Designation: G210 – 13

Standard Practice for Operating the Severe Wastewater Analysis Testing Apparatus[1]

This standard is issued under the fixed designation G210; 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 This practice covers the basic apparatus, procedures, and conditions required to create and maintain the severe wastewater analysis testing apparatus used for testing a protective coating or lining.

1.2 This apparatus may simulate the pertinent attributes of a typical domestic severe wastewater headspace (sewer) environment. The testing chamber comprises two phases: (*1*) a liquid phase containing a prescribed acid and saline solution, and (*2*) a vapor phase consisting of air, humidity, and concentrated sewer gas (Note 1). The temperature of the test chamber is elevated to create accelerated conditions and reaction rates.

NOTE 1—For the purposes of this practice, sewer gas is composed of hydrogen sulfide, carbon dioxide, and methane gas.

1.3 **Caution—**This practice can be extremely hazardous. All necessary precautions need to be taken when working with sewer gas, sulfuric acid, and a glass tank. It is highly recommended that a professional testing laboratory experienced in testing with hydrogen sulfide, carbon dioxide, and methane gases perform this practice.

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. Some specific hazards statements are given in Section 8 on Hazards.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A36 Specification for Carbon Structural Steel
C307 Test Method for Tensile Strength of Chemical-Resistant Mortar, Grouts, and Monolithic Surfacings
C387 Specification for Packaged, Dry, Combined Materials for Mortar and Concrete
C580 Test Method for Flexural Strength and Modulus of Elasticity of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes
D610 Practice for Evaluating Degree of Rusting on Painted Steel Surfaces
D638 Test Method for Tensile Properties of Plastics
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
D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
D2370 Test Method for Tensile Properties of Organic Coatings
D4541 Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
D6677 Test Method for Evaluating Adhesion by Knife
D7091 Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals
G193 Terminology and Acronyms Relating to Corrosion

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[1] This practice is under the jurisdiction of ASTM Committee G01 on Corrosion of Metals and is the direct responsibility of Subcommittee G01.05 on Laboratory Corrosion Tests.

Current edition approved Oct. 1, 2013. Published October 2013. DOI: 10.1520/G0210-13.

[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.

2.2 *ISO Standards:*[3]

ISO 16773 Paints- and Varnishes- Electrochemical Impedance Spectroscopy (EIS) on High Impedance Coated Samples. Part 1: Terms and Definitions

ISO 16773 Paints- and Varnishes- Electrochemical Impedance Spectroscopy (EIS) on High Impedance Coated Samples. Part 2: Collection of Data

ISO 16773 Paints- and Varnishes- Electrochemical Impedance Spectroscopy (EIS) on High Impedance Coated Samples. Part 3: Processing and Analysis of Data from Dummy Cells

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *domestic wastewater, n*—wastewater discharged from residences and from commercial, institutional, and similar facilities.

3.1.2 *sewer headspace, n*—the air space between the water surface and the top of the pipe (crown) or other enclosed structure.

3.2 For definitions of terms used in this practice, see Terminology G193.

4. Summary of Practice

4.1 The corrosion protection of steel, ductile iron, and concrete by a protective coating or lining may be altered by exposure to sewer gases and by the composition of the corrosive reagents found in headspace environments of domestic wastewater conveyance and treatment structures.[4]

4.2 This practice provides a controlled corrosive environment, which has been utilized to produce a simulated severe sewer headspace condition by wetting the coated samples in a cyclic fashion with a corrosive solution and then exposing the samples to air containing sewer gas. This condition is responsible for reducing the barrier properties of protective coatings and linings.

4.3 Test specimens are positioned on a carousel and placed inside an airtight testing apparatus (chamber) maintained at a temperature of 150 ± 5°F (65 ± 3°C). The chamber contains a prescribed aqueous solution (liquid phase) at the bottom and a headspace (vapor phase) containing sewer gas. The test specimens are immersed into liquid phase for a period of 15 min each. After immersion, the specimens are exposed to the vapor phase the balance of the time. This constitutes one complete cycle with three cycles occurring per day. This cyclic exposure continues for a period of 28 days.

