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ACCELERATED CORROSION STUDY OF PRIMERS FOR MARK 82 BOMBS

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ABSTRACT

This evaluation was conducted to provide information on the comparative corrosion protection properties of ten different primers applied to MK82 bombs. The processing requirements and characteristics of the candidate primers, costs, and the accelerated corrosion test results were considered in determining the selection of a replacement primer(s).

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BACKGROUND

HQ USAF/LEYW, Munitions and Missile Division Office and PRAM, HQ AFALD, HQ ASD requested the technical support of this agency in the investigation of a wide spread corrosion problem being encountered with bombs at outdoor storage sites. More than 100,000 Mark 82 five-hundred pound bombs stored at Guam are involved (see photos #1 and #2). The bombs have been in outside storage on the island since the 1974 cessation of bombing activities in S.E. Asia. SAC efforts to obtain inside storage at Guam were unsuccessful. The following excerpt from PRAM's Statement of Work, dated 13 April 1981, on the Bomb Corrosion Control Project, describes the bomb corrosion problem at Andersen AFB, Guam:

"- - - the following conditions usually appear on newly renovated bombs one-two years after maintenance: Moderate to heavy rust present on outer booster/fuze well threads; set screws rusted in place; scale rust under the nose cap; corrosion and rust inside the booster and fuze well; light to heavy rust on the exterior bomb body; deteriorated nose/tail plugs which break under pressure; base metal and cadmium plating on the bomb lugs corroded, as well as rusted in some cases, and finally the markings become illegible. The ultimate outcome of this problem is that these 100,000 bombs worth some \$47,000,000* will eventually be declared unserviceable and destroyed unless a long term solution can be found."

Currently, thirty workers are employed in a \$1.5 million bomb renovation plant at Guam. Though high humidity, high ambient temperatures, excessive sunlight and exposure to salt laden atmosphere have made Guam the location of the most severe problem, costly AF losses have also occurred at other AF bases. Corroded bombs that have been renovated three times by abrasive blasting of the fuze wells must be destroyed by detonation. This is necessary because of the reduction in the wall thickness of the fuze wells, resulting from corrosion and abrasive blasting, could result in a complete collapse of the fuze wells under the pressure exerted by the TNT within the bomb. The replacement cost per bomb is \$1,180.

The environmental simulation facilities and technical capabilities of this agency were volunteered to evaluate various primer coatings. The Air Force Packaging Evaluation Agency (AFPEA) has one of the few walk-in rain/salt fog chambers in the Department of Defense (DOD) large enough to accommodate test bombs (see photo #3).

*The \$47,000,000 figure in the PRAM Statement of Work is outdated. The actual replacement cost of the bombs is currently \$118,000,000.

PREPARATION OF TEST SPECIMENS

Ten different primers selected for evaluation, together with a top coat material, were applied to sets of empty bombs, fins, and test panels. Table 1 lists for each candidate primer the sponsoring AF activity, name of the person who was technically responsible for its application, and the manufacturer and commercial designation of the primer system. The following sequence was followed in preparation of the test specimens:

1. Empty and opened MK82 General Purpose 500-Pound Bombs, conical fins, and one square foot steel panels were abrasive blasted using steel shot on bombs and glass beads on fins and steel panels. CMSgt George E. Landers, HQ USAF/LEYW, and CMSgt James N. Elledge, HQ SAC/LGWC, directed the operations. Processing was equivalent to the automatic blasting specified in T.O. 11A1-5-7, the applicable technical manual for storage and maintenance procedures.

2. The test specimens were immediately wrapped in heavy kraft paper and taped after the automated steel shot or glass bead blasting.

3. The wrapped specimens were double wrapped in MIL-B-131 barrier material and sealed with 2-inch wide filament tape.

4. Test specimens were transported to a heated painting facility and remained wrapped until ready for grit removal, priming and top coating. Residual grit was removed with oil free compressed air.

5. Primers selected for test together with a MIL-C-83286 top coat were applied by the 4750th Test Wing personnel under technical guidance provided by the individuals listed in Table 1. Two primers were used on specimen #7, an Emerson and Cuming epoxy on the nose and a Witco coating on the center and tail sections. All primers except the Witco material on specimen #7 and the CMT product on specimen #8 were applied by spraying. These primers were too viscous for spraying and therefore were applied by brush. The technical advisors supervised the application of the coatings for which they were responsible. The interval between applications of the primer and top coat was 30 minutes. The decision was made to assure standardization after specimens #1 and #2 had been processed in that manner. For bomb renovation at Guam the nominal interval used is five to ten minutes. The manufacturers' prescribed minimum intervals varied from five minutes for Capsulated Systems, Inc. (specimen nos. 9 and 10), to more than four hours for Witco (specimen #7). The intervals between the application of the top coat and the beginning of the salt fog evaluation were in the 24 to 90 hour range. Processing equipment breakdown was responsible for the unplanned weekend break in the painting program. Specimen Nos. 1, 2, 5, and 7 were primed and painted Friday, 5 March 1982. They, therefore, received the benefits of the longer curing periods prior to the salt fog evaluation.

6. Primed and painted bombs were palletized; bombs, fins, and panels were transported to AFPEA.

TEST PROCEDURES

Film Thickness. Coating thickness measurements were made on the bombs and fins by Mr. Sidney Childers, AFWAL/MLSA. Readings were witnessed and recorded by Mr. Avery Watson, AFALD/PTPT. A Type EC4e-2TX-DC 150 isoscope manufactured by The Twin City Testing Corporation, Tonawanda, N. Y., was used to make the eddy current measurements.

Salt fog test, ASTM B117-73, "Standard Method of Salt Spray (Fog) Testing."
The salt fog test evaluation was performed in the following sequence:

a. Test specimens were first subjected to 500 hours of salt fog IAW ASTM B117.

b. The salt fog was followed by five minutes of rain @2"/hour, then four minutes of rain @5"/hour and finally ten minutes of rain @2"/hour. The test specimens were then fan dried and removed from the chamber.

c. The specimens were inspected, photographed and evaluated. Those which were considered to be in satisfactory condition were returned to the chamber. Selection of specimens for continued testing was made by Mr. Stanley Norick, HQ AFLC/LOWM, Capt John Wagner, ASD/AEMOF(RA), and Mr. Avery Watson, AFALD/PTPT.

d. Specimens were subjected to an additional 250 hours of salt fog. The positions of the bombs and fins were rotated to insure maximum uniformity of exposure.

e. Step b. was repeated.

f. Specimens were inspected, photographed and evaluated.

g. Panel and fin specimen nos. 9 and 10 were sent to AFWAL/MLU for identification of the white corrosion products on their surfaces.

h. Specimens were subjected to an additional 250 hours of salt fog. The positions of the bombs and fins in the chamber were changed again.

i. Step b. was repeated.

j. Specimens were inspected, photographed, and evaluated.

k. Panel and fin specimen nos. 9 and 10 were again sent to AFWAL/MLU for analyses. AFWAL/MLU was requested to determine the percentages of chlorides in the white deposits on the surfaces.

EVALUATION PARAMETERS

After each of the three exposure periods to salt fog, the sets of bombs, fins, and panels were evaluated. Four parameters were considered in determining the relative merits of the ten primers. The most important parameter was the demonstrated ability to prevent corrosion of steel, the base material. At the 2 March 1982, Bomb Corrosion Control Conference, it was decided that the internal "plumbing" of the bombs should be completely exposed, though this was not typical of service conditions (see Figure 1). This decision was made to simulate a "worse" case situation with regard to corrosion potential. Compatibility of the primer with the MIL-C-83286 polyurethane top coat was also considered to be a very important parameter. For AF applications, the MIL-C-83286 top coat is most widely used on ground support equipment. Compatibility determinations were made IAW Federal Test Method Standard 141, Method 6301.1, Wet Adhesion, Tape Test.

Two significant parameters of lesser importance are primer stability and legibility of markings. Bleeding through or separation of the primer component(s) may be an indication of latent primer instability. Legibility of bomb markings has been a persistent problem. As a potential solution, HQ AFLC/LOWM has given serious consideration to metal stamping. Though labor intensive, the method would insure the retention of lot numbers and other critical information. Primer stability and legibility of markings were evaluated visually.

RESULTS

Coating thicknesses. Film thicknesses on bombs and fins were determined using methods described in the Test Procedures section. The results are presented in Table 2.

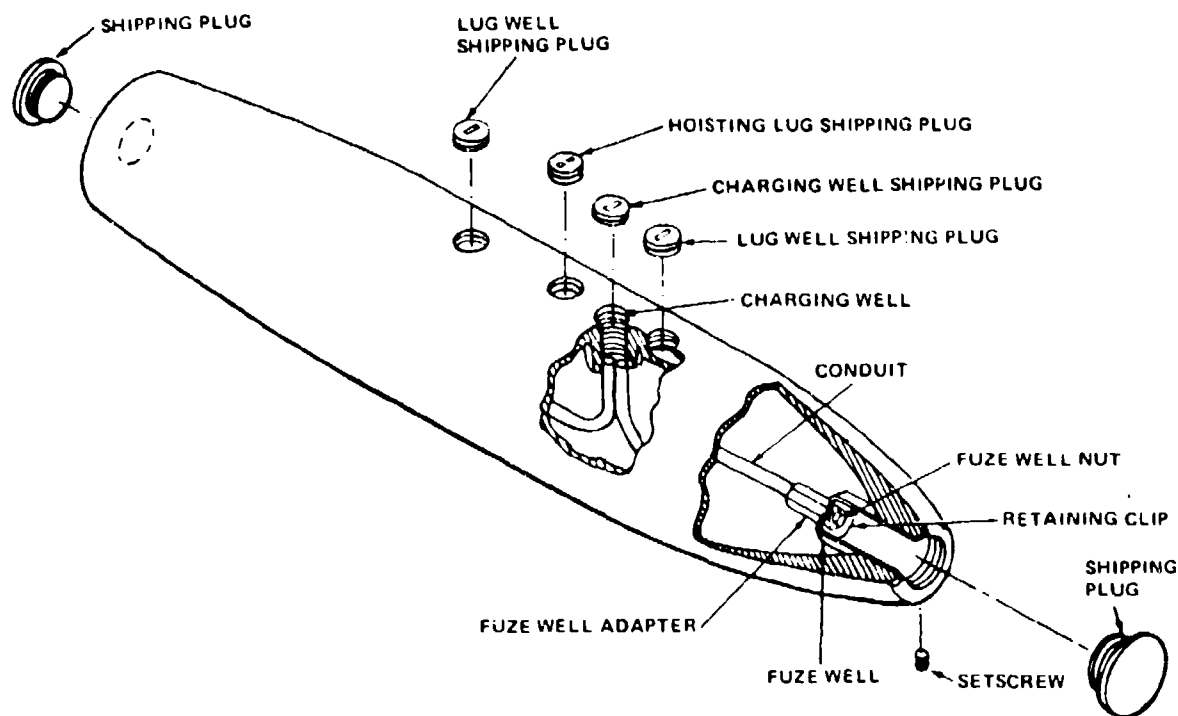


FIGURE 1. Bomb Parts

Five-hundred hours salt fog. Salt fog exposure was terminated on four of the ten specimens after 500 hours. Specimen nos. 1, 2, and 5 had experienced excessive corrosion (see photo nos. 4 thru 8). Specimen No. 6 was withdrawn from test because the peeling was an indication of very obvious and major incompatibility (see photo no. 9). Salt fog exposures were continued for specimen nos. 3, 4, 7, 8, 9, and 10. There were white deposits on the surfaces of specimen nos. 9 and 10. The deposits were on bombs, fins, and panels; however, they were most pronounced on the steel panels. On panel no. 9, the white deposits covered approximately 30% of the surfaces. On panel specimen no. 10, the coverage was approximately 75%. The deposits were relatively insoluble in water.

