Corrosion Testing Laboratories, Inc.

February 6, 2020 CTL REF #36537

Mr. Bill Jordan
Innovative Foundation-Supportworks
1325 S. Frandsen Ave.
Rush City, MN 55063

Re: SWAT Corrosion Testing on Zebron 386 Coating System

Dear Mr. Jordan:

Presented herein are the results of the above referenced testing. This work was authorized in accordance with Innovative Foundation-Supportworks Purchase Order #10001.

TEST SPECIMENS

Innovative Foundation-Supportworks submitted four (4) Zebron 386 coated steel test panels for corrosion testing per ASTM G210-13, Standard Practice for Operating the Severe Wastewater Analysis Testing Apparatus. The coating is a very smooth, high gloss off-white coating. Three panels out of four were chosen for exposure. The fourth sample had slight indentations in the center where the EIS apparatus needs to attach.

SUMMARY OF TEST METHOD

Three (3) steel coated test panels 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.

Coated Stainless steel Specimens

Each test specimen was photographed in the as-received condition and the dry film thickness of each was measured using a QuaNix Model 1500 Coating Thickness Gauge. The initial EIS (electrochemical impedance spectroscopy) data was then obtained and the test specimens prepared for exposure.

Initial EIS. One hole was drilled into the edge of each specimen to allow for an electrical connection. 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 platinum 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, the test specimens 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. Overnight, the specimens were kept in the raised position (vapor space).

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 was removed. The test vessel was reassembled with the remaining specimens and the exposure reinitiated as described above.

The specimen whose exposure had ended was cleaned, photographed, and the EIS data was collected 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.

Final Evaluation.
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 photo-documentation, EIS data collection, and Dry Film Thickness and data direct tensile adhesion testing (pull-off strength).

RESULTS

Initial evaluation of the test specimens prior to exposure indicated a quality coating with good adhesion and high impedance values.

After the first **10 days** of exposure, one specimen was removed from exposure. The coating was discolored, but no cracks or blisters were observed. Slight indentations that were present before exposure did not appear adversely affected. Slightly decreased EIS values were measured on the exposed specimen 36537-1. The remaining two specimens, did not show visual evidence of degradation. Both appeared in good condition and were returned to exposure.

At the **20 day** inspection, both specimens, 36537-2 and 36537-3, were discolored, but appeared to be in good visual condition. One specimen was removed for evaluation, 36537-2. Slightly decreased EIS values were measured on the exposed specimen as compared to pre-exposure values. No cracks were observed on the specimen, however, a gap was observed along the overlap border. The remaining specimen 36537-3 was in good condition and was returned to exposure.

After **30 days** of exposure, the final specimen, 36537-3, was removed and evaluated. Slightly decreased EIS values were measured on the exposed specimen. Adhesion breaks occurred at a relatively high psi between the coating and the base metal on two of the three dollies. The average pull off strength of the exposed specimens was higher than the control specimen, possibly because of the very smooth, qualities of the coating. No cracks were observed on 36537-3.

Tabulated results of the Dry Film Thickness Measurements of the Coated Panels before and after exposure) are summarized in **Table 1**.

Tabulated results of the Pull-off Adhesion Test are in **Table 2**.

The EIS data for each specimen is summarized in **Figure 2**. Impedance values are reported as the log of the area compensated impedance values, Log Zmod (ohms*cm^2)

Photo-documentation of the test panels including results of pull-off adhesion tests are presented in **Appendix A**.

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.

The test specimens representing the Zebron 386 coating system performed well in this test. Visually there was no evidence of degradation in the form of cracks, blisters, or delamination. Coating adhesion was not degraded as a result of exposure as the pull off strength obtained from the 30-day exposed specimen was similar to or higher than the unexposed control. Although the

EIS data showed a decrease in coating impedance values from 12 to 10, this is still well above the minimum value (Log Zmod ≥ 6.0) associated with a protective coating.

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

Very truly yours,
Corrosion Testing Laboratories, Inc.

Reviewed and approved by:

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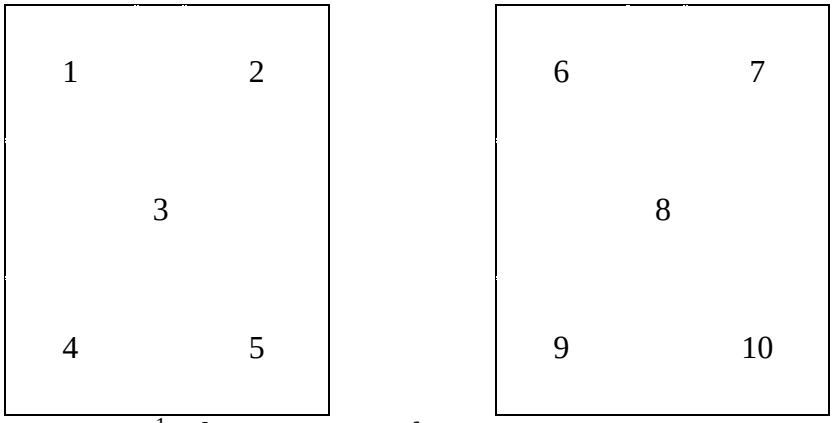
TABLE 1
Zebron 386
Dry Film Thickness Measurements of Coated Panels

