings applied to ferritic steels, stainless steel, zinc-coated (galvanized) steel, concrete, or masonry surfaces of water-cooled NPPs. Protective coatings that met these guidelines would presumably not degrade over the design life of the plant. However, operating history has shown that undesirable degradation, detachment, and other types of failures of coatings have occurred. These failures are described in Generic Letter (GL) 98-04, "Potential for Degradation of the Emergency Core Cooling System and the Containment Spray System after a Loss-of-Coolant Accident because of Construction and Protective Coating Deficiencies and Foreign Material in Containment" (Ref. 9). If protective coatings detach from a substrate, they can be transported to the intake structure of emergency core cooling systems (ECCS) and can damage the ECCS making them unable to provide cooling as required by GDCs 34, 35, and 36, or satisfy the requirement in 10 CFR 50.46(b)(5).

Rev. 0 of RG 1.54 endorses, with some conditions, American National Standards Institute (ANSI) Standard N101.4-1972, "Quality Assurance for Protective Coatings Applied to Nuclear Facilities," (Ref. 10) and provided a secondary indorsement of the guidance provided in ANSI N101.2-1972, "Protective Coatings (Paints) for Light-Water Nuclear Reactor Containment Facilities" (Ref. 11). ANSI formally withdrew ANSI N101.4-1972 and ANSI N101.2-1972 in 1988 and transferred the responsibility for updating, rewriting, and issuing appropriate replacement standards to the ASTM International, specifically ASTM International Committee D-33 on Protective Coating and Lining Work for Power Generation Facilities.

The ASTM International developed standards to replace ANSI N101.4-1972 and ANSI N101.2-1972. The NRC issued revision 1 of RG 1.54, "Service Level I, II, and III Protective Coatings Applied to Nuclear Power Plants," in July 2000 (Ref. 12), and revision 2 in October 2010 (Ref. 13), to provide the agency's endorsement and regulatory positions on ASTM International standards relevant to NPP protective coatings. Since the issuance of revision 2 of RG 1.54, the ASTM International has updated many of the standards that the RG endorses. The NRC staff is revising RG 1.54 to provide the agency's regulatory positions on the updated ASTM International standards relevant to NPP protective coatings. The NRC staff has reviewed the ASTM International standards cited in Section C of this guide for the selection, qualification, application, and maintenance of protective coatings applied to NPPs and considers them acceptable with the clarifications and exceptions noted in Section C of this RG.

ASTM International developed and issued ASTM D 5144-08 (2016) to provide a common basis on which protective coatings for the surfaces of nuclear power generating facilities may be qualified and selected through reproducible evaluation tests. This ASTM International standard provides guidance for the application and maintenance of protective coatings under the expected environmental, operating, and postulated accident conditions for pressurized-water reactors and boiling-water reactors. ASTM D 5144-08 (2016) addresses, by reference, the preparation of test specimens, radiation tolerance testing, ability to be decontaminated, physical properties, chemical resistance tests, fire evaluation tests, DBA testing, surface preparation, coating application and inspection, and thermal conductivity testing. The NRC staff views ASTM D 5144-08 (2016) as a top-level ASTM International standard that provides detailed requirements through reference to other key ASTM International standards. Figure 1 (below) shows the other ASTM International standards that supply application-specific guidance; each of these standards are discussed in Section C of this RG.

Guidance in ASTM International Standards

ASTM D 5144-08 (2016) and the other ASTM International standards discussed below provide guidance on practices and programs the NRC staff finds acceptable for the selection, application, qualification, inspection, and maintenance of protective coatings applied to NPPs. ASTM International, Committee D-33 has defined Service Level I, II, and III coating locations to include both safety-related and nonsafety-related regions as set forth below.

Service Level I, II, and III coatings are defined as follows:

a. Service Level I coatings are used in areas inside the reactor containment where coating failure could adversely affect the operation of post-accident fluid systems and thereby impair safe shutdown.

b. Service Level II coatings are used in areas where coating failure could impair, but not prevent, normal operating performance. The functions of Service Level II coatings are to provide corrosion protection and enhance the substrate's ability to be decontaminated in those areas outside the reactor containment that are subject to radiation exposure and radionuclide contamination. Service Level II coatings are not safety related.

c. Service Level III coatings are used in areas outside the reactor containment where failure could adversely affect the safety function of a safety-related SSC. (Note that a coating on the external surface of a reactor containment may be designated Service Level III, although no plants licensed under 10 CFR Part 50 have applied this designation.)

