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DRAFT REGULATORY GUIDE

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(Proposed Revision 2 of Regulatory Guide 1.54, dated July 2000)

SERVICE LEVEL I, II, AND III PROTECTIVE COATINGS APPLIED TO NUCLEAR POWER PLANTS

A. INTRODUCTION

Title 10, of the *Code of Federal Regulations*, Part 50, "Domestic Licensing of Production and Utilization Facilities" (10 CFR Part 50) (Ref. 1), Appendix A, "General Design Criteria for Nuclear Power Plants," 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 that they will perform. GDC 1 also requires that a quality assurance (QA) program be established and implemented to provide adequate assurance that these SSCs will satisfactorily perform their safety functions.

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

Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50 establishes overall QA program requirements for the design, fabrication, construction, and operation of safety-related nuclear power plant (NPP) SSCs.

The U.S. Nuclear Regulatory Commission (NRC) maintenance rule, 10 CFR 50.65, "Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," includes in its scope 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 (1) that are relied on to mitigate accidents

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This regulatory guide is being issued in draft form to involve the public in the early stages of the development of a regulatory position in this area. It has not received final staff review or approval and does not represent an official NRC final staff position.

Public comments are being solicited on this draft guide (including any implementation schedule) and its associated regulatory analysis or value/impact statement. Comments should be accompanied by appropriate supporting data. Written comments may be submitted to the Rulemaking and Directives Branch, Office of Administration, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001; submitted through the NRC's interactive rulemaking Web page at http://www.nrc.gov; or faxed to (301) 492-3446. Copies of comments received may be examined at the NRC's Public Document Room, 11555 Rockville Pike, Rockville, MD. Comments will be most helpful if received by May 12, 2010.

Electronic copies of this draft regulatory guide are available through the NRC's interactive rulemaking Web page (see above); the NRC's public Web site under Draft Regulatory Guides in the Regulatory Guides document collection of the NRC's Electronic Reading Room at http://www.nrc.gov/reading-rm/doc-collections/; and the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html, under Accession No. ML093410510.

or transients or are used in plant emergency operating procedures, (2) whose failure could prevent safety-related SSCs from fulfilling their safety-related functions, and (3) whose failure could cause a reactor scram or an actuation of a safety-related system. To the extent that protective coatings meet these criteria, they are within the scope of the maintenance rule. The maintenance rule requires that licensees monitor the effectiveness of maintenance for protective coatings within its scope (as discrete systems or components or as part of any SSC) or demonstrate that their performance or condition 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. Regulatory Guide (RG) 1.160, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," Revision 2, issued March 1997 (Ref. 2), provides further guidance.

The NRC issues regulatory guides 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 accidents, and to provide guidance to applicants. Regulatory guides are not substitutes for regulations and compliance with them is not required.

This regulatory guide contains information collection requirements covered by 10 CFR Part 50 that the Office of Management and Budget (OMB) approved under OMB control number 3150-0011. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number.

B. DISCUSSION

Protective coatings have been used extensively in NPPs to protect the surfaces of facilities and equipment from corrosion and contamination from radionuclides and for wear protection during plant operation and maintenance activities. For plants that have a design basis that includes a commitment to RG 1.54, "Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants," issued June 1973, the regulations cited above require that protective coatings be qualified and capable of surviving a design-basis accident (DBA) without adversely affecting safety-related SSCs needed to mitigate the accident.

The NRC issued RG 1.54 to describe 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. The presumption was that protective coatings that met these guidelines would 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, as 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," dated July 14, 1998 (Ref. 3). Detached coatings from the substrate that are transported to emergency core cooling system intake structures may make those systems unable to satisfy the requirement in 10 CFR 50.46(b)(5) to provide long-term cooling.

RG 1.54, Revision 0, conditionally endorsed American National Standards Institute (ANSI) N101.4, "Quality Assurance for Protective Coatings Applied to Nuclear Facilities," (Ref. 4) and indirectly endorsed guidance provided in ANSI N101.2, "Protective Coatings (Paints) for Light-Water Nuclear Reactor Containment Facilities" (Ref. 5). ANSI N101.4 and N101.2 were formally withdrawn in 1988; responsibility for updating, rewriting, and issuing appropriate replacement standards was

transferred to the American Society for Testing and Materials (ASTM), specifically ASTM Committee D-33 on Protective Coating and Lining Work for Power Generation Facilities.

