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.

Designation: D5499 – 94 (Reapproved 2021)

Standard Test Methods for Heat Resistance of Polymer Linings for Flue Gas Desulfurization Systems[1]

This standard is issued under the fixed designation D5499; 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.

1. Scope

1.1 These test methods are intended to evaluate the resistance of polymer linings applied to carbon steel substrates to elevated temperatures. Two separate methods are included as follows:

1.1.1 Test Method A Continuous elevated temperature exposure, and

1.1.2 Test Method B Cycling elevated temperature exposure.

1.2 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.

1.3 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A36/A36M Specification for Carbon Structural Steel

D660 Test Method for Evaluating Degree of Checking of Exterior Paints

D661 Test Method for Evaluating Degree of Cracking of Exterior Paints

D714 Test Method for Evaluating Degree of Blistering of Paints

D772 Test Method for Evaluating Degree of Flaking (Scaling) of Exterior Paints

D1474 Test Methods for Indentation Hardness of Organic Coatings

D4417 Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel

D4541 Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers

2.2 *Steel Structures Painting Council Standards (SSPC):*[3]

SSPC VIS 1–89 Visual Standard

SSPC No. SP5 Blast Cleaning to White Metal

SSPC PA-2 Measurement of Dry Paint Thickness with Magnetic Gauges

3. Significance and Use

3.1 The results obtained by these test methods can be used in combination with other test methods for the selection of a lining in flue gas desulfurization (FGD) systems.

3.2 These methods are intended to evaluate effects of heat alone upon a lining system as applied to a carbon steel substrate. These methods do not produce the thermal gradient that may exist in actual applications. Actual lining performance may also be effected by concurrent physical mechanical or chemical effects.

3.3 These methods evaluate major failure modes of linings applied to square test panels.

3.4 The recommended test temperatures of 200°F (93°C) and 350°F (177°C) are based on typical maximum operating zone temperatures in flue gas desulfurizations systems. Other temperatures may be evaluated as desired.

4. Apparatus

4.1 *Forced-air Circulation Oven,* capable of maintaining the selected test temperature within 4°F (2°C).

4.2 *A Rack or Stand* to support the test panels vertically in the oven while maintaining a distance of at least 1 in. (25 mm) between the panels and between the panels and oven walls.

[1] These test methods are under the jurisdiction of ASTM Committee D33 on Protective Coating and Lining Work for Power Generation Facilities and is the direct responsibility of Subcommittee D33.09 on Protective Lining for Air Quality Control Systems.

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[2] 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* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Society for Protective Coatings (SSPC), 40 24th St., 6th Floor, Pittsburgh, PA 15222-4656, http://www.sspc.org.

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5. Test Specimens

5.1 *Substrate:*

5.1.1 Test panels shall be new commercial quality carbon steel conforming to Specification A36/A36M. Panels shall be a minimum of ¼ in. (6 mm) thick, and 8 in. (200 mm) square.

5.1.2 These test panels are large enough and rigid enough for linings and coatings up to 0.25-in. (6-mm) thick. For thicker linings, the test panels shall be at least 32 times the lining thickness in each direction.

5.1.3 One test panel shall be prepared for each test temperature, for each method (Test Method A or Test Method B), in addition to a control panel, which shall be maintained at laboratory conditions without elevated temperature exposure.

5.2 *Preparation:*

5.2.1 Prepare one side of each panel in accordance with SSPC No. SP5 to the degree of cleanliness represented in SSPC VIS 1–89. Clean, new, angular abrasive shall be used. The surface profile shall be as recommended by the lining manufacturer. Determine and record the average profile depth in accordance with Test Method D4417, Test Method A using a visual surface profile comparator or Test Method B, using a tape replica.

5.2.2 Apply the lining to the prepared surface of the test panels in a manner as closely simulating field application as possible and as prescribed by the manufacturer's latest technical bulletin. Record the manufacturer's batch numbers or manufacturing dates, mixing method, mixing time, and method of application.

5.2.3 The lining may be terminated at the edges of the panel or may be wrapped around the panel edges.

5.2.4 The lining thickness shall be within 10 % of the maximum lining thickness specified by the manufacturer.

5.3 *Specimen Measurements:*

5.3.1 Determine and record the thickness of the lining material using an appropriate dry-film thickness gage in accordance with SSPC PA-2.

5.4 *Conditioning of Test Panels:*

5.4.1 Condition test panels for a period of 7 days at 73 ± 4°F (23 ± 2°C). Additional conditioning of test panels, including longer cure times or elevated cure temperature, may be conducted if specified. Actual conditioning time and temperature shall be recorded and stated in the test report.