4.4 The specified operating temperature, aqueous solution, sewer gases, and duration parameters are considered the standard for the purposes of this practice. The specifications may be adjusted to replicate specific environments if mutually agreed upon between the client and testing facility. Any deviations from this practice shall be reported.

5. Significance and Use

5.1 Domestic wastewater headspace environments are corrosive due to the presence of sewer gases and sulfuric acid generated during the biogenic sulfide corrosion process.[5] This operating procedure provides an accelerated exposure to sewer gases and concentration of sulfuric acid commonly produced by bacteria within these sewer environments.[6]

5.2 The results obtained by the use of this practice can be a means for estimating the protective barrier qualities of a protective coating or lining for use in severe sewer conditions.

5.3 Some protective coatings or linings may not withstand the exposure temperature specified in this practice but have demonstrated satisfactory performance in actual sewer exposures, which are at lower temperatures.

6. Apparatus

6.1 The testing apparatus consists of the following:

6.1.1 *Glass Tank*—Minimum diameter 16 by 12 in. (40 by 30 cm) tall. The glass tank, when fitted with a polypropylene lid (tank cover) and elastomeric seal, creates an air-tight test chamber. The glass tank is inert to the aggressive reagents at the testing temperature. The glass tank shall be transparent to permit visual examination of the test specimens throughout specified testing duration.

6.1.2 *Polypropylene Lid*—Octagon or round shaped, minimum 1 in. (2.54 cm) thick by 18 in. (46 cm) span. The polypropylene lid has a 1.5 in. (3.81 cm) diameter center port to accommodate the shaft of the sample carousel. The shaft slides through an O-ring seal which is secured and tensioned with a polypropylene fitting (Note 2). The shaft slides easily up and down through the O-ring seal while preventing the release of test gases. Silicone grease lubricant can be used to facilitate movement of the shaft.

NOTE 2—Polypropylene has been found to be an acceptable material for this service. Other materials, such as polytetrafluoroethylene (PTFE) or polyetheretherketone (PEEK) may also provide acceptable service.

6.1.2.1 The polypropylene lid is designed with two ports for fittings, which accommodate inlet and outlet lines.

6.1.2.2 The side of the polypropylene lid which faces into the tank has a circular, shallow 1-in. (2.54-cm) wide groove. The groove accommodates a suitable corrosion resistant elastomeric seal (gasket) required to seal the lid of the glass tank.

6.1.2.3 The polypropylene lid also includes eight equally-spaced holes along the outer edge to accommodate eight threaded rod fasteners with wing nuts, nuts, and washers. The eight threaded rods connect the polypropylene lid to a solid, chemical resistant base plate made of laminated wood or

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[3] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, http://www.iso.org.

[4] O'Dea, V. et al., "Testing Permeation Resistance in Coatings for Wastewater Structures," *Journal of Protective Coatings and Linings*, September 2010, pp. 16–28.

[5] O'Dea, V., "Understanding Biogenic Sulfide Corrosion," *Materials Performance*, November 2007, pp. 36–39.

[6] O'Dea, V. et al, "Assessing Coatings & Linings for Wastewater: Accelerated Test Evaluates Resistance to Severe Exposures," *Journal of Protective Coatings and Linings*, April 2008, pp. 44–57.

equivalent materials, located under the glass tank, hence clamping the lid to the glass tank, thereby creating an air-tight testing chamber.

6.1.3 *Specimen Carousel*—Constructed of polypropylene (or other suitable corrosion-resistant material) to accommodate the various types of samples. Coated steel specimens will sit in slots and rest vertically, arranged radially (Fig. 1). Coated concrete specimens will sit in slots oriented vertically. Cast shapes and free films will be oriented either vertically or horizontally, depending upon their dimensions.

6.1.3.1 The specimen carousel consists of a tray with a perpendicular central shaft, which facilitates raising and lowering of the carousel within the chamber to the liquid phase (lowered position) or vapor phase (raised position).

6.1.3.2 When the carousel is in the liquid phase (lowered position) the specimen carousel, including the test specimens, must be completely immersed in the aqueous solution.