Seven-hundred fifty hours salt fog. Primers on specimen nos. 3, 4, 9, and 10 provided better corrosion resistance than products used on specimen nos. 7 and 8. Although specimen nos. 7 and 8 were no longer considered as viable "candidates" after the 750 hour salt fog exposure, because of the excessive rust that was visible, salt fog exposure was not terminated. Though corrosion was present on specimen nos. 7 and 8 it was not of the extent present on specimens discontinued after 500 hours. Continuation of salt fog to 1,000 hours should and did provide more definitive corrosion resistance evaluations for specimen nos. 7 and 8.

There were slight increases in the amounts of white substances on the surfaces of panel nos. 9 and 10. Substances on the surfaces of these panels and fins were analyzed and the concentrations of metallic elements that were identified are listed in Table 3. Adhesion tests were conducted to determine the effectiveness of the primer-top coat bonds. The results are provided in Table 4. Note that there was a critical loss of adhesion on bomb specimen no. 10.

One-thousand hours salt fog. Though bombs, fins, and panels designated specimen no. 10 had a lower average coating thickness than specimen nos. 3, 4, and 9, the zinc rich acrylic primer manufactured by CSI provided unquestionably superior corrosion resistance (see photo nos. 10 thru 13). Specimen nos. 4 and 9 were rated as good and very good, respectively, as regards corrosion resistance. Specimen no. 4 is the MIL-P-26915 zinc rich epoxy primer manufactured by Crown Metro Incorporated, and provided by AFWAL/MLSA. Specimen no. 9 is the EDM-2 microencapsulated zinc rich epoxy primer manufactured by CSI under a PRAM contract. There was less corrosion in the nose fuze well of specimen no. 4 than on specimen no. 9 (see photo nos. 14 and 15). There was less evidence of corrosion on the tail fuze well and fin of specimen no. 9 than on specimen no. 4's tail fuze well and fin (see photo nos. 16, 17, and 18). After 1,000 hours salt fog some surface areas of nos. 9 and 10 would be unsatisfactory for legible markings (see photo nos. 12, 18, 21, 22, and 23).

Though specimen nos. 3 and 4 were primed and painted with the same materials by the same painter, the primer on specimen no. 3 parts provided consistently inferior corrosion resistance (see photo nos. 12, 14, 16, 18, 19, and 20). (The additional exposure to 1,000 hours increased the severity and sizes of corrosion products on specimen nos. 7 and 8 making the differences between them and specimen no. 3 far more obvious. Specimen no. 3, among the specimens acceptable after 750 hours, had the least corrosion resistance). After the 1,000 hour exposure, there was significant corrosion on the specimen no. 3 bomb and fins.

DISCUSSION OF RESULTS

PRAM specimen no. 1, MIL-P-11414D primer. After completion of the 500 hour salt fog exposure test it was clearly evident from examination of specimen no. 1 that the MIL-P-11414D primer currently being used at Guam is significantly inferior to all other primers evaluated in this study (see photo nos. 4, 5, and 6). The MIL-P-11414D primer is a cellulose nitrate lacquer that is required to provide only 48 hours salt fog protection on steel panels. It should be noted that the average total film thickness readings for the specimen no. 1 bomb and fin were only 3.2 and 1.2 mils, respectively (see Table 2). Coatings were applied IAW the operating practices at SAC facilities at Andersen AFB, Guam. CMSgt James N. Elledge, HQ SAC/LGWC, the technical advisor for the application of the MIL-P-11414D primer and Mr. Wilfred L. Peters, OO-ALC/MMETP, were contacted concerning the total bomb and fin coating thicknesses on specimen no. 1. Mr. Peters' organization, OO-ALC/MMET, is the preparing activity for the applicable T.O. (11A1-5-7). CMSgt Elledge stated that the coating buildups on the bomb and fin represented current practices. Coating thickness requirements are not specified in the T.O.s. Most of the primers except the zinc rich primers are applied as mist coats to increase the adhesion of the top coats. Nominal primer thicknesses for materials such as the MIL-P-11414D lacquer and MIL-P-23377 epoxy polyamide, specimen nos. 1 and 2 respectively, are in the 0.5 to 1.0 mil range. In Table 2, it is clearly shown that specimen nos. 1 and 2 have significantly less film buildups than the zinc rich materials, specimen nos. 3, 4, 6, 8, 9, and 10.

In the "Intended use" section of MIL-P-11414, "bombs" are included in the listed applications. A major characteristic of the cellulose nitrate rust inhibiting lacquer is its rapid drying properties. When seeking a primer that had processing characteristics suitable for the quick drying requirements of Guam's production line, lacquers were most likely among the first materials considered. It is possible that the designation "Rust Inhibiting" in the specification title

plus the fact that bombs are listed in Intended use section were factors that led to the use of this primer in spite of its inadequate 48 hour salt fog requirement.

The significant difference between the salt fog requirements of the MIL-P-11414 material and other primers considered in this study are illustrated below:

<u>PRAM SPECIMEN NUMBER</u>	<u>APPLICATION</u>	<u>REQUIRED ASTM B117 EXPOSURE PERIODS</u>
1	MIL-P-11414D, Lacquer used on MK82 bombs at Guam.	48 hrs. on steel
2	MIL-P-23377D, Epoxy-Polyamide specified in applicable T.O. for spray painting MK82 fuze wells. Standard system used on USAF aircraft and ground support equipment.	1,000 hrs. on chromated aluminum
3 and 4	MIL-P-26915, Type I, Class B -Air-dry cure, zinc rich primer, intended primarily for ground support equipment. Used primarily with the standard MIL-C-83286.	114 hrs. on steel
7	MIL-C-83933, Corrosion Preventive Compound, Cold-Applcation (for motor vehicles). Material is intended for use in preserving the underside and internal areas of vehicles. This Ziebart type coating was used initially in Vietnam.	500 hrs. on steel

PRAM Specimen no. 2, MIL-P-23377 primer. This primer was used at OO-ALC for MK82 bombs. This highly regarded primer has been successfully used in many critical ground support and airborne applications. In this evaluation it did not provide adequate protection after 500 hours salt fog. Nevertheless, it afforded at least 100% better protection than the MIL-P-11414D lacquer (see photo nos. 7, 8, 9, 24, and 25).

Off-the-shelf products. Five of the ten primers evaluated were proprietary products that required longer primer-top coat application intervals than the 30 minutes established for renovation processes. These "off-the-shelf" primers (see Tables 1 and 2) were those used on specimen nos. 5 and 6, specimen no. 7 (Witco, Emerson & Cuming), and specimen no. 8 (CM Technologies).

Special primers. The primers used on specimen nos. 3, 4, 9, and 10 were modified or formulated specifically for the Mark 82 bomb application. They included specimen nos. 3 and 4, Crown Metro 10-P3-2 with EC-113; specimen no. 9, CSI EDM-2 and specimen no. 10, EXP14. After the 1,000 hour evaluation, the results indicated primer nos. 4, 9, and 10 had provided good corrosion resistance.

Estimates of primer thicknesses. Coating thickness measurements made on one of the two steel panels prepared at the same time the bomb specimen was prepared were used to estimate the thicknesses of the primer and top coat on the bomb itself. A calibrated eye piece magnifier (60X) was used to measure the coating thicknesses of a "cross-sectioned" portion of the panel. The thickness ratios of primer/combined coating and top coat/combined coating for the steel panel were then used in conjunction with the overall combined thickness measurements made on the bombs, with an isoscope, to estimate the primer and top coat thicknesses. The primer and top coat thicknesses for specimen nos. 4 and 9, the two best performers are as follows:

PRAM SPECIMEN NO.	DESCRIPTION	COMBINED COATINGS ACTUAL READINGS (mils)	PRIMER (mils)	TOP COAT (mils)
4	MIL-P-26915, 10-P3-2 and EC113 by Crown Metro	7.0	4.7	2.3
9	EDM-2 by Capsulated Systems Inc.	10.4	7.0	3.4

Note that specimen no. 9, with the CSI EDM-2 system had a 49% heavier film buildup than specimen no. 4 with the Crown Metro product.

Differences between specimen nos. 3 and 4. Although specimen nos. 3 and 4 were primed and top coated by the same painter with materials from the same guns there was a wide disparity between the performance of these two specimens. This difference in performance was discussed with Mr. Sidney Childers (AFWAL/MLS), the technical advisor for the application of the Crown Metro MIL-P-26915 primer; however no plausible explanation could be provided. It was noticed that there was slightly more film buildup on specimen no. 3 bombs, fins, and panels which provided less corrosion resistance during the salt fog evaluations than the no. 4 specimens. These results were evident following the 500, 750, and 1,000 hour evaluations (see photo nos. 12, 14, 16, 18, 19, and 20).

