Coating Performance in Duluth Superior Harbor—Part 2

RICHARD I. RAY AND BRENDA J. LITTLE, FNACE,
Naval Research Laboratory, Stennis Space Center, Mississippi

Nine coatings were evaluated for corrosion protection of carbon steel coupons and I-beams around Duluth Superior Harbor after 46 and 35 months, respectively. Coupons were intentionally scribed to metal before exposure. Part 1 (September 2012 MP) described the coatings used and the locations of coupons and I-beams. Part 2 discusses the results of the evaluation.

Sixteen miles (26 km) of carbon steel (CS) sheet piling (12-mm thick ASTM A328[1] cold rolled) used for docks, bridges, and bulkheads in the Duluth Superior Harbor (DSH) in Minnesota and Wisconsin are corroding at an accelerated rate of 3 mm/y or higher. The corroded pilings have an orange rusty appearance characterized by tubercles (i.e., corrosion products and deposits covering areas of localized corrosion). Barrier coatings provide one option for protection of extensive structures in fresh water, and nine coatings were evaluated for corrosion protection of CS coupons and I-beams around DSH after 46 and 35 months, respectively. Part 1 (September 2012 *MP*) described the coatings used and the locations of coupons and I-beams. Part 2 discusses the results of the evaluation.

Products

The following coatings were selected for this evaluation:

1 Aquapure HR†
2 Chevron Phillips TZ9043†
3 Standard epoxy
4 Humidur ML†
5 Wasser MC-zinc/MC-tar†
6 Sherwin-Williams Fast clad ER†
7 Poly-Spec LPE 5100†
8 Coal tar epoxy
9 Zinc-rich primer VZ108/V766

These products are identified throughout the article by number.

Coupons

There were no corrosion products or tubercles on any of the painted coupon surfaces like those that covered areas of localized corrosion on unprotected piling surfaces. The outward-facing coated surfaces were colonized with zebra mussels and a freshwater sponge. Zebra mus-

†Trade name.

FIGURE 1

Coating 1 (Side A) Coating 1 (Side B)

U.S. Coast Guard Cell B
White two-part solvent-free polyamine epoxy
Total exposure time 46 months

Observations
Few byssal threads still attached
Both sides covered in sponge material
Top layer of coating peeling in places
Corrosion evident in scribe (artificial defect)
Muddy coating on surface

Coating 1 (Side A) Coating 1 (Side B)

U.S. Coast Guard Cell C
White two-part solvent-free polyamine epoxy
Total exposure time 46 months

Observations
Few byssal threads still attached
Algae growing on one side of coupon
Top layer of coating peeling from scribe
Corrosion evident in scribe (artificial defect)
Muddy coating on surface

Coating 1 coupons.

FIGURE 2

Coating 4 (Side A) Coating 4 (Side B)

U.S. Coast Guard Cell B
Green two-part solvent-free polyamine epoxy
Total exposure time 46 months

Observations
Few byssal threads still attached
Coating appears intact even in scribe area
Corrosion evident in scribe
Muddy coating on surface

Coating 4 (Side A) Coating 4 (Side B)

U.S. Coast Guard Cell C
Green two-part solvent-free polyamine epoxy
Total exposure time 46 months

Observations
Few byssal threads still attached
Coating appears intact even in scribe area
Corrosion evident in scribe
Muddy coating on surface except where silicone caulk used to attach Teflon holder

Coating 4 coupons.