6.1.3.3 When the carousel is in the raised position, it is locked in place with a retaining pin assembly outside the top of the oven. The aqueous solution must drain away from the test specimens through drain holes in the carousel.

6.1.4 *Gas Inlet*—A flexible and resilient polypropylene or polyethylene gas supply line connects the sewer gas supply to a polypropylene inlet fitting on the tank cover. The inlet fitting assembly accommodates a polypropylene extension tube, which runs to the bottom of the chamber. The vertical extension tube allows the sewer gas mixture to be sparged through the aqueous solution.

6.1.4.1 Gas supply line includes a gas flow controller and indicator (for example, rotameter) to measure instantaneous flow rate.

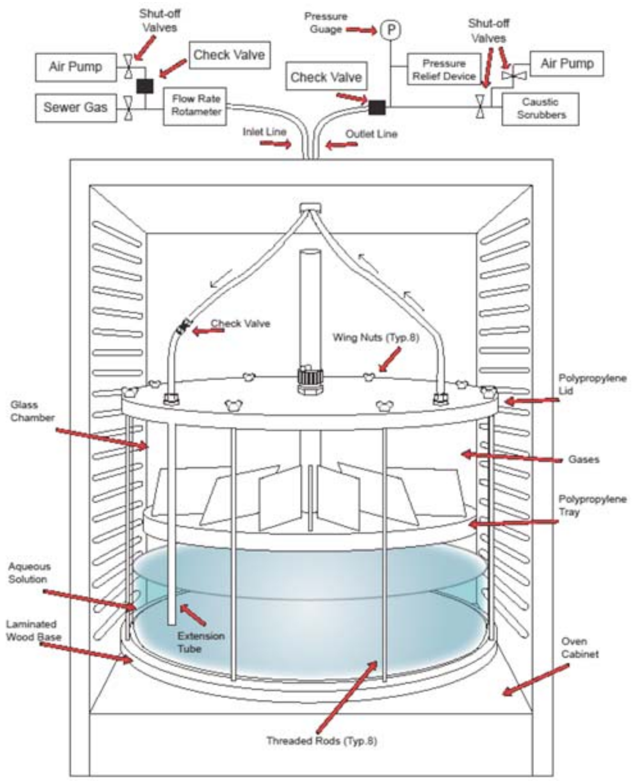

FIG. 1 Severe Wastewater Analysis Testing Apparatus

6.1.4.2 Gas supply line includes a polypropylene stopcock valve with low-friction plug of PTFE and a polypropylene gas check valve with a suitable fluoroelastomer (FKM)-coated diaphragm.

6.1.5 *Air Purge Inlet*—An external flexible and resilient polypropylene or polyethylene fresh air supply line connects the air pump to the tank through a tee into the Gas Inlet line.

6.1.5.1 Air supply line includes a polypropylene stopcock valve with low-friction plug of PTFE and a polypropylene gas check valve with FKM-coated diaphragm.

6.1.6 *Gas Outlet*—An external flexible and resilient polypropylene or polyethylene line from the tank cover with a polypropylene connector is connected to caustic scrubbers to capture H_2S from the effluent gases.

6.1.6.1 Outlet line includes a check valve, a polypropylene stopcock valve with low-friction plug of PTFE, a pressure relief valve (0.5 psi or 3.4 kPa), and a pressure gauge (0 to 1.5 psig range or 0 to 10 kPa) teed into the gas outlet line using PTFE coated isolation diaphragm. An air pump is teed into the line to the caustic scrubbers to facilitate sewer gas removal from the scrubber lines.

6.1.6.2 *Secondary Containment*—A polypropylene tray of suitable volume may be placed under the test chamber as an additional precaution against acid spillage.

6.1.7 *Oven*—Convection (forced air) oven of sufficient capacity to accommodate the test chamber and be capable of maintaining a temperature of 150 ± 5°F (65 ± 3°C) throughout the duration of the test exposure. This ensures a uniform temperature throughout the chamber for the testing duration. The top of the oven must have a 3-in. (75-mm) through-wall opening to accommodate the inlet and outlet gas lines and the shaft of the specimen carousel and its movement.

