Corrosion Testing Laboratories, Inc.

March 18, 2020 CTL REF #36518

Gary Mock
OBIC Products, LLC
01116 County Road 17
Bryan, OH 43506 USA

Re: SWAT Corrosion Testing on One Coating System on Steel and Concrete

Dear Mr. Mock:

Presented herein are the results of the above referenced testing. This work was authorized in accordance with OBIC Products, LLC PO #0276. OBIC Products, LLC requested corrosion testing of two coatings in accordance with per ASTM G210-13, Standard Practice for Operating the Severe Wastewater Analysis Testing Apparatus. The coatings were applied to steel plates and on concrete cylinders.

TEST SPECIMENS

The OBIC Products, LLC Company submitted four coated steel plates and four coated concrete cylinders for each of the two coatings tested. Upon receipt, each specimen was given a CTL specimen number. One specimen of each coating configuration was designated as a control. **Table 1** (below) tabulates the specimen identification data.

Table 1.
Specimen Identification

CTL Specimen numbers	Description	Coating system part number
36518-1-1 through 36518-1-4	Orange coating on steel	**OBIC 1000**
36518-2-1 through 36518-2-4	Orange coating on concrete	
36518-3-1 through 36518-3-4	Grey coating on steel	**OBIC 1200**
36518-4-1 through 36518-4-4	Grey coating on concrete	

SUMMARY OF TEST METHOD

Three (3) steel and three (3) concrete coated test specimens of each coating were exposed to an aggressive environment that replicates conditions present in a wastewater treatment facility. The test chamber consists of a glass vessel fitted with a polymeric lid and movable carousel. The test specimens are mounted on the carousel that is periodically lowered into the test solution to wet the specimens. The test specimens remain in the vapor space for the majority of the exposure.

The test solution consists of 4% sodium chloride in a 10% sulfuric acid solution. The chamber is periodically purged with a simulated sewer gas composed of 500 ppm hydrogen sulfide, 10,000 ppm carbon dioxide, and 5,000 ppm methane in dry air. The apparatus is placed into a convection oven maintained at 65°C throughout the test. The steel and concrete specimens were exposed in separate test chambers.

The test specimens were photographed in the as-received condition. The coating thickness and the initial EIS (electrochemical impedance spectroscopy) data was obtained on the coated steel specimens only as these tests cannot be performed on the coated concrete specimens.

Initial EIS. Electrochemical impedance spectroscopy (EIS) is an electrochemical test that measures the AC impedance of the surface of a test specimen. In this application, the surface is a coating. The EIS spectrum is typically obtained over a broad range of frequencies from very high to very low. The impedance values of interest in this application are the low values where the AC impedance represents primarily the electrical resistance of the coating. High impedance values (> 6 Log Z_{mod}) indicate a coating that is providing protection of the substrate while low values (<6 Log Z_{mod}) indicate a coating that is compromised. When performed over time, the results can be used to predict the future performance of the coating. Decreasing values with time suggest a coating that may not be suitable for the intended environment. Low EIS values are typically observed before visual evidence of coating deterioration such as blistering, cracks, delamination, etc.

The EIS results are reported as Log Z_{mod} which is a modification made to the measured impedance values to account for exposed surface area. A Log Z_{mod} value of 6.1 represents an impedance value of 1×10^6 ohms/cm^2.

One hole was drilled through on one corner of each specimen to allow for an electrical connection to the steel substrate. A glass cylindrical test vessel was clamped to one face (front) of each test specimen. The cylinder was filled with 5% NaCl solution and the specimen conditioned for a minimum of 16 hours at laboratory ambient temperature. After conditioning, a saturated calomel reference electrode and a graphite counter electrode were inserted into the test vessel. The test vessel was placed in a faraday cage (to minimize the influence of any external electrical fields) and connected to a Gamry IFC 1010 potentiostat. The EIS data was obtained at 0.1, 0.01, and 0.001 Hz. After testing, the specimens were rinsed with de-ionized water and dried. The exposed hole was filled with silicone, and the specimens stored until the exposure portion of the test initiated.

Chamber Exposure. After the initial EIS data had been collected on each test specimen they were loaded on a carousel and placed into the vapor space of the exposure chamber. The chamber was partially filled with the test solution, sealed and placed into an oven and heated to 65°C. The carousel was lowered into the acid solution such that all of the test specimens were immersed for 15 minutes and then returned to the vapor space. The chamber was then purged with the test gas (compressed air with 500 ppm hydrogen sulfide 10,000 ppm carbon dioxide, and 5,000 ppm methane, all ± 2%) for four hours. After purging, the specimens were immersed two additional periods for 15 minutes each separated by approximately 3 hours.

This exposure sequence was carried out on each working day, Monday through Friday, except that the gas purge time was decreased to 60 minutes. On weekends and holidays the specimens were kept in the vapor space. A total of 20 daily cycles ((20 gas purges, 60 immersions) were completed over a 30 day exposure period.

Intermediate evaluations. On Day 10 and Day 20 the chamber was purged with clean air and allowed to cool to room temperature. The chamber was opened and one specimen of each coating type was removed. The test vessel was reassembled with the remaining specimens and the exposure reinitiated as described above.

Coated Steel Specimens
One test specimen was removed at each intermediate interval, cleaned and photographed. The EIS data was collected for each specimen similarly as described above. The glass cylinders were clamped on the same face as the initial data collection (unless severe blistering or cracking forced use of the opposite side), filled with 5% NaCl solution, and conditioned overnight prior to testing.

Coated Concrete Specimens
The coated concrete specimens were exposed in the same manner as the steel specimens except that no EIS data was collected from the (non-conductive) coated concrete specimens and no intermediate evaluations were made. Both sets of three replicates were exposed uninterrupted for the entire test period.

Final Evaluation
Coated Steel
At the end of the 30 day exposure (20 gas purges, 60 immersions), the last test specimen was removed from the test chamber, cleaned, photographed, and evaluated. The evaluation included visual, EIS data collection, and direct tensile adhesion testing (pull-off strength).

Coated Concrete Specimens
After exposure, the concrete specimens were cleaned, photographed and evaluated. The evaluation consisted of visual, parallel scribe adhesion, and cross-section to determine the depth of permeation.

RESULTS

Both the coated steel and coated concrete specimens appeared unaffected except for slight surface-only discoloration, Appendix A (steel) and B (concrete). Visually there was only slight discoloration, no delamination, no blistering or cracking was observed on any of the exposed specimens.

