



# REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

## REGULATORY GUIDE 1.54

(Draft was issued as DG-1076)

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

#### A. INTRODUCTION

In Appendix A to 10 CFR Part 50, "General Design Criteria for Nuclear Power Plants," Criterion 1, "Quality Standards and Records," requires, in part, that structures, systems, and components important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. Criterion 1 also requires that a quality assurance program be established and implemented in order to provide adequate assurance that these structures, systems, and components will satisfactorily perform their safety functions.

In Appendix A to 10 CFR Part 50, Criterion 4, "Environmental and Dynamic Effects Design Bases," requires, in part, that structures, systems, and components (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 to 10 CFR Part 50, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," establishes overall quality assurance program requirements for the design, fabrication, construction, and operation of safety-related nuclear power plant SSCs.

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This guide was issued after consideration of comments received from the public. Comments and suggestions for improvements in these guides are encouraged at all times, and guides will be revised, as appropriate, to accommodate comments and to reflect new information or experience. Written comments may be submitted to the Rules and Directives Branch, ADM, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001.

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The 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 upon to remain functional during and following design basis events with respect to specified functions and non-safety-related SSCs (1) that are relied upon to mitigate accidents or transients or are used in plant emergency operating procedures, (2) whose failure could prevent safety-related SSCs from fulfilling their safety-related function, 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 (a)(2), as appropriate. Further guidance is provided in Revision 2 of Regulatory Guide 1.160, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants" (Ref. 1).

This revision to Regulatory Guide 1.54 is being developed in accordance with Public Law 104-113, OMB Circular A-119, and the NRC's Strategic Plan for FY 1997 - 2002, which encourages industry to develop codes, standards, and guides that can be endorsed by the NRC and carried out by industry. The ASTM standards cited in the Regulatory Position of this guide for the selection, qualification, application, and maintenance of protective coatings in nuclear power plants have been reviewed by the NRC staff and found to be acceptable with the exceptions noted.

The information collections contained in this regulatory guide are covered by the requirements of 10 CFR Part 50, which were approved by the Office of Management and Budget, approval number 3150-0011. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

## **B. DISCUSSION**

Protective coatings (paints) have been used extensively in nuclear power plants 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 Regulatory Guide 1.54, 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.

In July 1973, Regulatory Guide 1.54, "Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants," was issued to describe an acceptable method for complying with the NRC's quality assurance requirements with regard to protective coatings applied to ferritic steels, stainless steel, zinc-coated (galvanized) steel, concrete, or masonry surfaces of water-cooled nuclear power plants. 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 (Ref. 2). 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.

Regulatory Guide 1.54 conditionally endorsed ANSI N101.4, "Quality Assurance for Protective Coatings Applied to Nuclear Facilities," and indirectly endorsed guidance provided in ANSI N101.2, "Protective Coatings (Paints) for Light Water Nuclear Reactor Containment Facilities." ANSI N101.4 and N 101.2 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. However, Regulatory Guide 1.54 was not revised as new ASTM Standards were developed for the application and maintenance of nuclear power plant protective coatings.

ASTM D 3843-00, "Standard Practice for Quality Assurance for Protective Coatings Applied to Nuclear Facilities" (Ref. 3), was approved and issued by ASTM as a partial replacement for ANSI N101.4. ASTM D 3911-95, "Standard Test Method for Evaluating Coatings Used in Light-Water Nuclear Power Plants at Simulated Design Basis Accident (DBA) Conditions" (Ref. 4), has been approved and issued by ASTM to replace the DBA test standard that was referenced in ANSI N101.4 and Regulatory Guide 1.54.

ASTM D 5144-00, "Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants" (Ref. 5), has been developed and issued by the ASTM 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 (PWRs) and boiling water reactors (BWRs). The additional ASTM standards, shown in Figure 1, provide application-specific guidance and are discussed below.

