



Designation: D8104 – 17

## Standard Guide for Determining Coating Qualification Test Data Applicability<sup>1</sup>

This standard is issued under the fixed designation D8104; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 The purpose of this guide is to identify evaluation variables that can be used to determine whether existing coating qualification test data (for example, design basis accident or DBA, chemical resistance, fire resistance, thermal conductivity, etc.) meet the respective nuclear power plant qualification requirements or whether requalification is required. Guidance on developing a coating qualification test plan/procedure to qualify a new coating is beyond the scope of this standard.

1.2 This guide is intended for use in new construction and for refurbishing existing coating systems applied to concrete and metal substrates within containment.

1.3 This guide is intended for the use by, or under the supervision of, a person knowledgeable in coating technology and coatings used in CSL I applications, such as a person meeting the requirements of Guide [D7108](#) or equivalent.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 *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.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

<sup>1</sup> This guide is under the jurisdiction of ASTM Committee [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.

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### 2. Referenced Documents

#### 2.1 *ASTM Standards:*<sup>2</sup>

- [D3911 Test Method for Evaluating Coatings Used in Light-Water Nuclear Power Plants at Simulated Design Basis Accident \(DBA\) Conditions](#)
- [D4060 Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser](#)
- [D4082 Test Method for Effects of Gamma Radiation on Coatings for Use in Nuclear Power Plants](#)
- [D4258 Practice for Surface Cleaning Concrete for Coating](#)
- [D4259 Practice for Abrading Concrete](#)
- [D4260 Practice for Liquid and Gelled Acid Etching of Concrete](#)
- [D4538 Terminology Relating to Protective Coating and Lining Work for Power Generation Facilities](#)
- [D4541 Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers](#)
- [D5139 Specification for Sample Preparation for Qualification Testing of Coatings to be Used in Nuclear Power Plants](#)
- [D5144 Guide for Use of Protective Coating Standards in Nuclear Power Plants](#)
- [D7108 Guide for Establishing Qualifications for a Nuclear Coatings Specialist](#)
- [E84 Test Method for Surface Burning Characteristics of Building Materials](#)
- [E1269 Test Method for Determining Specific Heat Capacity by Differential Scanning Calorimetry](#)
- [E1530 Test Method for Evaluating the Resistance to Thermal Transmission of Materials by the Guarded Heat Flow Meter Technique](#)
- [G14 Test Method for Impact Resistance of Pipeline Coatings \(Falling Weight Test\)](#)

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

## 2.2 Federal Standards:<sup>3</sup>

10CFR50 Ultimate design basis

Appendix A—Criterion 4 Environmental and Dynamic Effects

Appendix B—Part III Design Control

Appendix B—Part XI Test Control

## 2.3 U.S.NRC Standards:<sup>4</sup>

USNRC Regulatory Guide 1.54 Service Level I, II, and III Protective Coatings Applied to Nuclear Power Plants

USNRC APCS 9.5-1, Branch Technical Position APCS 9.5-1 Guidelines for Fire Protection for Nuclear Power Plants

## 2.4 ANSI Standards:<sup>5</sup>

ANSI N101.2 Protective Coatings (Paints) for Light Water Nuclear Reactor Containment Facilities

## 2.5 SSPC Standards:<sup>6</sup>

SSPC-SP 5 White Metal Blast Cleaning

SSPC-SP 6 Commercial Blast Cleaning

SSPC-SP 7 Brush-Off Blast Cleaning

SSPC-SP 8 Pickling

SSPC-SP 10 Near White Blast Cleaning

SSPC-SP 11 Power Tool Cleaning to Bare Metal

SSPC-SP WJ-1 Waterjet Cleaning of Metals—Clean

SSPC-SP WJ-2 Waterjet Cleaning of Metals—Very Thorough Cleaning

SSPC-SP WJ-3 Waterjet Cleaning of Metals—Thorough Cleaning

SSPC-SP WJ-4 Waterjet Cleaning of Metals—Light Cleaning

requirements critical to the new design are adequately addressed in the existing data or the need for additional coating testing is identified.