Specimen #, Duration of Exposure	Position[1]	Location of Measurement				
		1	**2**	**3**	**4**	**5**
		6	**7**	**8**	**9**	**10**
36537-1 10 day exposure	Before	134	138	144	114	120
	After	126	129	144	113	116
	Before	159	121	150	173	161
	After	157	118	143	168	156
36537-2 20 day exposure	Before	126	140	130	104	103
	After	94.4	102	128	114	106
	Before	131	137	131	103	142
	After	96.4	102	129	120	119
36537-3 30 day exposure	Before	126	126	140	130	125
	After	103	111	129	109	124
	Before	116	113	139	127	124
	After	101	104	126	111	124



[1]Relative position of DFT measurements

Table 2.
Zebron 386
Tensile Adhesion Testing (Pull-Off Strength)

Specimen #	Coating System	Result	Average	Failure Locations (%)				
				Metal/ Coating	Within Coating	Coating/ Glue	Within Glue	Glue/ Dolly
30 day exposure								
36537-3-1	**Zebron 386**	2233	1971	98	2	-	-	-
36537-3-2		2203		85	15	-	-	-
36537-3-3		1476		-	-	50	-	50
Control								
36537-4-1	**Zebron 386**	1945	1827	-	-	75	5	20
36537-4-2		1992		-	-	75	-	25
36537-4-3		1544		-	-	75	-	25

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. *Three dollies were pulled on each panel except Tnemec Coating 2168, OCH Knox (CTL #34084-12-2) due to pre-test drilling error.

Innovative Foundation-Supportworks
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Zebron 386 30 Day Exposure to SWAT test (20 purges, 60 immersions)

CTL #	DFT (mils)	EIS Results (ZMod, Ω-cm2)												Comment
		Initial			10 days			20 days			30 days			
		.1 Hz	.01 Hz	.001 Hz	.1 Hz	.01 Hz	.001 Hz	.1 Hz	.01 Hz	.001 Hz	.1 Hz	.01 Hz	.001 Hz	
36537-1	135-133	12.46	12.2	11.46	11.19	12.12	12.37	-	-	-	-	-	-	Discoloration
36537-2	147-144	12.31	12.16	12.47	-	-	-	111.14	11.99	12.46	-	-	-	Discoloration
36537-3	129-130	12.84	12.13	12.37	-	-	-	-	-	-	10.15	10.82	11.54	Discoloration

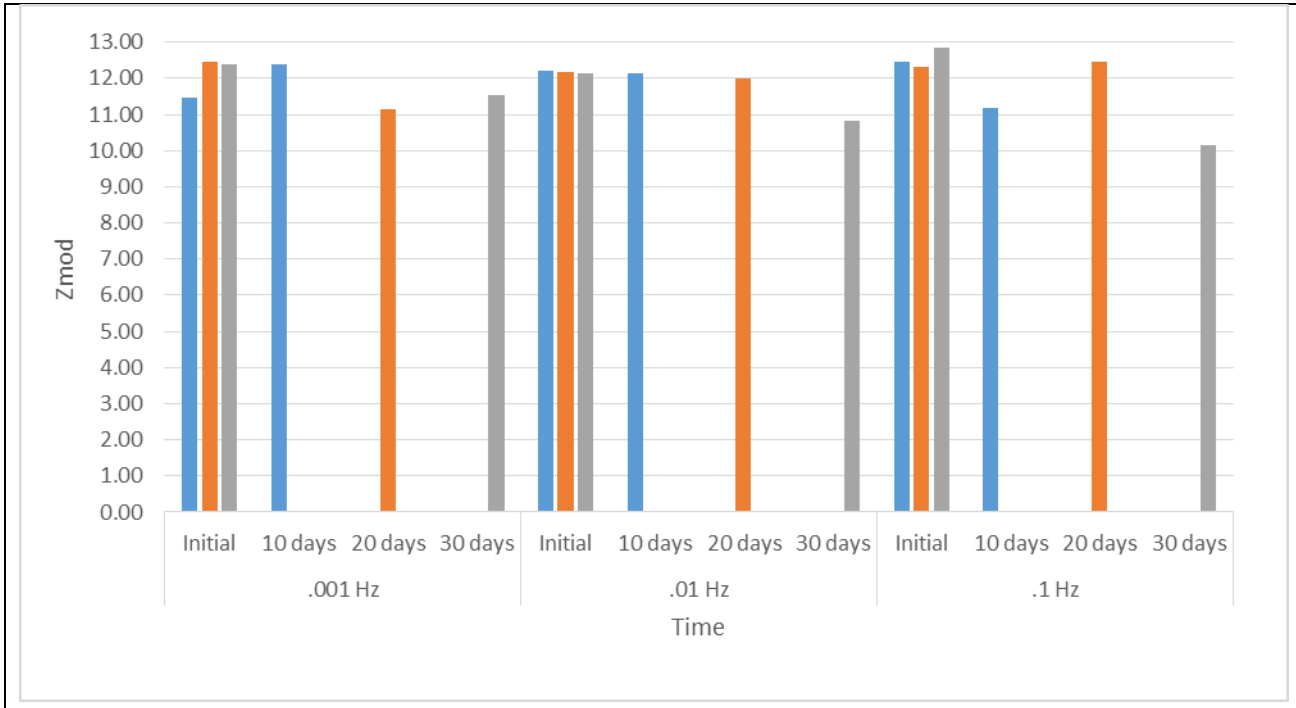

Table 3. **Zebron 386** EIS results

36537-3

Zebron 386 after 30-days exposure.