~~Designation:D5144–00~~ Designation: D 5144 – 08

Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants[1]

This standard is issued under the fixed designation D 5144; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

Protective coatings (paints) have been used extensively in the nuclear industry to protect the surfaces of facilities and equipment from corrosion and contamination by radioactive nuclides in accordance with ALARA. In the absence of a standard method of selecting, testing, and evaluating coatings, many sites evaluated paints by empirical tests to determine which were useful in their particular operation. Understandably, the methods of testing were not uniform throughout the industry. It has been very difficult, consequently, to compare the results obtained at one site with those obtained at another. Standard tests whereby industrial (nuclear) users of paints systematically prepare specimens and subject them to selected evaluations, thus permitting uniform comparisons, are advantageous, internationally as well as domestically.

The designer of light water-moderated nuclear reactor systems must consider the possibility of a Design Basis Accident (DBA) and the subsequent events which might lead to the release or expulsion of a fraction of the fission-product inventory of the core to the reactor containment facility. Engineered safety features, principally a reactor containment facility, are provided to prevent the release of fission products to the biological environment during and after this improbable event. The design, fabrication, quality assurance, and testing of these engineered safety features ensure reliable operation and safety under all anticipated conditions.

Large areas of the reactor-containment facility are painted with safety-related coatings. If severe delamination, peeling, or flaking causes significant portions of the coating to be discharged into the common water reservoir, the performance of the safety systems could be seriously compromised by the plugging of strainers, flow lines, pumps, spray nozzles, and core coolant channels. Safety-related coatings may also exist outside of the reactor-containment.

This guide is the result of a comprehensive examination of the experience and data that have been developed on protective coatings in the nuclear industry over approximately 40 years. Standards pertaining to nuclear coatings have historically been covered by ANSI ~~N5.12, N101.2~~N5.12, ANSI N101.2, and ANSI N101.4. Responsibility for updating, rewriting, and issuing appropriate ANSI replacement standards has been transferred to ASTM, specifically ASTM Committee ~~D-33,~~D33, on Protective Coating and Lining Work for Power Generation Facilities.

The objective of this guide is to provide a common basis on which ~~to define and specify~~ protective coatings for the ~~performance requirements for the coatings that will~~surfaces of nuclear power generating facilities may be ~~used in nuclear facilities.~~ qualified and selected by reproducible evaluation tests. This guide also provides guidance for application and maintenance of protective coatings. Quality assurance in the nuclear industry is a mandatory requirement for all aspects of safety-related nuclear coatings work. Licensees of nuclear power plants are required to determine if coated surfaces are within the scope of 10CFR50.65~~," The~~, "The Maintenance ~~Rule".~~Rule." Any coated surfaces found to be within the scope of 10CFR50.65 must satisfy the requirements of 10CFR50.65. ASME Section XI, Subsection IWE contains the requirements for periodic evaluation of the reactor-containment steel pressure boundary.

[1] This guide is under the jurisdiction of ASTM Committee ~~D 33~~ D33 on Protective Coating and Lining Work for Power Generation Facilities and is the direct responsibility of Subcommittee D33.02 on Service and Material Parameters.

~~Current edition approved May 10, 2000. Published July 2000. Originally published as D5144–91. Last previous edition D5144–97.~~

Current edition approved Nov. 15, 2008. Published January 2009. Originally approved in 1991. Last previous edition approved in 2000 as D 5144 – 00.

1. Scope

1.1 This guide provides 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 guide also provides guidance for application and maintenance of protective coatings. Under the environmental operating and accident conditions of nuclear power generation facilities, encompassing pressurized water reactors ~~(PWR's)~~(PWRs) and boiling water reactors ~~(BWR's),~~(BWRs), coating performance may be affected by exposure to any one, all, or a combination of the following conditions: ionizing radiation; contamination by radioactive nuclides and subsequent decontamination processes; chemical and water sprays; high-temperature high-pressure steam; and abrasion or wear.

1.2 The content of this guide includes:

	Section
Referenced Documents	2
Terminology	3
Significance and Use	4
Coating Material Testing	5
Thermal Conductivity	5
Surface Preparation, Coating Application, and Inspection for Shop and Field Work	6
~~Thermal Conductivity~~	Quality Assurance
~~Quality Assurance~~	~~8~~
~~Keywords9~~	~~8~~
Keywords	8

1.2.1 In addition, this guide addresses technical topics within ANSI N5.12 and ANSI N101.2 that are covered by separate ASTM standards, for example, surface preparation, (shop and field) and coating application, (shop and field).

