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FINAL REPORT

LONG-TERM WEAR AND IMMERSION TESTS OF POLYMERIC COATINGS

CONTRACT NO. N68335-76-M-1629

PREPARED BY
R. D. Brown

D. L. Behmke

APPROVED BY

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This report describes an evaluation of four polymeric coatings, applied over AISI 4130 steel, subjected to conditions simulating those occurring in catapult accumulators used on Navy aircraft carriers. Both wear and immersion specimens were exposed to MIL-H-22072 Hydraulic Fluid which was heated to 160 F eight hours per day, five days per week for six months. Duplicate tests of each type were run. The wear (ring) specimens were also

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20. ABSTRACT (CONT'D)

subjected to reciprocating sliding motion against bronze block specimens under an eight-lb load. Evaluation criteria included coating wear life expressed as hours of sliding or sliding distance and corrosion resistance based on microscopic examinations of the immersion specimens. Principal wear results for the coatings were as follows: two Nylon 11 specimens and one LNP-ETF-2001 specimen exhibited no failure after six months of testing (1,226,000 ft sliding distance). Specimens which failed in the wear test were LNP-ETF-2001 (390,000 ft), Ryton P2 (1,160,000 and 390,000 ft), and Urethane 3699 (77,200 and 77,200 ft). In the immersion tests, all coatings provided good corrosion protection of the AISI 4130 base material.

I. INTRODUCTION

A. BACKGROUND. This report describes an evaluation of the wear and corrosion resistance of four polymeric coatings subjected to conditions simulating those experienced in catapult accumulators used on Navy aircraft carriers. This work is a consequence of an earlier, two-phase program described in NAEC-ENG-7884 Evaluation of Coatings for Air/Fluid Accumulators. In that program, involving both metallic and polymeric coatings, Nylon 11 coating failures were attributed to improper substrate preparation. In order to verify that conclusion, this program was undertaken using both Nylon 11 and three other polymeric coatings over carefully prepared substrates.

B. EVALUATION PLAN. The wear and corrosion resistance of four polymeric coatings were evaluated on the basis of long-term (6 month) tests. Both wear and immersion specimens were exposed to MIL-H-22072 Hydraulic Fluid which was heated to 160°F eight hours per day, five days per week for six months. The wear (ring) specimens were also subjected to reciprocating sliding motion against brass block specimens under an eight-lb load. Evaluation criteria were coating wear life expressed as hours of sliding or sliding distance and corrosion resistance based on microscopic examinations of the immersion specimens.

C. PROGRAM PERFORMANCE DATA. This program was performed at Southwest Research Institute under contract N68335-76-M-1629. The period of performance was from January 30, 1976 to February 28, 1977. The project leader at SwRI was R. D. Brown, Senior Engineer, Department of Materials Sciences.

II. SUMMARY

A. MATERIALS. Materials included Bronze Alloy No. 865; AISI 4130 steel; MIL-H-22072 Hydraulic Fluid, Catapult; and polymeric coatings Nylon 11, Ryton P2, LNP-ETF-2001 and Urethane 3699. The coatings were applied over a subcoating of flame-sprayed nickel-aluminide and MIL-P-23377 Primer.

B. PROCEDURES. Two types of tests were performed as follows:

1. Wear Test Procedures. Bronze block specimens were loaded against rotating polymeric-coated steel rings partially immersed in MIL-H-22072 fluid. Contact pressures, sliding speeds, and fluid temperatures simulated those experienced in service. The ring specimens were rotated eight hours each working day in a cyclic sequence: clockwise for 10 seconds, three seconds at rest, counterclockwise for 10 seconds, and three seconds at rest. The ring specimens were partially immersed in MIL-H-22072 Hydraulic Fluid which was heated to 160°F during the 8-hr rotation period. Wear test data included ring and block wear based on weight measurements and coating integrity based on post-test visual examination.

2. Immersion Test Procedures. Polymeric-coated steel coupons were immersed in MIL-H-22072 Hydraulic Fluid in the same two reservoirs in which the wear tests were conducted. These specimens were visually examined and weighed at one-month intervals during the six-month test duration. At the end of the test, the specimens were sectioned and examined microscopically to determine coating integrity.

C. RESULTS. Principal wear results for the coatings were as follows: two Nylon 11 specimens and one LNP-ETF-2001 specimen exhibited no failure after six months of testing (1,226,000 ft sliding distance). Specimens which failed were LNP-ETF-2001 (390,000 ft), Ryton P2 (1,160,000 and 390,000 ft), and Urethane 3699 (77,200 and 77,200 ft). In the immersion tests, all coatings provided good corrosion protection of the AISI 4130 base material.

D. CONCLUSIONS. The best overall performance was exhibited by the Nylon 11 coating. The other coatings, ranked in order of decreasing effectiveness, were LNP-ETF-2001, Ryton P2, and Urethane 3699.

E. RECOMMENDATIONS. The Nylon 11 coating is recommended as a promising material for evaluation in full-size or small-scale accumulators.

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VI. LONG-TERM WEAR AND IMMERSION TESTS OF POLYMERIC COATINGS

A. INTRODUCTION. This program involved the evaluation of the wear and corrosion resistance of four polymeric coatings subjected to conditions similar to those encountered in air/fluid catapult accumulators on Navy aircraft carriers.

1. Objective. The objective of this program was to evaluate the wear and corrosion resistance of four polymeric coatings subjected to long-term (6 month) exposure to MIL-H-22072 Hydraulic Fluid, Catapult at temperatures, loads, and sliding velocities simulating those encountered in air/fluid catapult accumulators.

2. Background. Considerable detail about the corrosion and wear problems encountered in air/fluid accumulators used in aircraft launching and arresting systems is presented in an earlier report, NAEC-ENG-7884. On the basis of that work, two metallic coatings, Tribaloy 800 and Nedox, were recommended as suitable for evaluation in small-size or full-size accumulators. In addition, further corrosion and wear evaluation of Nylon 11 coatings was recommended, with particular attention to coating applications parameters. The work reported herein is a consequence of the latter recommendation, expanded to include three other promising polymeric coatings.

B. TEST MATERIALS AND SPECIMENS. Test materials, coatings, and test fluid used in the evaluation tests, and the details of the wear and immersion test specimens are described in this section.

1. Specimen Materials. Two specimen materials were used in this program, as follows:

Material	Material Application in Accumulator	Material Application in Test Program
AISI 4130	Cylinders	Substrate material for coatings
Bronze alloy (QQ-C-390 Type I, Alloy No. 865)	Retraction engine bearing	Wear blocks

a. The AISI 4130 steel for the wear specimens was obtained as 1-3/4-in. diameter bar stock in the normalized condition; its composition and properties, as stated in the mill test report, are as follows:

Composition:	0.32C, 0.53 Mn, 0.009 P, 0.009S, 0.27 Si, 1.02 Cr, 0.21 Ni, 0.22 Mo, 0.13 Cu

Yield strength:	91,000 psi
Tensile strength:	96,500 psi
Elongation:	16%
Reduction of area:	53%
Brinell hardness:	207

Ring wear specimens were fabricated from this material without further heat treatment.

b. Steel Immersion Specimens. The steel corrosion specimens were fabricated from normalized AISI 4130 sheet material, 1/8-in. thick.

c. Bronze Specimens. Bronze Alloy No. 865 was obtained as 1-in. x 2-in. x 13-in. cast bars from which wear blocks were machined.