## 5. Variables and Their Use

5.1 Variables that can be used to evaluate existing test data are provided in **Table 8**. Also provided in **Table 8** are criteria to assess the test values for each variable and a brief explanation of the significance of the variable relative to qualification of the coating system. Each variable should be used to compare the existing qualification test data to the respective nuclear plant's license basis and coating qualification requirements. If comparison of the existing test data for a given variable to the plant's qualification requirements shows that the test data does not satisfy the criteria described in **Table 8**, the existing test data is not applicable.

5.1.1 Example: The existing test data shows that the test was conducted at a peak temperature of 207°F, but the plant's DBA peak temperature is 238°F. The DBA test data are not applicable to the plant because the DBA test peak temperature is less than the postulated peak temperature for the plant's DBA.

5.2 An example approach to evaluating existing qualification test data for applicability: A plant wants to use a single product coating system to repair the existing coating system inside reactor containment. The coating has not previously been applied in the plant. The following describes one possible approach to evaluating the existing qualification test data for applicability to the plant using the variables in **Table 8**. Other approaches may be used. The specific variables to be used may vary with the particular scope of the search; not all variables may be applicable or necessary.

5.2.1 Step 1: Search the existing DBA test reports and select those applicable to the coating system.

5.2.2 Step 2: Review the reports selected in Step 1 and using the variable assessment criteria for DBA testing, select the reports that satisfy the criteria applicable to the plant.

5.2.3 Step 3: Review the reports selected in Step 2 and using the variable assessment criteria for Irradiation, select the reports that satisfy the criteria applicable to the plant.

5.2.4 Step 4: Review the reports selected in Step 3 and using the variable assessment criteria for Coupon Preparation, select the reports that satisfy the criteria applicable to the plant.

5.2.5 Step 5: Review the reports selected in Step 4 and using the variable assessment criteria for Coating Application, select the reports that satisfy the criteria applicable to the plant.

5.2.6 If, at the completion of Step 5, there are no acceptable DBA test reports, then satisfactory DBA testing of the coating to the plant's qualification requirements is required before the coating can be applied in the plant as a qualified coating.

5.2.7 If one or more DBA test reports are found to satisfy the criteria used in Steps 1 through 5, additional evaluation may be required prior to full approval of the coating for use as required by the plant's license basis and qualification requirements using the variable assessment criteria for Other Coating Properties.

5.2.8 Step 6: As required to satisfy the plant's qualification requirements, review the reports selected in Step 5 and using the variable assessment criteria for Other Coating Properties,

## 3. Terminology

3.1 Definitions for use with this standard are shown in Terminology **D4538** or other applicable standards.

## 4. Significance and Use

4.1 For conformance with the intent of the criteria listed in **2.2** and **2.3**, coating qualification tests are founded on plant-specific test parameters that realistically reflect or bound the material and process variables that can reasonably be expected to influence qualification testing performance.

4.2 This guide provides guidance for evaluating existing coating system qualification data for applicability to the nuclear plant desiring to use a coating system not previously used in the plant or to qualify an existing coating system.

4.3 It is recognized that new-build plants, as well as small modular reactors currently under development, may have design features that differ from those of the operating plants that formed the basis for the existing test data. Therefore, careful review is required to assure that coating performance

<sup>3</sup> Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, <http://www.access.gpo.gov>.

<sup>4</sup> Available from U. S. Nuclear Regulatory Commission (NRC), 11555 Rockville Pk., Rockville, MD 20852, <http://www.nrc.gov>.

<sup>5</sup> Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

<sup>6</sup> Available from Society for Protective Coatings (SSPC), 800 Trumbull Dr., Pittsburgh, PA 15205, <http://www.sspc.org>.