## **C. REGULATORY POSITION**

### **1. GUIDANCE IN ASTM STANDARDS**

ASTM D 5144-00 (Ref. 5) and the other ASTM standards discussed below provide guidance on practices and programs that are acceptable to the NRC staff for the selection, application, qualification, inspection, and maintenance of protective coatings applied in nuclear power plants. However, the ASTM Committee has revised definitions of Service Level I, II, and III coatings locations to include both safety-related and non-safety-related regions as set forth below.

The quality assurance provisions and guidance contained in the standards in this Regulatory Position are generally acceptable and provide methods acceptable to the NRC staff for complying with the pertinent quality assurance requirements of Appendix B to 10 CFR Part 50 subject to the following two exceptions.

- (1) When using this regulatory guide, NRC licensees should meet the quality assurance provisions and guidance contained in the standards in this regulatory guide and must also meet the commitments and provisions contained in their Quality Assurance Program description.
- (2) Service Level I, II, and III coatings are defined as:

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.

Service Level II coatings are used in areas where coatings failure could impair, but not prevent, normal operating performance. The functions of Service Level 2 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.

Service Level III coatings are used in areas outside the reactor containment where failure could adversely affect the safety function of a safety-related structure, system, or component.

ASTM D 5144-00 (Ref. 5) 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 5144-00 can be viewed as a top-level ASTM standard that incorporates by reference other key ASTM standards as shown in Figure 1.

## 2. **QUALITY ASSURANCE**

ASTM D 3843-00 (Ref. 3) provides quality assurance 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 practices described may be used as the basis for limited quality assurance for protective coating work in coating Service Level II areas of nuclear facilities.

ASTM D 5139-96 (Ref. 6) provides guidance that is acceptable to the NRC staff on the size, composition, and surface preparation for test samples of protective coatings for use in qualification testing of coatings to be used in nuclear power plants as described in ASTM D 3911-95 and D-4082-95 (Refs. 4 and 7).

ASTM D 3911-95 (Ref. 4) provides guidance that is acceptable to the NRC staff on procedures for evaluating protective coating systems test specimens under simulated DBA conditions. ASTM D 911-95 also provides guidance on conditions and test apparatus for temperature-pressure testing, conditions for radiation testing, and procedures for preparing, examining, and evaluating samples.

ASTM D 4082-95 (Ref. 7) provides a standard test method that is acceptable to the NRC staff for evaluating the effects of gamma radiation on the lifetime radiation tolerance of Service Level I and II coatings.

ASTM D 4537-96 (Ref. 8) provides guidance that is acceptable to the NRC staff on the qualification and certification of personnel who inspect protective coatings in nuclear facilities. This standard provides guidance on inspection of the education, training, experience, qualifications, and certification of Level I, II, and III coatings inspectors.

### **3. TRAINING AND QUALIFICATION OF PROTECTIVE COATINGS INSPECTORS AND COATINGS APPLICATORS**

ASTM D 5498-94 (Ref. 9) provides guidance acceptable to the NRC staff for persons responsible for developing a training program for the indoctrination and training of personnel for inspecting coating work in nuclear facilities and also recommends areas of proficiency that are embodied in the ASTM standards shown in Table 1 in ASTM D 5498-94.

ASTM D 4227-95 (Ref. 10) provides guidance acceptable to the NRC staff for the qualification of coatings applicators to verify that they are proficient and able to attain the quality required for applying specified coatings to concrete surfaces, including those in a nuclear facility.

ASTM D 4228-95 (Ref. 11) provides guidance acceptable to the NRC staff for the qualification of coatings 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 4286-96 (Ref. 12) provides criteria and methods that are acceptable to the NRC staff to assist utility owners, architects, engineers, and contractors in determining the overall qualifications of a coatings contractor to execute coating work for the primary containment and other safety-related facilities of nuclear power plants. The criteria and requirements for contractors address the contractor's capability to execute nuclear coating work.

### **4. MAINTENANCE OF COATINGS**

ASTM D 5163-96 (Ref. 13) provides guidelines that are acceptable to the NRC staff for establishing an in-service coatings monitoring program for Service Level I coating systems in operating nuclear power plants and for Service Level II and other areas outside containment (as applicable).

