Effect of Repeated Cleanings using Multiple Tools on Condition of a Fouling-release Coating

Eric R. Holm[1], Joseph R. Curran[1], Abraham P. Stephens[2], Geoffrey W. Swain[2], and Elizabeth G. Haslbeck[1]

[1]Naval Surface Warfare Center, Carderock Division, [2]Florida Institute of Technology

Introduction

The US Navy is currently investigating using next-generation fouling-release hull coatings throughout the fleet. Operators of commercial vessels have claimed significant fuel savings from use of these coatings. In contrast to commercial vessels, however, Navy ships tend to be inactive for long periods of time and typically operate at relatively slow speeds. Under these conditions fouling-release coatings may experience heavy encrustations of organisms requiring frequent or aggressive cleaning in order to ensure efficient ship operations. Cleaning may impact the coating's surface characteristics or integrity, compromising subsequent performance. We are examining the effects of multiple applications of six hull cleaning tools (Table 1) on the surface characteristics and release performance of a fouling-release coating.

Methods

The test coating was applied to 25.4 x 30.5 x 0.64 cm Garolite panels following manufacturer's specifications. Before exposure all coated test panels were characterized for surface roughness and adhesion strength of epoxy pseudobarnacles. Nine position-registered micrographs (ProScope, 50x) were taken of each panel face. Panels were then immersed from a raft at Port Canaveral, FL, for accumulation of fouling. Fouling at this site is seasonal but communities appear to be dominated by serpulid tubeworms *Hydroides* spp. (Fig. 1).

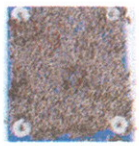


Fig. 1. Heavy fouling of coating by serpulid polychaete worms (tubeworms). Panel had been immersed for approximately 50 days, Oct. – Nov. 2009.

After fouling reached a sufficient level to warrant cleaning (often after as little as 4 weeks of immersion, depending on season) replicate (3) coated panels were subjected to cleaning by the tools listed in Table 1. Panels were attached to fiberglass support frames that were fit into 'windows' in a 7.6 x 2.4 m steel test rig designed to mimic the flat side of a ship (Fig. 2). Utilization of the test rig allowed cleaning tools to be applied as they would be to an actual ship. All cleaning tools were applied by professional divers experienced in underwater cleaning of US Navy hulls. Before and after cleaning the test face of each panel was photographed to record fouling level, remaining fouling, and extent of any macroscopic damage, and 9 position-registered micrographs (50x) were taken of each test face after cleaning to record microscopic damage (if any, Fig. 3). Spatial extent of damage was quantified as percent cover using a point-intercept methodology.

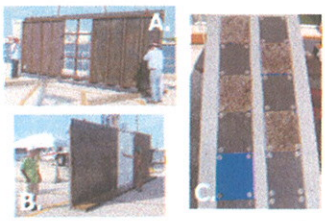


Fig. 2. Test rig [A]; test rig with fiberglass support frames inserted [B] and coated and blank panels attached to fiberglass support frame [C]. Multi-brush cleaning units (SCAMP, Mini-pamper) ran from left to right on the test rig, starting in the large area to left of the support panels and turning around to the right of the support panels after completely passing over the test coatings.

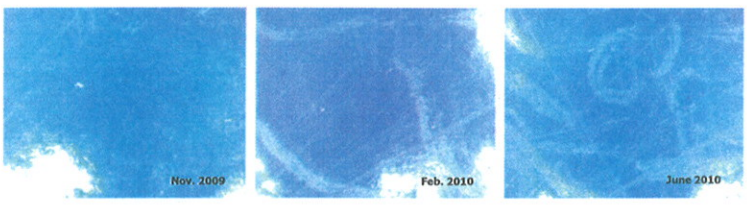
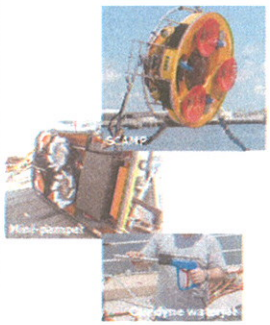


Fig. 3. Example of accumulation of scratches and residue of polychaete tubes and cement on surface of coating. Pictures are from the same location on the surface of a single panel. Coating was cleaned using the single brush unit with A-4 brush.

SCAMP – E4 and E5 brushes
Mini-pamper – M1 brush
Single brush unit – A-4 brush
Cavidyne LG1620 cavitating waterjet
Non-cavitating waterjet

Table 1. Cleaning tools used in experiments.



Results

1. Microscopic scratches and macroscopic damage accumulated on coating surfaces that were cleaned using a contact method (brushes) (Fig. 3, Fig. 4).
2. There was little damage or damage accumulation on coating surfaces that were cleaned using non-contact methods (waterjets) (Fig. 4).
3. Coating surfaces with no fouling suffered less damage on application of brush-type tools than coatings with fouling (data not shown).
4. Over three trials, all coatings accumulated residue from polychaete tubes or (presumably) tube cement, regardless of the cleaning tool applied (Fig. 3).
5. Over three trials, none of the cleaning tools had any significant effect on surface roughness (as measured by R_A and R_T). However, larger roughness elements (small flaws in coating surface partway through topcoat, or through to tiecoat or anticorrosive coat) could be observed with increasing frequency as the number of trials increased. These elements were rare relative to the total surface area of the coating and were generally not detected by our sampling methods.
6. There is a trend toward increased adhesion strength of epoxy pseudobarnacles for coatings cleaned using the SCAMP and single brush unit. The trend is not currently significant ($p < 0.09$; Fig. 5).

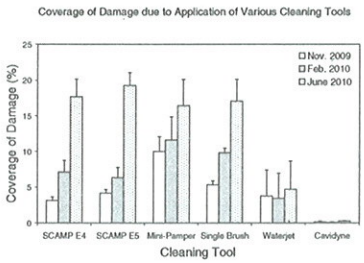


Fig. 4. Accumulation of damage to coating surface over three trials. All means for brush-type tools are significantly > 0%. No means for waterjets are significantly > 0%.

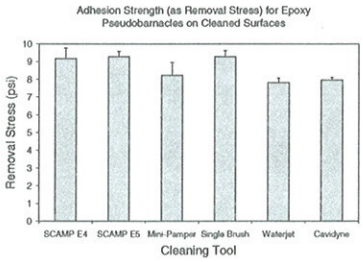


Fig. 5. Adhesion strength (as removal stress) for epoxy pseudobarnacles after three trials. There is no significant difference among the cleaning tools ($p < 0.09$).

Moving Forward

- Complete two additional tests of cleaning tools
- Final test includes repeated application of brush-type tools until coating is destroyed
- Analyze final sets of tubeworm adhesion as well as damage, roughness and pseudobarnacle adhesion data
- Complete reporting of results, make recommendations to NAVSEA as to tools and procedures for hull cleaning

Acknowledgements: This work was funded by the Naval Sea Systems Command and the Office of Naval Research. We wish to thank T. McCue (NAVSEA); D. Lynn, E. Satchell, D. Stamper (NSWCCD); K. McMonagle, J. Coogan, E. Ralston (FIT); C. Rosskamp and D&D Marine (Port Canaveral); Seaward Marine Services and Oceaneering, Inc.; J. Canning-Clode (SERC); and NOTU/Cape Support (Port Canaveral) for their contributions to the successful completion of this project.

Disclaimer: Results reported herein are preliminary; all tests have yet to be completed. The results reported do not imply any US Navy endorsement or approval of particular hull cleaning tools or practices for use on fouling-release coatings.