Coated Steel Specimens.
The coating impedance was measured using EIS remained high (> 9.0 log Z_{mod}) throughout the test. EIS results are summarized in **Table 2 (**results**), Figure 1 (OBIC 1000)** and **Figure 2** (**OBIC 1200**).

The dry film thickness (DFT) measurements are presented in **Table 3**, and the pull-off adhesion results are presented in Table 4.

Coated Concrete Specimens
The parallel knife adhesion test performed on the concrete specimens. The coating was somewhat difficult to remove and when it broke free concrete was adhered to the backside. The concrete specimens were then cross-section and the coating examined at up to 20X on a stereo microscope to determine of there was visual indications of permeation. No visually discernible evidence of permeation of the coating and no evidence of deterioration to the concrete substrate was observed.

Photo-documentation of the coated steel specimens is included in **Appendix A.**

Photo-documentation of the coated concrete specimens is included in **Appendix B.**

DISCUSSION

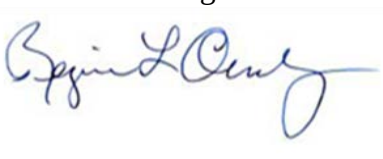
The SWAT test is an aggressive exposure. A coating that survives the 30 day exposure without visible deterioration with good EIS and adhesion results would be expected to perform well in the headspace of a wastewater environment. For comparison, a coal tar epoxy will typically fail due to blistering within the first 10 days of exposure in this test while high performance coating systems will survive the test without discernible degradation other than discoloration.

Both coating systems performed well. Visually there was no evidence of degradation: only slight discoloration, no delamination, no blistering or cracking was observed on any of the exposed specimens. Both coating systems retained high EIS values and good adhesion after the exposure. Cross-sections of the coated concrete specimens indicated no visually discernible permeation of the coating.

OBIC Products, LLC
March 18, 2020

If you have any questions or need further information, please call.

Very truly yours,
Corrosion Testing Laboratories, Inc.



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Policy Statement

This study was performed and this report was prepared based upon specific samples and/or information provided to Corrosion Testing Laboratories, Inc. (CTL) by OBIC Products, LLC. The information contained in this report represents only the materials tested or evaluated. Such work was performed in accordance with CTL's Quality Assurance Manual, Revision 13, issued 22 June 2009. The conclusions and opinions provided were developed within a reasonable degree of scientific certainty and are based upon materials and information provided to date. Should additional information become available (e.g., on further continued review of the material received or submission of additional samples for examination), we reserve the right to adjust our professional opinions.

CTL assumes no responsibility for variations in sample or data quality (composition, appearance, performance, etc.) or any other feature of similar subject matter produced (measured, manufactured, fabricated, etc.) by persons or under conditions over which we have no control. This report may not be altered, added to or subtracted from and, if this does occur, CTL does not accept responsibility for such alterations, additions, or deletions. This report shall not be reproduced, except in full, without the written approval of CTL. All material that was received by CTL will be discarded six (6) months after this report has been issued, unless other arrangements are agreed upon.

TABLE 2
Summary of EIS Test Results

Specimen #		EIS Log Z_{mod} Ω•cm^2			Posttest Comments
		0.1 Hz	0.01 Hz	0.001 Hz	
OBIC 1000					
36518-1-1 10 days	Pretest	11.41	12.18	12.24	Smooth, Shiny
	10 days	9.17	9.17	9.17	
36518-1-2 20 days	Pretest	11.26	11.47	11.68	Slight Discoloration, Smooth, Shiny
	20 days	9.90	10.18	10.23	
36518-1-3 30 days	Pretest	11.23	11.42	11.53	Slight Discoloration, Smooth, Shiny
	30 days	9.99	10.26	10.31	
OBIC 1200					
36518-3-2 10 days	Pretest	11.46	12.18	12.92	Slight Discoloration, Smooth, Shiny
	10 days	10.16	11.19	11.35	
36518-3-4 20 days	Pretest	11.36	12.42	12.78	Slight Discoloration, Smooth, Shiny
	20 days	10.14	10.55	10.76	
36518-3-3 30 days	Pretest	11.46	12.37	12.71	Slight Discoloration, Smooth, Shiny
	30 days	10.21	11.17	11.32	

Log Z_{mod}: $11.55=5.5*10^{11}$ Ω/cm^2.
Samples exposed to 5% NaCl for a minimum of 16 hours prior to EIS testing.

TABLE 3
Summary of DFT Test Results

Specimen ID	Measurement Locations		
	Top, Front And Back	Middle	Bottom, Front And Back
OBIC 1000			
36518-1-1 10 days	**85.2**	**83.8**	**79.5**
36518-1-2 20 days	**75.7**	**75.8**	**79.3**
36518-1-3 30 days	**76.2**	**78.9**	**75.0**
OBIC 1200			
36518-3-1 10 days	**69.2**	**66.1**	**68.0**
36518-3-2 20 days	**70.5**	**68.5**	**71.7**
36518-1-3 30 days	**64.6**	**69.5**	**73.9**

[1] Dry Film Thickness – Average of 5 measurements per side.

Table 4.
Adhesion Testing

CTL Specimen #	Coating System	Result	Average	Failure Locations (%)				
				Metal/ Coating	Within Coating	Coating/ Glue	Within Glue	Glue/ Dolly
OBIC 1000 30 DAY EXPOSURE								
36518-1-3-1	**OBIC 1000**	1455	**1610**	-	100	-	-	-
36518-1-3-2		1663		-	70	30	-	-
36518-1-3-3		1712		-	80	20	-	-
OBIC 1000 CONTROL								
36518-1-4-1	**OBIC 1000**	≥3000	**2656**	-	-	-	-	-
36518-1-4-2		3000		100	-	-	-	-
36518-1-4-3		1967		100	-	-	-	-
OBIC 1200 30 DAY EXPOSURE								
36518-3-3-1	**OBIC 1200**	1398	**1444**	99	1	-	-	-
36518-3-3-2		1549		100	-	-	-	-
36518-3-3-3		1384		100	-	-	-	-
OBIC 1200 CONTROL								
36518-3-4-1	**OBIC 1200**	1866	**1933**	99	1	-	-	-
36518-3-4-2		1995		100	-	-	-	-
36518-3-4-3		1938		100	-	-	-	-

Defelsko PosiTest AT-A Automatic Adhesion Tester, S/N AT07023, (a Type IV tester).Setup: 20 mm dollies, 100psi per second, psi. Adhesive: 3M DP-420 Off-White 2 part epoxy.