2. Coatings. Four different coatings were evaluated in this program. The coating types, compositions, and the organizations which applied the coatings are given in Table I.

3. Fluid. Wear and immersion tests were performed in MIL-H-22072 Hydraulic Fluid, Catapult. The test fluid was obtained from hydraulic fluid removed from in-service accumulators at time of overhaul. The as-received viscosity was 44.7 cs (centistokes), measured at 100°F.

4. Wear Specimen Details. Wear specimen geometry and dimensions are given in Figure 1. Hardness and initial surface roughness of the block specimens were 56-66 R_B and 15-30 μ in. CLA.

Coating thickness and initial weight data for the ring specimens are given in Table II.

5. Immersion Specimen Details. The immersion specimens consisted of 2-in. squares of 1/8-in. thick normalized AISI 4130 sheet. These specimens were ground on both sides to a thickness of 0.1185 in. Each of these specimens was coated all over. Small holidays at the corners of the immersion specimens were filled with sealer (Products Research and Chemical Corporation No. PR-1436-G A-2).

C. EQUIPMENT AND PROCEDURES

1. Wear Test Equipment and Procedures. The wear tests were run in the rig shown schematically in Figure 2. Eight tests can be run simultaneously in this rig, four at either end of the drive shaft. The major rig components are shown on the left side of Figure 2. The block specimens

are loaded against the rotating ring specimen by means of 8-lb weights and a pulley system. A timing motor and cam system is used to stop and reverse the motor to provide the simulated reciprocating motion. Thermocouples are used to measure fluid temperatures and to activate the temperature controller. A close-up view of one side of the test rig is shown in Figure 3.

a. Test Fluid Reservoir. The test fluid was contained in steel reservoirs (4-7/8-in. wide x 6-in. high x 14-5/8-in. long). The fluid level was maintained at a depth of 3-in., which was 1/8 inch above the bottom of the wear rings and completely covered the immersion specimens. Fluid viscosity was checked periodically and maintained in the range of 33.1 to 54.1 cs by adding hydraulic fluid or distilled water.

b. Test Conditions. Test conditions are given in Table III.

2. Immersion Test Equipment and Procedures. The immersion specimens were continuously exposed to test fluid for the six-month test duration.

a. Test Equipment. The immersion tests were conducted in the two wear test reservoirs. Four immersion specimens (one with each coating) were in each reservoir. These specimens were held in racks in a vertical position approximately 3/8-in. apart.

b. Test Procedure. Immersion specimens were removed from the reservoirs, visually examined and weighed at one-month intervals. At the end of the test, the specimens were also examined at low magnification (10-40X) and then sectioned and examined metallographically to establish the nature and extent of corrosive attack.

D. WEAR TEST RESULTS

1. Wear Data Summary. A summary of the data from the eight wear tests is given in Table IV. Wear data consists of weight changes of block and ring specimens.

2. Ring Wear. Examination of the data in Table IV shows that the two Nylon 11-coated rings exhibited the best performance in the wear tests. The coating on these rings was still intact at the end of the six-month test (4272 hr exposure and 1,226,000 ft of sliding) and diametral wear measured 0.002 and 0.003 in. in the two sets. The next best performance was exhibited by the LNP-ETF-2001 coating. The coating on one ring was still intact at the end of the test and diametral wear was 0.003 in. The coating on the second ring was dislodged from one-half of the circumference after 1344 hr exposure (390,000 ft). The Ryton P2 coating ranked third, one ring had failed at 4104 hr exposure (1,161,000 ft) and the other at 1344 hr (390,000 ft). The poorest performance was exhibited by the Urethane 3699

coating, both rings had failed at 696 hr (77,190 ft). At one-month intervals during the test, the ring specimens were weighed, these weights are given in Table V. Because of the competing mechanisms of wear (weight loss), absorption of fluid by the coatings (weight gain), and surface deposits on the rings (weight gain), it appears that the weight data has limited utility. As expected, low weight loss or weight gain, were observed (+0.0268 -0.0020,+ 0.0326) for the three coatings which survived the six-month wear test without failure. In all other tests, involving coatings which failed, weight losses ranged from 0.0847 to 0.1734 g. (See figures 4 to 7)

3. Block Wear. Block wear was low and nearly the same in the three tests in which the coatings remained intact: Nylon-11 0.1312 and 0.1376 g and LNP-ETF-2001 0.1313 g. Block wear was even lower (0.0713 and 0.0739 g) for the tests on Ryton P2 even though both Ryton P2 coatings failed. Apparently, these two tests were terminated soon after coating failure had occurred, since the bronze blocks wear rapidly when rubbing against the rough metal substrate to which the polymers are bonded. Severe wear of the bronze blocks was observed in the three tests (two involving Urethane 3699 coating and one involving LNP-ETF-2001 coating) in which all, or a large part of the coating was disrupted from the wear track.

E. IMMERSION TEST RESULTS. Three types of immersion test data were collected: specimen weight change with time, visual and low magnification examination, and microscopic examination of metallographic sections.

1. Specimen Weight Changes. The immersion specimens were weighed at one-month intervals throughout the six-month test; these data are given in Table VI. Weight gains were exhibited by all of the immersion specimens except the two with the LNP-ETF-2001 coating which exhibited very small weight losses (0.0005 and 0.0011 g). The accuracy of the weight loss data was probably adversely affected by the fact that the sealer material used on the holidays was softened by the exposure and some of this material was lost during handling and weighing.

2. Visual and Low Magnification Examination. Visual examinations of the immersion specimens were made at one-month intervals. No cracking, blistering or other coating deterioration was observed for any of the specimens during the first five months of the test. At the final visual examination, it was observed that one of the Nylon-11 specimens (No. 2) had a very small split at one corner. Using 40X magnification, rust was visible in this split. It is believed that this defect was caused during handling in earlier examinations and only became visible after the formation of rust. The only other defects observed during 40X examination were small rust patches at the corners of the Ryton P2 specimens (Nos. 11 and 12) where the sealer had come off. These are not considered to be

coating defects since the coating protected the steel substrate at all the areas away from the improperly sealed holidays. The immersion specimens are shown, before and after test in Figures 8-11.

3. Metallographic Examinations. All of the immersion specimens were sectioned and a piece of each specimen was mounted in plastic for metallographic examination. No blistering, cracking, debonding or other coating deterioration was observed during microscopic examination. Typical sections of each coating are shown in Figures 12-15. It was possible to determine polymeric coating and substrate coating thicknesses by microscopic examination, these data are given in Table VII along with the total substrate plus polymer coating as based on thickness measurements on ground specimens and on coated specimens before the immersion test. Slight differences in total coating thickness as determined by the two techniques are attributed to variations in coating thickness and to metal removed by abrasive blasting of the surfaces before application of the flame-sprayed nickel-aluminide coating (generally around 0.001-in. thick).