White corrosion products on CSI specimens. The cause of the white corrosion products on specimen nos. 9 and 10 has not been determined. Mr. Joseph T. Menke, a corrosion expert for the U.S. Army (ARRCOM Logistics Engineering Directorate, Rock Island, IL 61299), stated that the white deposit may be of little significance. He indicated zinc rich coatings that gave similar salt spray results did not exhibit white corrosion products after lengthy (more than a year) outside exposure at Cape Kennedy. Conversely, Mr. John Keane, Executive Director of the Steel Structures Paint Council at Mellon Institute, Pittsburgh, Pa., has stated that the white corrosion products occur rarely during ASTM B117 testing of top coated zinc rich primers.

It is believed that possible causes for the white deposits include excessive particle size of the zinc pigment, inadequate interval between applications of primer and top coat and poor pigment-volume ratio. Though six of the ten primer materials were zinc rich primers, that is, the primers on specimen nos. 3, 4, 6, 8, 9, and 10, only the two primers, on specimen nos. 9 and 10, from Capsulated Systems, Inc., produced white corrosion products during salt fog exposure.

An analysis by AFWAL revealed that the white deposits were not zinc chloride (see Table 3). Panel specimen nos. 9 and 10 contained 10% and 50% zinc, respectively. No chlorides were present on specimen no. 9, while specimen no. 10 contained only 1 to 3% chlorides. None of the white salt deposits were identified as sodium chloride from the salt spray.

CSI's initial explanation for the white corrosion products on specimen nos. 9 and 10 coated with their primers is presented in the following statement made by Mr. R. G. Bayless, president of CSI:

"When the parts were sprayed by AF personnel using conventional equipment, it was evident that the drying time of the primer-solvent was too fast. This caused solvent entrapment in the primer. This entrapment was a factor in the formation of the white corrosion products."

This explanation was supported by the condition of a 3" x 5" steel panel that CSI stated had been subjected to a 528 hour salt fog test at their facility, IAW ASTM B117. The panel, coated with the primer used on specimen no. 9, appeared to have been unaffected (see photo no. 26). It was the CSI position that their small panel was sprayed with the specimen no. 9 primer (EDM-2) and an air gun that did not result in solvent entrapment. Mr. Britton, Chief Engineer, ASD/AEMOE(RA), suggested that a Fourier Transform Infra Red (FTIR) spectral analysis be performed to determine the validity of the CSI claim. The FTIR was used on a known sample of the CSI primer mixed with solvent and a sample of the primer from the specimen no. 9 steel panels. A characteristic match would indicate that solvents had been entrapped. Samples were submitted to AFWAL/MLUA for analysis. The results of the analysis did not indicate the presence of entrapped solvent. In its efforts to eliminate the formation of white corrosion products during the salt fog evaluations, CSI has made PRAM authorized modifications in the formulation of the approved primer (specimen no. 9). CSI has proposed that the EDM-2 primer (specimen no. 9) should be replaced by an EC-2 primer if the salt fog tests of EC-2 material provide the desired results. EC-2 is EDM-2 primer in which each zinc pigment particle has been microencapsulated with a one micron film of a CSI proprietary product. CSI believes that this modification will eliminate corrosion product formation.

Currently CSI is manufacturing 42 gallons of EDM-2 primer for AF evaluation at Andersen AFB, Guam. Evaluations in process at this agency will determine which of the two CSI products, EDM-2 or EC-2, may be furnished for additional AF contracts.

This agency received four 12' x 12' steel test panels from CSI. Panels had been primed with their EC-2 and top coated with a polyurethane paint IAW the applicable specification, MIL-C-83286. Three of the panels are now being subjected to a 500 hour salt fog test. The results of this evaluation will be provided in an addendum to this report.

CSI indicated they were not surprised by the formation of very noticeable white corrosion products on specimen no. 10, after only 500 hours in the salt fog chamber since the zinc rich acrylic primer had a 91% loading of zinc which is an unusually high loading for this type of primer. CSI submitted EXPl4, specimen no. 10, because it had displayed vastly superior salt fog resistance. During this salt fog evaluation, it clearly provided the best corrosion protection for the steel surfaces. However, as indicated in Table 5, it was incompatible with the top coat after 750 hours, it appeared to exhibit questionable primer stability and it was definitely unsuitable for applications requiring markings.

CONCLUSIONS

1. Though there are no direct correlations between the salt fog exposure test of ASTM B117 and service life, this study has clearly indicated the inadequacy of the currently used primer and the relative merits of the other primers evaluated for this application (see Table 5).
2. The zinc rich epoxy coating systems used on specimen nos. 4 and 9, i.e. Crown Metro Inc., (10-P3-2 and EC113) and Capsulated Systems Inc. (EDM-2), respectively, would increase the anticipated storage life of Mark 82 bombs at Andersen AFB from the current one to two years to at least seven years.
3. A heavier film of CSI EDM-2 is required to assure protection similar to that provided by Crown Metro's 10-P3-2 and EC113 primer.
4. CSI EXPl4, the zinc rich acrylic primer used on specimen no. 10 provides the best corrosion resistance for steel surfaces. This primer with adequate modifications to insure top coat compatibility and material stability, could be used for applications that do not require markings.

RECOMMENDATIONS

1. The technical advisors for the Crown Metro, Inc., 10-P3-2 and EC113 primer and Capsulated System, Inc., EDM-2 primer should prepare detailed instructions for duplicating coating systems that provided the adequate salt fog protection after 1,000 hours IAW ASTM B117.
2. The nature and cause of the white corrosion products on surfaces subjected to salt fog/salt laden atmospheres should be determined experimentally.
3. Requirements in a procurement specification or similar document should not eliminate consideration of microencapsulated products.
4. An agitated pressure pot should be included in the equipment for spraying zinc rich primer(s). This would insure maximum uniformity of coating.
5. When Mark 82 bombs or materiel having similar surface areas are to be primed and/or painted, the vendor should be required to demonstrate the suitability of the proposed materials on the same type of surfaces. Test specimens should have a surface area large enough to adequately assess the coating characteristics of the material being evaluated. A minimum specimen size of 18" x 18" is recommended.

6. Based on the findings of this study technical orders and drawings involving corrosion protection of bombs should be reviewed and all reference to MIL-P-11414D deleted and replaced by appropriate specifications or primer type designation.

The Army Materials and Mechanics Research Center, the preparing activity for MIL-P-11414D, will be requested to clearly delineate in the Scope and Applications sections the limitations, exclusions and specific uses for the primers covered by this document. Specifically they will be asked to delete all references to items similar in nature and composition to those evaluated, which it is expected could be subjected to extreme environmental conditions representative of those used in this study.

TABLE 1 - TECHNICAL ADVISORS AND PRIMER DESIGNATIONS

<u>Test Specimen No.</u>	<u>Primer Designation</u>	<u>Manufacturer</u>	<u>Technical Advisor(s)</u>
1	XP-500	U.S. Rust Control Corp. 1455-61 N.W. 23rd St. Miami, Florida 33142	CMSgt James N. Elledge, HQ SAC/LGWC, AV 271-2256 CMSgt George E. Lander, HQ USAF/LEYW, AV 227-5760
2	Durbond M	Ultra Guard Products Co. P.O. Box 1282 Wichita, Kansas	Wilfred L. Peters (Elledge, and Lander), 00-ALC/MMETP, AV 458-7378
3 and 4	10-P3-2 and EC-113	Crown Metro, Inc. P.O. Box 5695 Greenville, S.C. 29606	Sidney Childers, AFWAL/MLSA AV 785-3637
5	Polane T F63B12	Sherwin-Williams Co. Chemical Coatings Div. Chicago, Ill. 60628	Avery Watson, HQ AFALD/PTPT, AV 787-4519
6	Sermetel #384	Sermetel, Inc. Limerick, PA 19468	Capt. John Wagner, ASD/AEMOF(RA), AV 785-2132
7	SF 871 1011	Southwest Petro-Chem Div. Witco Chemicals Co. Overland Park, KS 66210	Avery D. Watson, HQ AFALD/PTPT, AV 787-4519
7	Stycast 1264M	Emerson & Cuming, Inc. Canton, Mass 01021	Avery D. Watson, HQ AFALD/PTPT, AV 787-4519
8	CMT2000	CM Technologies, Inc. 1100 17th St., NW Suite 1000/VEF Washington DC 20036	Capt John Wagner, ASD/AEMOF(RA), AV 785-2132
9	EDM-2	Capsulated Systems, Inc. 8330 Dayton-Springfield Rd. Fairborn, OH 45324	Robert G. Bayless, President Capsulated Systems, Inc. (513) 878-1992
10	EXP-14	Capsulated Systems, Inc. 8330 Dayton-Springfield Rd. Fairborn, OH 45324	Robert G. Bayless, President Capsulated Systems, Inc. (513) 878-1992

TABLE 2 - COATING THICKNESS MEASUREMENTS

THICKNESS READINGS (0.001")
(Primer plus Top coat)

Primer Specimen Number and Classification	B O M B S			Average	F I N S			Average
	Minimum		Maximum		Minimum	Maximum		
1 MIL-P-11414D Lacquer, Rust Inhibiting	1.7		4.5	3.2	1.0	1.5		1.2
2 MIL-P-23377D Epoxy-Polyamide	1.4		3.8	2.5	1.2	2.2		1.7
3 MIL-P-26915 Zinc Rich Epoxy	5.2		10.2	7.7	7.0	7.8		7.4
4 Same as #3	5.2		8.7	7.3	5.4	8.1		6.5
5 Sherwin-Williams Polane T Polyurethane	2.3		4.0	3.2	2.3	3.2		2.9
6 Zinc Powder in Aqueous Alkali Silicate (No Organics)	3.8		9.3	6.1	3.2	4.0		3.6
7 Witco Automotive Coating Emerson & Cuming Inc., Epoxy	8.0 4.4		11.2 7.0	9.5 5.4	4.6 ---	5.5 ---		5.2 ---
8 CM Technology, Inc., Zinc Rich Epoxy	4.6		7.8	5.6	3.0	4.5		3.9
9 Capsulated Systems, Inc., Zinc Rich Epoxy	7.3		14.0	10.4	8.0	10.7		9.2
10 Capsulated Systems, Inc., Zinc Rich Acrylic	4.4		10.0	7.1	5.2	6.6		6.0
AVERAGE				6.2				4.8

TABLE 3 - ANALYSIS OF ELEMENTS IN WHITE SUBSTANCES ON SURFACES OF CSI SPECIMEN NOS. 9 AND 10

Element	P E R C E N T A G E		P E R C E N T A G E	
	Plate #9	Cone #9	Plate #10	Cone #10
Silicon	5	3	8	7
Magnesium	0.05	0.02	0.1	0.03
Lead	3	2	2	0.7
Iron	5	3	0.5	0.1
Zinc	10	0.5	50.0	50.0
Titanium	1	0.7	0.3	0.01
Chromium	0.7	0.5	0.3	0.1
Calcium	1	1	0.2	0.07

Tests were conducted by AFWAL/MLU after 750 hour exposure. Elements were determined by emission spectrographic analysis, a semi quantitative method.