6.1.8 *Air Pump*—Variable-flow air pump to purge the test chamber and outlet lines of the hydrogen sulfide gas (and other sewer gases) at the completion of the exposure time. Pump delivery pressure and pressure relief valve should be sized to avoid accidentally over-pressurizing the glass tank.

6.1.8.1 An air flow rate of at least 1.5 litres per minute (L/min) is recommended.

6.1.9 *Caustic Scrubbers*—Capable of removing H_2S from the exhaust test gas. A typical scrubber consists of a 4-L polypropylene carboy, half filled with 15 % sodium hydroxide (NaOH). Bubble dispersion media is added to the carboy.

6.1.9.1 "Percent" is defined as grams of solute per volume of solution. 15 % NaOH contains 150 g of sodium hydroxide per litre of solution, which is the same as 3.75 mol of sodium hydroxide per litre of solution.

6.1.9.2 Carboy cap is equipped with polypropylene fittings which accommodate a 0.25 in. (6.35 mm) polyethylene inlet dip tube and outlet tube (exhaust).

6.1.9.3 The use of two or more scrubbers in series improves removal efficacy and reduces the likelihood of accidental release of H_2S when scrubber capacity is exceeded.

NOTE 3—Carbon dioxide is also absorbed by the scrubber, reducing their capacity accordingly.

6.1.10 *Fume Hood*—Ventilation apparatus of sufficient capacity to encase the oven and provide necessary negative air flow to evacuate the surrounding air of any fugitive gas emissions.

6.1.11 *Gas Sensors*—Hydrogen sulfide sensors and other pertinent safety monitors to ensure operator safety.

7. Reagents and Materials

7.1 *Aqueous Solution:*

7.1.1 10 % sulfuric acid (H_2SO_4)—Twelve litres or the volume required for the samples to be completely immersed when the specimen carousel is in the liquid phase (lowered position).

7.1.1.1 "Percent" is defined as the volume of concentrated sulfuric acid (at 95 %) per volume of solution. Ten percent H_2SO_4 contains 100 ml of concentrated sulfuric acid per litre of acid solution, which is the same as 1.8 mol of sulfuric acid per litre of acid solution. The solution is equivalent to 17 % by mass, and can be prepared on a mass basis by adding 170 g of concentrated sulfuric acid (96 %) to 830 g of water, producing a final solution mass of 1000 g.

7.1.2 0.4 % (4000 ppm_w) sodium chloride (NaCl)—Solute by mass per litre of acid solution.

7.1.2.1 "Percent" is defined as mass of solute per volume of acid solution. 0.4 % contains 4.000 g of sodium chloride per litre of 10 % acid solution, which is the same as 0.06897 mol of sodium chloride per litre of acid solution.

7.2 *Sewer Gas:*

7.2.1 500 ± 50 ppm_v analyzed hydrogen sulfide (H_2S) gas.

7.2.2 10 000 ± 200 ppm_v analyzed carbon dioxide (CO_2) gas.

7.2.3 5 000 ± 100 ppm_v analyzed methane (CH_4) gas.

7.2.4 Balance dry air (for example, 78 % nitrogen, 21 % oxygen, 0.93 % argon, 0.039 % carbon dioxide).

7.2.5 Gases are based on volume percent and shall be commercially purchased as a gas mixture with accompanying assay.

8. Hazards

8.1 This practice can be extremely hazardous. The glass chamber must not be over-tightened or over-pressurized. Extreme caution needs to be taken when working with hydrogen sulfide gas, sulfuric acid, and any other gases incorporated into the wastewater testing chamber. It is highly recommended that this procedure only be performed by a professional testing laboratory with experience and provisions for safe handling of these dangerous gases and reagents.

9. Test Specimens

9.1 Test specimens shall be the type, quantity, and dimensions as agreed upon by all parties. Appendix X1 discusses various testing specimens that can be utilized in this practice.