**TABLE 8 Coating Qualification Test Report Assessment Variables**

Variable	Assessment Criteria	Significance of Variable/Basis of Assessment Criteria
Coupon Preparation		
Substrate	<p>a. Carbon steel coupon can be used to represent carbon steel, cast steel, and cast iron.</p> <p>b. Austenitic stainless steel coupon can be used to represent austenitic stainless steel.</p> <p>c. Galvanized carbon steel can be used to represent galvanized carbon steel (Specification <b>D5139</b>).</p> <p>d. A welded coupon can be used to represent installed welds.</p> <p>e. Copper, brass, and bronze substrates are alloy-specific.</p>	<p>a. Due to the low alloy content, carbon steel, cast steel, and cast iron present a carbon steel substrate for coating. Test data for another metal is not applicable to carbon steel.</p> <p>b. Test data for another metal is not applicable to austenitic stainless steel.</p> <p>c. The surface and reactivity of zinc is unique and test data for a non-galvanized surface is not applicable to galvanized steel. For the purposes of this document, galvanizing is considered to be a substrate.</p> <p>d. The preparation performed on welded coupons is unique.</p> <p>e. Test data is specific for the alloy tested and not applicable to other alloys.</p>
Steel substrate cleanliness	<p>A specific level of cleanliness can be used to qualify a coating applied to a surface with a more stringent level of cleanliness, but not a less stringent level of cleanliness.</p> <p>a. Cleanliness produced by SSPC-SP 11 can be considered to be approximately equivalent to the cleanliness produced by SSPC-SP 10.</p> <p>b. Cleanliness produced by SSPC-SP 8 can be considered to be approximately equivalent to the cleanliness produced by SSPC-SP 5.</p> <p>c. Cleanliness produced by SSPC-WJ-1 can be considered to be approximately equivalent to the cleanliness produced by SSPC-SP 5.</p> <p>d. Cleanliness produced by SSPC-WJ-2 can be considered to be approximately equivalent to the cleanliness produced by SSPC-SP 10.</p> <p>e. Cleanliness produced by SSPC-WJ-3 can be considered to be approximately equivalent to the cleanliness produced by SSPC-SP 6.</p> <p>f. Cleanliness produced by SSPC-WJ-4 can be considered to be approximately equivalent to the cleanliness produced by SSPC-SP 7.</p>	<p>A more stringent level of cleanliness enhances coating adhesion and performance. Therefore, testing with a less stringent level of cleanliness is more conservative. SSPC SP COM ranks SSPC SP standards in terms of cleanliness achieved.</p> <p>a. SSPC-SP 10 allows for some staining and SSPC-SP 11 allows for small discrete residue due to mill scale and previous coating material in the bottom of pits if the steel substrate is pitted.</p> <p>b. Acid cleaning (pickling) to SSPC-SP 8 removes all rust and mill scale with no discussion of staining.</p> <p>c. This equivalency is discussed in SSPC-SP WJ-1.</p> <p>d. This equivalency is discussed in SSPC-SP WJ-2.</p> <p>e. This equivalency is discussed in SSPC-SP WJ-3.</p> <p>f. This equivalency is discussed in SSPC-SP WJ-4.</p>
Steel substrate profile height	<p>a. A specific profile height range was used to qualify the coating.</p> <p>b. If qualifying an existing coating in the plant, the DBA Test profile height must be within the manufacturer's published recommendations for the existing applied coating DFT.</p>	<p>a. Coating application to a substrate profile height outside the qualified profile height range requires qualification.</p> <p>b. The assumption is that the existing coating was applied to a surface with a profile height within the manufacturer's published recommendations for the applied coating DFT.</p>
Steel substrate anchor pattern	<p>a. A less than sharp angular anchor pattern can be used to qualify coating applied to a sharp angular pattern.</p>	<p>a. Manufacturer testing indicates that profile pattern is not a critical attribute. But, applicator experience suggests anchor pattern is a significant variable.</p>
Concrete curing compounds	<p>a. Addition of curing compounds to the coupon can be used to qualify coating applied to concrete with no added curing compounds.</p>	<p>a. In some cases, curing compounds can adversely affect coating adhesion and performance. Therefore, the addition of curing compounds is more conservative.</p>
Concrete substrate surface condition	<p>a. Inclusion of bug holes and/or porosity can be used to qualify coating applied to concrete with no bug holes or porosity (Specification <b>D5139</b>).</p>	<p>a. Bug holes and porosity increase the risk of developing air pockets under the coating, reducing adhesion strength under DBA conditions. Therefore, the inclusion of bug holes and/or porosity is more conservative.</p>
Concrete substrate profile	<p>a. Coupons prepared to Specification <b>D5139</b> can be used to qualify coatings applied to coupons prepared to Practices <b>D4258</b>, <b>D4259</b>, or <b>D4260</b>.</p>	<p>a. Coupons prepared to Specification <b>D5139</b> are conservative in that form release agents and curing compounds may be used and surface cleaning is by light wire brushing the broom finish surface and compressed air blow of the as-cast surfaces.</p>
Coating Application		
Steel coating system	<p>Single, multiple coat system</p>	<p>Must be same number of coats and same coating material combination (includes repair coatings or feathered interface)</p>
Concrete coating system	<p>Single, multiple coat system</p>	<p>Must be same number of coats and same coating material combination (includes repair coatings or feathered interface)</p>
Thinning	<p>Manufacturer's published recommendations for solvent used and amount</p>	<p>Current manufacturer's published recommendations are acceptable</p>
Color	<p>Manufacturer's color or color number tested</p>	<p>Change in color number requires verification from manufacturer that it meets the qualified formulation or requires qualification</p>