TABLE 4 - ADHESION (TAPE TEST) 750 HOURS

R E S U L T S	
<u>Specimen Number</u>	<u>Federal Test Method Standard 141, Method 6301.1</u>
3	Satisfactory
4	Excellent
7 (Nose end, E and C)	Very Good
8	Incompatible
9	Satisfactory
10	Incompatible

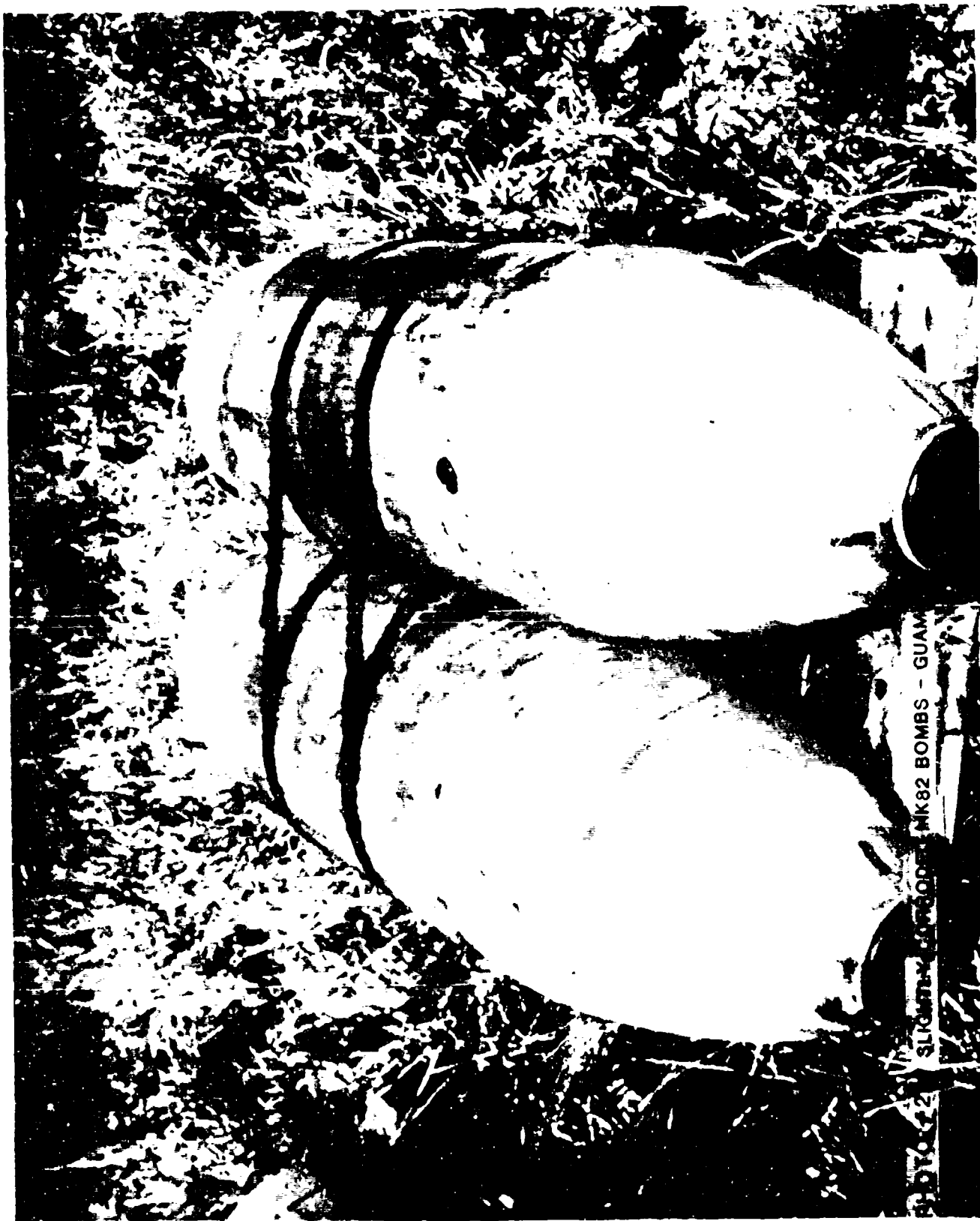
TABLE 5 - SUMMARY OF SALT FOG EVALUATIONS (PARAMETERS)

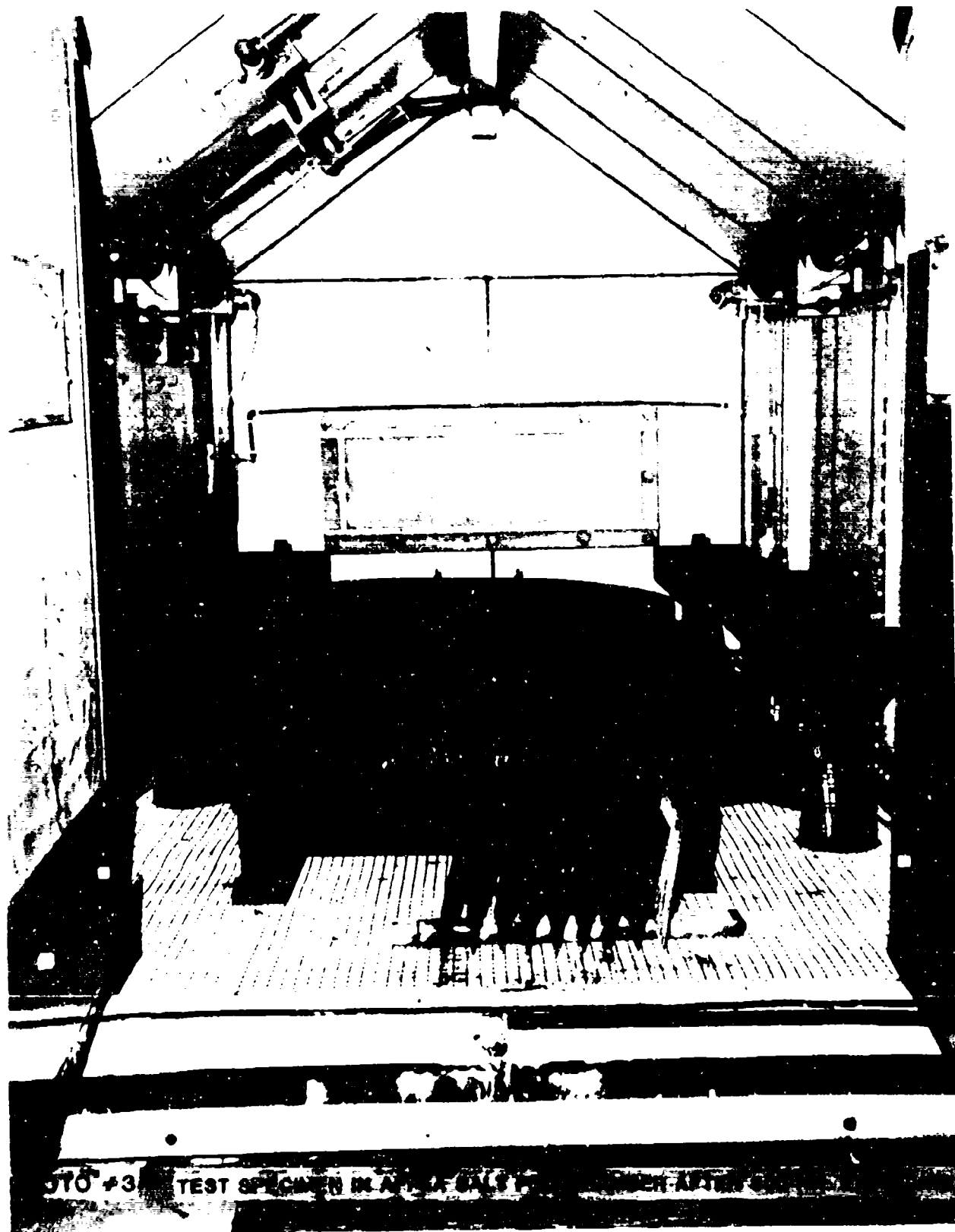
Primers	Corrosion Prevention Properties	Compatibility of primers with the MIL-C-93286 polyurethane top coat		Visual Evidence of primer Stability	Legibility of Markings
1 MIL-P-11414D, Rust Inhibiting, Cellulose Nitrate Lacquer	Excessive Corrosion 500 hrs - WFEF*	*		*	*
2 MIL-P-23377, Epoxy Polyamide	Excessive Corrosion 500 hrs - WFEF*	*		*	*
3 MIL-P-26915, Zinc Rich Epoxy	Significant Corrosion 1,000 hrs - WFEF*	Excellent	Very Good	Good	
4 MIL-P-26915, Zinc Rich Epoxy	Good Corrosion Resistance - 1,000 hrs	Excellent	Very Good	Very Good	
5 Sherwin-Williams Polane (Polyurethane)	Excessive Corrosion 500 hrs - WFEF*	*	*	*	*
6 Sermetel #384, Zinc Powder in Aqueous Alkali Silicate (No Organics)	Good Corrosion Resistance - 500 hrs	Incompatible 500 hrs - WFEF*	*	*	*
7 Milco Automotive, (Ziebart) Corrosion Prevent-active	Excessive Corrosion 750 hrs - WFEF*	Acceptable after 1,000 hrs	Acceptable	Marginal	
Emerson Epoxy & Cumling Inc., Epoxy	Marginal 500 hrs, Excessive Corrosion 750 hrs - WFEF*	Good after 1,000 hrs	Good	Acceptable	
8 MIL-P-23236, Paint Coating System, Zinc Rich Coating CM Technologies	Excessive Corrosion 750 hrs - WFEF*	Incompatible 750 hrs - WFEF*	Good	Acceptable	
9 Zinc Rich Epoxy	Very Good Corrosion Resistance 1,000 hrs	Good	Questionable	Acceptable	
10 Zinc Rich Acrylic	Excellent Corrosion Resistance 1,000 hrs	Incompatible 750 hrs - WFEF*	Appears to be Unstable	Illegible 750 hrs - WFEF*	