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OBIC 1000 - 30 Day Exposure to SWAT test (20 purges, 60 immersions)

CTL #	DFT (mils)		EIS Results (Log Z_{Mod} Ω-cm2)											
			Initial			10 days			20 days			30 days		
	Location	Range	.1 Hz	.01 Hz	.001 Hz	.1 Hz	.01 Hz	.001 Hz	.1 Hz	.01 Hz	.001 Hz	.1 Hz	.01 Hz	.001 Hz
36518-1-1	1-2-3 Table 2.	80-85	11.41	12.18	12.24	9.17	9.17	9.17						
36312-1-2		76-79	11.26	11.47	11.68				9.90	10.18	10.23			
36312-1-3		75-79	11.23	11.42	11.53							9.99	10.26	10.31

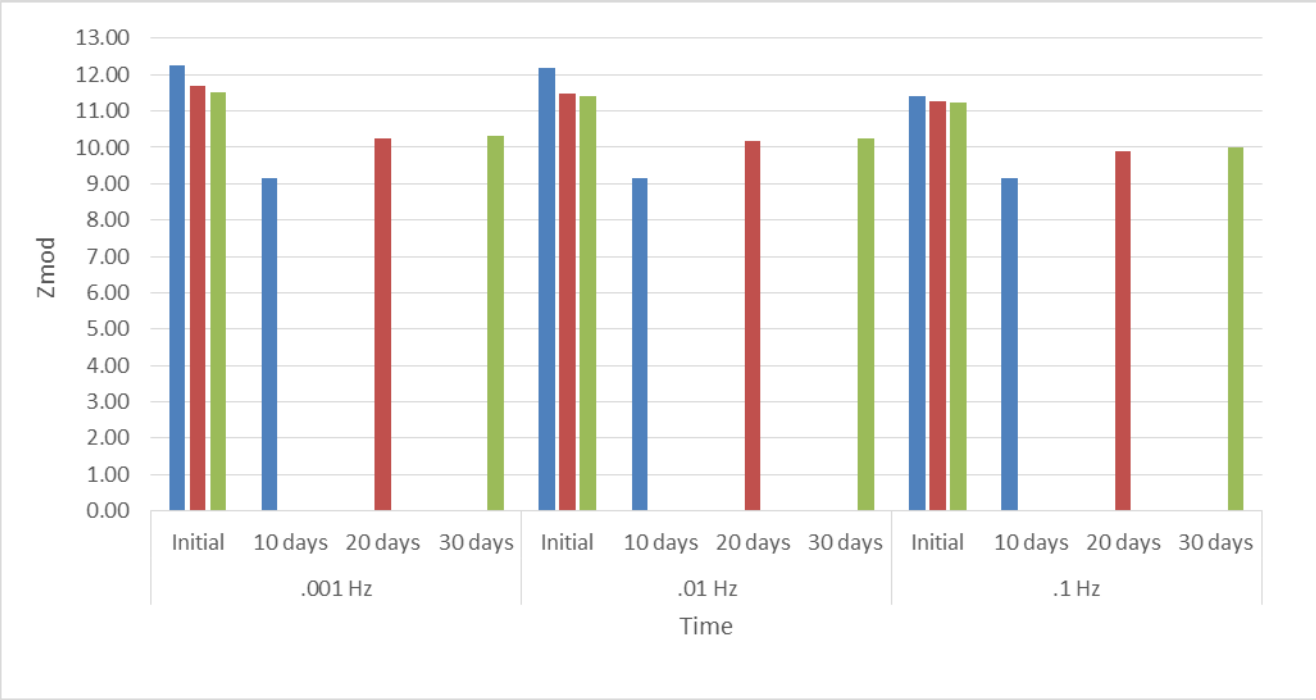

Figure 1. EIS results

OBIC 1000: 36518-1-3

After 30-days exposure

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OBIC 1200 - 30 Day Exposure to SWAT test (20 purges, 60 immersions)

CTL #	DFT (mils)		EIS Results (Log Z_{Mod} Ω-cm2)											
			Initial			10 days			20 days			30 days		
	Location	Range	.1 Hz	.01 Hz	.001 Hz	.1 Hz	.01 Hz	.001 Hz	.1 Hz	.01 Hz	.001 Hz	.1 Hz	.01 Hz	.001 Hz
36518-3-2	1-2-3	66-69	11.46	12.18	12.92	10.16	11.19	11.35						
36312-3-4		69-72	11.36	12.42	12.78				10.14	10.55	10.76			
36312-3-3	Table 2.	65-74	11.46	12.37	12.71							10.21	11.17	11.32

