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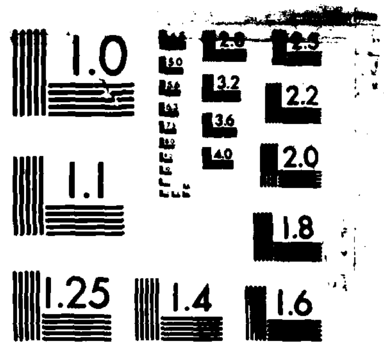

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TECHNICAL NOTE

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ASSESSMENT UNDER DYNAMIC AND STATIC CONDITIONS OF UNDERWATER PAINT SYSTEMS FOR USE ON THE GLASS REINFORCED PLASTICS (GRP) MINEHUNTER

I.C. Dunstan and J.A. Lewis

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ABSTRACT

Twelve underwater paint systems were assessed for use on the RAN glass reinforced plastics (GRP) Minehunter. The paint systems were applied to GRP panels and tested for durability under dynamic flow conditions on the MRL rotor apparatus. All paint systems exhibited satisfactory adhesion to the GRP and would therefore be suitable for application onto the hull of the Minehunter. However, most of the antifouling paints suffered some surface deterioration during the rotor trial. The panels were subsequently immersed on a static raft to determine antifouling performance of the systems, and to compare them to identical paint systems that were not initially exposed to dynamic flow. It was apparent that initial exposure to dynamic flow had some affect on the antifouling capabilities of the paint systems.

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	Erosion	Dynamic flow
		Deterioration

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Twelve underwater paint systems were assessed for use on the RAN glass reinforced plastics (GRP) Minehunter. The paint systems were applied to GRP panels and tested for durability under dynamic flow conditions on the MRL rotor apparatus. All paint systems exhibited satisfactory adhesion to the GRP and would therefore be suitable for application onto the hull of the Minehunter. However, most of the antifouling paints suffered some surface deterioration during the rotor trial. The panels were subsequently immersed on a static raft to determine antifouling performance of the systems, and to compare them to identical paint systems that were not initially exposed to dynamic flow. It was apparent that initial exposure to dynamic flow had some affect on the antifouling capabilities of the paint systems.

CONTENTS

ASSESSMENT UNDER DYNAMIC AND STATIC CONDITIONS OF UNDERWATER PAINT SYSTEMS FOR USE ON THE RAN GLASS REINFORCED PLASTICS (GRP) MINEHUNTER

1. INTRODUCTION

The external wall of the hull of the Royal Australian Navy's replacement Minehunter is to be constructed from a glass reinforced plastics (GRP) material. In response to concern that the standard RAN underwater paint systems may not be suitable for the GRP, Materials Research Laboratories recommended an underwater paint scheme based on a Royal Navy concept [1]. The system consisted of:

(a) surface preparation by cleaning and light abrasion,
(b) epoxy barrier coat,
(c) acrylic tie coat, and
(d) black antifouling to GPC-C-42/5.

To verify the suitability of this paint system for practical use on GRP naval vessels, it was considered necessary to conduct exposure trials.

Traditionally, antifouling paint trials have relied upon exposure on static rafts [2,3]. Similarly, the Australian Standards Association specifies raft exposure as the basis for assessment of underwater paint systems [4]. However, as the behaviour of antifouling paint can differ under dynamic flow compared to static water conditions [2], the integrity of antifouling paints is better assessed under dynamic conditions. Ideally, the testing of antifouling paints should combine ageing under dynamic flow conditions, to determine the resistance of the system to physical degradation, with intermittent static raft exposure to assess fouling resistance [3]. The paint system suggested for use on the minehunter was therefore tested using a dynamic flow facility and a static immersion raft at Williamstown Naval Dockyard (WND).

Several other paint systems were included in the study for comparison purposes. These systems included a standard RAN antifouling paint and several GRP compatible systems supplied by commercial paint companies. Of particular interest was a self-polishing co-polymer system (SPC). SPC coatings have become increasingly popular for both commercial [5] and naval applications [6-9], although some reservations are held as to their effectiveness for use on naval vessels [10].

2. PAINT SYSTEMS TESTED

The following paint systems were exposed during this investigation. The commercial paints are coded so as not to prejudice any product.

(a) MRL system (based on an RN scheme) comprising a clear epoxy barrier coat, acrylic tie coat and a black synthetic resin based antifouling finish (AF1) containing cuprous oxide and organotin biocides. A second system without the tie-coat was also included.