*WFEF - Withdrawn From Evaluation Program



PHOTO #1 CORRODED NOSE FUZE WELL - GUAM





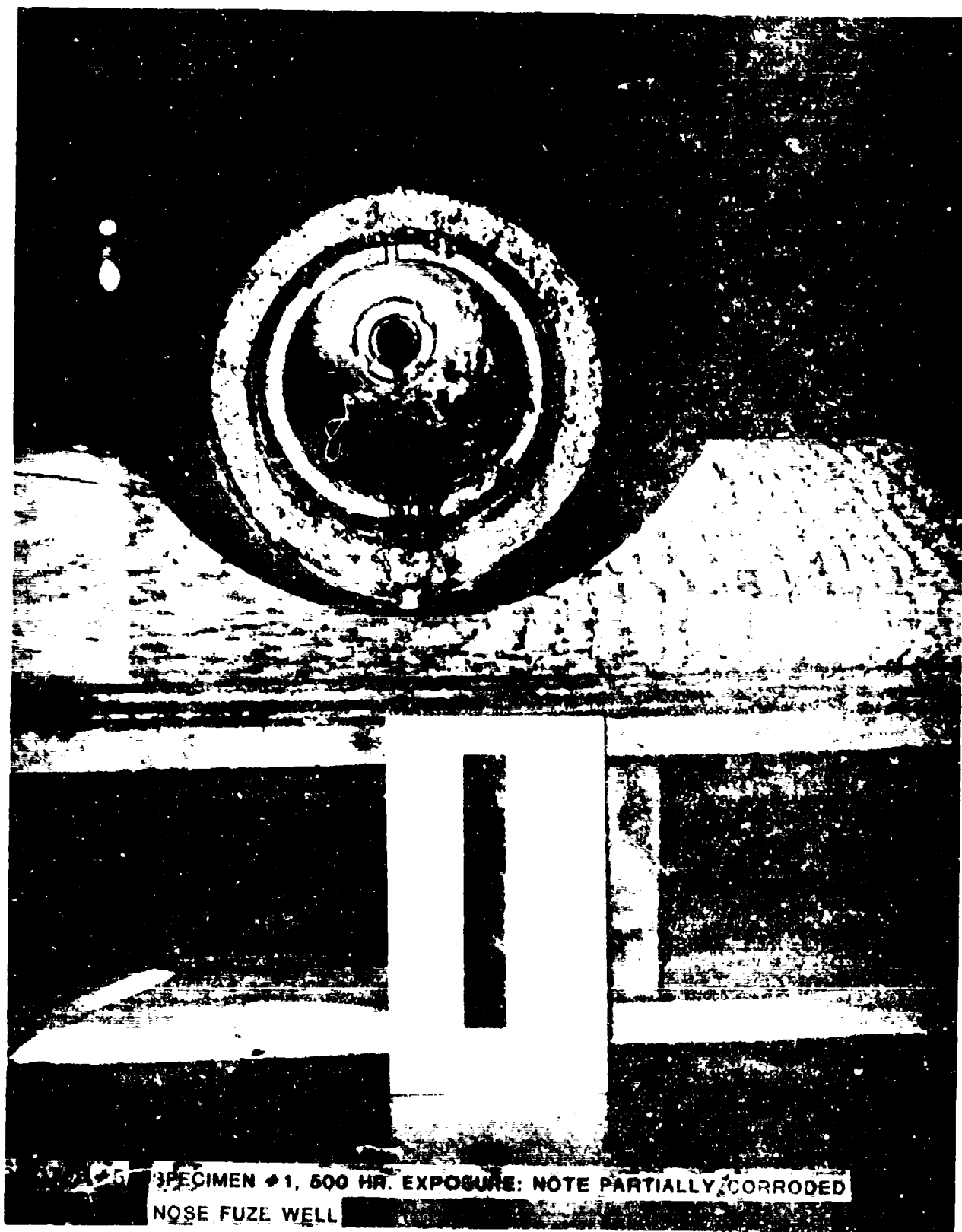
OTO #3

TEST SPECIMEN IN APLA-SALT

BEFORE AFTER



PHOTO #4 SPECIMEN #1, 500 HR. EXPOSURE: REPRESENTS EXTREMELY EXCESSIVE
CORROSION OCCURRING WITH PRESENTLY USED PRIMER



5 SPECIMEN #1, 500 HR. EXPOSURE: NOTE PARTIALLY CORRODED
NOSE FUZE WELL



PHOTO

SPECIMEN + 1,500 HR. EXPOSURE: SEVERELY CORRODED TAIL FIN

ELL



2 6 5