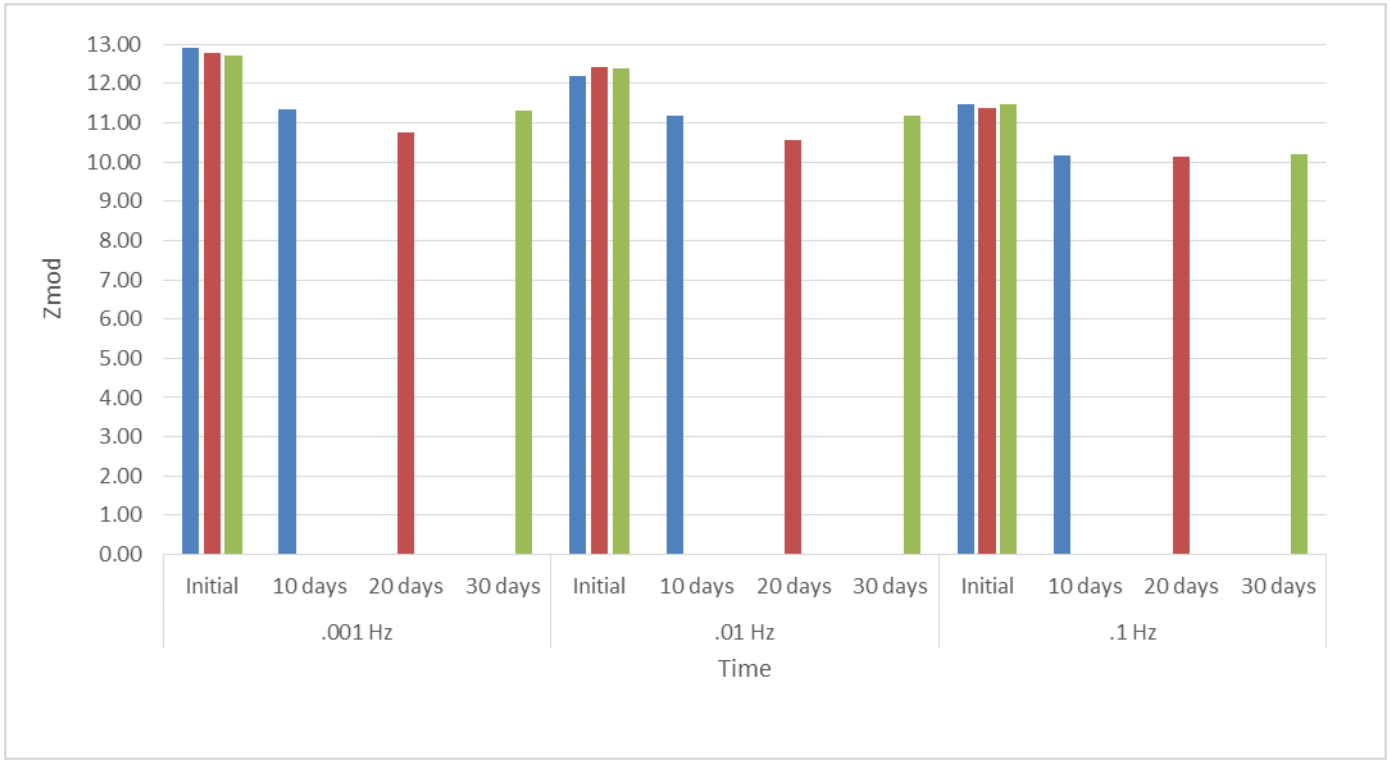

Figure A2. EIS results

OBIC 1200: 36518-3-3

After 30-days exposure

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Appendix A

Photo-Documentation of Coated Steel Test Panels

ASTM G210, *The Standard Practice for Operating the Severe Wastewater Analysis Testing Apparatus*

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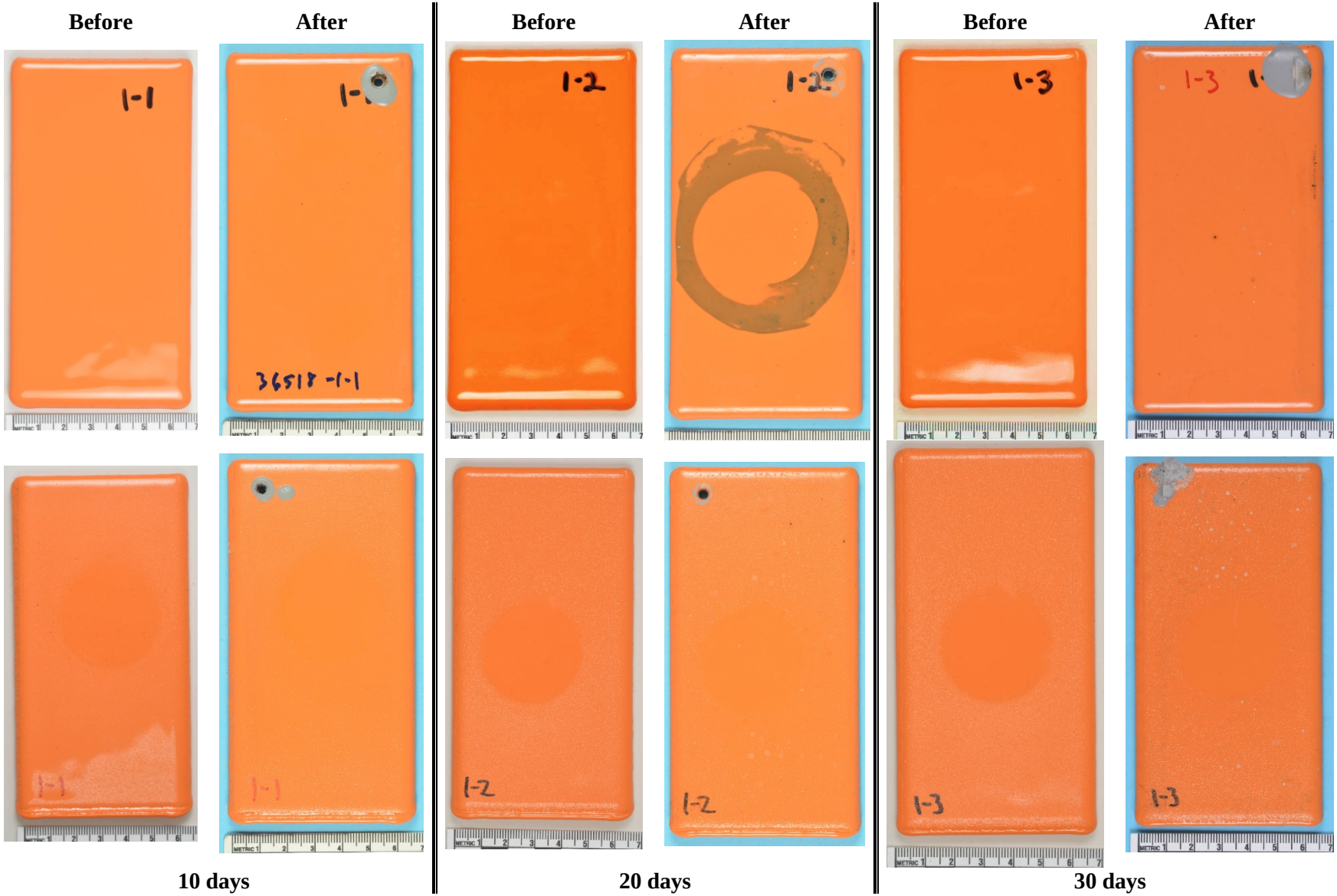

Figure A1. OCIB 1000 Coated specimens before and after exposure to SWAT Cabinet. Test face on top row, ID face on bottom row.