4. Coating Adherence. After pieces had been cut off the immersion specimens for metallographic examination, the remainder of the specimens were examined further. By using a razor blade it was possible to cut through the coatings and to separate the coating from the substrate. There was no evidence of blistering of the coatings and no rust under any of the coatings, indicating that all coatings were impervious to the MIL-H-22072 Hydraulic Fluid. There were however differences in the bond strength. The Nylon 11 and Urethane 3699 coatings were very tightly bonded and difficult to separate from the substrate. Both coatings were flexible. The Ryton P2 was tightly bonded but flaked off easily after inserting a razor blade between the coating and the substrate; this coating was brittle. The LNP-ETF-2001 coating was easily peeled from the substrate and was flexible.

F. DISCUSSION OF RESULTS. The sliding speeds, loads and specimen geometries used in this program are the same as those used in the 72-hr simulated catapult accumulator tests in Phase II of the earlier program described in NAEC-ENG-7884. It is of interest to compare the wear rates of the Nylon-11 coatings and contacting bronze blocks against those of the Tribaloy 800 coating (best metallic coating in the earlier program) and uncoated steel rings (tested in earlier program). The wear rates are as follows:

Coating Material	Avg. Wear Rate, in^3/rev. Ring	Avg. Wear Rate, in^3/rev. Bronze Block
Nylon -11	4.71×10^{-10}	3.13×10^{-10}
Tribaloy 800	0.32×10^{-10}	6.34×10^{-10}
None	0.41×10^{-10}	5.35×10^{-10}

The wear rate of the Nylon 11 is seen to be about 15 times that of the Tribaloy 800 and the wear rate of the bronze rubbing on Nylon 11 is about one-half that of bronze on Tribaloy 800. Neither coating was appreciably better, from the standpoint of wear alone, than the uncoated steel. The principal advantage of the coatings is the reduction of corrosion. In the earlier program, severe corrosive attack of uncoated steel specimens was observed following 273 days exposure. In the present program, involving 178 days exposure, all four of the polymeric coatings provided complete protection of the steel immersion specimens.

G. CONCLUSIONS. On the basis of the test results and analyses reported herein, the major conclusions are as follows:

1. The Nylon 11 coating exhibited the best performance in the wear tests; no coating failure had occurred in either of two tests after 1,226,000 ft of sliding contact with bronze blocks under 8-lb load (102 psi).

2. A second coating, LNP-ETF-2001 provided the second best performance--one specimen survived 1,226,000 ft of sliding without failure and the other specimen had failed at 390,000 ft of sliding.

3. Two other coatings, Ryton P2 and Urethane 3699, exhibited coating failures before the end of the test.

4. All four coatings provided good corrosion protection of the AISI 4130 steel base material. No coating failures were observed on any of the immersion specimens.

5. No quantitative measure of coating bond strength was obtained, but on the basis of manually peeling strips off of the immersion specimens, the coatings ranked in order of decreasing adherence as follows: Nylon 11, Urethane 3699, Ryton P2, and LNP-ETF-2001.

6. The wear rate of the Nylon 11 coating, tested in this program, was 15 times that of the Tribaloy 800 coating which exhibited the best overall performance of metallic coatings tested in an earlier program (see NAEC-ENG-7884).

7. The wear rate of bronze blocks rubbing agains the Nylon 11 was approximately one-half that of bronze rubbing against Tribaloy 800 (see NAEC-ENG-7884).

H. RECOMMENDATIONS. On the basis of the coating evaluation program reported herein, recommendations are as follows:

1. It is recommended that two coatings should be evaluated in reduced-size or full-size accumulators under conditions simulating those existing during actual catapult accumulator operations. One of these coatings is Nylon 11, which provided the best overall performance of the polymers, as reported herein. The other coating is Tribaloy 800 which provided the best overall performance of the metallic coatings tested earlier, as reported in NAEC-ENG-7884.

VII. TABLES

TABLE I. IDENTIFICATION OF POLYMERIC COATINGS

Coating[a]	Polymer Manufacturer
Nylon 11	Rilsan Glen Rock, New Jersey
Ryton P2	Phillips Petroleum Co. Bartlesville, Oklahoma
LNP-ETF-2001	Liquid Nitrogen Processing Co. Malvern, Pennsylvania
Urethane 3699 (DuPont)	DuPont Wilmington, Delaware

a. The AISI 4130 steel specimens were coated with flame-sprayed nickel-aluminide at NAEC. MIL-P-23377 primer was used on all specimens. The polymer coatings were applied by an electrostatic method at NADC.

TABLE II. RING SPECIMEN PRE-TEST DATA

Specimen No.	Coating	Outside Diameter, in. Before Coating	Outside Diameter, in. After Coating	Coating Thickness[a], in.	Weight, g	Used in Test Reservoir
1	Nylon 11	1.480	1.498	.009	56.0180	A
2	Nylon 11	1.480	1.498	.009	54.3695	B
4	Ryton P2	1.479	1.505	.013	53.4584	A
5	Ryton P2	1.479	1.509	.015	54.3521	B
7	LNP-ETF-2001	1.480	1.492	.006	53.8042	A
8	LNP-ETF-2001	1.480	1.493	.0065	54.3193	B
10	Urethane 3699	1.481	1.493	.006	54.4888	A
11	Urethane 3699	1.480	1.501	.0105	55.1583	B

a. Includes sub-coatings and primers,

TABLE III. WEAR TEST CONDITIONS

Condition	Condition Value
Normal load, lb.	8
Contact pressure, psi	100
Fluid temperature, F	160
Cycle sequence	
Time forward, sec	10
Time off, sec	3
Time reverse, sec	10
Time off, sec	3
Maximum speed, rpm	65
Maximum sliding speed, fpm	25.5
Test duration, month	6
Test schedule	
Cyclic operation, hrs/day	8
Test operation, days/week	5
Total cycles, approximate	144,000
Total cylinder revolutions, approximate	3,120,000
Total sliding distance, approximate, ft	1,173,800
Block material	Bronze

TABLE IV. WEAR TEST DATA

Coating	Reservoir	Test Duration, hr. Exposure	Test Duration, hr. Sliding	Revolutions	Ring Weight Change, g	Ring Diametral Change, in.	Brass Block Weight Change, g
Nylon 11	A	4272	1077	3,121,840 (1.226×10^6 ft)	+0.0268	-0.002	-0.1376
Nylon 11	B	4272	1077	3,121,840 (1.226×10^6 ft)	+0.0326	-0.003	-0.1312
Ryton P2	A	4104	1047	2,957,402 (1.161×10^6)	-0.1002	-0.010[a]	-0.0713
Ryton P2	B	1344	330	992,809 (0.390×10^6)	-0.1416	-0.009[b]	-0.0739
LNP-ETF-2001	A	1344	330	992,809 (0.390×10^6)	-0.0851	-0.006[c]	-0.3308
LNP-ETF-2001	B	4272	1077	3,121,840 (1.226×10^6)	-0.0020	-0.003	-0.1313
Urethane 3699	A	696	27	77,190 (30,300)	-0.0847	-0.010[d]	-0.3403
Urethane 3699	B	696	27	77,190 (30,300)	-0.1743	-0.010[d]	-0.6212

a. Circumferential grooves worn through coating around complete circumference.
b. Coating intact in wear track but it has separated in adjacent areas.
c. Coating gone on one-half of circumference, measurement includes intact coating on one side of ring.
d. Coating gone over complete circumference.