On November 14, 2014, the NRC staff issued the interim staff guidance (ISG), LR-ISG-2013-01, "Aging Management of Loss of Coating or Lining Integrity for Internal Coatings/Linings on In-Scope Piping, Piping Components, Heat Exchangers, and Tanks" (Ref. 14). The ISG was issued based on the NRC staff's review of industry operating experience related to degradation of coatings. Appendix C of the ISG provides an AMP, GALL Report AMP XI.M42, and "Internal Coatings/Linings for In-Scope Piping, Piping Components, Heat Exchangers, and Tanks." AMP XI.M42 includes recommendations related to managing loss of coating or lining integrity because of blistering, cracking, flaking, peeling, delamination, rusting, or physical damage, and spalling for cementitious coatings/linings, of in-scope piping, piping component, heat exchanger, and tank internal coatings/linings. Internal coatings are not included in the definitions of Service Level I or III. Examples of internally coated components that are not included within the Service Level I and III definitions include: (1) components inside containment with internal coatings (e.g., internally coated reactor coolant pump lubricating oil cooler), (2) SSCs that support a fire-protection-intended function (e.g., internal coatings on a fire water storage tank), and (3) SSCs that support a station blackout intended function (e.g., internal coatings on a makeup water line that provides an alternative source of cooling water inventory). The first example is not covered by the Service Level I definition because degradation of these coatings would not adversely affect the operation of post-accident fluid systems. The latter two examples are not covered by the Service Level III definition because the fire protection and station blackout functions are typically nonsafety-related. Rather than citing the Service Level III term in AMP XI.M42, the staff defined the scope of coatings covered by the AMP as internal coatings/linings for in-scope piping, piping components, heat exchangers, and tanks. The use of this terminology: (1) compensates for the gap in the existing Service Level I and III definitions, and (2) establishes that the scope includes only coatings on the internal surfaces of in-scope components.

Harmonization with International Standards

There are no International Atomic Energy Agency safety standards that directly address the qualification, application, and maintenance of protective coatings in nuclear power plants.

The external guidance endorsed in this RG is developed by ASTM International, whose voluntary consensus standards are developed for international use, and have been adopted for use in many countries and by many international corporations. Currently, over 12,000 ASTM International standards are used around the world to improve product quality, enhance health and safety, and strengthen market access and trade. This RG endorses, with certain clarifications and limitations, the use of multiple ASTM International standards that describe proper QA, worker qualification, application and maintenance of protective coatings for nuclear power plants.

Documents Discussed in Staff Regulatory Guidance

This RG endorses, in part, the use of one or more codes or standards developed by external organizations, and other third party guidance documents. These codes, standards and third party guidance documents may contain references to other codes, standards or third party guidance documents ("secondary references"). If a secondary reference has itself been incorporated by reference into NRC regulations as a requirement, then licensees and applicants must comply with that standard as set forth in the regulation. If the secondary reference has been endorsed in an RG as an acceptable approach for meeting an NRC requirement, then the standard constitutes a method acceptable to the NRC staff for meeting that regulatory requirement as described in the specific RG. If the secondary reference has neither been incorporated by reference into NRC regulations nor endorsed in an RG, then the secondary reference is neither a legally-binding requirement nor a "generic" NRC approved acceptable approach for meeting an NRC requirement. However, licensees and applicants may consider and use the information in the secondary reference, if appropriately justified, consistent with current regulatory practice, and consistent with applicable NRC requirements.