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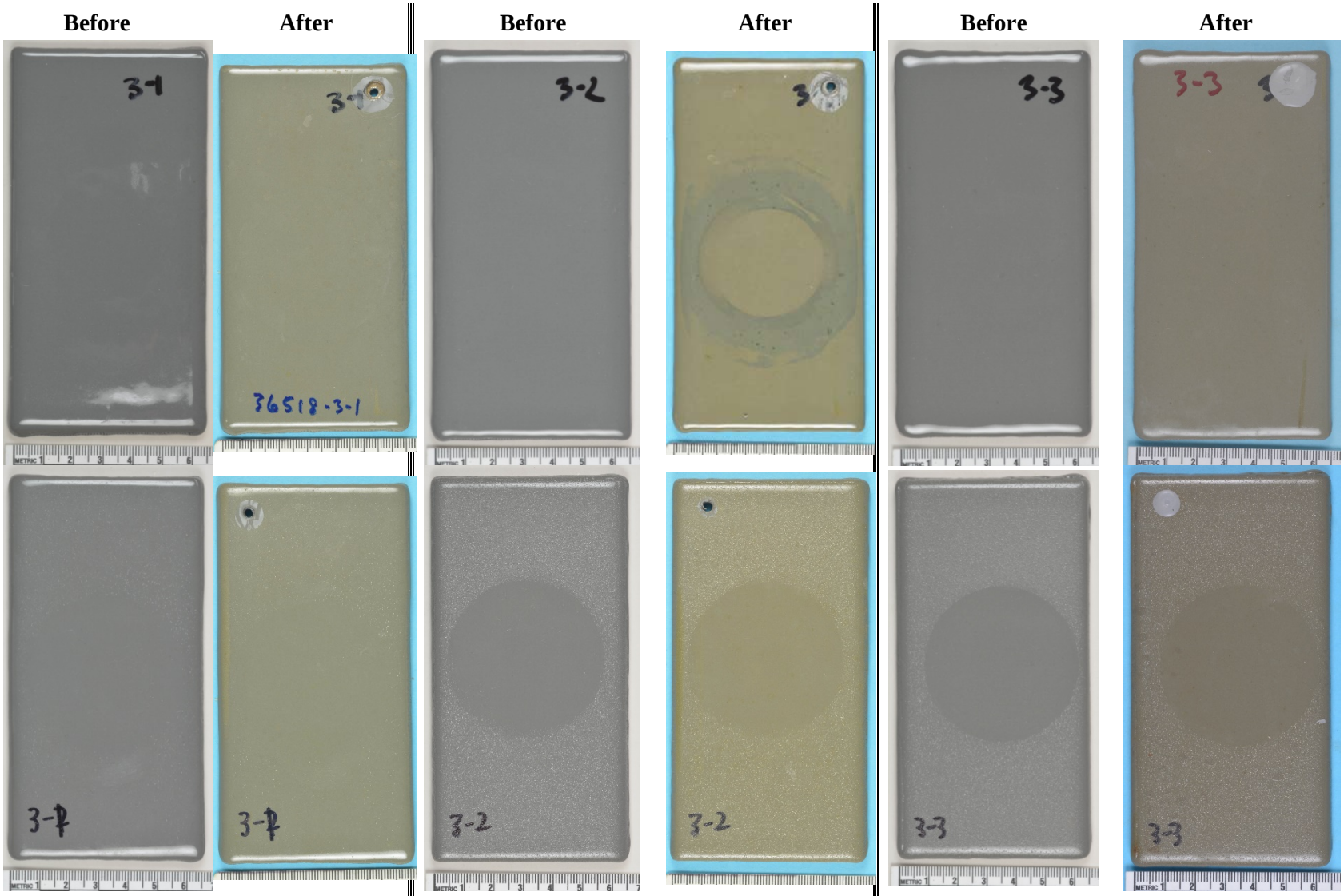

Figure A2. OCIB 1200 Coated specimens before and after exposure to SWAT Cabinet.

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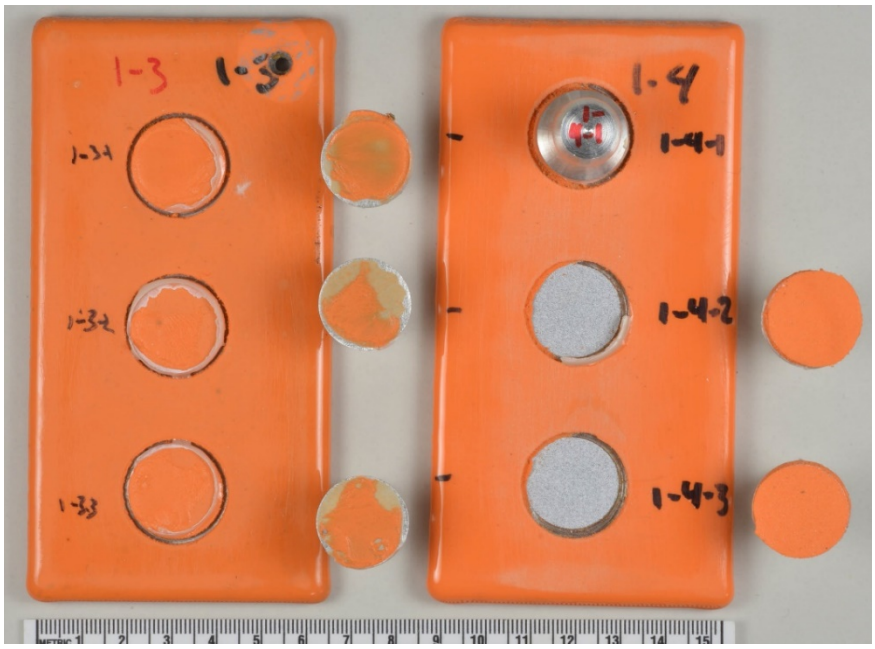
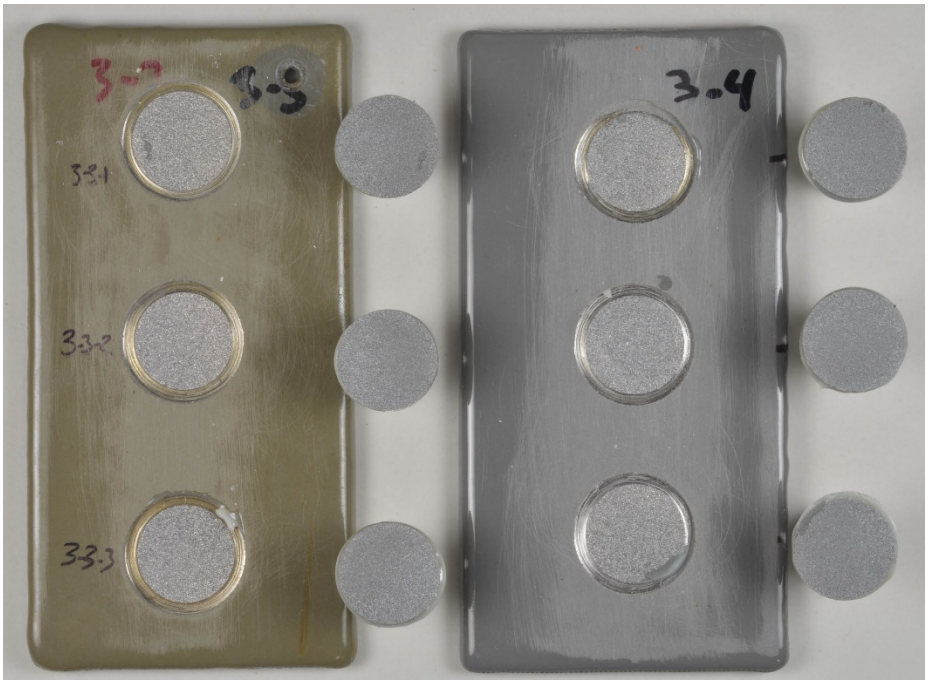
Adhesion Test