TABLE V. RING WEAR SPECIMEN WEIGHT DATA

Month	Nylon 11		Ryton P2		LNP-ETF-2001		Urethane 3699	
	A(1)[a]	B(2)	A(4)	B(5)	A(7)	B(8)	A(10)	B(11)
0	56.0180	54.3695	53.4584	54.3521	53.8042	54.3193	54.4888	55.1583
1	56.0458	54.4069	53.4389	54.3207	53.8000	54.3234	54.4442	55.0206
2	56.0459	54.4104	53.4083	54.2244	53.7226	54.3167	–	–
3	–	–	–	–	–	–	–	–
4	56.0415	54.4092	53.4006	–	–	54.3140	–	–
5	56.0460	54.4045	53.3635	–	–	54.3140	–	–
6	56.0448	54.4021	53.3582	54.2105	53.7191	54.3173	54.4041	54.9840
Change	+0.0268	+0.0326	-0.1002	-0.1416	-0.0851	-0.0020	-0.0847	-0.1743

a. Letter represents test reservoir; specimen number in parentheses.

TABLE VI. IMMERSION SPECIMEN WEIGHT DATA

Weights in grams

	Nylon 11		Ryton P2		LNP-ETF-2001		Urethane 3699	
Month	A(1)[a]	B(2)	A(4)	B(5)	A(7)	B(8)	A(10)	B(11)
0	61.6357	61.7637	68.9859	63.2754	61.0183	61.2313	61.2453	65.7288
1	61.7103	61.8515	69.0731	63.3141	61.0305	61.2444	61.4718	65.9308
2	61.7181	61.8524	69.2104	63.3150	61.0246	61.2450	61.5170	65.9340
3	61.6890	61.8214	69,2119	63.3079	61.0242	61.2373	61.2863	65.8390
4	61.6875	61.8229	69.2115	63.3063	61.0170	61.2336	61.3516	65.8290
5	61.6953	61.8330	69.2114	63.3100	61.0200	61.2376	61.4463	65.9354
6	61.6785	61.8130	69.2116	63.2955	61.0178	61.2302	61.3149	65.8019
Change	+0.0428	+0.0493	+0.2257	+0.0201	-0.0005	-0.0011	+0.0696	+0.0731

a. Letter represents test reservoir; specimen numbers in parentheses.

TABLE VII. THICKNESS OF POLYMERIC COATINGS AND SUBSTRATE COATINGS ON IMMERSION SPECIMENS

Coating	Total Coating Thickness[a], in. by measurement	by microscopy
Nylon 11		
No. 1	0.009	0.012
No. 2	0.011	0.015
No. 3 (not immersed)	0.008	0.010
Ryton P2		
No. 10	0.028	0.033
No. 11	0.019	0.019
No. 12 (Not immersed)	0.024	0.024
LNP-ETF-2001		
No. 4	0.006	0.006
No. 5	0.006	0.005
No. 6 (Not immersed)	0.006	0.004
Urethane 3699		
No. 7	0.008	0.013
No. 8	0.014	0.015
No. 9 (Not immersed)	0.010	0.009

a. Includes flame-sprayed nickel-aluminide.

VIII. FIGURES

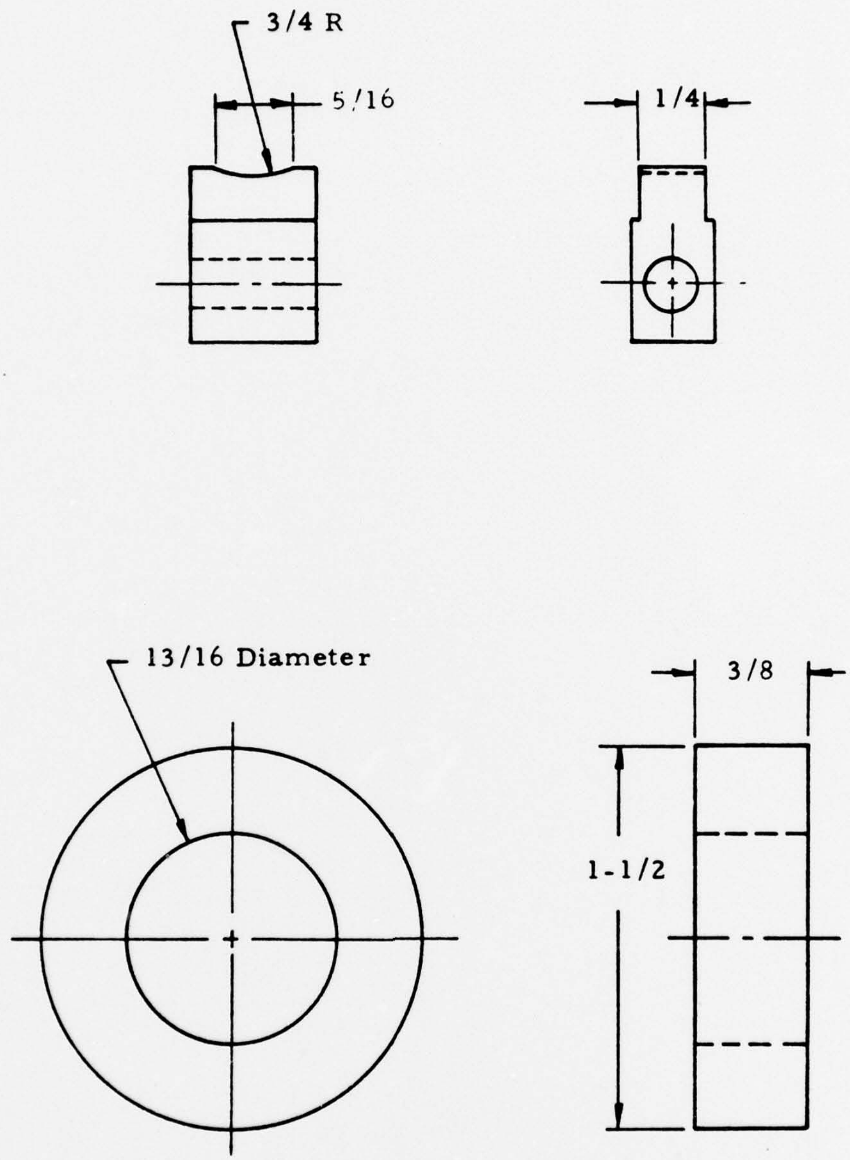


FIGURE 1. WEAR SPECIMENS.