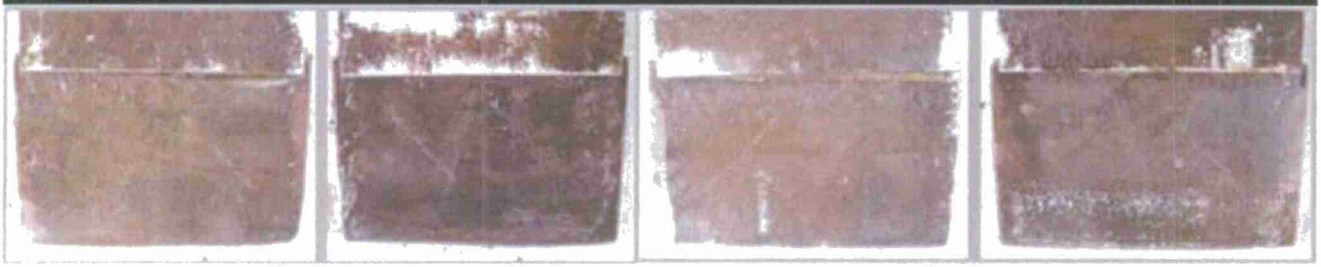
sels were removed prior to digital imaging to accommodate the shipping container size. Algae colonized the backside. Both sides were covered in a thin film of mud. There were no indications of coating degradation caused by the fouling. Localized corrosion on the coupons was limited to the intentional scribe area. The topcoat of Coating 1 was peeling from the scribe. Coatings 4, 5, 6, 7, and 9 remained intact and there were no indications of delamination even in the scribe area. Figures 1 through 4 present descriptions and observations.

I-Beams

Table 1 summarizes I-beam coating performance after exposure.

The topcoat of Coating 1 delaminated and peeled from the surface of the I-beam (Figure 5).

FIGURE 3



Coating 5

(Side A) **(Side B)**

U.S. Coast Guard Cell C
Red urethane micaceous iron oxides and refined coal tar
Total exposure time 46 months

Observations
Few byssal threads still attached
Some algae on coating surface
Coating appears intact even in scribe area
Corrosion evident in scribe
Muddy coating on surface

Coating 9

(Side A) **(Side B)**

U.S. Coast Guard Cell C
Blue/grey zinc primer/vinyl copolymers
Total exposure time 46 months

Observations
Few byssal threads still attached
Some algae on coating surface
Coating appears intact even in scribe area
Corrosion evident in scribe
Muddy coating on surface

Coatings 5 and 9 coupons.

FIGURE 4

Coating 6

(Side A) **(Side B)**

U.S. Coast Guard Cell B
White amine epoxy (one coat)
Total exposure time 46 months

Observations
Few byssal threads still attached
Coating appears intact even in scribe area
Coating lumpy and thick
Corrosion evident in scribe
Muddy coating on surface

Coating 7

(Side A) **(Side B)**

U.S. Coast Guard Cell C
Black polysulfide modified epoxy novolac
Total exposure time 46 months

Observations
Few byssal threads still attached
Some algae on coating surface
Coating appears intact even in scribe area
Corrosion evident in scribe
Muddy coating on surface

Coatings 6 and 7 coupons.

The-I beams were not scribed so the intentional defect was not necessary to initiate the delamination. The base coat remained intact and no localized corrosion was obvious. Coating 7 peeled from the surface in large sections, exposing uncoated steel with corrosion and tubercles (Figure 6).

All other coatings performed adequately. Chips along the edges of the I-beams may have occurred during transport.

Conclusions

Over a three- to four-year period, coatings prevented the formation of tubercles and localized corrosion on CS surfaces. Coating performance varied among the products and two products (Coatings 1 and 7) failed due to peeling. None of the coatings protected the substratum at an intentional defect.

Details showing all coating results are available from the authors.

Reference

1 ASTM Standard A328/A328M-07, "Standard Specification for Steel Sheet Piling" (West Conshohocken, PA: ASTM International, 2007).

RICHARD I. RAY is a physical scientist at the Naval Research Laboratory, Code 7332, Stennis Space Center, MS 39529-5004. He has worked for the Naval Research Laboratory for 29 years, operating scanning electron microscopes for research on biodeterioration and biodegredation of materials in marine environments. He bes a B.S. degree in biology from the University of Southern Mississippi and received four Alan Bermen Research Publication Awerds end the Sigme XI Awerd.