10. Operating Procedure

10.1 *Preparation of the Wastewater Testing Chamber:*

10.1.1 Add the aqueous solution to the glass tank. It is convenient to have the tank on a table in front of the oven, where the table is set at the same height as the bottom of the oven.

10.1.2 Insert the test specimens into the respective slots of the specimen carousel.

10.1.3 Place the specimen carousel into the glass tank in the aqueous phase (lowered position). Quickly complete the remaining assembly of the chamber to minimize sample exposure time to the aqueous solution.

10.1.4 Fit the lid onto the glass tank by carefully sliding it over the central shaft of the carousel through the O-ring seal.

10.1.5 As an alternative to 10.1.3 and 10.1.4, if the oven is sufficiently tall, the top can be assembled onto the carousel at the "raised position" and the top/carousel assembly placed on top of the tank without exposing the test specimens to the acid solution.

10.1.6 Seal the lid onto the glass tank with the eight threaded rods that run between the base plate and polypropylene lid. Wing nuts and washers are used to evenly tension the seal in the lid to create a gas-tight chamber. **Caution—**Tighten the wing nuts in such a way that pressure is applied evenly between the lid and the glass tank in order to avoid cracking the glass. Avoid excessive force.

10.1.7 Tighten the central O-ring seal on the lid.

10.1.8 Slide the assembled wastewater chamber into the convection oven. Raise the carousel into the vapor phase of the test chamber, through the 3-in. (75-mm) opening in the top of the oven, and lock into place.

10.1.9 Connect the inlet and outlet lines.

10.1.10 Check the gas-tight seal of the test chamber by pumping air into the chamber, closing the valves, and monitoring the chamber pressure. **Caution—**Do NOT overpressurize the chamber.

10.1.11 Turn on the oven and allow the wastewater chamber to achieve a testing temperature of 150 ± 5°F (65 ± 3°C). (This normally takes 1 to 1.5 h.)

10.1.12 Repeat a check on the gas-tight seal of the test chamber as per 10.1.10.

10.2 *Testing Procedure:*

10.2.1 Lower the test specimens into the aqueous solution for 15 min.

10.2.2 Raise the carousel to the vapor phase (raised position). Open the inlet and outlet stopcock valves and initiate flow of the test gas directing the exhaust gases through the caustic scrubbers. Continue to purge the test chamber with the test gas delivered at a rate of 1.5 ± 0.25 litres per minute (Lpm) for a minimum of 4 h to achieve saturation. Then terminate the gas flow and close the inlet and outlet stopcock valves.

10.2.3 After the sewer gas purge, the scrubbers shall be purged with air to minimize the risk of caustic flow back.

10.2.4 The test panels are immersed two more times for 15 min at evenly spaced time intervals over the remaining duration of the day after the gas sparge is complete.

10.2.5 This completes day one.

10.3 *Testing Procedure for Subsequent Weekdays:*

10.3.1 At the first of each subsequent weekday, lower the test specimens into the liquid phase (lowered position) for a period of 15 min.

10.3.2 Raise the carousel to the vapor phase (raised position). Open the inflow and outflow stopcock valves and sparge the test chamber with the wastewater gas delivered at a rate of 1.5 ± 0.25 Lpm for 50 min to re-saturate solution. Then terminate gas flow and close the inlet and outlet stopcock valves.

10.3.3 After the sewer gas purge, the scrubbers shall be purged with air to minimize the risk of caustic flow back.

10.3.4 Immerse the test panels two more times for a period of 15 min each at 3 h intervals (±1 h) for each working day and return to the vapor phase (raised position).

10.3.5 Repeat the cycle testing for each working weekday for the 28 day testing duration.

10.4 *Testing Procedure for Weekends:*

10.4.1 During the weekend the test specimens are left in the vapor phase (raised position) of the test chamber and are not to be immersed during this time. The oven remains on at the prescribed temperature. No gas sparge is conducted.

10.5 *Completion of the 28 Day (Note 4) Test:*

NOTE 4—Periodic visual inspection and EIS testing may be performed to obtain additional data (that is, 10 day and 20 day intervals). Total exposure time is to be extended accordingly to equal 28 days of chamber exposure.