**TABLE 8 Continued**

Variable	Assessment Criteria	Significance of Variable/Basis of Assessment Criteria
Accelerator	Manufacturer's formulation	Addition or deletion of accelerator requires qualification
Application method	Manufacturer's published recommendations	Outside manufacturer's published recommendations require qualification
Dry film thickness	DFT per coat and total DFT (range for each)	Outside individual coat qualified range or outside system total qualified range requires qualification
Other variables including environmental conditions, curing, etc.	Manufacturer's published recommendations	Outside manufacturer's published recommendations require qualification
DBA Testing		
Governing standard	Coating testing conducted in accordance with the governing standards committed in the plant's design basis (for example, ANSI N101.2, Test Method <a href="#">D3911-95</a> , Test Method <a href="#">D3911-03</a> , etc.)	There are differences in the testing requirements and acceptance criteria between the various governing standards that could cause a need for coating qualification
Temperature profile	Coatings to be used in a given plant containment can be qualified by testing performed to a temperature profile that meets or exceeds the plant specific design basis accident profile.	To provide sufficient basis that applied coatings will perform satisfactorily, testing must demonstrate performance at an accident profile enveloping (that is, as or more severe than) the plant design basis accident profile.
Pressure profile	Coatings to be used in a given plant containment can be qualified by testing performed to a pressure profile that meets or exceeds the plant specific design basis accident profile.	To provide sufficient basis that applied coatings will perform satisfactorily, testing must demonstrate performance at an accident profile enveloping (that is, as or more severe than) the plant design basis accident profile.
Spray chemistry	Solution A, B, or C as described in Test Method <a href="#">D3911</a> unless otherwise specified in the plant design basis	Solution C, deionized or distilled water, is often used when the plant does not specify the spray solution
Coupon location in chamber	Test coupons may be exposed to total immersion, liquid-vapor interface, or total vapor as determined by plant specific requirements	Testing under one exposure does not qualify a coating for use under either of the other two exposures.
Radiation tolerance	Total Integrated Dose must meet or exceed plant specific requirements. Dose Rate must be 1 by 10 <sup>6</sup> Rads/hr. or greater unless otherwise specified by the licensee (Test Method <a href="#">D4082</a> ).	Low dose rates and high dose rates can have different effects on the coatings.
Other Coating Properties (as identified by the plant)		
Density	Density testing of a given coating material in a given color is only applicable to that material in that color.	Different colors are based on different pigments, which impact dry film density.
Fire resistance	Test Method <a href="#">E84</a> testing thickness shall be considered the maximum thickness qualified by testing. Flame spread and smoke generation limits are established by the plant design basis.	Based on NRC Branch Technical Position APCS 9.5-1 and Guide <a href="#">D5144</a>
Chemical resistance	Coating resistance to spill and splash (short term) and immersion (long term) exposures to chemical solutions. The chemicals and acceptance criteria are established by the plant.	Applicable to coatings applied in areas with anticipated exposure to chemical solutions during plant operation or accident conditions
Adhesion	200 psi (Test Method <a href="#">D4541</a> , using Elcometer adhesion tester)	Based on Guide <a href="#">D5144</a>
Direct impact strength	Falling weight test (Test Method <a href="#">G14</a> ) determines the energy required to rupture the coating	Provides indication of the coating's resistance to mechanical damage
Abrasion resistance	175 mg/1000 cycles (Test Method <a href="#">D4060</a> )	Based on Guide <a href="#">D5144</a>
Thermal conductivity	Limits established by the plant design or the plant design basis accident analysis	Thermal conductivity affects the containment temperature and pressure profile during accident conditions