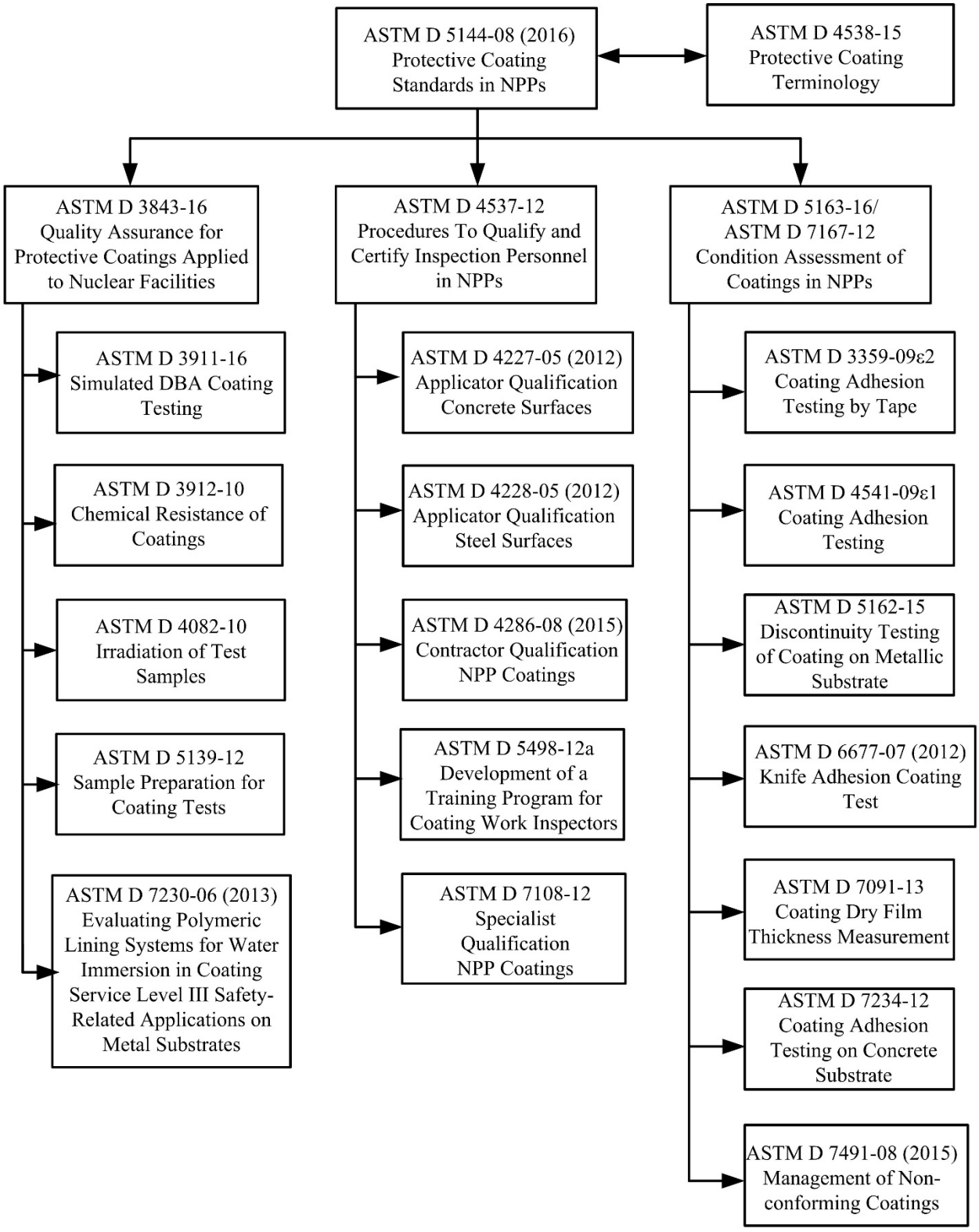

Figure 1. - ASTM standards relevant to NPP Service Level I, II, and III protective coatings and coatings within the scope of GALL Report AMP XI.M42

C. STAFF REGULATORY GUIDANCE

The guidance discussed below describes practices and programs the NRC staff finds acceptable for the selection, application, qualification, inspection, and maintenance of protective coatings applied to NPPs. This guidance may be applicable to Service Level I, II, and III coatings as well as internal coatings and linings on components within the scope of license renewal as described in Section B of this revision (revision 3) of RG 1.54.

1.0 Use of Protective Coating Standards in Nuclear Power Plants

1.1 ASTM D 5144-08 (2016) provides a common basis on which protective coatings for the surfaces of nuclear power generating facilities may be qualified and selected through reproducible evaluation tests. ASTM D 5144-08(2016) should be viewed as a top-level ASTM International standard that provides detailed requirements through reference to other key ASTM International standards.

1.2 ASTM D 4538-15, "Standard Terminology Relating to Protective Coating and Lining Work for Power Generation Facilities," (Ref. 15) defines standard terms related to protective coating and lining work for power generation facilities that the NRC staff finds acceptable and that are also relevant to protective coatings applied to NPPs.

2.0 QA Requirements for Protective Coatings

2.1 ASTM D 3843-16, "Standard Practice for Quality Assurance for Protective Coatings Applied to Nuclear Facilities" (Ref. 16). The ASTM International approved and issued ASTM International Standard D 3843-16 as a replacement for ANSI N101.4-1972. ASTM D 3843-00 provides QA practices that are acceptable to NRC staff and are applicable to safety related protective coating work in coating Service Level I areas of nuclear facilities. Service Level II coatings as defined above are not safety related, but they are approved for their particular application. Licensees and applicants may use applicable portions of the QA practices described in ASTM D 3843-16 as the basis for limited QA for protective coating work in coating Service Level II areas of nuclear facilities.

2.2 ASTM D 3911-16, "Standard Test Method for Evaluating Coatings Used in Light-Water Nuclear Reactor Power Plants at Simulated Design Basis Accident (DBA) Conditions" (Ref. 17). The ASTM International issued ASTM D 3911-95, (same title) (Ref. 18), to replace the DBA test standard referenced in ANSI N101.4-1972 and the NRC endorsed it in revision 0 of RG 1.54. ASTM International then revised ASTM D 3911-95 and issued it as ASTM D 3911-08 (same title) (Ref. 19) which was endorsed in revision 2 of RG 1.54. In 2016 ASTM international revised the standard and issued ASTM D 3911-16. Licensees and applicants may use the test methods described in ASTM D 3911-16 for evaluating test specimens for protective coating systems under simulated DBA conditions. ASTM D 3911-16 also provides guidance on conditions and test apparatus for temperature-pressure testing; on conditions for radiation testing; and on procedures for preparing, examining, and evaluating samples. ASTM D 3911-16 does not specify minimum acceptance criteria. For Service Level I coatings, the licensees or applicants should meet the following minimum acceptance criteria:

a. Peeling and delamination should not be permitted.

b. Cracking should not be considered a failure unless it is accompanied by delamination or loss of adhesion.

c. Blisters should be limited to intact blisters that are completely surrounded by sound coating bonded to the surface.