ASTM has developed appropriate standards to replace ANSI N101.4 and N101.2. The NRC issued RG 1.54, Revision 1, in July 2000 to provide NRC endorsement and regulatory positions on ASTM standards as applicable to NPP protective coatings. Since the issuance of RG 1.54, Revision 1, many of the ASTM standards endorsed by RG 1.54 have been updated to reflect the current industry practice. This revision to RG 1.54 is being developed to provide NRC regulatory positions on the updated ASTM standards relevant to NPP protective coatings. The NRC has reviewed the ASTM standards cited in Section C of this guide for the selection, qualification, application, and maintenance of protective coatings in NPPs and considers them acceptable with the exceptions noted.

ASTM approved and issued ASTM D 3843-00, "Standard Practice for Quality Assurance for Protective Coatings Applied to Nuclear Facilities", as a partial replacement for ANSI N101.4. ASTM D 3843-00 was reapproved in 2008 with no changes as ASTM D 3843-00 (Reapproved 2008) (Ref. 6). ASTM has approved and issued ASTM D 3911-95, "Standard Test Method for Evaluating Coatings Used in Light-Water Nuclear Power Plants at Simulated Design-Basis Accident (DBA) Conditions," to replace the DBA test standard that was referenced in ANSI N101.4 and RG 1.54. ASTM revised ASTM D 3911-95; the latest revision is ASTM D 3911-03 (Ref. 7).

The ASTM developed and issued ASTM D 5144-08, "Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants" (Ref. 8), to provide a common basis on which protective coatings for the surfaces of nuclear power generating facilities may be qualified and selected by reproducible evaluation tests. This ASTM 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 addresses, by reference, the preparation of test specimens, radiation tolerance testing, decontaminability of coatings, physical properties, chemical resistance tests, fire evaluation tests, DBA testing, surface preparation, coating application and inspection, and thermal conductivity testing. Therefore, ASTM D 5144-08 can be viewed as a top-level ASTM standard that provides detailed requirements through reference to other key ASTM standards. Figure 1 shows the additional ASTM standards that provide application-specific guidance; these standards are discussed below.