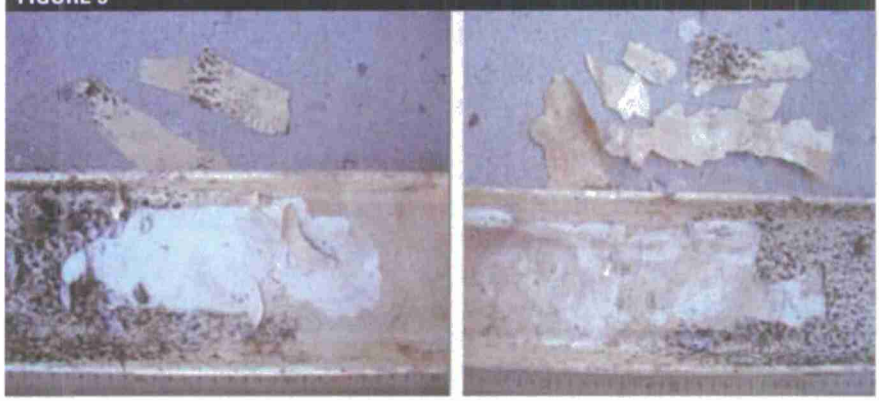
BRENDA J. LITTLE, FNACE, is a senior scientist at the Nevel Reseerch Laboratory. She uses surface analytical chemistry, electron microscopy, and electrochemical techniques to investigate adsorption, biofouling, biodegradation, bioremediation, and corrosion in marine environments. She is a NACE International Fellow and has been a NACE member since 1984. MP

TABLE 1

Coating performance after exposure

Product/Chemistry	Pass/Fail	Description
1—white two-part solvent-free polyamine epoxy	Fail	Delamination, blistering, peeling
2—light green/white two-part epoxy	Pass	Thick, uneven, intact, chips
3—grey two-part polyamide epoxy/ zinc primer	Pass	Thick, smooth, intact, chips
4—dark green two-part polyamine epoxy	Pass	Thick, lumpy, intact, chips
5—red urethane micaceous iron oxides/refined coal tar	Pass	Thin, intact, fingerprints, chips
6—white amine epoxy (one coat)	Pass	Thick, lumpy, intact, chips
7—black polysulfide modified epoxy novolac	Fail	Broken, peeling, corrosion
8—black two-part coal tar polyamide epoxy	Pass	Thin, smooth, intact, few chips
9—blue/grey zinc primer/vinyl copolymers	Pass	Thin, rough, intact, chips

FIGURE 5



Coating 1 shown on the I-beams.

FIGURE 6

Coating 7 shown on the I-beams.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
14-11-2012	Journal Article	

4. TITLE AND SUBTITLE
Coating Performance in Duluth Superior Harbor - Part 2

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
W56MES00404548

6. AUTHOR(S)
Richard I. Ray and Brenda Little

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER
73-9776-00-5

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Research Laboratory
Oceanography Division
Stennis Space Center, MS 39529-5004

8. PERFORMING ORGANIZATION REPORT NUMBER
NRL/JA/7330--12-1384

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
US Army Engineer District Detroit
PO Box 1027
Detroit, MI 48231-1027

10. SPONSOR/MONITOR'S ACRONYM(S)
Army

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
Sixteen miles (26 km) of carbon steel (CS) sheet piling (12-mm thick ASTM A3281 cold rolled) used for docks, bridges, and bulkheads in the Duluth Superior Harbor (DSH) in Minnesota and Wisconsin are corroding at an accelerated rate of 3 mm/y or higher. The corroded pilings have an orange rusty appearance characterized by tubercles (i.e., corrosion products and deposits covering areas of localized corrosion). Barrier coatings provide one option for protection of extensive structures in fresh water, and nine coatings were evaluated for corrosion protection of CS coupons and I-beams around DSH after 46 and 35 months, respectively. Part 1 (September 2012 *MP*) described the coatings used and the locations of coupons and I-beams. Part 2 discusses the results of the evaluation.

15. SUBJECT TERMS
carbon steel, coatings, evaluation, corrosion, protection

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Richard Ray
Unclassified	Unclassified	Unclassified	UL	4	19b. TELEPHONE NUMBER *(Include area code)* (228) 688-4690