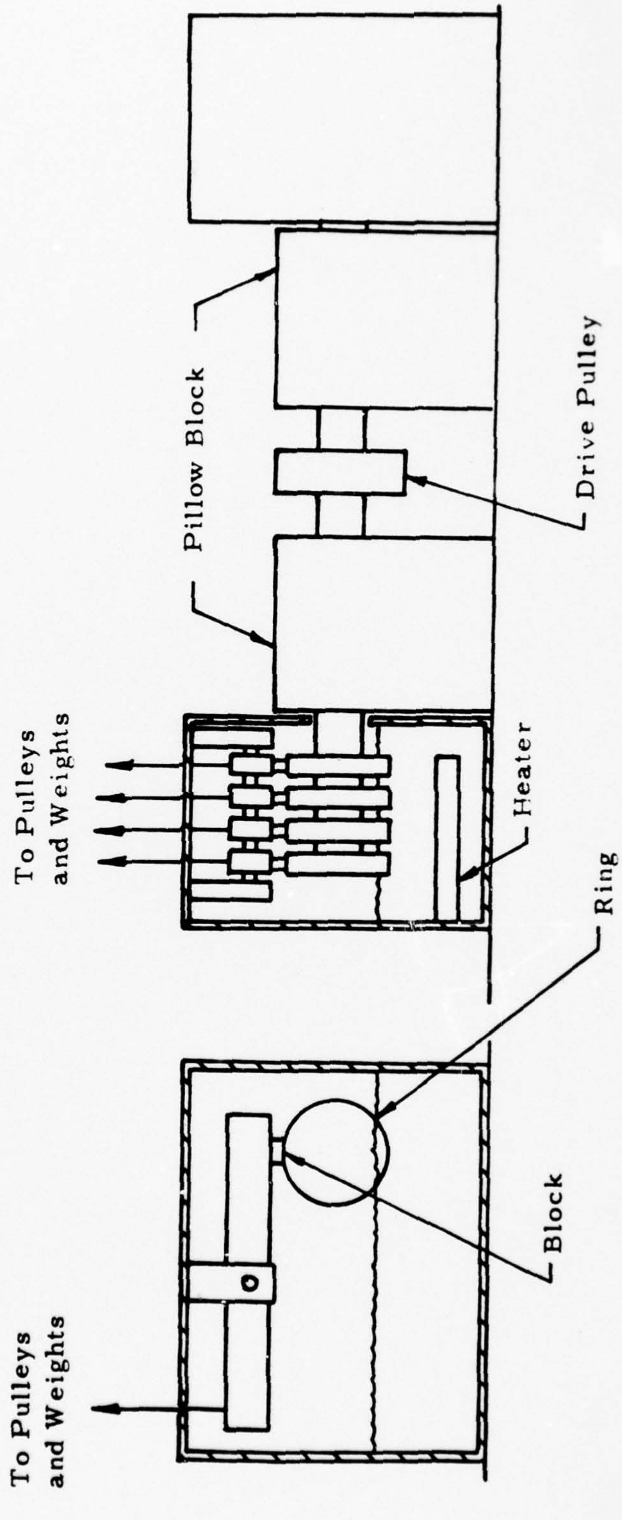


FIGURE 2. SCHEMATIC OF WEAR TEST RIG.

FIGURE 3. PHOTOGRAPH OF WEAR TEST RIG.

(a) Before Test

(b) After Test

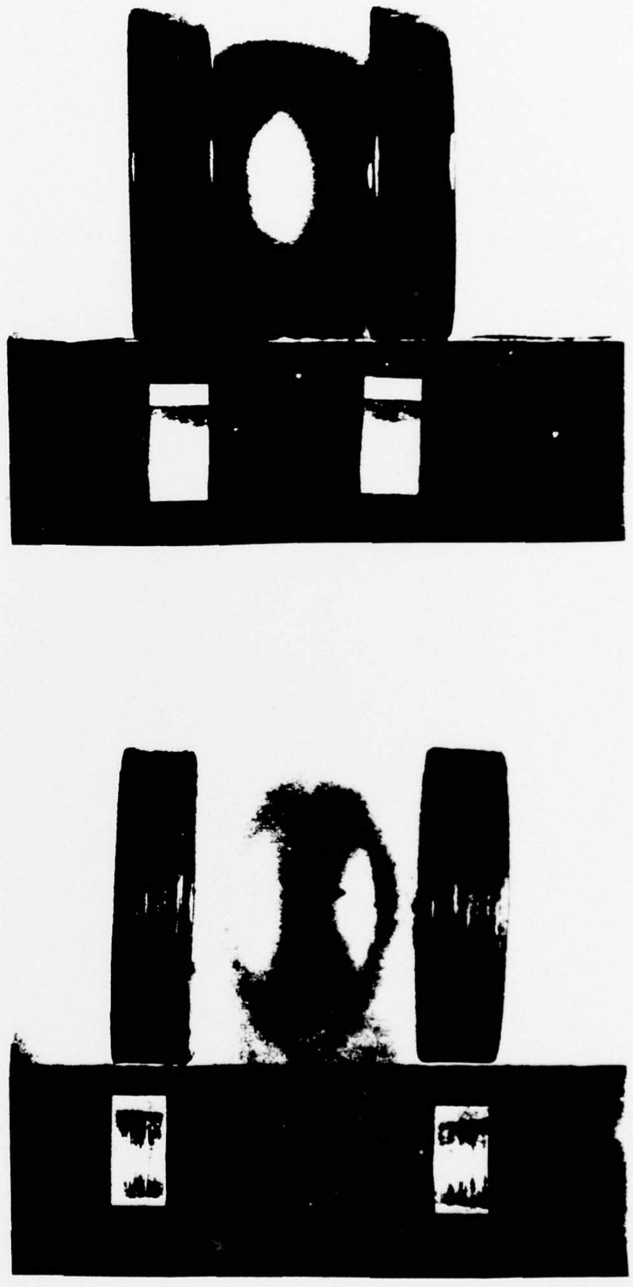
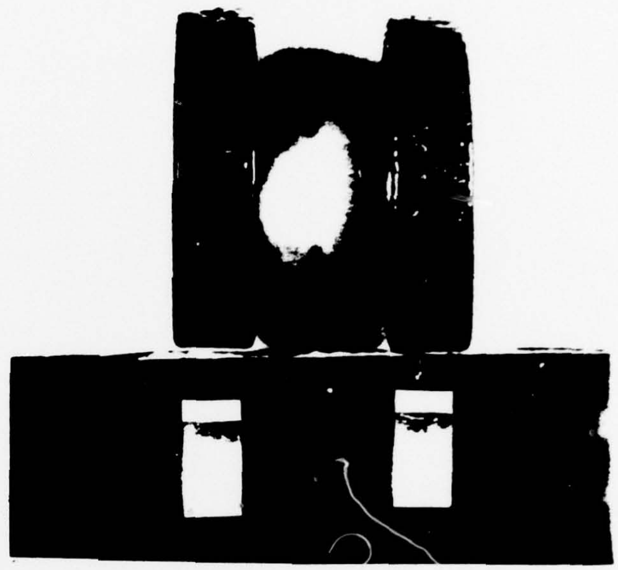


FIGURE 4. NYLON 11 WEAR SPECIMENS.