ASTM D 4541-95 (Ref. 14) provides guidance acceptable to the NRC staff for a procedure for evaluating the pull-off strength of coatings using fixed-alignment adhesion testers.

ASTM D 3359-95, Revision A (Ref. 15), provides guidance that is acceptable to the NRC staff on test methods for measuring adhesion using tape tests.

ASTM D 3912-95 (Ref. 16), provides guidance that is acceptable to the NRC staff on evaluation of the chemical resistance of coatings used in light-water nuclear power plants.

ASTM D 5962-96 (Ref. 17) provides guidance that is acceptable to the NRC staff on maintaining unqualified coatings (paints) within Level I areas of a nuclear power facility.

## **5. ASTM STANDARD TERMINOLOGY**

ASTM D 4538-95 (Ref. 18) defines standard terms related to protective coating and lining work for power generation facilities that are acceptable to the NRC staff and that are also applicable to protective coatings employed in nuclear power plants.

## **6. ADDITIONAL INFORMATION**

Additional information on the selection, application, inspection, and maintenance of nuclear plant safety-related protective coatings is provided in EPRI Report TR-109937 (Ref. 19), which provides a detailed discussion of important considerations related to protective coatings and can be used to supplement the ASTM Standards guidelines as deemed necessary.

## **D. IMPLEMENTATION**

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this regulatory guide.

Except in those cases in which an applicant proposes an acceptable alternative method for the condition monitoring and maintenance of safety-related containment coatings, unless different regulatory requirements apply, the ASTM standards endorsed in this guide will be used in the evaluation of the effectiveness of maintenance activities of licensees who are required to comply with 10 CFR 50.65. Current licensees may, at their option, comply with the guidance in this regulatory guide.