(b) An RAN system used by Garden Island Naval Dockyard based on a metallic primer overcoated with black antifouling (ABR paint scheme U6 [11]). Two topcoats were tested. The first was that described in (a) above, and the second (BF1) contained organotin and thiuram biocides.

(c) Eight commercial underwater paint systems. Two paint companies (Companies A and B) each supplied two systems, while a third company (Company C) provided four systems based on a combination of two primers and two topcoats (including a self polishing copolymer, SPC).

Descriptions of the paints used are given in Table 1, while the paint systems tested are shown in Table 2.

3. EXPERIMENTAL

Paints were applied according to manufacturers specifications to 15 cm x 15 cm GRP panels that had been lightly abraded and cleaned with methylated spirits. Each paint system was applied to three panels, two of which were placed on the rotating drum of the rotor facility at Williamstown Naval Dockyard [12], and the third stored in a plastic bag containing seawater. After 1000 hours rotation at 10 m/sec the panels on the rotor were inspected for any deterioration of the paint film. All panels, as well as two unpainted control panels, were then placed on racks suspended from the raft at WND. The panels were immersed on 26/3/1985 and removed on 28/5/1985.

Fouling on the panels was assessed using a frequency count of the major organism groups [13]. The presence or absence of each species within one hundred 5 mm x 5 mm squares scribed on a perspex overlay was determined.

The number of squares in which a species was present gives the percentage probability of that species occurring in the assessment area.

Further planned exposure on the rotor was not possible due to its shutdown prior to relocation of the facility.

4. RESULTS AND DISCUSSION

4.1 Durability of the Paint Systems

Table 3 describes the condition of the paints tested after 1000 hour exposure on the rotor. For all paint systems the duplicate panels behaved similarly and are consequently covered by the one description.

All paint systems except those with the chlorinated rubber (CF1) and the SPC (CF2) finishes suffered some degree of deterioration during exposure to dynamic flow. The surfaces of all the systems with the AF1 finish were significantly roughened, as sections of the top coat were smeared across the face of the panels (Plate 1). In addition to surface roughening, the MRL system without the tie-coat exhibited pitting through to the primer. Pitting did not occur on the MRL system with the tie-coat. Some erosion and pitting of the BF1 antifouling occurred over the BP3 epoxy primer. The BF1 top coat over other primers showed only slight pitting. The most substantial deterioration was sustained by the Diesel-oil Resistant top coat (AF2) which underwent marked pitting and surface layer smearing.

The degradation of the paint films occurred after a rigorous exposure programme equivalent to a continuous 35,000 km journey at 19 knots. Such exposure produces accelerated ageing under natural conditions so that the relative performances of antifouling paints can be assessed more rapidly than is possible using a raft. The paint systems would not encounter such conditions in service on the MH1 which has a design speed of 10 knots and which will be at sea intermittently. Thus the smearing and pitting of the surface layers of the paint systems reported in Table 3 give little cause for concern. There was no indication of any loss of adhesion of the paint systems to the GRP panels.

4.2 Antifouling Performance

Table 4 lists the frequency counts of the major fouling organism groups following immersion on the raft. The figure for panels exposed on the rotor prior to raft immersion is the average value for the two panels.

All of the paint systems fouled to some degree on the raft, but to a much lesser extent than the unpainted control panels. The finish containing organotin and cuprous oxide biocides (AF1) exhibited the best fouling resistance, with only one of eight panels with this top coat showing more than slime fouling. The AF2 top coat that had been exposed on the rotor was fouled by algae. While generally free from algal fouling, the panels with organotin and thiuram (BF1) exhibited significant barnacle and amphipod settlement during the two month exposure (Plate 2).

The panels covered with the SPC (systems c#2 and c#4) and both of the chlorinated rubber systems that had initially been aged on the rotor (c#1 and c#3), were fouled by algal growth. Significantly, fouling on the two SPC panels that had not undergone rotor exposure occurred in discrete areas on the panels (Plate 3). Close inspection, including SEM examination, indicated that the fouled areas were covered by a film which did not allow any biocide release from the paint surface. Plate 4 shows the raised film covering the paint surface on the left of the picture, while on the right there is no surface film, and several pits left by the leached toxicant particles are apparent. Physical and chemical changes occurring at the surface of the antifouling paint during storage in the plastic bags prior to placement on the raft is considered to be the most likely cause of the surface film. The SPC-painted panels exposed on the rotor were also fouled by algae, but in these cases the algae grew randomly over the face of the panels.