(a) Before Test



(b) After Test

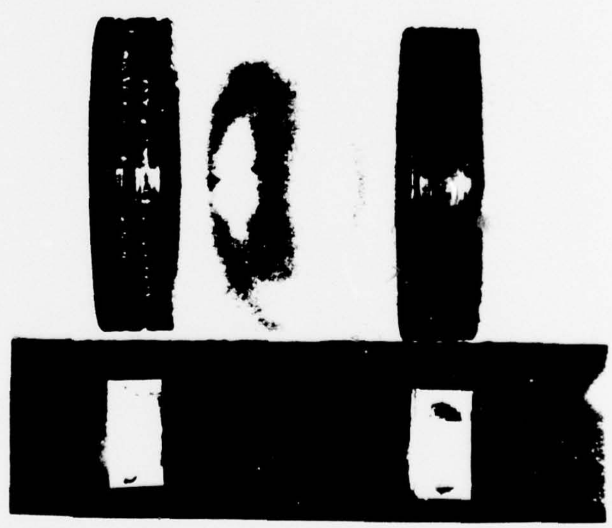
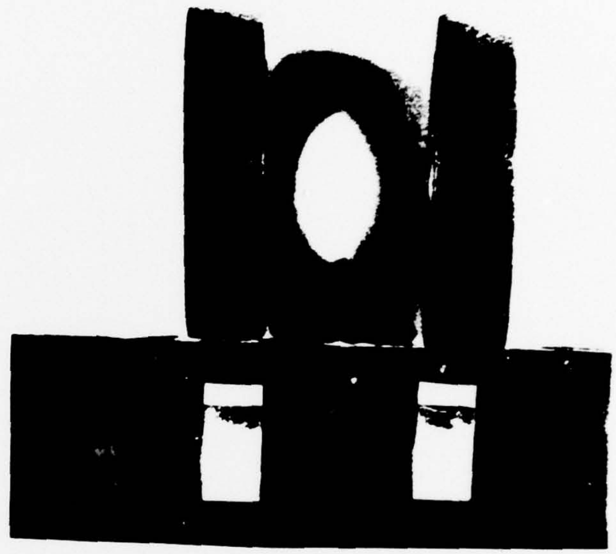


FIGURE 5. RYTON P2 WEAR SPECIMENS.

(a) Before Test



(b) After Test

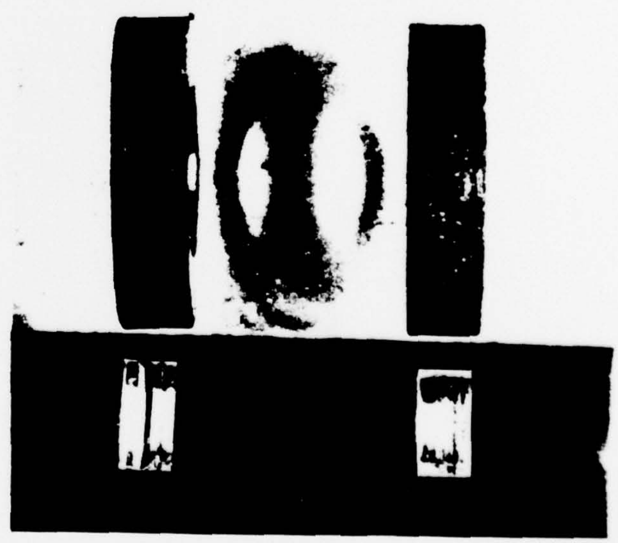
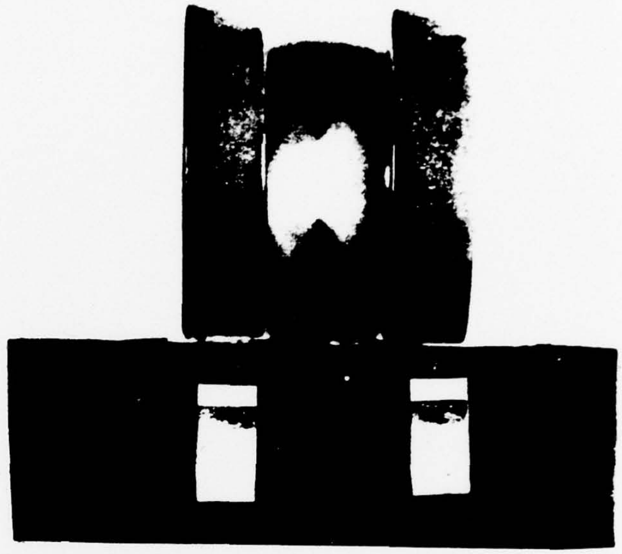


FIGURE 6. LNP-ETF-2001 WEAR SPECIMENS.

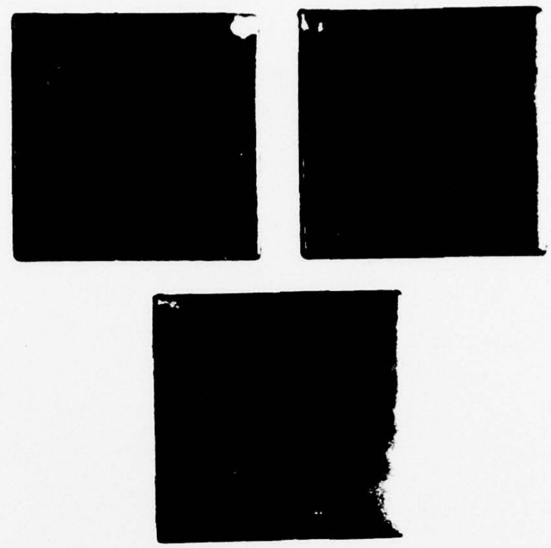
(a) Before Test



(b) After Test

FIGURE 7. URETHANE 3699 WEAR SPECIMENS.

(a) Before Test



(b) After Test

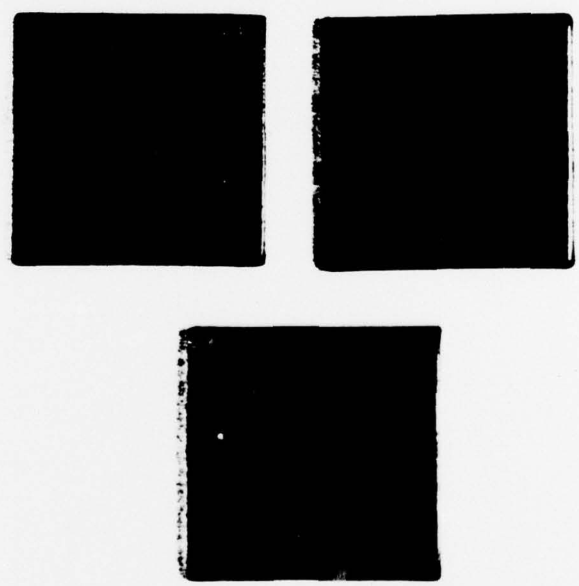
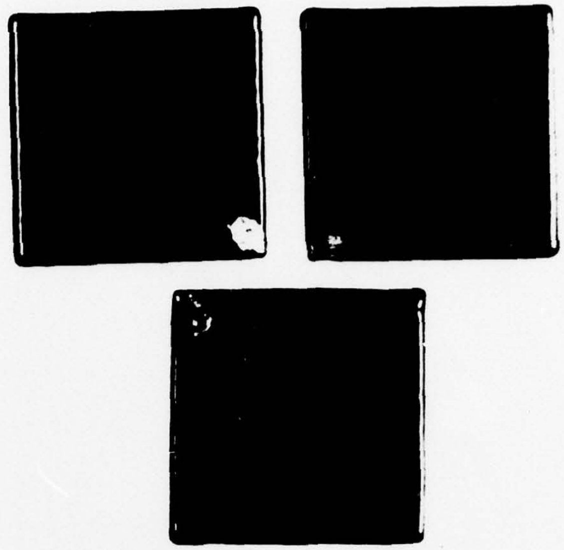


FIGURE 8. NYLON 11 IMMERSION SPECIMENS.