The licensee or applicant may establish more stringent acceptance criteria; the above criteria are meant as minimum standards only.

Appendix X2 to ASTM D 3911-16 discusses witness coupons in primary containment. These test coupons, if properly placed, provide a realistic mechanism to test and evaluate the aging of coatings. Selected coupons could be periodically removed and tested to identify changes in various physical properties and could be DBA-tested to provide much better and more realistic predictions of coating life. New NPPs should consider the installation of coated test coupons at various locations in the primary containment. The coated test coupons would be representative of the aged condition of similar coatings within the primary containment. The licensee could use the test coupons for coating condition analysis and aging studies during the commercial life of the NPP.

2.3 ASTM D 3912-10, "Standard Test Methods for Chemical Resistance of Coatings and Linings for Use in Nuclear Power Plants," (Ref. 20) offers guidance that the NRC staff finds acceptable for evaluating the chemical resistance of coatings applied to light-water NPPs.

2.4 ASTM D 4082-10, "Standard Test Methods for Effects of Gamma Radiation on Coatings for Use in Nuclear Power Plants," (Ref. 21) provides a standard test method that the NRC staff finds acceptable for evaluating the effects of gamma radiation on the lifetime radiation tolerance of Service Level I and II coatings.

2.5 ASTM D 5139-12, "Standard Specification for Sample Preparation for Qualification Testing of Coatings To Be Used in Nuclear Power Plants," (Ref. 22) offers guidance that the NRC staff finds acceptable on the size, composition, and surface preparation for test samples of protective coatings for use in the qualification testing of coatings that will be applied to NPPs, as described in ASTM D 3911-08 and in ASTM D 4082-10.

2.6 ASTM D 7230-06, (reapproved in 2013), "Standard Guide for Evaluating Polymeric Lining Systems for Water Immersion in Coating Service Level III Safety-Related Applications on Metal Substrates," (Ref. 23) establishes procedures NRC staff finds acceptable for evaluating lining systems under simulated operating conditions.

2.7 The QA provisions and guidance contained in the ASTM International standards identified in this RG are generally acceptable and provide methods that the NRC staff finds acceptable for complying with the pertinent QA requirements in Appendix B to 10 CFR Part 50, subject to the following two exceptions:

a. When using this RG, NRC licensees and applicants should meet the QA provisions and guidance contained in the ASTM International standards identified in this RG and must also meet the commitments and provisions contained in their QA program descriptions.

b. Applicants may propose to use coatings in ways that do not conform to the service level definitions above. For example, an applicant could propose to designate coatings in certain areas of containment as Service Level II based on an evaluation that demonstrates

that these coatings cannot be transported to the ECCS. Such exceptions may be acceptable to NRC staff if the applicant provides a technical justification and corresponding technical and quality requirements in a licensing-basis document such as the final safety analysis report.

3.0 Training and Qualification of Nuclear Coating Specialists, Protective Coating Inspectors, and Coating Applicators

3.1 ASTM D 4537-12, "Standard Guide for Establishing Procedures to Qualify and Certify Personnel Performing Coating and Lining Work Inspection in Nuclear Facilities," (Ref. 24) offers guidance that the NRC staff finds acceptable on the qualification and certification of personnel who inspect protective coatings in nuclear facilities. This standard provides guidance on the education, training, experience, qualifications, and certification of Service Level I, II, and III coatings inspectors.

3.2 ASTM D 4227-05 (reapproved in 2012), "Standard Practice for Qualification of Coating Applicators for Application of Coatings to Concrete Surfaces," (Ref. 25) provides guidance that the NRC staff finds acceptable for the qualification of coating applicators to verify that they are proficient and can attain the quality required for the application of specified coatings to concrete surfaces, including those in a nuclear facility.

3.3 ASTM D 4228-05 (reapproved in 2012), "Standard Practice for Qualification of Coating Applicators for Application of Coatings to Steel Surfaces," (Ref. 26) provides guidance that the NRC staff finds acceptable for the qualification of coating applicators to verify that they are proficient and can attain the quality required for applying specified coatings to steel surfaces, including those in a nuclear facility.

3.4 ASTM D 4286-08 (reapproved in 2015), "Standard Practice for Determining Coating Contractor Qualifications for Nuclear Powered Electric Generation Facilities," (Ref. 27) offers criteria and methods that the NRC staff finds acceptable to assist utility owners, architects, engineers, and contractors in determining the overall qualifications of a coating contractor to perform coating work for the primary containment and other safety-related facilities of NPPs. The criteria and requirements for coating contractors address their capabilities to perform nuclear coating work.

3.5 ASTM D 5498-12a, "Standard Guide for Developing a Training Program for Personnel Performing Coating Work Inspection for Nuclear Facilities," (Ref. 28) provides guidance that the NRC staff finds acceptable for developing a training program for personnel who perform coating work inspection at nuclear facilities.