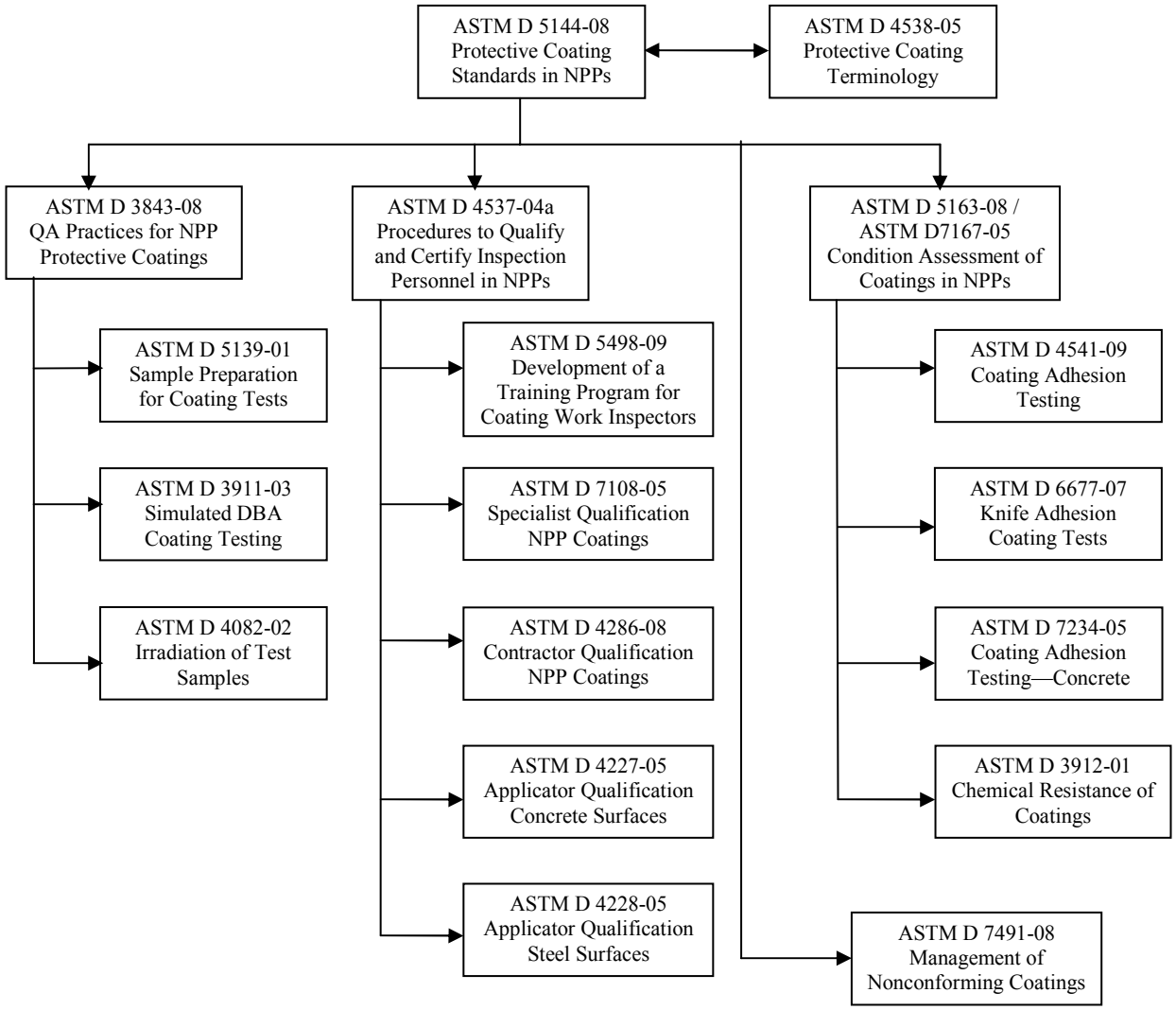

Figure 1. ASTM Standards Relevant to NPP Class I, II, and III Protective Coatings

This RG was developed using definitions and insights from operating reactors. New reactor designs may employ design features that are different from the operating reactors that formed the basis for this RG, and adjustments may be necessary. For example, a plant with passive containment cooling features may have different requirements for protective coatings on containment surfaces, or a plant might rely on the density of failed protective coating particles inside containment that limits their transport to the emergency core cooling system. Therefore, for new reactor designs, the guidance is provided with the recognition that the licensee or applicant may need to adjust some sections based on the particular plant design features.

C. REGULATORY POSITION

1. Guidance in American Society for Testing and Materials Standards

ASTM D 5144-08 and the other ASTM standards discussed below provide guidance on practices and programs that the NRC staff finds acceptable for the selection, application, qualification, inspection,

and maintenance of protective coatings applied in NPPs. However, the ASTM Committee has revised the definitions of 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:

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

(2) 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 decontaminability in those areas outside the reactor containment that are subject to radiation exposure and radionuclide contamination. Service Level II coatings are not safety related.

(3) 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 so applied this designation.)

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

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

b. Applicants for design certifications and combined licenses under 10 CFR Part 52 have proposed using 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 demonstrating that these coatings cannot be transported to the ECCS. Such exceptions may be acceptable to the 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.

2. Quality Assurance

ASTM D 3843-00 (Reapproved 2008) provides QA practices that are acceptable to the NRC staff and are applicable to safety-related protective coating work in coating Service Level I areas of nuclear facilities. Applicable portions of the QA practices described in ASTM D 3843-00 may be used as the basis for limited QA for protective coating work in coating Service Level II areas of nuclear facilities.

ASTM D 5139-90 (Reapproved 2001), "Standard Specification for Sample Preparation for Qualification Testing of Coatings To Be Used in Nuclear Power Plants" (Ref. 9), provides 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 to be used in NPPs, as described in ASTM D 3911-03 and ASTM D 4082-02, "Standard Test Method for Effects of Gamma Radiation on Coatings for Use in Light-Water Nuclear Power Plants" (Ref. 10).