36518-1-3 30 days exposure. 36518-1-4 Unexposed control

Figure A3. **OBIC 1000**: Photos after adhesion testing.



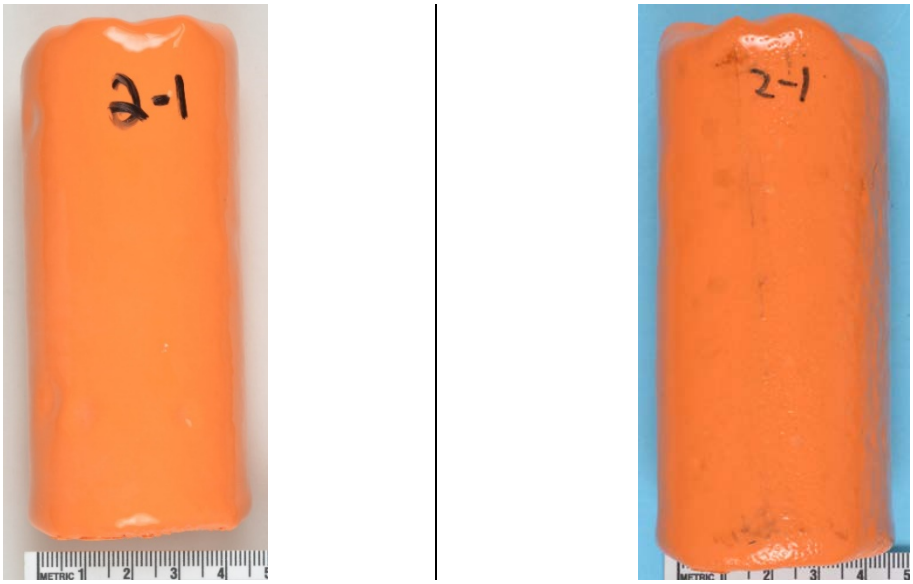
36518-3-3 30 days exposure. 36518-3-4 Unexposed control
Figure A4. **OBIC 1200:** Photos after adhesion testing.

Appendix B

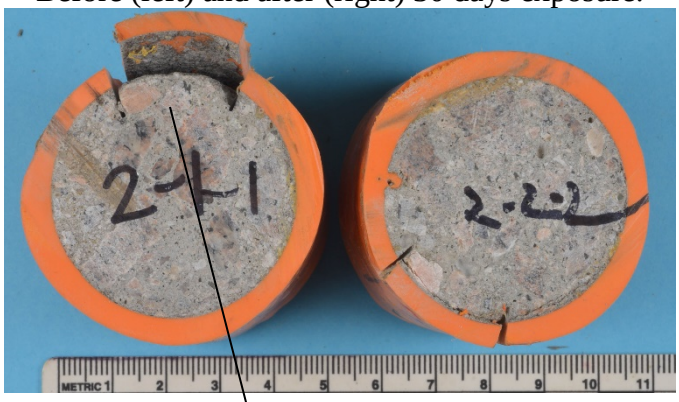
Photo-Documentation of Concrete

ASTM G210, The Standard Practice for Operating the Severe Wastewater Analysis Testing Apparatus

OBIC 1000
37008-2-1



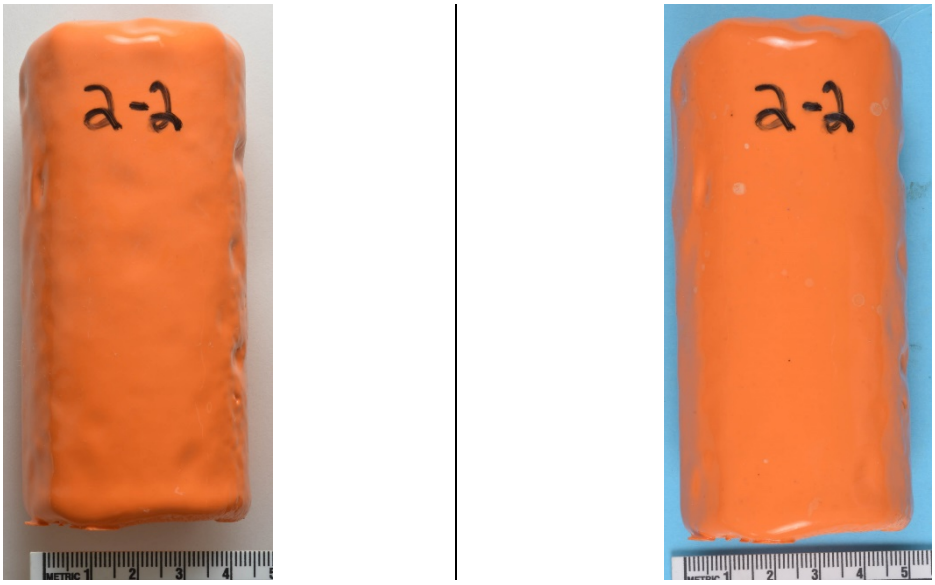
Before (left) and after (right) 30 days exposure.



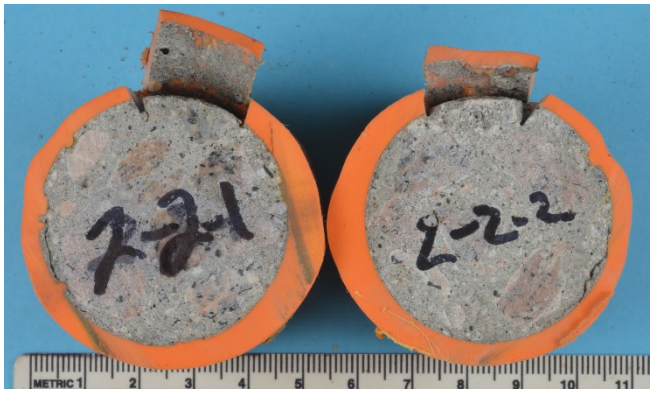
36518-2-1 cross-section

Figure B1. 36518-2-1 coating adhering to concrete, 11X magnification.