3.6 ASTM D 7108-12, "Standard Guide for Establishing Qualifications for a Nuclear Coatings Specialist," (Ref. 29) provides guidance that the NRC staff finds acceptable for establishing qualifications for a nuclear coatings specialist. A nuclear coatings specialist should meet one of the combinations of qualification attributes provided in Table 2 of ASTM D 7108-12 prior to performing inspections at nuclear facilities.

4.0 Maintenance of Coatings

4.1 ASTM D 5163-16, "Standard Guide for Establishing a Program for Condition Assessment of Coating Service Level I Coating Systems in Nuclear Power Plants," (Ref. 30) provides guidelines the NRC staff finds acceptable for establishing an in-service coating monitoring program for

Service Level I coating systems in operating NPPs and for Service Level II and other areas outside containment (as applicable) with the following conditions:

a. Licensees should establish an acceptable condition assessment program using qualified personnel and should perform condition assessments over a time interval that would allow them to detect potential coating degradation and to implement repairs before such degradation would adversely impact post-accident safety systems.

b. Licensees should perform condition assessments under the direction of a nuclear coating specialist, as defined in ASTM D 7108-12.

c. Licensees should evaluate degraded coatings identified during condition assessments for their effect on the ECCS post-accident function consistent with the guidance in RG 1.82 "Water Sources for Long-Term Recirculation Cooling following a Loss-Of-Coolant Accident," (Ref. 31) and in accordance with applicable licensing-basis documents.

d. Although the ASTM D 5163-08 standard reasonably ensures that qualified coatings left in service after a visual inspection will remain adhered to their substrates under accident conditions, it does not guarantee that visual inspection will detect all degraded coatings. Therefore, the licensee or applicant should include a safety margin in their debris-generation calculations for the ECCS strainer performance that allows for an additional quantity of debris from failed coatings or perform a debris transport analysis showing that the debris will not reach the ECCS strainer.

4.2 ASTM D 7167-12, "Standard Guide for Establishing Procedures to Monitor the Performance of Safety-Related Coatings Service Level III Lining Systems in an Operating Nuclear Power Plant," (Ref. 32) provides guidelines that the NRC staff finds acceptable for establishing procedures to monitor the performance of Service Level III lining systems in an operating NPP.

4.3 ASTM D 3359-09$^{\varepsilon 2}$,[1] "Standard Test Methods for Measuring Adhesion by Tape Test," (Ref. 33) offers guidance that the NRC staff finds acceptable for assessing the adhesion of coating films to metallic substrates by using pressure-sensitive tape.

4.4 ASTM D 4541-09$^{\varepsilon 1}$, "Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers," (Ref. 34) provides guidance that the NRC staff finds acceptable for a test method used to evaluate the pull-off strength of coatings on metal substrates using fixed-alignment adhesion testers.[2]

4.5 ASTM D 5162-15, "Standard Practice for Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates," (Ref. 35) offers guidance that the NRC staff finds acceptable for determining discontinuities using low voltage wet sponge and high voltage spark testers.

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1 The "ε2" symbol at the end of ASTM International, standard D 3359-09$^{\varepsilon 2}$ is used by ASTM International to identify an ASTM standard that was revised to correct an editorial error. The copyright date of the edited standard differs from the original publication date of the standard.

2 A fixed-alignment adhesion Tester Type II (Test Method B) is the test method that NPPs have historically used.

4.6 ASTM D 6677-07 (reapproved 2012), "Standard Test Method for Evaluating Adhesion by Knife," (Ref. 36) provides guidance that the NRC staff finds acceptable for a test method used to evaluate adhesion using a knife.

4.8 ASTM D 7091-13, "Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals," (Ref. 37) provides guidance that the NRC staff finds acceptable for using magnetic and eddy current gages to obtain coating dry film thickness measurements.

4.9 ASTM D 7234-12, "Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers" (Ref. 38), provides guidance that the NRC staff finds acceptable for a test method used to evaluate the pull-off strength of coatings on concrete using portable pull-off adhesion testers.

4.10 ASTM D 7491-08 (reapproved 2015) "Standard Guide for Management of Non-Conforming Coatings in Coating Service Level I Areas of Nuclear Power Plants," (Ref. 39) offers guidance that the NRC staff finds acceptable for managing nonconforming coatings within the Service Level I areas of a NPP.

5.0 Additional Information

5.1 Electric Power Research Institute (EPRI) Report No. 1019157, "Guideline on Nuclear Safety-Related Coatings," Revision 2, issued December 2009 (formerly EPRI Topical Report Nos. TR-109937 and TR-1003102), (Ref. 40) provides additional information on the selection, application, inspection, and maintenance of safety-related protective coatings applied to NPPs. EPRI Report No. 1019157 discusses, in detail, the important considerations related to protective coatings and can be used to supplement the ASTM International standards as deemed necessary. The NRC staff approves the use of EPRI Report No. 1019157 with the exception of Section 3.4.2, which discusses the application of specialized coatings for restoring the structural integrity of a component. The NRC staff does not approve the use of specialized coatings for restoring structural integrity.