PHOTO #7 SPECIMEN NOS. 2, 6, AND 5, 500 HR EXPOSURE: NOTE
SEVERELY CORRODED FUZE WELL IN SPECIMEN NO. 2

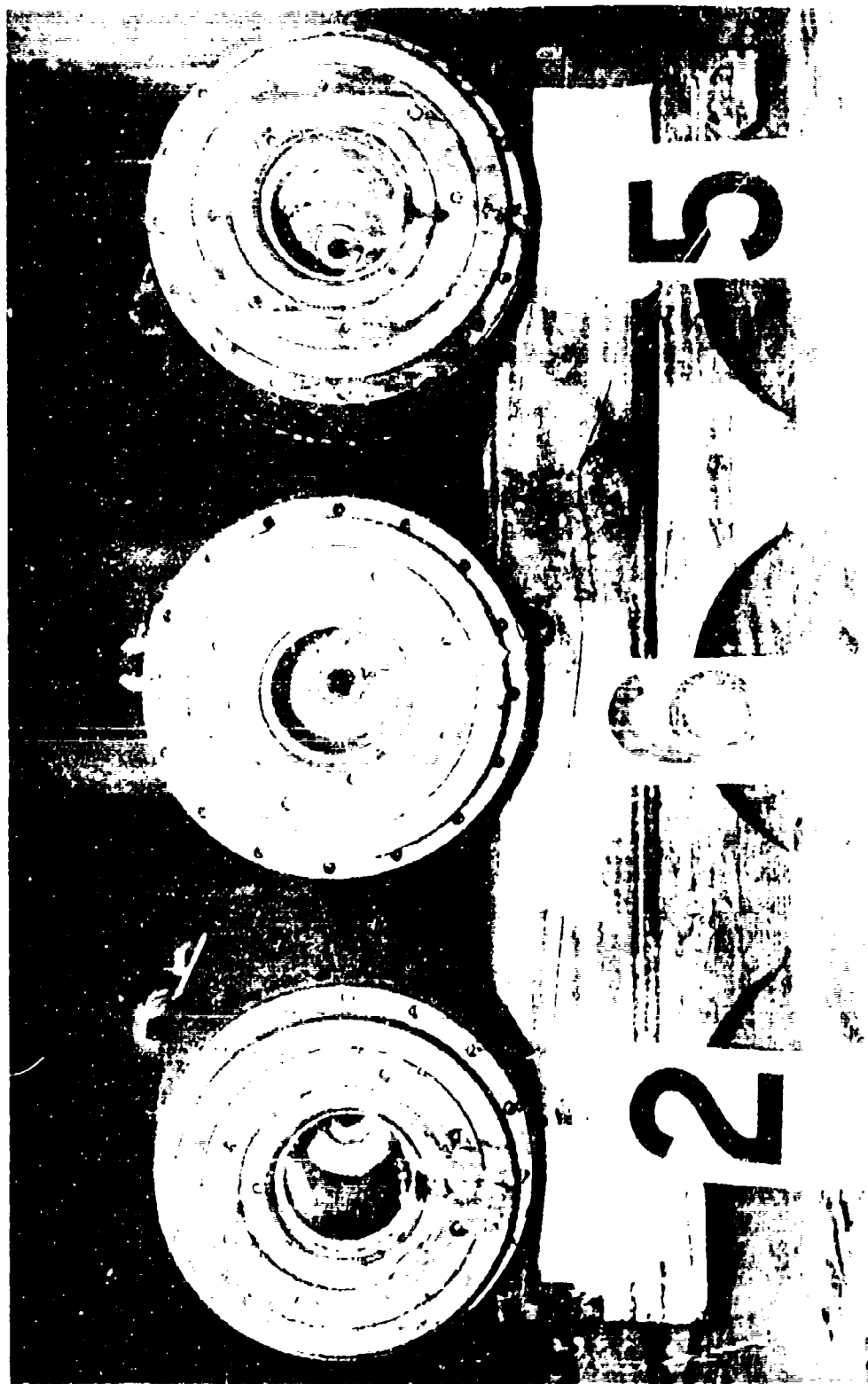


PHOTO #8 SPECIMEN NOS. 2, 6, AND 5, 500 HR. EXPOSURE: NOTE RANGE OF CORROSION DEPOSITS

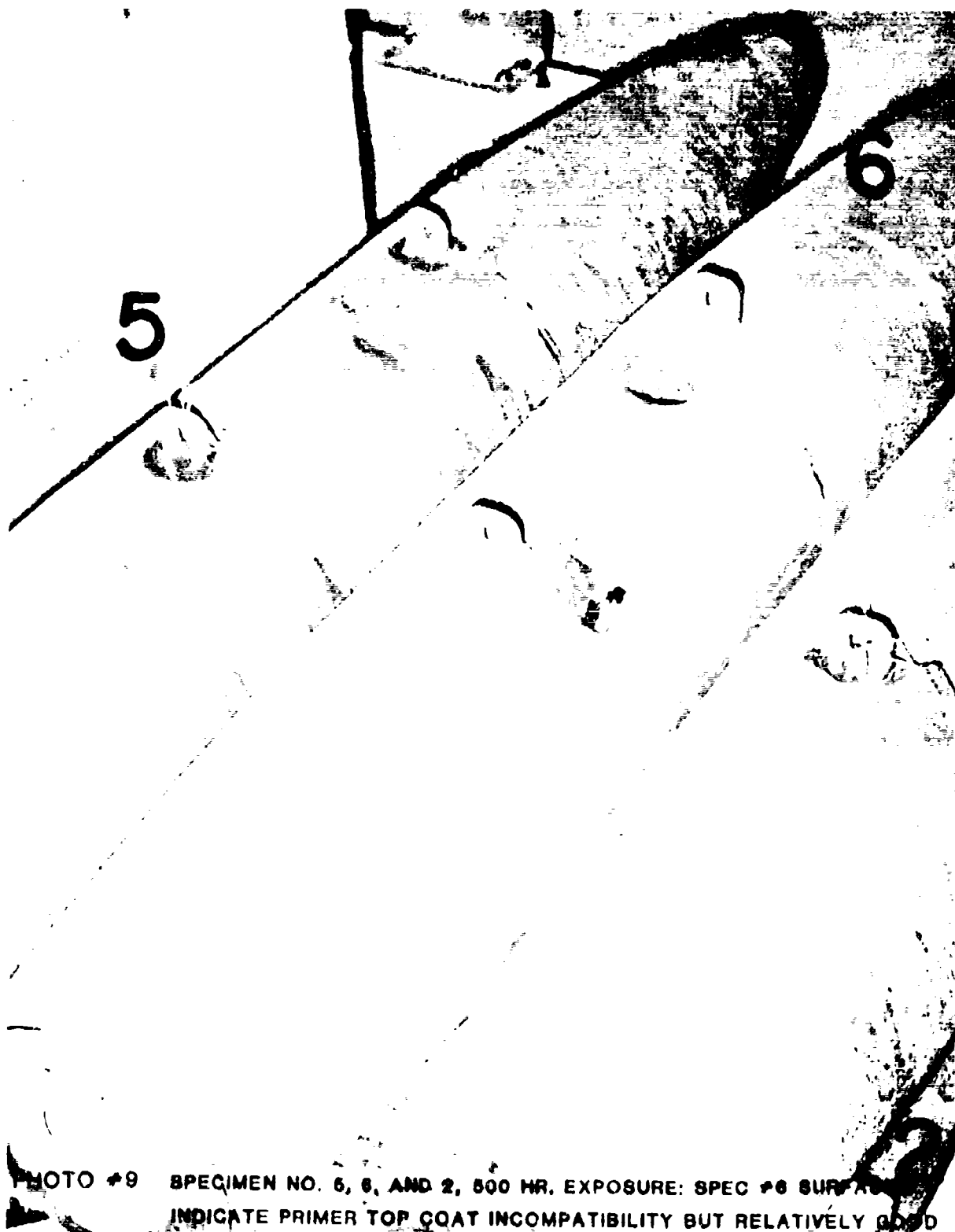
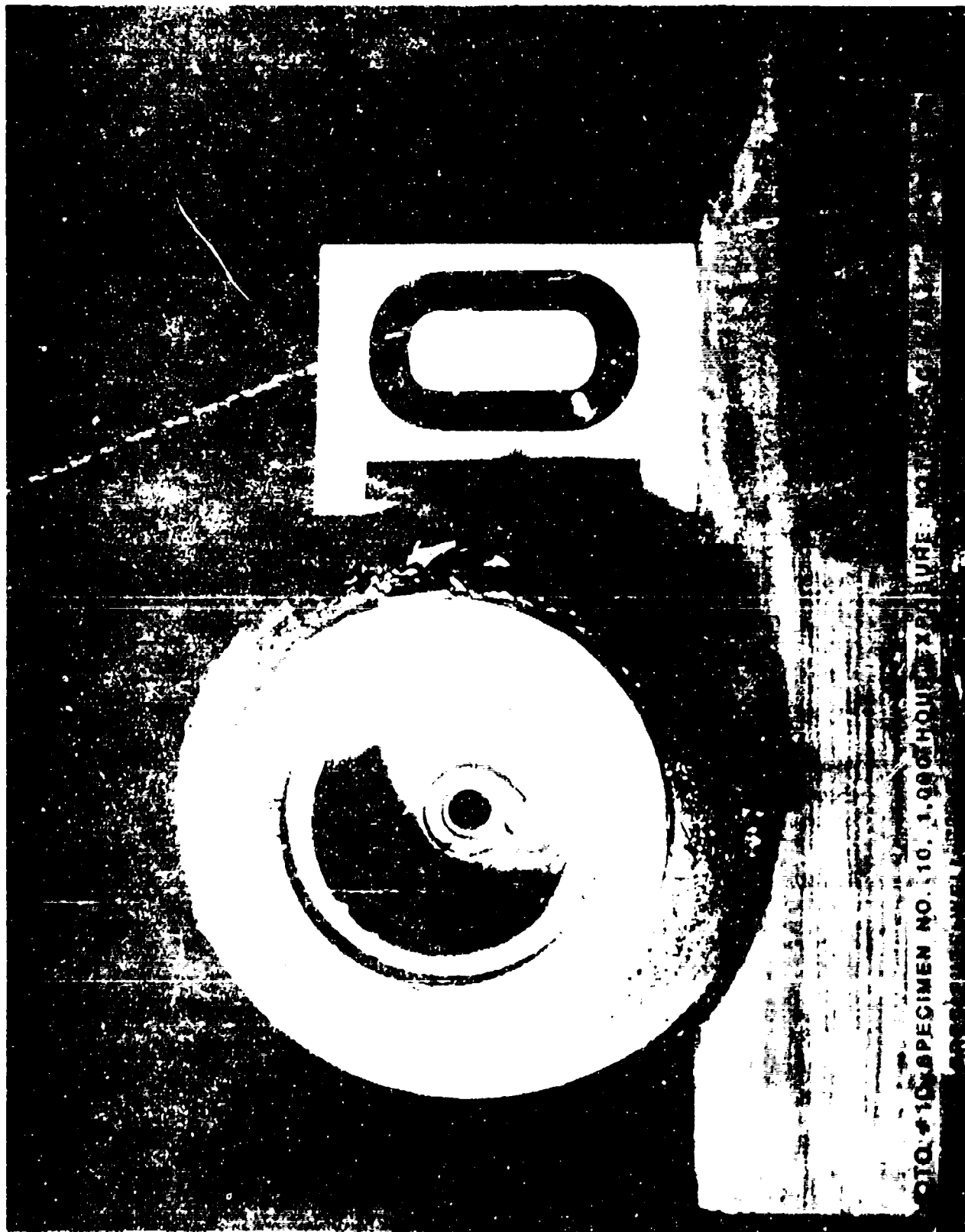


PHOTO #9 SPECIMEN NO. 5, 6, AND 2, 500 HR. EXPOSURE: SPEC #6 SURFACE
INDICATE PRIMER TOP COAT INCOMPATIBILITY BUT RELATIVELY GOOD
CORROSION RESISTANCE