1.2.2 Applicable sections of this guide and specific acceptance criteria may be incorporated into specifications and other documents where appropriate.[2]

~~1.3~~

1.3 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C 177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus

D 3843 Practice for Quality Assurance for Protective Coatings Applied to Nuclear Facilities

D 3911 Test Method for Evaluating Coatings Used in Light-Water Nuclear Power Plants at Simulated Design Basis Accident (DBA) Conditions

D 3912 Test Method for Chemical Resistance of Coatings Used in Light-Water Nuclear Power Plants

D 4060 Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser

D 4082 Test Method for Effects of Gamma Radiation on Coatings ~~Used~~ for Use in Light-Water Nuclear Power Plants

D 4227 Practice for Qualification of Coating Applicators for Application of Coatings to Concrete Surfaces

D 4228 Practice for Qualification of Coating Applicators for Application of Coatings to Steel Surfaces

D 4537 Guide for Establishing Procedures to Qualify and Certify ~~Inspection~~ Personnel Performing Coating Work Inspection in Nuclear Facilities

D 4538 Terminology Relating to Protective Coating and Lining Work for Power Generation Facilities

D 4541 Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers

D 5139 Specification for Sample Preparation for Qualification Testing of Coatings to ~~B~~be Used in Nuclear Power Plants

D 5163 Guide for Establishing a Program for Condition Assessment of Coating Service Level I Coating Systems in Nuclear Power Plants

D 7167 Guide for Establishing Procedures to Monitor the Performance of Safety-Related Coating Service Level III Lining Systems in an Operating Nuclear Power Plant

D 7230 Guide for Evaluating Polymeric Lining Systems for Water Immersion in Coating Service Level III Safety-Related Applications on Metal Substrates

---

[2] Certain ASTM standards are available in compilation form (which includes this guide), as *Compilation of ASTM Standards for Use of Protective Coating Standards in Nuclear Power Plants* for expedient reference and usage by personnel involved in nuclear coating work.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* ~~, Vol 04.06.~~volume information, refer to the standard's Document Summary page on the ASTM website.

D 7234 Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers
D 7491 Guide for Management of Non-Conforming Coatings in Coating Service Level I Areas of Nuclear Power Plants
E 84 Test Method for Surface Burning Characteristics of Building Materials
E 684 Practice for Approximate Determination of Current Density of Large-Diameter Ion Beams for Sputter Depth Profiling of Solid Surfaces
E 1461 Test Method for Thermal Diffusivity ~~of Solids~~ by the Flash Method
E 1530 Test Method for Evaluating the Resistance to Thermal Transmission of Materials by the Guarded Heat Flow Meter Technique

2.2 *Other Standards:*

ANSI N5.12 Protective Coatings (Paints) for the Nuclear Industry[4]
ANSI N101.2 Protective Coatings (Paints) for Light Water Nuclear Reactor Containment Facilities[4]
ANSI N101.4 Quality Assurance for Protective Coatings Applied to Nuclear Facilities[4]
~~ASME Boiler and Pressure Vessel Code (BPVC), Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components,"Subsection IWE"Requirements for Class MC and Metallic Liners of Class CC Components of Light-Water Cooled Power Plants"~~ ASME Boiler and Pressure Vessel Code (BPVC) Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components, Subsection IWE Requirements for Class MC and Metallic Liners of Class CC Components of Light-Water Cooled Power Plants[5]
EPRI 1003102 (November 2001) Guideline on Nuclear Safety-Related Coatings Revision 1 (formerly TR-109937)[6]
~~EPRI TR-109937 (1998)Guideline on Nuclear Safety-Related Coatings~~ 10CFR50 Appendix B: Title 10, Chapter 1, Energy, Part 50, Domestic Licensing of Production and Utilization Facilities, Appendix B, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants[7]
~~10CFR50. Appendix B: Title 10, Chapter 1, Energy, Part 50,Domestic Licensing of Production and Utilization Facilities, Appendix B, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants~~
10CFR50.65~~Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants[11]~~ Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants[7]
Guide 1.54 Regulatory/(1973) Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants[7]
~~Guide 1.54Regulatory/(1973) Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants[11]~~ USNRC Standard Review Plan 6.1.2 Protective Coating Systems (Paints) Organic Materials[7]
~~USNRC Review Plan 6.1.2Protective Coating Systems (Paints) Organic Materials[11]~~
~~10CFR20.1(C)Standards for Protection Against Radiation; Purpose[11]~~
USNRC Regulatory Guide 8.8 Information Relevant to Ensuring that Occupational Radiation Exposures At Nuclear Power Stations Will Be As Low As Is Reasonably Achievable[7]

3. Terminology

3.1 *Definitions*—Definitions for use with this guide are shown in Terminology D 4538 or other applicable standards.

~~3.2*Definitions of Terms Specific to This Standard:*~~

~~3.2.1*ALARA*—the concept of reducing radiation exposure to personnel to levels "as low as is reasonably achievable," as defined in the USNRC Regulation Guide 8.8, and 10CFR20.1(C).~~

~~3.2.2*Coating Service Level I*—Terms used to describe areas inside the reactor-containment where coating failure could adversely affect the operation of post-accident fluid systems and, thereby, impair safe shutdown.~~

~~3.2.3*Coating Service Level II*—Terms used to describe areas outside the reactor-containment where coating failure could impair, but not prevent, normal operating performance. The function of *Coating Service Level II* coatings is to provide corrosion protection and decontaminability in those areas outside the reactor-containment subject to radiation exposure and radionuclide contamination. *Service Level II* coatings are not safety-related.~~