4.3 Effects of Dynamic Flow on Antifouling Performance

The antifouling capabilities of the MRL systems, the ABR coating with the AF1 finish and both the commercial systems with the CP2 primer did not appear to be changed by the 1000 hour exposure to dynamic flow conditions (Table 4). However, after exposure on the rotor the ABR system with the BF1 finish showed markedly less slime fouling than the same system that had not been subjected to dynamic flow. The remaining six paint systems appeared more susceptible to algal fouling following exposure on the rotor. Whilst these paint systems did not show any algal fouling when placed directly onto the raft, the c#5, c#6, c#7 and c#8 paint systems experienced light algal settlement, and both the systems with the chlorinated rubber based finish (c#1 and c#2) had significant algal growth.

As the results are based on a small sample and a single cycle of rotor/raft exposure, it would be premature to speculate on the significance of these results. However, it is apparent that initial exposure on the rotor definitely had some affect on the antifouling capabilities of these paint schemes. Consequently, further investigations into the effect of the dynamic flow on the performance of Naval antifouling paint systems are clearly warranted.

5. CONCLUSIONS

1. A paint scheme recommended for the new RAN Minehunter by Materials Research Laboratories, as well as several RAN and commercial paint systems, exhibited satisfactory adhesion to GRP panels under accelerated testing on the MRL rotor apparatus. This suggests that the paints would be suitable for application onto the GRP hull of the Minehunter.

2. However, all of the systems tested, except those with a chlorinated rubber or SPC finish, suffered some degree of surface deterioration during the exposure trial.

3. Initial ageing on the rotor apparatus affected the antifouling efficiency of the paint systems. The results confirm the importance of dynamic testing in the evaluation of antifouling compositions.

4. The results obtained will enable MRL to make specific recommendations on suitable paint systems for use on the hull of the Minehunter.

6. ACKNOWLEDGEMENTS

Mrs Karen Challis supplied the GRP panels and Mrs Veronica Silva carried out the SEM investigation for this trial, and their assistance is gratefully acknowledged.

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TABLE 1. DESCRIPTION OF PAINTS USED DURING THE TRIAL

PAINT CODE	DESCRIPTION	SPECIFICATION
PRIMERS		
AP1	Polyamide cured epoxy	
BP1	Metallic, Aluminium pigment	GPC-C-42/3
BP2	Polyamide cured epoxy	GPC-C-29
BP3	Epoxy	
CP1	Vinyl/tar, aluminium pigment	GPC-C-42/1/2/4
CP2	Vinyl/tar, aluminium pigment	GPC-C-42/1/2/4
FINISHES		
AF1	Synthetic resin base, Organotin and cuprous oxide biocides	GPC-C-42/5
AF2	Diesel-oil resistant antifouling formulation	
BF1	Organotin and thiuram biocides	
CF1	Chlorinated rubber base with organotin and cuprous oxide	
CF2	Organotin copolymer, copper compound pigments (SPC)	GPC-C-42/5

TABLE 2. PAINT SYSTEMS TESTED

SYSTEM			PRIMER	FINISH
a.	MRL	#1	i. clear epoxy ii. acrylic tie-coat*	AF1
		#2	clear epoxy	AF1
b.	ABR U6	#1	BP1	BF1
		#2	BP1	AF1
c.	Commercial	#1	CP1	CF1
		#2	CP1	CF2 (SPC)
		#3	CP2	CF1
		#4	CP2	CF2 (SPC)
		#5	BP2	BF1
		#6	BP3	BF1
		#7	AP1	AF1
		#8	AP1	AF2

* Based on "Acryloid B84" manufactured by Rohm & Haas.

TABLE 3. CONDITION OF PAINT SYSTEMS FOLLOWING 1000 HOURS EXPOSURE ON THE MRL DYNAMIC FLOW FACILITY

SYSTEM		CONDITION
a. MRL	#1	Significant smearing of surface layers of top coat.
	#2	Significant smearing of surface layers of top coat. Some pitting through to primer.
b. ABR U6	#1	Slight pitting.
	#2	Significant smearing of surface layers of top coat. Some pitting through to primer.
c. Commercial	#1	Intact
	#2	Intact
	#3	Intact
	#4	Intact
	#5	Numerous pitted areas
	#6	Some erosion and pitting of finish through to primer.
	#7	Significant smearing of surface layers of top coat.
	#8	Large amounts of pitting exposing undercoat.