6. Procedure

6.1 Preheat the oven to the required test temperature of 200°F (93°C) or 350°F (177°C) unless otherwise specified.

6.2 Place the elevated temperature exposure panels in the oven in a vertical position such that there is a minimum 1-in. (25-mm) space between the panels and between the panels and the oven walls.

6.3 *Test Method A:*

6.3.1 Remove the panels at the end of each exposure period. Place the panels in a vertical position with a minimum of 1-in. space between panels and allow them to condition at laboratory temperatures of 73 ± 4°F (23 ± 2°C) for a minimum of 4 h.

6.3.2 Evaluate the panels after each oven exposure as follows:

Exposure Number	Oven Time, days	Total Oven Time, days
1	7	7
2	7	14
3	14	28
4	28	56

6.3.3 After each exposure, evaluate the panels in accordance with Section 7 and record the results.

6.3.4 Place the panels back in the oven for the next exposure until the test is complete.

6.3.5 After the test is complete, evaluate the panels in accordance with Section 7 and record the results.

6.4 *Test Method B:*

6.4.1 Place the panels in the oven and evaluate as in 6.3 for Test Method A with the following difference:

6.4.1.1 Remove the panels from the oven once daily such that the exposure time in the oven for each daily cycle is 16 ± ½ h.

6.4.1.2 Condition the panels for 4 h in a vertical position with a minimum of 1 in. (2.5 cm) at a temperature of 73 ± 4°F (23 ± 2°C).

6.4.1.3 Optionally, the panels may be left in the oven during the weekend.

6.4.1.4 Evaluate the panel in accordance with Section 7 and record results.

6.4.1.5 Terminate the test after 28 daily cycles.

7. Panel Evaluation

7.1 Visually inspect the lining surface of all panels before the test exposure for the presence of voids and cracks, and for blisters or loss of adhesion as described in 7.3.1.

7.2 The lining evaluation shall consider only the center 6-in. (152-mm) diameter of the panel. This area will have been exposed to the maximum stresses expected due to temperature changes as well as any changes in the lining due to the thermal exposure. Note only any effects related to and limited to the edges of the panel.

7.3 Examine the panel for the following effects:

7.3.1 Evaluate and record blistering in accordance with Test Method D714.

7.3.2 Some linings may not give clear visual indication of blisters. Blisters may be detected by lightly tapping the surface of the lining with a fingernail or small metal object. Where a blister or loss of adhesion has occurred, the sound will change from a solid tap to a more hollow sound. Mark with an indelible marker the apparent edges of a blistered or delaminated area or any other heat caused defect such as pinholing or cratering.

7.3.3 Examine the lining for cracking, checking, flaking, and softening, and record the results. Refer to Test Methods D661 for cracking, D660 for checking, D772 for flaking, and D1474 for hardness.

7.4 For the final evaluation, test the lining for adhesion pull-off strength in accordance with Method D4541 and record the results including the exact mode(s) and location of failure and approximate percentage of area for each (that is, 50 % adhesion to steel and 50 % cohesion in lining basecoat).

Forcibly remove the lining from an area of the panel approximately 1 by 2 in. (25 by 50 mm) using a knife or hammer and chisel to qualitatively evaluate adhesion and condition of the substrate. This procedure will also determine whether blistering or loss of adhesion occurred between coats or at the surface of the substrate.

8. Report

8.1 Report the following information:

8.1.1 Lining manufacturer's name, product designation, batch numbers, and generic type.

8.1.2 Description of panel preparation including the resulting depth of profile and degree of cleanliness.

8.1.3 A description of equipment and procedures used in application of the lining.

8.1.4 Results of visual inspections and thickness measurements.

8.1.5 Curing/Conditioning procedure.

8.1.6 Test temperature and time and whether Test Method A or Test Method B was used.

8.1.7 The results of each interim inspection as outlined in Section 7, noting any changes in appearance including cracking, crazing, softening, blistering, or loss of adhesion.

8.1.8 The final evaluation should include an appraisal of the cohesion/adhesion of the lining in accordance with 7.4.

9. Precision and Bias

9.1 These test methods are specific as possible in establishing reproducible methods and procedures. Final test results and reports however, depend upon visual observations and subjective evaluation.

10. Keywords

10.1 adhesion; blistering; cracking; flue gas desulfurization; heat resistance; polymer linings; thermal effects

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