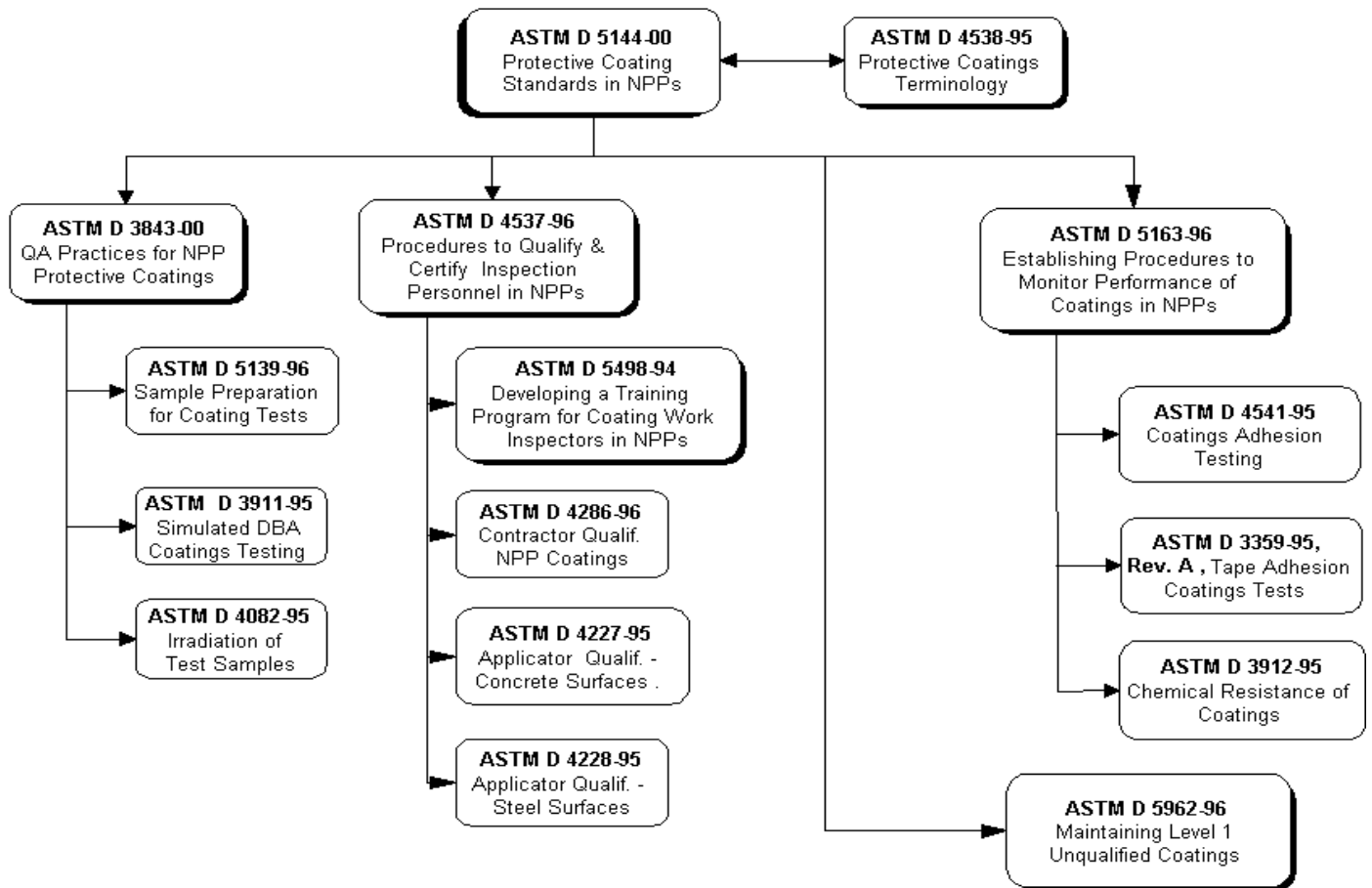


Figure 1, ASTM Standards Relevant to NPP Class I, II and III Protective Coatings

## REFERENCES

1. USNRC, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," Regulatory Guide 1.160, Revision 2, March 1997.<sup>1</sup>
2. USNRC, "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," Generic Letter 98-04, July 14, 1998.<sup>2</sup>
3. American Society for Testing and Materials, "Standard Practice for Quality Assurance for Protective Coatings Applied to Nuclear Facilities," ASTM D 3843-00.<sup>3</sup>
4. American Society for Testing and Materials, "Standard Test Method for Evaluating Coatings Used in Light-Water Nuclear Power Plants at Simulated Design Basis Accident (DBA) Conditions," ASTM D 3911-95.<sup>3</sup>
5. American Society for Testing and Materials, "Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants," ASTM D 5144-00.<sup>3</sup>
6. American Society for Testing and Materials, "Standard Specification for Sample Preparation for Qualification Testing of Coatings To Be Used in Nuclear Power Plants," ASTM D 5139-90 (Reapproved 1996).<sup>3</sup>
7. American Society for Testing and Materials, "Standard Test Method for Effects of Gamma Radiation on Coatings for Use in Light-Water Nuclear Power Plants," ASTM D 4082-95.<sup>3</sup>
8. American Society for Testing and Materials, "Standard Guide for Establishing Procedures To Qualify and Certify Inspection Personnel for Coating Work in Nuclear Facilities," ASTM D 4537-91 (Re-approved 1996).<sup>3</sup>

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<sup>1</sup> Single copies of regulatory guides, both active and draft, and draft NUREG documents may be obtained free of charge by writing the Reproduction and Distribution Services Section, OCIO, USNRC, Washington, DC 20555-0001, or by fax to (301)415-2289, or by email to <DISTRIBUTION@NRC.GOV>. Active guides may also be purchased from the National Technical Information Service on a standing order basis. Details on this service may be obtained by writing NTIS, 5285 Port Royal Road, Springfield, VA 22161; telephone (703)487-4650; online <<http://www.ntis.gov/ordernow>>. Copies of certain guides and many other NRC documents are available electronically on the internet at NRC's home page at <[WWW.NRC.GOV](http://WWW.NRC.GOV)> in the Reference Library. Documents are also available through the Electronic Reading Room (NRC's ADAMS document system, or PARS) at the same web site.