10.5.1 At the completion of the testing duration, a total of 60 immersions and 20 gas purges are completed.

10.5.2 Turn off the oven, leaving the convection fan on if possible. Open the air inflow stopcock valve and initiate fresh air flow using the air purge pump (flow rate approximately 1 to 1.5 Lpm) to flush the test gas from the chamber. After 30 min, open the oven door to hasten cool down. Continue the fresh air purge until the chamber is cool and the hydrogen sulfide has been reduced below five ppm. (This may take up to 2 to 4 h.)

10.5.3 Check the effluent air with appropriate gas detectors to ensure the levels are within pertinent safety limits.

10.5.4 Release the carousel shaft and gently drop the carousel into the aqueous phase. Release the gas flow lines, and remove the test chamber from the oven. Continue with disassembly of the test chamber.

10.5.5 Remove the test specimens and rinse with tap water.

10.5.6 Proceed with testing. Suggested testing procedures are detailed in Appendix X1.

11. Report

11.1 The following information shall be documented and reported:

11.1.1 Sewer gas mixture and concentrations.
11.1.2 Aqueous solution and concentrations.
11.1.3 Operating temperature.
11.1.4 Number of total days exposure.
11.1.5 Number of weekend days.
11.1.6 Any periodic or interval testing.
11.1.7 Number of total chamber gas purges.
11.1.8 Number of total immersion cycles.
11.1.9 Any deviations from this practice.

12. Keywords

12.1 accelerated testing; biogenic sulfide corrosion; hydrogen sulfide gas; protective coatings; protective linings; severe wastewater analysis tests; sewer corrosion; sewer gases; sewer testing; test chambers; wastewater; wastewater gases

APPENDIXES

(Nonmandatory Information)

X1. TESTING SPECIMENS

X1.1 General

X1.1.1 A variety of testing specimens may be used in this practice. Specimens constructed of coated steel, coated ductile iron, coated concrete, cast coating materials, or coating free films are commonly used to assess the polymer's performance and barrier qualities.

X1.1.2 It is important that the test specimens be smooth, completely-continuous films or castings of uniform thickness throughout the test area. The coating thickness shall not vary by more than 10 % of the total thickness recommended by the manufacturer.

X1.1.3 All coating materials to be tested or compared shall be applied to the same type and grade of substrate for a given test series.

X1.1.4 The size and shape of the test specimens may vary to conform to the dimensions of the chamber. The total weight shall not exceed the capabilities of the carousel. Examples of useful specimen types and dimensions are described below.

X1.2 Steel Specimens

X1.2.1 For each coating to be tested, abrasive blast clean four Specification A36 hot-rolled flat steel panels, minimum size 3 by 4 by ⅛ in. (7.5 by 10 by 0.32 cm) to the surface cleanliness and anchor profile recommended by the coating manufacturer.

X1.2.2 Apply the candidate coating or lining system at the recommended thickness to the front and back of the panels. Dip the edges (sides, top, bottom) using the candidate coating system (or other compatible material) to protect the edges from corrosion break-through.

X1.2.3 Test specimens shall provide a minimum of 24 in.^{2} (61 cm^2) front and back of coated surface area.

X1.2.4 Steel test specimens are convenient when changes in barrier properties of coatings are to be determined using the EIS technique (ISO 16773).[7]

X1.3 Concrete Specimens

X1.3.1 For each coating to be tested, cast four concrete cylinders using minimum 5000 psi (34 MPa) compressive strength Portland Type 1 design mix conforming to Specification C387. The cylinders are to be a minimum size of 1½ by 4 in. (4 cm diameter by 10 cm tall). Abrasive blast clean the concrete cylinders as recommended by the coating manufacturer.

X1.3.2 Apply recommended resurfacing material to fill bugholes and surface irregularities of the concrete specimens as recommended by the coating manufacturer.

X1.3.3 Apply the candidate coating or lining system at the recommended thickness to all surfaces, taking care to ensure good coverage of edges.