(a) Before Test



(b) After Test

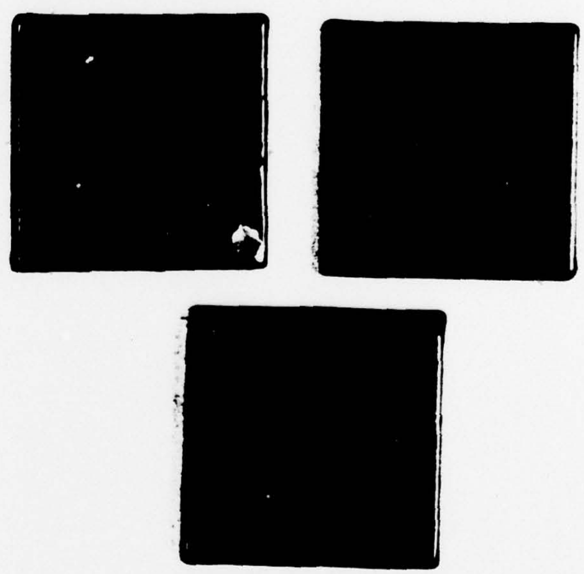


FIGURE 9. RYTON P2 IMMERSION SPECIMENS.

(a) Before Test

(b) After Test

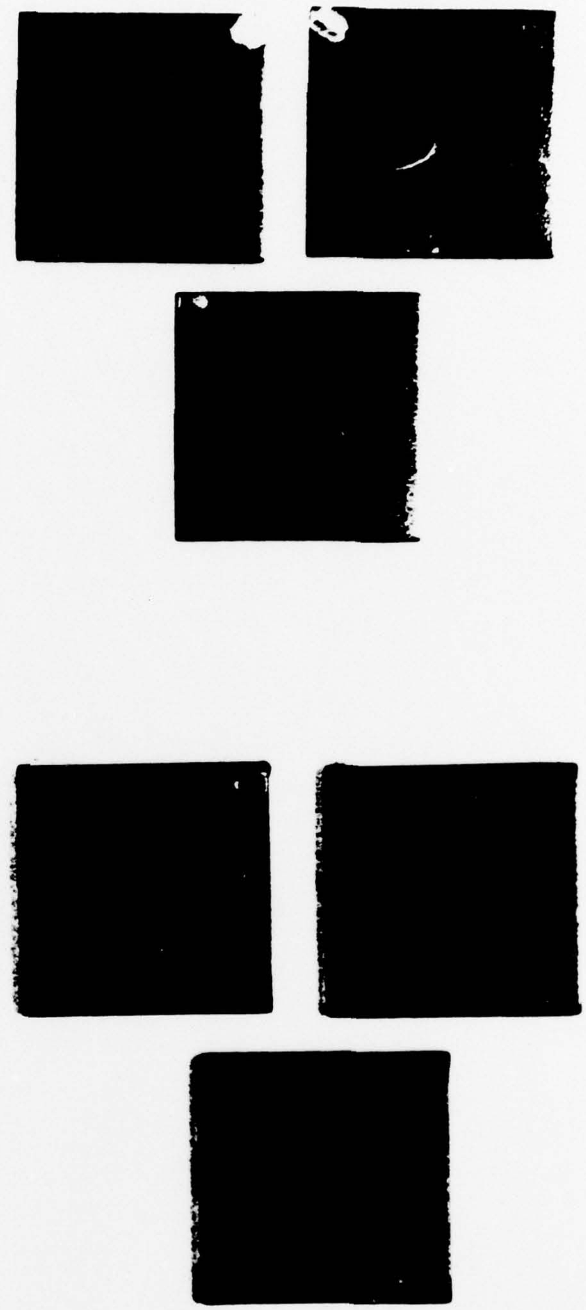
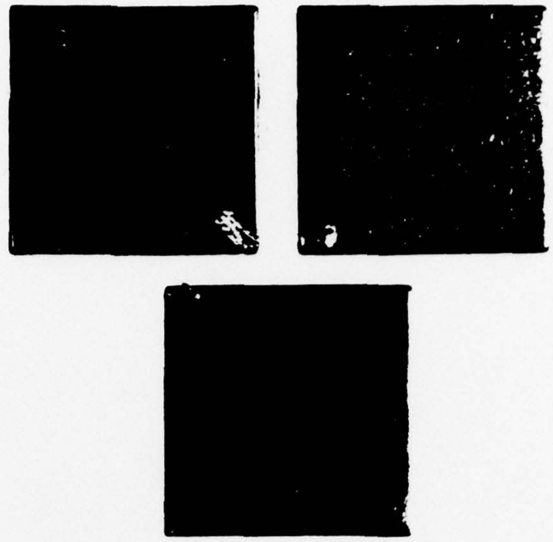


FIGURE 10. LNP-ETF-2001 IMMERSION SPECIMENS.

(a) Before Test



(b) After Test

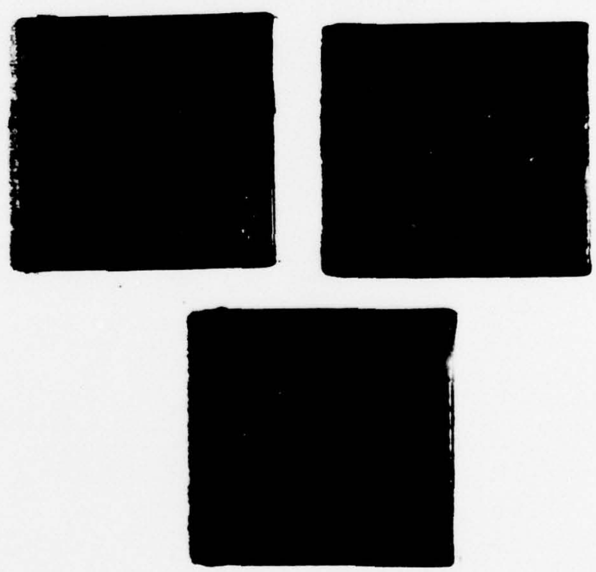


FIGURE 11. URETHANE 3699 IMMERSION SPECIMENS.