TABLE 4. FREQUENCY OF MAJOR FOULING GROUPS ON PAINT SYSTEMS AFTER TWO MONTHS EXPOSURE ON THE WND RAFT

SYSTEM		TREATMENT[2]		FOULING ABUNDANCE[1] (%)			
				SLIME	ALGAE	BARNACLES	AMPHIPOD TUBES
a.	MRL	#1	E	100			+
			N/E	100			+
		#2	E	100			+
			N/E	100			+
b.	ABR	#1	E			3	52
			N/E	64		+	47
		#2	E	100			+
			N/E	100			
c.	Commercial	#1	E	98	77		+
			N/E	100			+
		#2	E	81	10		
			N/E	66	9		
		#3	E	80	58		
			N/E	100			+
		#4	E	92	6		+
			N/E	51	49		
		#5	E		17	28	62
			N/E	+		83	58
		#6	E	18	+		20
			N/E	4		23	100
		#7	E	100	2		+
			N/E	100			+
		#8	E	100	5	+	+
			N/E	12			
CONTROL[3]					100	18	95

1. + = Present in small numbers.
2. E = Previously exposed to dynamic flow.
   N/E = Not previously exposed to dynamic flow.
3. = Control also Tubeworms (Rating 23), Molluscs (2), Bryozoans (5) and Ascidians (47).

PLATE 1. Smeared surface of AF1 Finish (System MRL #2) after exposure to dynamic flow.

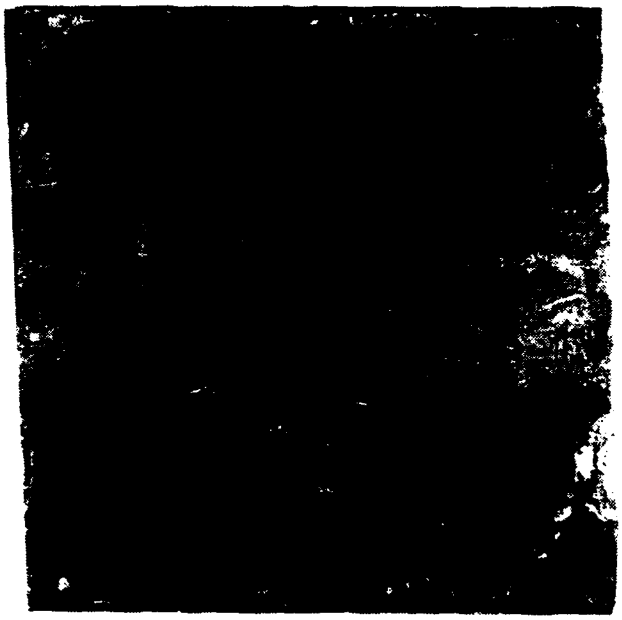
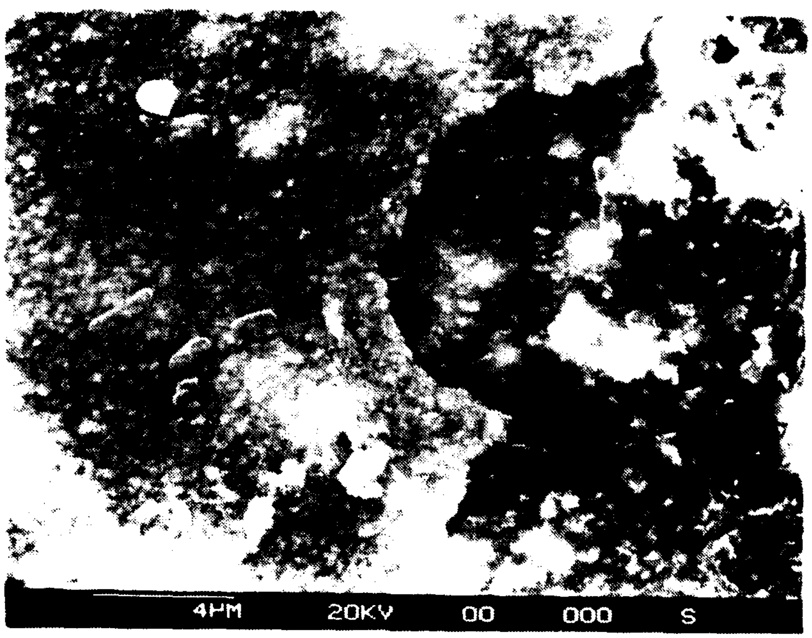


PLATE 2. Barnacle fouling on BF1 Finish (System c#5)

PLATE 3. Algal fouling on SPC Finish (System c#4)

PLATE 4. SEM micrograph of surface film covering SPC finish (System c#4)



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