OBIC 1000
37008-2-2



Before (left) and after (right) 30 days exposure.

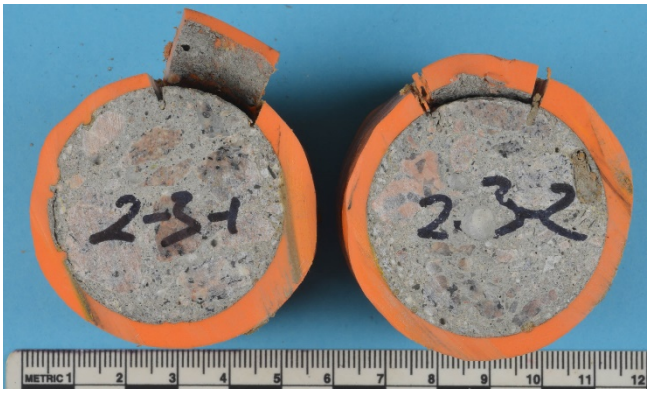


36518-2-2 cross-section

Figure B2. 36518-2-2 coating adhering to concrete, 11X magnification.

OBIC 1000
37008-2-3

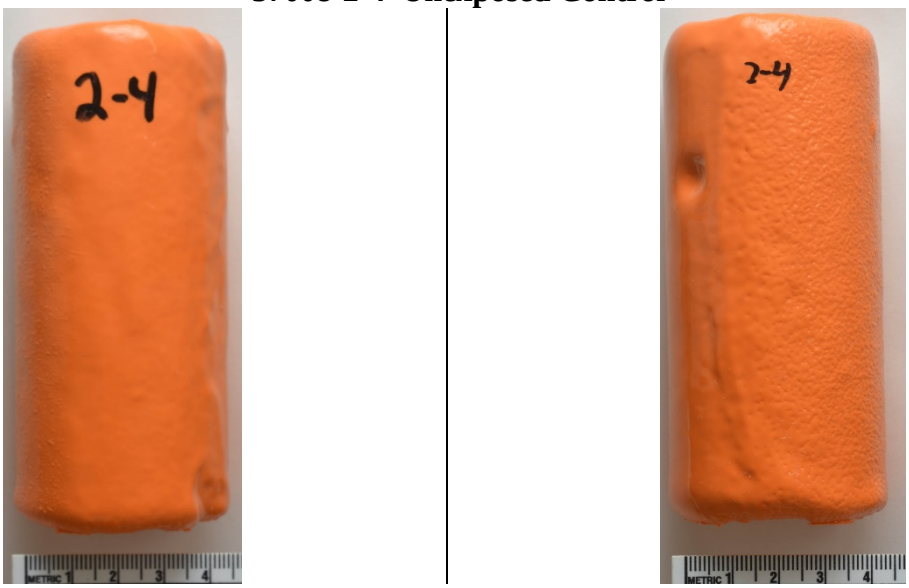
Before (left) and after (right) 30 days exposure.



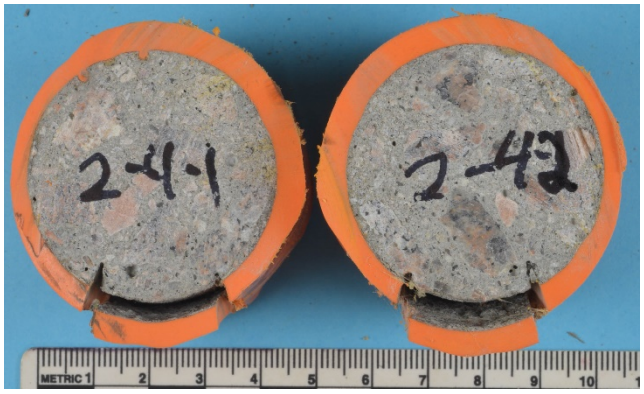
36518-2-3 cross-section

Figure B3. 36518-2-3 coating adhering to concrete, 11X magnification.

OBIC 1000
37008-2-4 Unexposed Control



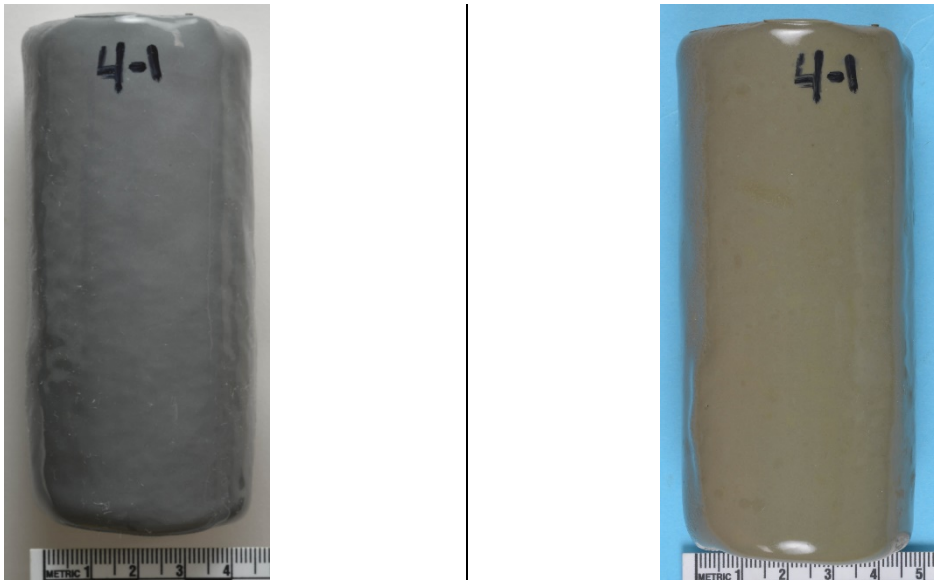
Smooth and rough sides of coated concrete.