<sup>2</sup> Copies are available electronically at NRC's home page <[WWW.NRC.GOV](http://WWW.NRC.GOV)> in the Reference Library. Copies are also available for inspection or copying for a fee from the NRC Public Document Room at 2120 L Street NW., Washington, DC; the PDR's mailing address is Mail Stop LL-6, Washington, DC 20555; telephone (202)634-3273 or (800)397-4209; fax (202)634-3343; email <[PDR@NRC.GOV](mailto:PDR@NRC.GOV)>.

<sup>3</sup> ASTM documents may be purchased from ASTM at 100 Barr Harbor Drive, West Conshohocken, PA 19428; email to <[SERVICE@ASTM.ORG](mailto:SERVICE@ASTM.ORG)>.



9. American Society for Testing and Materials, "Standard Guide for Developing a Training Program for Coating Work Inspectors in Nuclear Facilities," ASTM D 5498-94.<sup>3</sup>
10. American Society for Testing and Materials, "Standard Practice for Qualification of Coating Applicators for Application of Coatings to Concrete Surfaces," ASTM D 4227-95.<sup>3</sup>
11. American Society for Testing and Materials, "Standard Practice for Qualification of Coating Applicators for Application of Coatings to Steel Surfaces," ASTM D 4228-95.<sup>3</sup>
12. American Society for Testing and Materials, "Standard Practice for Determining Coating Contractor Qualifications for Nuclear Powered Electric Generation Facilities," ASTM D 4286-90 (Re-approved 1996).<sup>3</sup>
13. American Society for Testing and Materials, "Standard Guide for Establishing Procedures To Monitor the Performance of Safety Related Coatings in an Operating Nuclear Power Plant," ASTM D 5163-96.<sup>3</sup>
14. American Society for Testing and Materials, "Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers," ASTM D 4541-95.<sup>3</sup>
15. American Society for Testing and Materials, "Standard Test Methods for Measuring Adhesion by Tape Test," ASTM D 3359-95, Revision A.<sup>3</sup>
16. American Society for Testing and Materials, "Standard Test Method for Chemical Resistance of Coatings Used in Light-Water Nuclear Power Plants," ASTM D 3912-95.<sup>3</sup>
17. American Society for Testing and Materials, "Standard Guide for Maintaining Unqualified Coatings (Paints) Within Level Areas of a Nuclear Power Facility," ASTM D 5962-96.<sup>3</sup>
18. American Society for Testing and Materials, "Standard Terminology Relating to Protective Coating and Lining Work for Power Generation Facilities," ASTM D 4538-95.<sup>3</sup>
19. Electric Power Research Institute, "Guidelines on the Elements of a Nuclear Safety-Related Coatings," EPRI Report TR-109937, March 1998.

## **REGULATORY ANALYSIS**

The guidance in Regulatory Guide 1.54, “Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants” (June 1973), has become outdated because the ANSI standards endorsed by the guide have been withdrawn and replaced by ASTM standards. Public Law 104-113, OMB Circular A-119, and NRC’s Strategic Plan for FY1997-2002 encourage the use of codes, standards, and guides that have been developed by industry and that can be endorsed by the NRC and carried out by industry. The most cost-beneficial method to update the guidance in Regulatory Guide 1.54 would be to issue a revision of Regulatory Guide 1.54 that endorses updated ASTM standards.

## **BACKFIT ANALYSIS**

The regulatory guide does not require a backfit analysis as described in 10 CFR 50.109(c) because it does not impose a new or amended provision in the NRC’s rules or a regulatory staff position interpreting the NRC’s rules that is either new or different from a previous applicable staff position. In addition, this regulatory guide does not require the modification or addition to systems, structures, components, or design of a facility or the procedures or organization required to design, construct, or operate a facility. Rather, a licensee or applicant can select a preferred method for achieving compliance with a license or the rules or the orders of the NRC as described in 10 CFR 50.109(a)(7). This regulatory guide provides an opportunity to use industry-developed standards, if that is a licensee’s or applicant’s preferred method.