(a) Specimen No. 1
(after immersion test)

Nylon 11

Subcoat

Steel

(b) Specimen No. 2
(after immersion test)

(c) Specimen No. 3
(not tested)

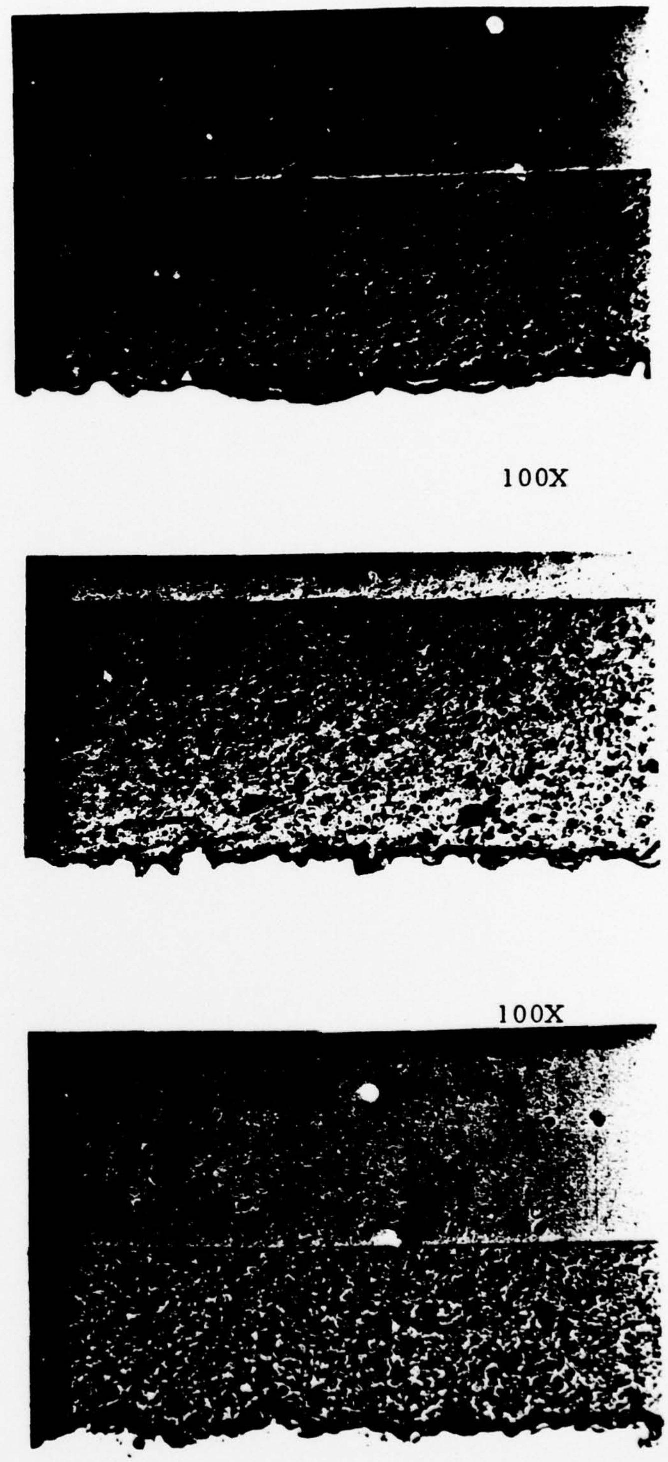
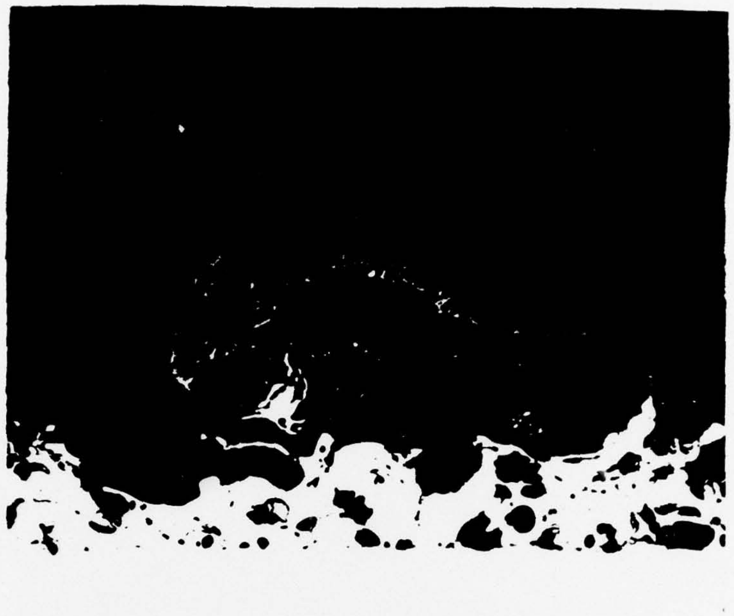
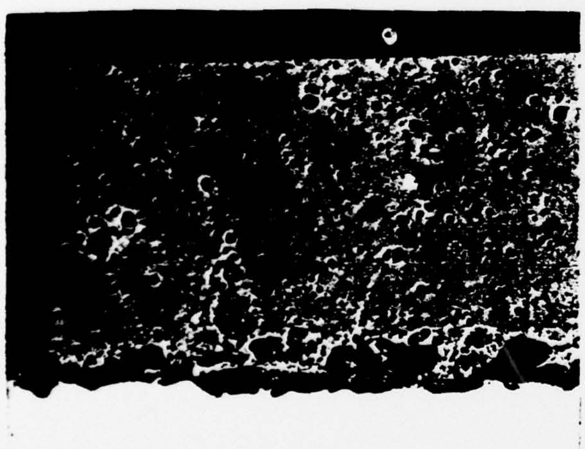


FIGURE 12. SECTIONS OF NYLON 11 IMMERSION SPECIMENS.



(a) Specimen No. 10 (after immersion test)



(b) Specimen No. 11 (after immersion test)

(c) Specimen No. 12 (not tested)

FIGURE 13. SECTIONS OF RYTON P2 IMMERSION SPECIMENS.

(a) Specimen No. 4
(after immersion test)

LNP-ETF-2001

Subcoat

Steel

100X

(b) Specimen No. 5
(after immersion test)

100X

(c) Specimen No. 6
(not tested)

100X

FIGURE 14. SECTIONS OF LNP-ETF-2001 IMMERSION SPECIMENS.

(a) Specimen No. 7
(after immersion test)

Urethane 3699

Subcoat

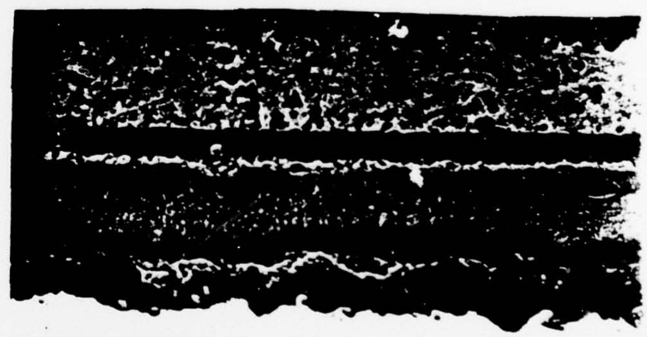
Steel

100X

(b) Specimen No. 8
(after immersion test)

100X

(c) Specimen No. 9
(not tested)



100X

FIGURE 15. SECTIONS OF URETHANE 3699 IMMERSION SPECIMENS.

Long-Term Wear and Immersion Tests of Polymeric Coatings | NAEC-ENG-7934

Four polymeric coatings were evaluated for wear and corrosion protection of AISI 4130 steel under conditions simulating those in catapult accumulators on aircraft carriers. On the basis of six-month wear and immersion tests in MIL-H-22072 Hydraulic Fluid, Nylon 11 provided the best wear resistance followed by, in order of decreasing effectiveness, LNP-ETF-2001, Ryton P2, and Urethane 3699. All four coatings provided good corrosion resistance based on the six-month static immersion tests.

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