5.2 Thermal conductivity is a material property of a coating system that is used in evaluating NPP containment performance. In particular, it is used in calculations of containment peak temperature and pressure for accident analyses. The applicable regulatory requirements and guidance used to evaluate NPP containment performance can be found in the following:

- 10 CFR Part 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors;"
- 10 CFR Part 50, Appendix A, GDCs 38 and 50;
- 10 CFR Part 50, Appendix K; and
- NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," (Ref. 41) Sections 6.1.2, 6.2.1, 6.2.1.1.A, 6.2.1.1.C, and 6.2.1.5.

EPRI Report No. 1019157 provides further discussion on the significance of thermal conductivity of coating systems. ASTM D 5144-08 (2016) lists test methods for determining thermal

conductivity of a coating and a table of thermal conductivity values for coatings used in NPP containments. The coating types and the thermal conductivity values provided in the table are described as "typical." The NRC staff accepts the use of ASTM D 5144-08(2016) for thermal conductivity with the following exceptions:

- In reviews of activities involving safety-related coatings, the staff may find it acceptable to determine thermal conductivity by methods other than those listed in ASTM D 5144-08(2016) if adequate technical justification is provided.

- If the generic values of thermal conductivity listed in Table X1.1 of D 5144-08(2016) are used in an analysis involving a safety-related coating, the licensee/applicant should confirm that the values are justified for the actual coating.

5.3 The Society for Protective Coatings (SSPC)[3] PA 2, "Procedure for Determining Conformance to Dry Coating Thickness Requirements," revised January 2015 (Ref. 42), provides guidance that the NRC staff finds acceptable for determining conformance of coating to a specified dry film thickness range on ferrous and non-ferrous metal substrates using nondestructive coating thickness gages (magnetic and electronic) described in ASTM D 7091.

D. IMPLEMENTATION

The purpose of this section is to provide information on how applicants and licensees[4] may use this guide and information regarding the NRC's plans for using this RG. In addition, it describes how the NRC staff complies with 10 CFR 50.109, "Backfitting" and any applicable finality provisions in 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants."

Use by Applicants and Licensees

Applicants and licensees may voluntarily[5] use the guidance in this document to demonstrate compliance with the underlying NRC regulations. Methods or solutions that differ from those described in this RG may be deemed acceptable if they provide sufficient basis and information for the NRC staff to verify that the proposed alternative demonstrates compliance with the appropriate NRC regulations. Current licensees may continue to use guidance the NRC found acceptable for complying with the identified regulations as long as their current licensing basis remains unchanged.

Licensees may use the information in this RG for actions that do not require NRC review and approval such as changes to a facility design under 10 CFR 50.59, "Changes, Tests, and Experiments." Licensees may use the information in this RG or applicable parts to resolve regulatory or inspection issues.

3 The Society for Protective Coating (SSPC) was known as the Steel Structures Painting Council (SSPC) before 1997.

4 In this section, "licensees" refers to licensees of nuclear power plants under 10 CFR Parts 50 and 52; and "applicants," refers to applicants for licenses and permits for (or relating to) nuclear power plants under 10 CFR Parts 50 and 52, and applicants for standard design approvals and standard design certifications under 10 CFR Part 52.

5 In this section, "voluntary" and "voluntarily" mean that the licensee is seeking the action of its own accord, without the force of a legally binding requirement or an NRC representation of further licensing or enforcement action.

Use by NRC Staff

The NRC staff does not intend or approve any imposition or backfitting of the guidance in this RG. The NRC staff does not expect any existing licensee to use or commit to using the guidance in this RG, unless the licensee makes a change to its licensing basis. The NRC staff does not expect or plan to request licensees to voluntarily adopt this RG to resolve a generic regulatory issue. The NRC staff does not expect or plan to initiate NRC regulatory action that would require the use of this RG. Examples of such unplanned NRC regulatory actions include issuance of an order requiring the use of the RG, requests for information under 10 CFR 50.54(f) as to whether a licensee intends to commit to use of this RG, generic communication, or promulgation of a rule requiring the use of this RG without further backfit consideration.

During regulatory discussions on plant specific operational issues, the staff may discuss with licensees various actions consistent with staff positions in this RG, as one acceptable means of meeting the underlying NRC regulatory requirement. Such discussions would not ordinarily be considered backfitting even if prior versions of this RG are part of the licensing basis of the facility. However, unless this RG is part of the licensing basis for a facility, the staff may not represent to the licensee that the licensee's failure to comply with the positions in this RG constitutes a violation.

If an existing licensee voluntarily seeks a license amendment or change and (1) the NRC staff's consideration of the request involves a regulatory issue directly relevant to this new or revised RG and (2) the specific subject matter of this RG is an essential consideration in the staff's determination of the acceptability of the licensee's request, then the staff may request that the licensee either follow the guidance in this RG or provide an equivalent alternative process that demonstrates compliance with the underlying NRC regulatory requirements. This is not considered backfitting as defined in 10 CFR 50.109(a)(1) or a violation of any of the issue finality provisions in 10 CFR Part 52.