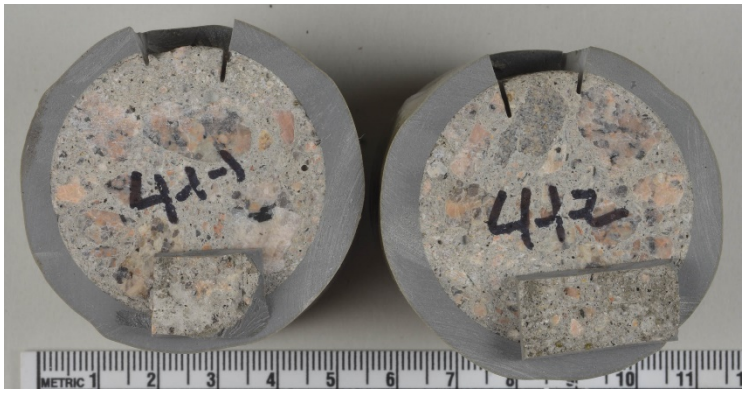
36518-2-4 cross-section

Figure B4. 36518-2-4 coating adhering to concrete, 11X magnification.

OBIC 1200
37008-4-1



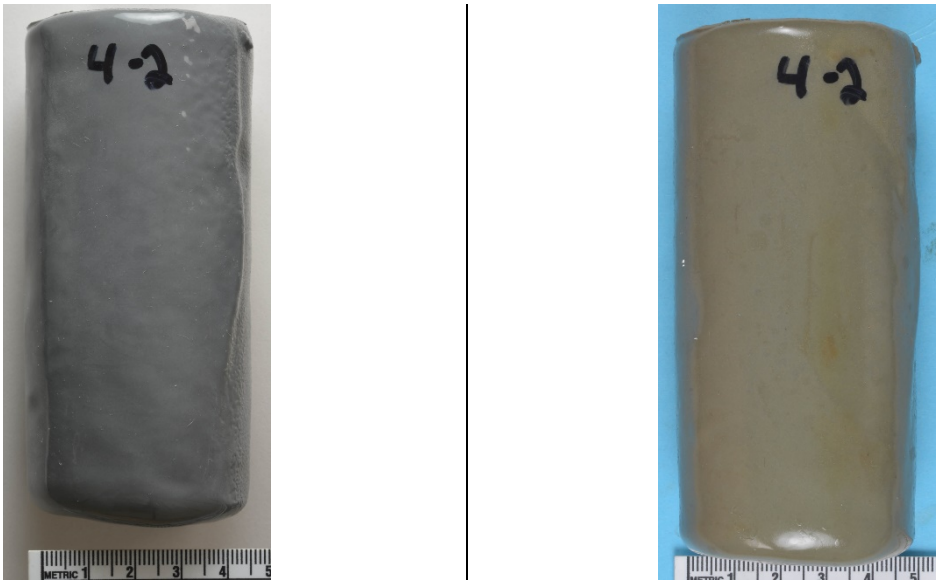
Before (left) and after (right) 30 days exposure.



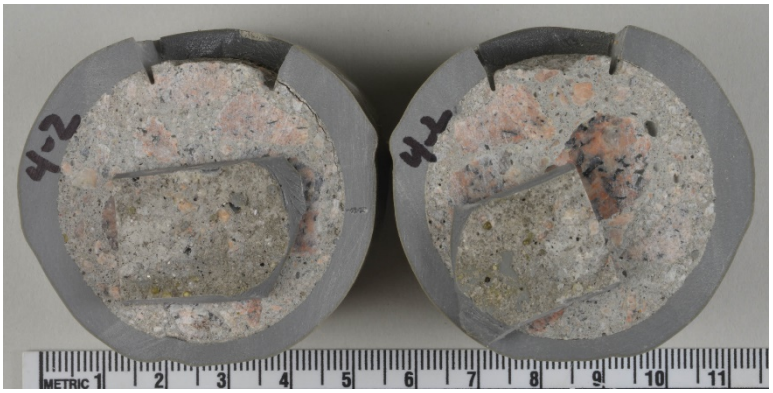
36518-4-1 cross-section

Figure B5. 36518-4-1 coating adhering to concrete, 11X magnification.

36518-4-2
OBIC 1000



Before (left) and after (right) 30 days exposure.

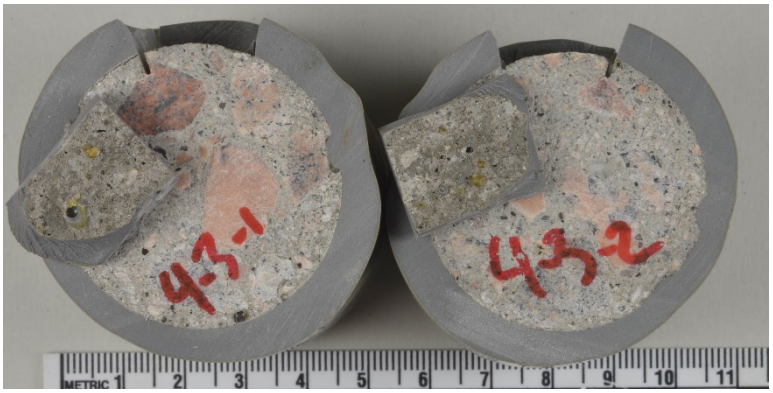


36518-4-2 cross-section

Figure B6. 36518-4-2 coating adhering to concrete, 11X magnification.

OBIC 1200
37008-4-3

Before (left) and after (right) 30 days exposure.

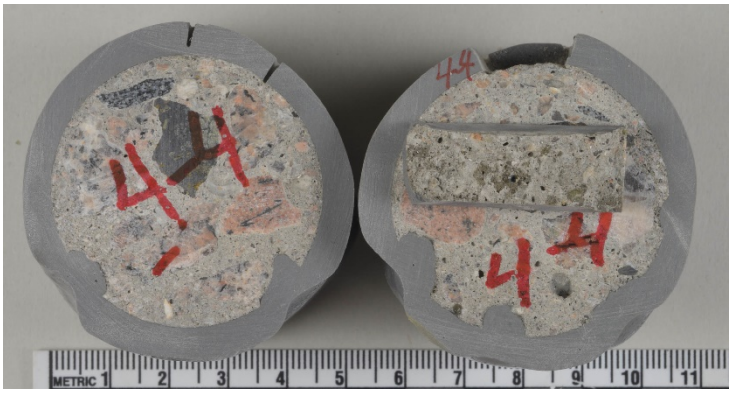


36518-4-3 cross-section

Figure B7. 36518-4-3 coating adhering to concrete, 11X magnification.

OBIC 1200
37008-4-4 Unexposed Control

Smooth and rough sides of coated concrete.



36518-4-4 cross-section

Figure B8. 36518-4-4 coating adhering to concrete, 11X magnification.