ASTM D 3911-03 provides guidance that the NRC staff finds acceptable on procedures for evaluating test specimens for protective coating systems under simulated DBA conditions. ASTM D 3911-03 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 3911-03 does not specify minimum acceptance criteria. For Service Level I coatings, licensees or applicants shall meet the following minimum acceptance criteria:

- Peeling and delamination shall not be permitted.
- Cracking is not considered a failure unless it is accompanied by delamination or loss of adhesion.
- Blisters shall be limited to intact blisters that are completely surrounded by sound coating bonded to the surface.

An owner may establish more stringent acceptance criteria; the above criteria are meant to establish minimum standards only.

ASTM D 4082-02 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.

ASTM D 4537-04a, "Standard Guide for Establishing Procedures to Qualify and Certify Personnel Performing Coating Work Inspection in Nuclear Facilities" (Ref. 11), provides 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 inspection of the education, training, experience, qualifications, and certification of Service Level I, II, and III coatings inspectors.

3. Training and Qualification of Nuclear Coating Specialists, Protective Coating Inspectors, and Coating Applicators

ASTM D 5498-09, "Standard Guide for Developing a Training Program for Personnel Performing Coating Work Inspection for Nuclear Facilities" (Ref. 12), provides guidance that the NRC staff finds acceptable for developing a training program for personnel who perform coating work inspection in nuclear facilities.

ASTM D 7108-05, "Standard Guide for Establishing Qualifications for a Nuclear Coatings Specialist" (Ref. 13), provides guidance that the NRC staff finds acceptable for establishing qualifications for a nuclear coatings specialist. A nuclear coatings specialist must meet one of the combinations of qualification attributes provided in Table 2 of ASTM D 7108-05.

ASTM D 4227-05, "Standard Practice for Qualification of Coating Applicators for Application of Coatings to Concrete Surfaces" (Ref. 14), 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.

ASTM D 4228-05, "Standard Practice for Qualification of Coating Applicators for Application of Coatings to Steel Surfaces" (Ref. 15), provides guidance that the NRC staff finds acceptable for the qualification of coating applicators to verify that they are proficient and able to attain the quality required for applying specified coatings to steel surfaces, including those in a nuclear facility.

ASTM D 4286-08, "Standard Practice for Determining Coating Contractor Qualifications for Nuclear Powered Electric Generation Facilities" (Ref. 16), provides 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 execute coating work for the primary containment and other safety-related facilities of NPPs. The criteria and requirements for coating contractors address their capabilities to execute nuclear coating work.

4. Maintenance of Coatings

ASTM D 5163-08, "Standard Guide for Establishing a Program for Condition Assessment of Coating Service Level I Coating Systems in Nuclear Power Plants" (Ref. 17), provides guidelines that 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).

ASTM D 7167-05, "Standard Guide for Establishing Procedures To Monitor the Performance of Safety-Related Coating Service Level III Lining Systems in an Operating Nuclear Power Plant" (Ref. 18), 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.

ASTM D 4541-09, "Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers" (Ref. 19), provides guidance that the NRC staff finds acceptable for a procedure for evaluating the pull off strength of coatings on metal substrates using fixed-alignment adhesion testers.

ASTM D 6677-07, "Standard Test Method for Evaluating Adhesion by Knife" (Ref. 20), provides guidance that the NRC staff finds acceptable on test methods for evaluating adhesion using a knife.

ASTM D 7234-05, "Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers" (Ref. 21), provides guidance that the NRC staff finds acceptable for a procedure for evaluating the pull off strength of coatings on concrete using portable pull off adhesion testers.

ASTM D 3912-95 (Reapproved 2001), "Standard Test Method for Chemical Resistance of Coatings Used in Light-Water Nuclear Power Plants" (Ref. 22), provides guidance that the NRC staff finds acceptable for evaluating the chemical resistance of coatings used in light-water NPPs.

ASTM D 7491-08, "Standard Guide for Management of Non-Conforming Coatings in Coating Service Level I Areas of Nuclear Power Plants" (Ref. 23), provides guidance that the NRC staff finds acceptable on managing nonconforming coatings within the Service Level I areas of an NPP.