Additionally, an existing applicant may be required to comply with new rules, orders, or guidance if 10 CFR 50.109(a)(3) applies.

If a licensee believes that the NRC is either using this RG or requesting or requiring the licensee to implement the methods or processes in this RG in a manner inconsistent with the discussion in this Implementation section, then the licensee may file a backfit appeal with the NRC in accordance with the guidance in NUREG-1409, "Backfitting Guidelines," (Ref. 43) and the NRC Management Directive 8.4, "Management of Facility-Specific Backfitting and Information Collection" (Ref. 44).

REFERENCES [6]

1. *U.S. Code of Federal Regulations* (CFR), "Domestic Licensing of Production and Utilization Facilities," Part 50, Title 10, "Energy," (10 CFR Part 50).

2. CFR, "Licenses, Certifications, and Approvals of Nuclear Power Plants," Part 52, Chapter 1, Title 10, "Energy," (10 CFR Part 52).

3. CFR, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants," Part 54, Chapter 1, Title 10, "Energy," (10 CFR Part 54).

4. U.S. Nuclear Regulatory Commission (NRC), Regulatory Guide (RG) 1.160, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," Washington, DC.

5. NRC, NUREG-1801, Revision 2, "Generic Aging Lessons Learned (GALL) Report – Final Report," December 2010, Agency Wide Document Access and Management System (ADAMS) Accession number ML103490041.

6. NRC, NUREG-2191, Generic Aging Lessons Learned for Subsequent License Renewal (GALL-SLR) Report, Volumes 1 and 2, (Draft Report for Comment), December 2015, ADAMS Accession numbers ML15348A111 and ML15348A153 respectively.

7. American Society for Testing and Materials (ASTM International), Standard D 5144-08 (2016), "Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants," April 2016, West Conshohocken, PA.[7]

8. NRC, RG 1.54, Revision 0, "Quality Assurance Requirements for Protective Coatings Applied to Water Cooled Nuclear Power Plants," June 1973, ADAMS Accession number ML003740187.

9. NRC, Generic Letter (GL) 98-04, "Potential for Degradation of the Emergency Core Cooling System and the Containment Spray System after a Loss-of-Coolant Accident because of Construction and Protective Coating Deficiencies and Foreign Material in Containment," July 14, 1998, ADAMS Accession No. ML031110081.

10. American National Standards Institute (ANSI), Standard N101.4-1972, "Quality Assurance for Protective Coatings Applied to Nuclear Facilities," Washington, DC.[8]

11. ANSI, Standard N101.2-1972, "Protective Coatings (Paints) for Light-Water Nuclear Reactor Containment Facilities," Washington, DC.

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6 All NRC regulations listed herein are available electronically through the Electronic Reading Room on the NRC's public Web site at http://www.nrc.gov/reading-rm/doc-collections/cfr/. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD; the mailing address is USNRC PDR, Washington, DC 20555; telephone 301-415-4737 or 800-397-4209; fax 301-415-3548; and e-mail pdr.resource@nrc.gov.

7 Copies of ASTM International (ASTM) standards may be purchased from ASTM, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, Pennsylvania 19428-2959; telephone (610) 832-9585. Purchase information is available through the ASTM Web site at http://www.astm.org.

8 Copies of American National Standards Institute (ANSI) standards may be purchased from ANSI, 1899 L Street, NW., 11th floor, Washington, DC 20036; telephone 202-293-8020. Purchase information is available through the ANSI Web site at http://webstore.ansi.org/.

12. NRC, RG 1.54, Revision 1, "Service Level I, II, and III Protective Coatings Applied to Nuclear Power Plants," Washington, DC, July 2000, ADAMS Accession No. ML003714475.

13. NRC, RG 1.54, Revision 2, "Service Level I, II, and III Protective Coatings Applied to Nuclear Power Plants," Washington, DC, October 2010, ADAMS Accession No. ML102230344.

14. NRC, Interim Staff Guidance (ISG), LR-ISG-2013-01, "Aging Management of Loss of Coating or Lining Integrity for Internal Coatings/Linings on In-Scope Piping, Piping Components, Heat Exchangers, and Tanks," Washington, DC, November 2014, ADAMS Accession No. ML14225A059.

15. ASTM International, Standard D 4538-15, "Standard Terminology Relating to Protective Coating and Lining Work for Power Generation Facilities," West Conshohocken, PA.

16. ASTM International, Standard D 3843-16, "Standard Practice for Quality Assurance for Protective Coatings Applied to Nuclear Facilities," West Conshohocken, PA.

17. ASTM International, Standard D 3911-16, "Standard Test Method for Evaluating Coatings Used in Light-Water Nuclear Power Plants at Simulated Design-Basis Accident (DBA) Conditions," West Conshohocken, PA.

18. ASTM International, Standard D 3911-95, "Standard Test Method for Evaluating Coatings Used in Light-Water Nuclear Power Plants at Simulated Design-Basis Accident (DBA) Conditions," West Conshohocken, PA.