~~3.2.4*Coatings Service Level III*—Terms used to describe areas outside the reactor-containment where coating failure could adversely affect the safety function of a safety-related structure, system or component (SSC).~~

~~3.2.5*Safety-Related Coating System*—A coating system used inside or outside of the reactor-containment, the detachment of which could adversely affect the safety function of a safety-related structure, system or component (SSC).~~

~~[4] Annual Book of ASTM Standards, Vol 06.02.~~
[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.
~~[5] Annual Book of ASTM Standards, Vol 06.01.~~
[5] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.
~~[6] Annual Book of ASTM Standards, Vol 04.07.~~
[6] Available from EPRI Distribution Center, 207 Coggins Drive, P.O. Box 23205, Pleasant Hills, CA 94523 (510) 934-4212.
~~[7] Annual Book of ASTM Standards, Vol 14.02.~~
[7] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, http://www.access.gpo.gov.

3.2.6*DBA Qualified Coating System*—A coating system used inside reactor-containment that can be attested to having passed the required laboratory testing, including irradiation and simulated Design Basis Accident (DBA), and has adequate quality documentation to support its use as DBA qualified.

3.2.7*DBA Unqualified Coating System*—A coating system used inside reactor-containment that *cannot* be attested to having passed the required laboratory testing, including irradiation and simulated Design Basis Accident (DBA), or has inadequate quality documentation, or both, to support its use as DBA qualified.

3.2.8*Acceptable Coating or Lining System*—A safety-related coating or lining system for which a suitability for application review which meets the plant licensing requirements has been completed and there is reasonable assurance that, when properly applied and maintained, the coating or lining will not detach under normal or accident conditions.

3.2.9*Indeterminate Coating or Lining System*—A safety-related coating or lining system for which there is insufficient evidence to demonstrate that it is suitable for its intended use and that it is acceptable.

3.2.9.1*Discussion*—Note that ultimately a decision must be made as to whether or not an indeterminate coating system is acceptable.

4. Significance and Use

4.1 This guide addresses the concerns of Regulation Guide 1.54 and USNRC Standard Review Plan 6.1.2, and the replacement of ANSI Standards N5.12, N101.2N5.12, N101.2, and N101.4. This guide covers coating work on previously coated surfaces as well as bare substrates. This guide applies to all coating work in Coating Service Level I and III areas (that is, safety-related coating work). Applicable sections of this guide may also be used to evaluate and select protective coatings for Coating Service Level II areas where deemed appropriate by the licensee.

4.2 The testing referenced in this guide is particularly appropriate for safety-related coatings inside the reactor-containment. Other test methods may be used for assessing the suitability for service of safety-related coatings outside the reactor-containment. Criteria for evaluationqualification and selection performance monitoring of Coating Service Level III coatings shall be addressed in job specifications. Guidance for selecting safety-related and other coatings located outside the reactor-containment performance monitoring of Coating Service Level III coatings is provided Guides D 7230 and D 7167 respectively, and Sections 4.4 and 4.5 of EPRI TR-109937(1998)1003102. (formerly TR-109937).

4.3 Users of this guide must ensure that coatings work complies not only with this guide, but also with the licensee's plant-specific quality assurance program and licensing commitments.

4.4 *Safety-Related Coatings*:

4.4.1The qualification of coatings for Service Levels I and III are different even though they are both safety-related. This standard guide provides the minimum requirements for qualifying Service Level I coatings and also provides guidance for additional qualification tests that may be used to evaluate Service Level I coatings. This standard guide does *not* provide minimum requirements for qualifying Service Level III coatings but does provide guidance for qualification tests that may be applicable for use in evaluating Service Level III coatings.

4.4.1 The qualification of coatings for Coating Service Levels I and III are different even though they are both safety-related. This guide provides the minimum requirements for qualifying Coating Service Level I coatings and also provides guidance for additional qualification tests that may be used to evaluate Coating Service Level I coatings. This guide also provides guidance concerning selection of Coating Service Level III coatings.

4.4.2 *Coating Service Level I Coatings*:

4.4.2.1 All Coating Service Level I coatings must be resistant to the effects of radiation and must be DBA qualified. The test specimens shall be prepared, irradiated and DBA tested and evaluated in accordance with the requirements of: (a)

(a) Test Method D 3911 or plant specific requirements as applicable, (b)

(b) Test Method D 4082, and (c)

(c) Specification D 5139.

4.4.2.2 In addition to the requirements of 4.4.2.1, Coating Service Level I coatings may be evaluated for additional qualities or may require application controls when deemed applicable by the job specifications or licensing commitments. The following documents provide guidance for application, possible additional testing or for the further evaluation of Coating Service Level I coatings when applicable: (a)

(a) Test Method C 177, (b)

(b) Practice D 3843, (c)

(c) Test Method D 3912, (d)

(d) Test Method D 4060, (e)

(e) Practice D 4227, (f)

(f) Practice D 4228, (g)

(g) Guide D 4537, (h)

(h) Test Method D 4541, (i)

(i) Test Method E 84, (j)

(j) Test Method E 1461, and (k)

(k) Test methodMethod E 1530.