5. American Society for Testing and Materials Standard Terminology

ASTM D 4538-05, "Standard Terminology Relating to Protective Coating and Lining Work for Power Generation Facilities" (Ref. 24), defines standard terms related to protective coating and lining work for power generation facilities that the NRC staff finds acceptable and that are also applicable to protective coatings employed in NPPs.

6. Additional Information

Additional information on the selection, application, inspection, and maintenance of safety-related protective coatings in NPPs is provided in Electric Power Research Institute (EPRI) Report No. 1003102, "Guideline on Nuclear Safety-Related Coatings," issued November 2001 (formerly EPRI Topical Report No. 109937) (Ref. 25), While the NRC does not formally endorse this EPRI document, it discusses in detail the important considerations related to protective coatings and can be used to

supplement the ASTM standards guidelines as deemed necessary with the exception of Section 3.4.2 of EPRI Report No. 1003102, which discusses the applications of specialized coatings for restoring the structural integrity of a component. The NRC does not agree with the use of specialized coatings for restoring structural integrity.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC's plans for using this draft regulatory guide. The NRC does not intend or approve any imposition or backfit in connection with its issuance.

The NRC has issued this draft guide to encourage public participation in its development. The NRC will consider all public comments received in development of the final guidance document. In some cases, applicants or licensees may propose an alternative or use a previously established acceptable alternative method for complying with specified portions of the NRC's regulations. Otherwise, the methods described in this guide will be used in evaluating compliance with the applicable regulations for license applications, license amendment applications, and amendment requests.

REGULATORY ANALYSIS

Statement of the Problem

The guidance in RG 1.54 (June 1973) has become outdated because the ANSI standards endorsed by the guide have been withdrawn and replaced by ASTM standards. The NRC issued Revision 1 to RG 1.54 in July 2000 to provide NRC endorsement and regulatory positions on ASTM standards as applicable to NPP protective coatings. Since the issuance of Revision 1 to RG 1.54, many of the ASTM standards endorsed by RG 1.54 have been updated to reflect the current industry practice. The most cost-beneficial method to update the guidance in RG 1.54 would be to issue a revision of RG 1.54 that would endorse updated ASTM standards.

Objective

The objective of this regulatory action is to provide NRC endorsement and regulatory positions on the updated ASTM standards relevant to NPP protective coatings.

Alternative Approaches

The NRC staff considered the following alternative approaches:

Do not revise Regulatory Guide 1.54.
Revise Regulatory Guide 1.54.

Alternative 1: Do Not Revise Regulatory Guide 1.54

Under this alternative, the NRC would not revise this guidance, and the original version of this regulatory guide would continue to be the available guidance. This alternative is considered the baseline or "no-action" alternative and, as such, involves no value or impact considerations. However, this alternative would not facilitate the licensees to use the current ASTM standards.

Alternative 2: Revise Regulatory Guide 1.54

Under this alternative, the NRC would revise Regulatory Guide 1.54 to endorse the updated ASTM standards applicable to NPP protective coatings.

One benefit of this action is that it would facilitate licensees to use the updated ASTM standards for the selection, qualification, application, and maintenance of protective coatings in NPPs.

The cost to the NRC would be the one-time cost of issuing the revised regulatory guide (which is expected to be relatively small), and applicants would incur little or no cost.

Conclusion

Based on this regulatory analysis, the NRC staff recommends revision of Regulatory Guide 1.54. The staff concludes that the proposed action will allow licensees to use the updated ASTM standards for the selection, qualification, application, and maintenance of protective coatings in NPPs.

REFERENCES[1]

1. CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," U.S. Nuclear Regulatory Commission, Washington, DC.

2. Regulatory Guide 1.160, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," Revision 2, U.S. Nuclear Regulatory Commission, Washington, DC, March 1997.

3. 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," U.S. Nuclear Regulatory Commission, Washington, DC, July 14, 1998

4. ANSI N101.4-1972, "Quality Assurance for Protective Coatings Applied to Nuclear Facilities," American National Standards Institute, Washington, DC.[2]

5. ANSI N101.2-1972, "Protective Coatings (Paints) for Light-Water Nuclear Reactor Containment Facilities," American National Standards Institute, Washington, DC.