Q10. #10 SPECIMEN NO. 10. 1.00 OF HOUSE XPH

URE. NO. 10. 1.00

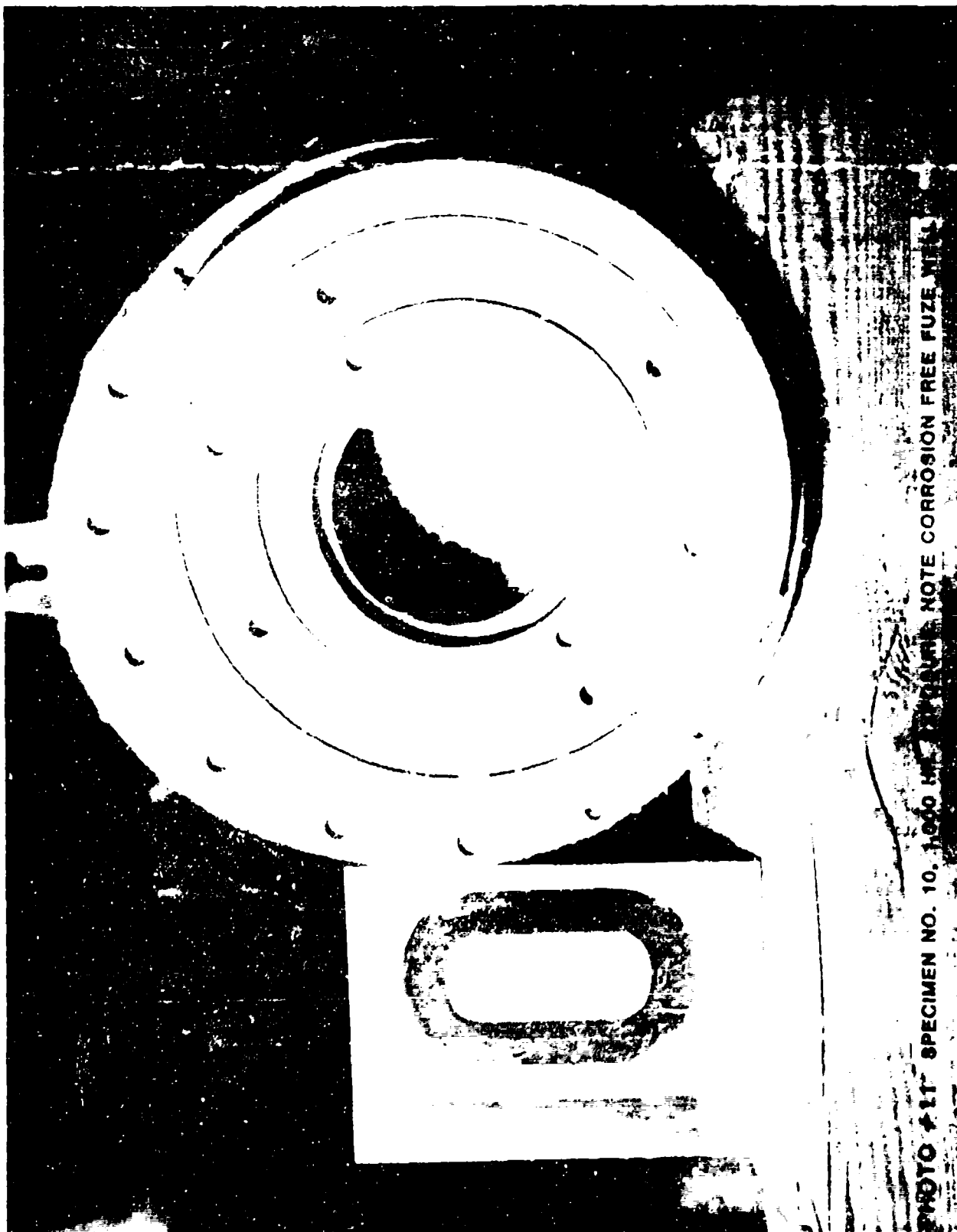


PHOTO #11 SPECIMEN NO. 10. 1000 H. 1000 H. NOTE CORROSION FREE FUZE WELD

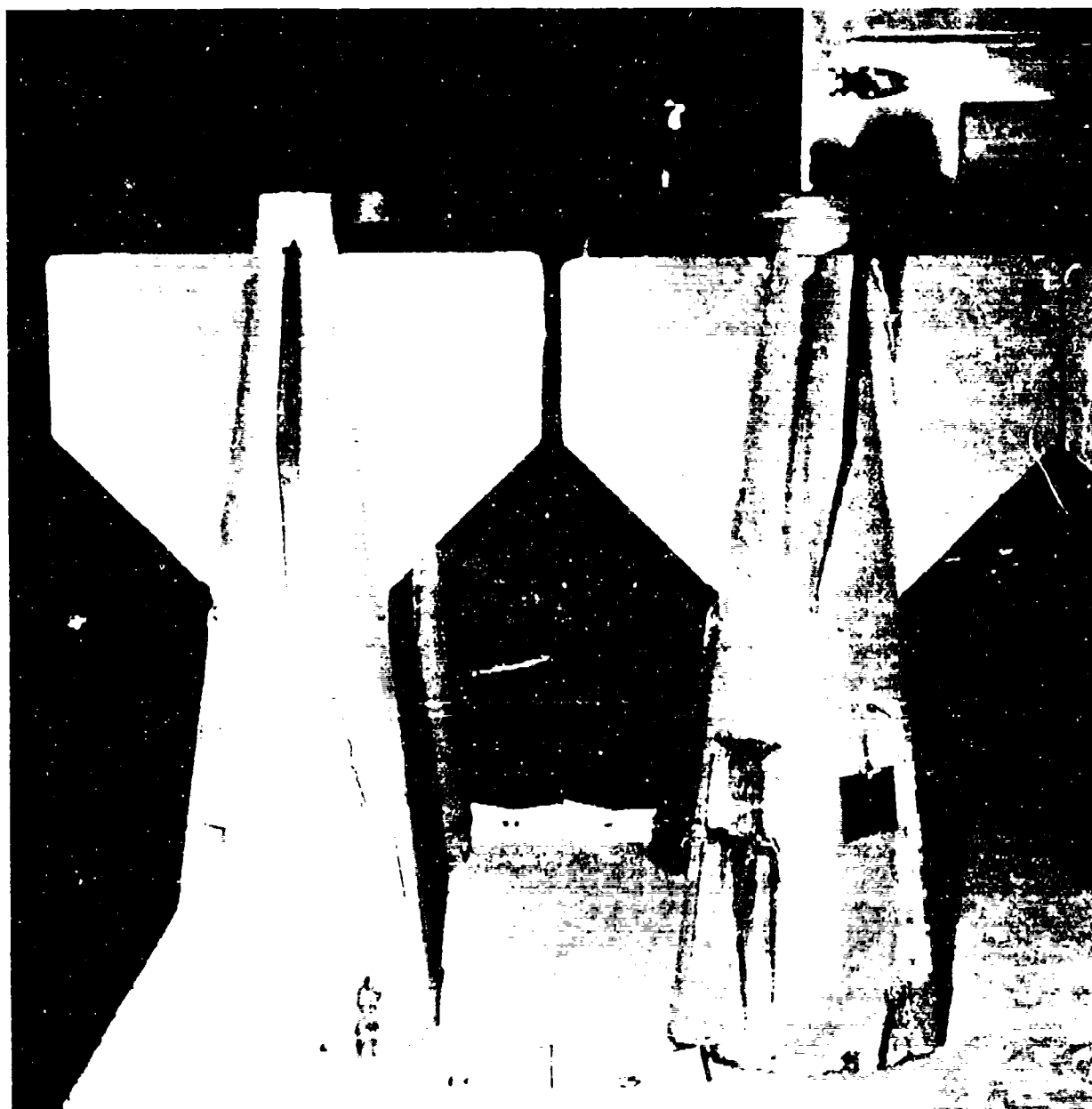
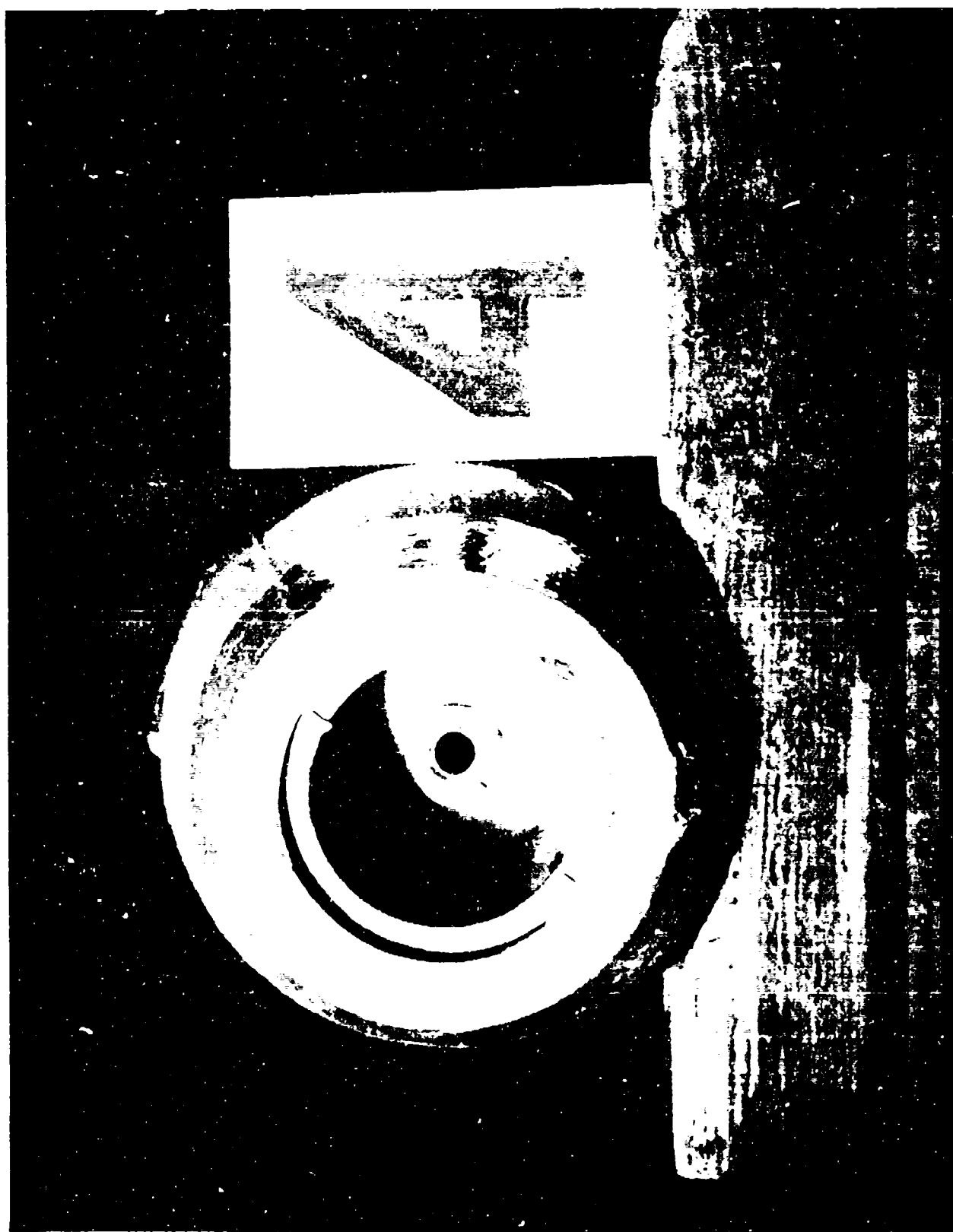