TABLE 8 Continued

Variable	Assessment Criteria	Significance of Variable/Basis of Assessment Criteria
Specific Heat	Used to evaluate the thermal energy storage capability of the coating material used on systems structures, and components associated with the containment shell and on the containment itself.	Establishes the amount of thermal energy absorbed by the coating material to raise its temperature.
Thermal emissivity	Used to evaluate heat transmission by radiant exchange.	For some new-build reactor plant designs, heat loss from the containment shell by thermal radiation can affect the containment temperature and pressure history during accident conditions by increasing cooling of the containment environment.
Coating Performance		
Blistering	Minimum acceptance criteria: Limited to intact blisters that are completely surrounded by sound coating bonded to the surface (Test Method D3911) No greater than #4 Few (ANSI N101.2) More stringent criteria may be established by the licensee	Reg. Guide 1.54 Rev. 2. The licensee is responsible for establishing acceptance criteria for Coating Service Level I coatings
Cracking	Minimum acceptance criteria: Cracking is not considered a failure unless it is accompanied by delamination or loss of adhesion More stringent criteria may be established by the licensee	Reg. Guide 1.54 Rev. 2. The licensee is responsible for establishing acceptance criteria for Coating Service Level I coatings
Peeling and Delamination	Minimum acceptance criteria: Not permitted	Reg. Guide 1.54 Rev. 2. The licensee is responsible for establishing acceptance criteria for Coating Service Level I coatings

select the reports that satisfy the plant's qualification requirements. In many cases, the test results for other coating properties may be provided in separate reports that may or may not be related to the DBA test report.

5.2.9 Upon completion of Step 6, determine if the test results are applicable to the plant and that the coating is qualified and approved for use in the plant.

## **6. Reporting**

6.1 A report documenting the comparison and evaluation of the existing test data for applicability to the respective nuclear plant's qualification requirements should include the following:

6.1.1 A listing of each variable considered.

6.1.2 A description of the differences between the existing test data and the respective nuclear plant's qualification requirements for each variable considered.

6.1.3 An evaluation of each difference to determine if the existing test data is applicable, additional testing is required, or restrictions are to be imposed on the use of a new coating in lieu of additional testing.

6.2 The report documenting the comparison and evaluation of the test data should be reviewed and assigned the appropriate Quality status and controls in accordance with the plant commitments and licensing requirements.

## **7. Keywords**

7.1 coating qualification; containment coating; DBA; DBA test data; design basis accident

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