19. ASTM International, Standard D 3911-08, "Standard Test Method for Evaluating Coatings Used in Light-Water Nuclear Power Plants at Simulated Design-Basis Accident (DBA) Conditions," West Conshohocken, PA.

20. ASTM International, Standard D 3912-10, "Standard Test Method for Chemical Resistance of Coatings and Linings for Use in Nuclear Power Plants," West Conshohocken, PA.

21. ASTM International, Standard D 4082-10, "Standard Test Method for Effects of Gamma Radiation on Coatings for Use in Nuclear Power Plants," West Conshohocken, PA.

22. ASTM International, Standard D 5139-12, "Standard Specification for Sample Preparation for Qualification Testing of Coatings To Be Used in Nuclear Power Plants," West Conshohocken, PA.

23. ASTM International, Standard D 7230-06, (reapproved in 2013), "Standard Guide for Evaluating Polymeric Lining Systems for Water Immersion in Coating Service Level III Safety-Related Applications on Metal Substrates," West Conshohocken, PA.

24. ASTM International, Standard D 4537-12, "Standard Guide for Establishing Procedures to Qualify and Certify Personnel Performing Coating Work Inspection in Nuclear Facilities," West Conshohocken, PA.

25. ASTM International, Standard D 4227-05 (reapproved in 2012), "Standard Practice for Qualification of Coating Applicators for Application of Coatings to Concrete Surfaces," West Conshohocken, PA.

26. ASTM International, Standard D 4228-05 (reapproved in 2012), "Standard Practice for Qualification of Coating Applicators for Application of Coatings to Steel Surfaces," West Conshohocken, PA.

27. ASTM International, Standard D 4286-08 (reapproved in 2015), "Standard Practice for Determining Coating Contractor Qualifications for Nuclear Powered Electric Generation Facilities," West Conshohocken, PA.

28. ASTM International, Standard D 5498-12a, "Standard Guide for Developing a Training Program for Personnel Performing Coating Work Inspection for Nuclear Facilities," West Conshohocken, PA.

29. ASTM International, Standard D 7108-12, "Standard Guide for Establishing Qualifications for a Nuclear Coatings Specialist," West Conshohocken, PA.

30. ASTM International, Standard D 5163-16, "Standard Guide for Establishing a Program for Condition Assessment of Coating Service Level I Coating Systems in Nuclear Power Plants," West Conshohocken, PA.

31. NRC, RG 1.82, "Water Sources for Long-Term Recirculation Cooling following a Loss-Of-Coolant Accident," Washington, DC.

32. ASTM International, Standard D 7167-12, "Standard Guide for Establishing Procedures To Monitor the Performance of Safety-Related Coating Service Level III Lining Systems in an Operating Nuclear Power Plant," West Conshohocken, PA.

33. ASTM International, Standard D 3359-09$^{\varepsilon 2}$, "Standard Test Methods for Measuring Adhesion by Tape Test," West Conshohocken, PA.

34. ASTM International, Standard D 4541-09$^{\varepsilon 1}$, "Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers," West Conshohocken, PA.

35. ASTM International, Standard D 5162-15, "Standard Practice for Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates," West Conshohocken, PA.

36. ASTM International, Standard D 6677-07 (reapproved 2012), "Standard Test Method for Evaluating Adhesion by Knife," West Conshohocken, PA.

37. ASTM International, Standard D 7091-13, "Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals," West Conshohocken, PA.

38. ASTM International, Standard D 7234-12, "Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers," West Conshohocken, PA.

39. ASTM International, Standard D 7491-08 (reapproved 2015), "Standard Guide for Management of Non-Conforming Coatings in Coating Service Level I Areas of Nuclear Power Plants," West Conshohocken, PA.

40. Electric Power Research Institute (EPRI) Report No. 1019157, Revision 2, "Guideline on Nuclear Safety-Related Coatings," December 2009, Palo Alto, CA.[9]

41. NRC, NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Chapter 6, "Engineered Safety Features," Sections 6.1.2, 6.2.1, 6.2.1.1.A, 6.2.1.1.C, and 6.2.1.5.

42. Society for Protective Coatings (SSPC), Procedure SSPC-PA 2, "Procedure for Determining Conformance to Dry Coating Thickness Requirements" January 2015, Pittsburgh, PA.[10]

43. NRC, Management Directive 8.4, "Management of Facility Specific Backfitting and Information Collection," October 2013.

44. NRC, NUREG 1409, "Backfitting Guidelines," July 1990.

9 Copies of the listed Electric Power Research Institute (EPRI) standards and reports may be purchased from EPRI, 3420 Hillview Ave., Palo Alto, CA 94304; telephone 800-313-3774; fax 925-609-1310.

10 Copies of procedures from the Society for Protective Coatings (SSPC) may be purchased from SSPC.Org, 800 Trumbull Drive, Pittsburgh, PA, Phone 410-281-2331 or 877-281-7772, E-mail info@SSPC.org or on the Web at http://www.sspc.org/standards/standards-home