X1.4 Mechanical Testing Specimens

X1.4.1 *Tensile Testing*—For each coating to be tested, cast two sets of the minimum number of samples specified by the ASTM standard using the candidate coating or lining in accordance with Test Methods C307, D638, or D2370.

X1.4.2 *Flexural Testing*—Cast two sets of the minimum number of samples specified by the ASTM standard using the candidate coating or lining in accordance with Test Method C580 or Test Method D790.

X2. METHOD FOR EVALUATING TEST SPECIMEN PERFORMANCE

X2.1 General

X2.1.1 Various testing procedures are available for assessing the performance of coated samples and free film samples under test cabinet conditions. The method selected may vary depending upon the nature of the coating and the substrate to which it is applied. Meaningful performance data is best obtained from a comparison of test results observed on reference panels to results observed on test panels.

X2.1.2 The following test methods have been used for evaluation of the performance of the coatings exposed to test cabinet conditions. Report the results as designated by the standard test methods.

X2.2 Steel or Ductile Iron Panels

X2.2.1 Label and take a picture of each test panel (including the front and back).

X2.2.2 Describe the color, appearance, (that is, rough, smooth, irregular) and any abnormalities.

X2.2.3 Measure the dry-film-thickness of the coating in accordance with Practice D7091.

X2.2.4 Evaluate blistering using Test Method D714.

X2.2.5 Evaluate rusting using Practice D610.

X2.2.6 Evaluate checking using Test Method D660.

X2.2.7 Evaluate cracking using Test Method D661.

X2.2.8 Measure coating impedance with Electrochemical Impedance Spectroscopy (EIS) Analysis using the methods of ISO 16773 Parts 1 to 3.[7]

X2.2.9 Measure tensile adhesion using Test Method D4541.

X2.2.10 Measure knife adhesion using Test Method D6677 or other standard methods. Other non-standard knife adhesion methods are also acceptable if the procedure is fully documented in the report.

X2.3 Concrete Specimens

X2.3.1 Label and take a picture of each test panel (including the front and back).

X2.3.2 Describe the color, appearance (that is, rough, smooth, irregular) and any abnormalities.

X2.3.3 Evaluate blistering using Test Method D714.

X2.3.4 Evaluate checking using Test Method D660.

X2.3.5 Evaluate cracking using Test Method D661.

X2.3.6 Measure tensile adhesion using Test Method D4541.

X2.3.7 Measure knife adhesion using Test Method D6677 or other standard methods. Other non-standard knife adhesion methods are also acceptable if the procedure is fully documented in the report.

X2.3.8 Evaluate test cabinet fluid penetration of the coating using the following method:

X2.3.8.1 Cut cross sections of the coating film at five randomly selected points in the samples using a very sharp utility knife. Alternatively, the cross sections of hard or brittle coatings can be created by chilling the coating (if necessary) and fracturing the coating by bending.

X2.3.8.2 Place the cross sections under a digitally enhanced microscope with a calibrated reticule.

X2.3.8.3 Measure the total film thickness and the distance of penetration (permeation) of discoloration from the coating surface using the calibrated reticule.

X2.3.8.4 Report the average film thickness, average permeation distance, percent permeation, and rate of permeation based on duration of the test.

X2.3.8.5 Photograph the cross sections and include a representative picture in the report.

X2.4 Mechanical Specimens

X2.4.1 Label and take a picture of each test panel (including the front and back).

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[7] Gray, Linda G. S., and Appleman, B. R., "EIS: Electrochemical Impedance Spectroscopy: *A Tool to Predict Remaining Coating Life?*," *Journal of Protective Coatings and Linings*, February 2003, pp. 66–74.

X2.4.2 Describe the color, appearance, (that is, rough, smooth, irregular) and any abnormalities.

X2.4.3 Evaluate checking using Test Method D660.

X2.4.4 Evaluate cracking using Test Method D661.

X2.4.5 Evaluate tensile strength, elongation, and compressive strength using the applicable mechanical Test Method C307, D638, D2370, or other suitable standard method.

X2.4.6 Evaluate fluid permeation of the coating using the method described in X2.3.8.

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