6. ASTM D 3843-00 (Reapproved 2008), "Standard Practice for Quality Assurance for Protective Coatings Applied to Nuclear Facilities," American Society for Testing and Materials, West Conshohocken, PA.[2]

7. ASTM D 3911-03, "Standard Test Method for Evaluating Coatings Used in Light-Water Nuclear Power Plants at Simulated Design-Basis Accident (DBA) Conditions," American Society for Testing and Materials, West Conshohocken, PA.

8. ASTM D 5144-08, "Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants," American Society for Testing and Materials, West Conshohocken, PA.

9. ASTM D 5139-90 (Reapproved 2001), "Standard Specification for Sample Preparation for Qualification Testing of Coatings To Be Used in Nuclear Power Plants," American Society for Testing and Materials, West Conshohocken, PA.

10. ASTM D 4082-02, "Standard Test Method for Effects of Gamma Radiation on Coatings for Use in Light-Water Nuclear Power Plants," American Society for Testing and Materials, West Conshohocken, PA.

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[1] Publicly available NRC published documents such as Regulations, Regulatory Guides, NUREGs, and Generic Letters 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/. 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.

[2] Copies of the non-NRC documents included in these references may be obtained directly from the publishing organization.

11. ASTM D 4537-04a, "Standard Guide for Establishing Procedures To Qualify and Certify Personnel Performing Coating Work Inspection in Nuclear Facilities," American Society for Testing and Materials, West Conshohocken, PA.

12. ASTM D 5498-09, "Standard Guide for Developing a Training Program for Personnel Performing Coating Work Inspection for Nuclear Facilities," American Society for Testing and Materials, West Conshohocken, PA.

13. ASTM D 7108-05, "Standard Guide for Establishing Qualifications for a Nuclear Coatings Specialist," American Society for Testing and Materials, West Conshohocken, PA.

14. ASTM D 4227-05, "Standard Practice for Qualification of Coating Applicators for Application of Coatings to Concrete Surfaces," American Society for Testing and Materials, West Conshohocken, PA.

15. ASTM D 4228-05, "Standard Practice for Qualification of Coating Applicators for Application of Coatings to Steel Surfaces," American Society for Testing and Materials, West Conshohocken, PA.

16. ASTM D 4286-08, "Standard Practice for Determining Coating Contractor Qualifications for Nuclear Powered Electric Generation Facilities," American Society for Testing and Materials, West Conshohocken, PA.

17. ASTM D 5163-08, "Standard Guide for Establishing a Program for Condition Assessment of Coating Service Level I Coating Systems in Nuclear Power Plants," American Society for Testing and Materials, West Conshohocken, PA.

18. ASTM D 7167-05, "Standard Guide for Establishing Procedures To Monitor the Performance of Safety-Related Coating Service Level III Lining Systems in an Operating Nuclear Power Plant," American Society for Testing and Materials, West Conshohocken, PA.

19. ASTM D 4541-09, "Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers," American Society for Testing and Materials, West Conshohocken, PA.

20. ASTM D 6677-07, "Standard Test Method for Evaluating Adhesion by Knife," American Society for Testing and Materials, West Conshohocken, PA.

21. ASTM D 7234-05, "Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers," American Society for Testing and Materials, West Conshohocken, PA.

22. ASTM D 3912-95 (Reapproved in 2001), "Standard Test Method for Chemical Resistance of Coatings Used in Light-Water Nuclear Power Plants," American Society for Testing and Materials, West Conshohocken, PA.

23. ASTM D 7491-08, "Standard Guide for Management of Non-Conforming Coatings in Coating Service Level I Areas of Nuclear Power Plants," American Society for Testing and Materials, West Conshohocken, PA.

24. ASTM D 4538-05, "Standard Terminology Relating to Protective Coating and Lining Work for Power Generation Facilities," American Society for Testing and Materials, West Conshohocken, PA.

25. EPRI Report No. 1003102 "Guideline on Nuclear Safety-Related Coatings," Electric Power Research Institute, Palo Alto, CA, November 2001.