PHOTO # 42 SPECIMEN NO. 10, 1,000 HR. EXPOSURE: REPRESENTS BEST PROTECTION

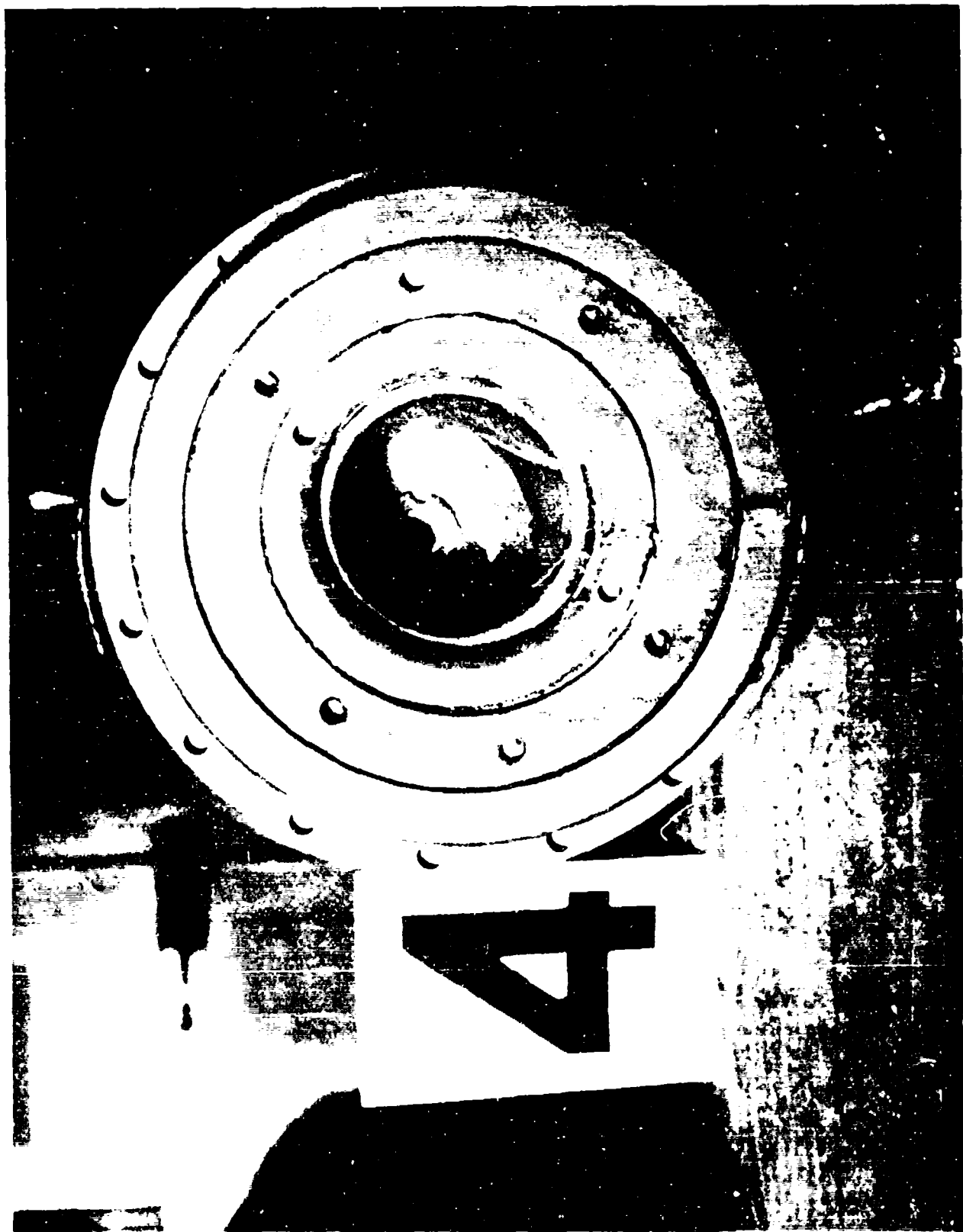


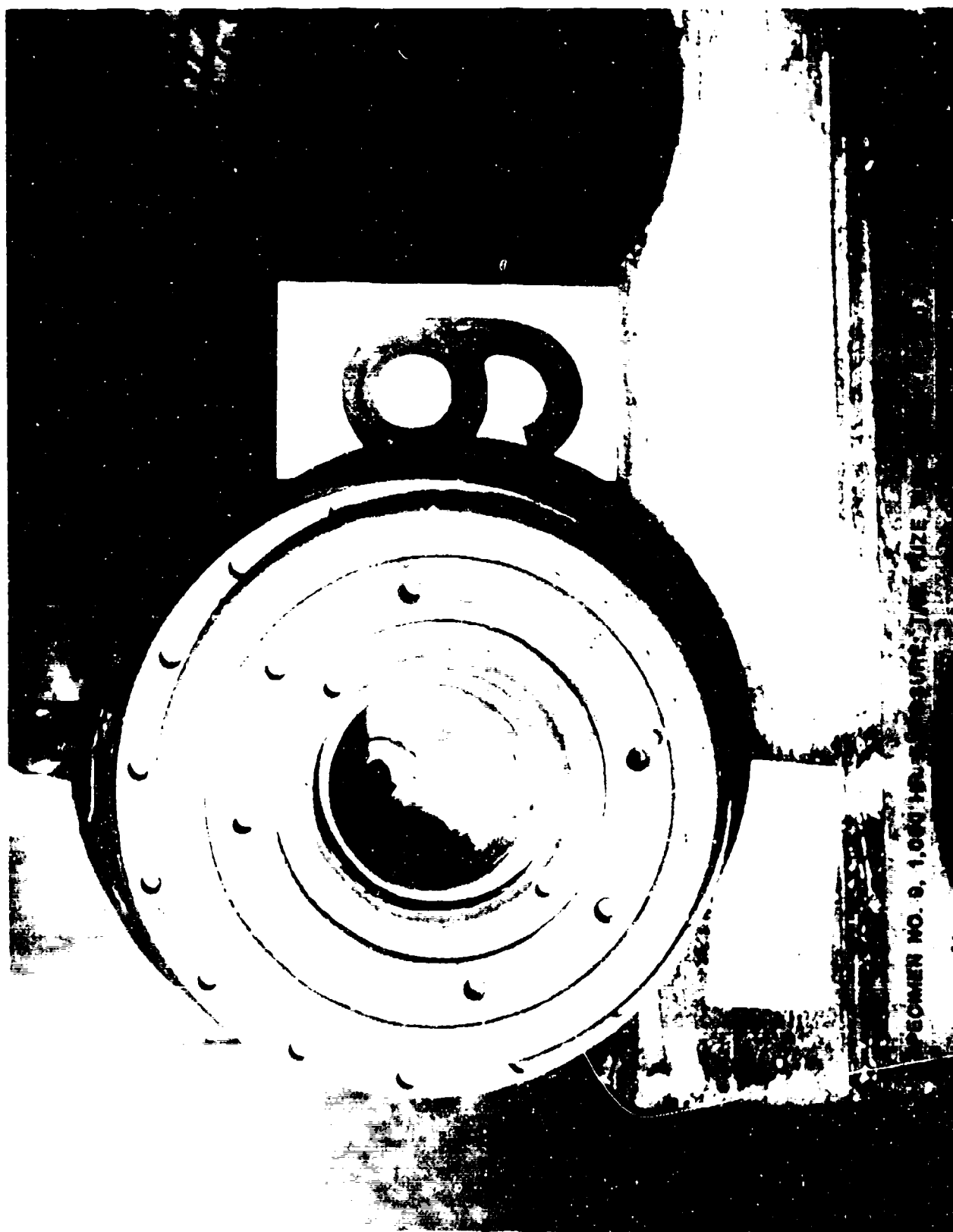
PHOTO #13 SPECIMEN NO. 10, 1,000 HR. EXPOSURE: CORRODED SUBSTANCES REDUCE LEDGIBILITY



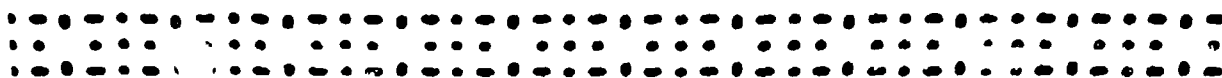
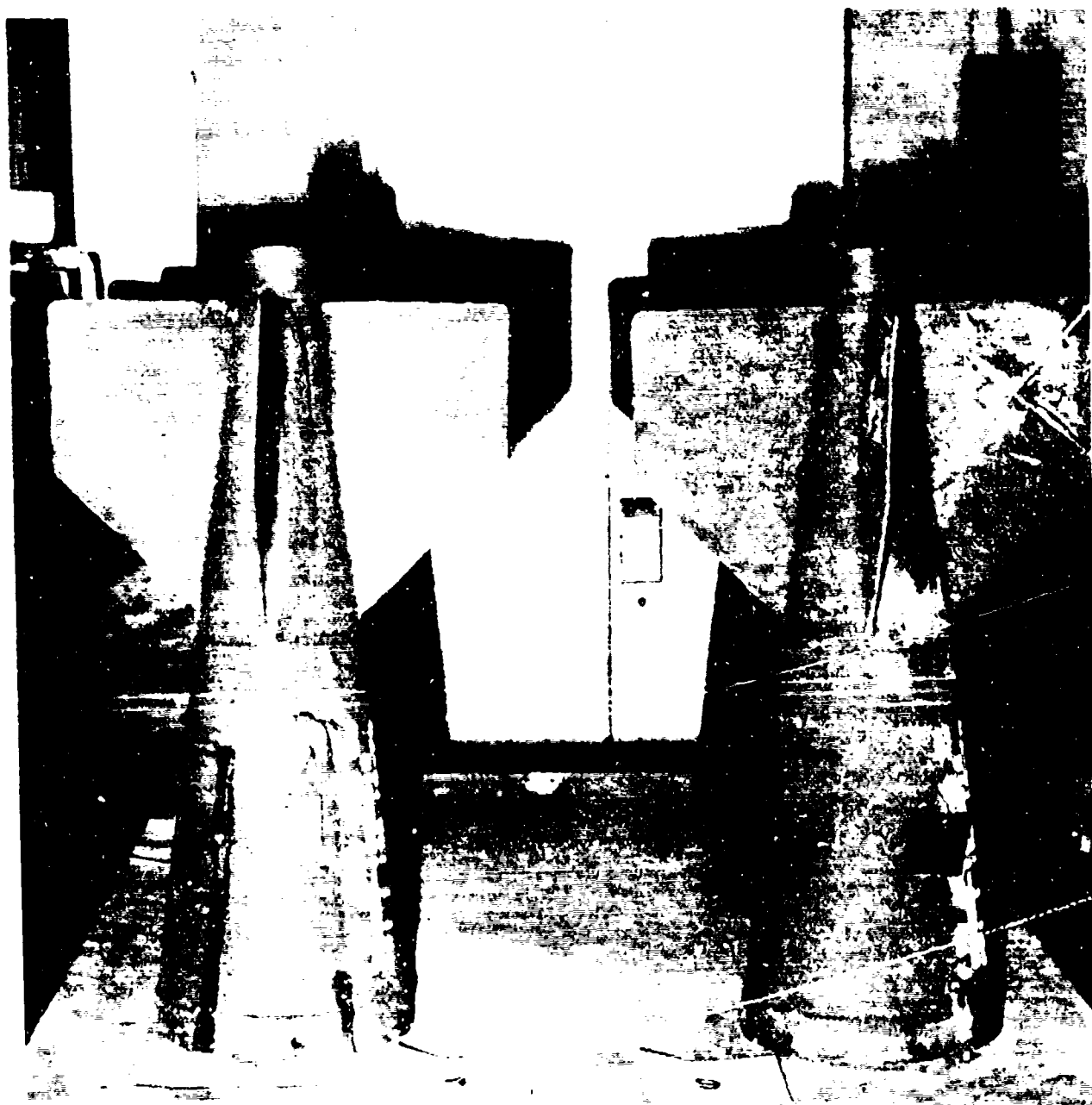


ORIGINAL NO. 1,000 HR. EXPOSURE: NO. 1,000





SPECIMEN NO. 8, 1,000 PSI, 1/2" DIA. FLANGE







SPECIMEN NO. 1068 MR. EX-100



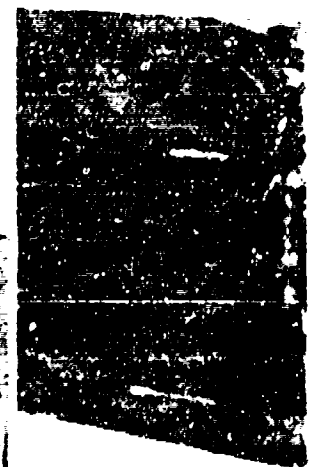
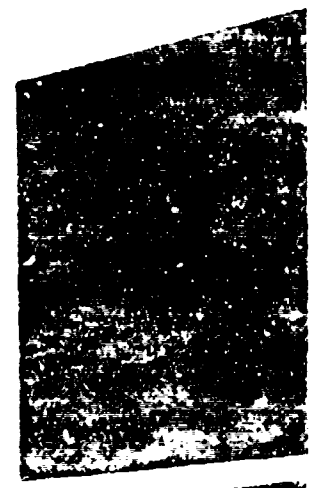
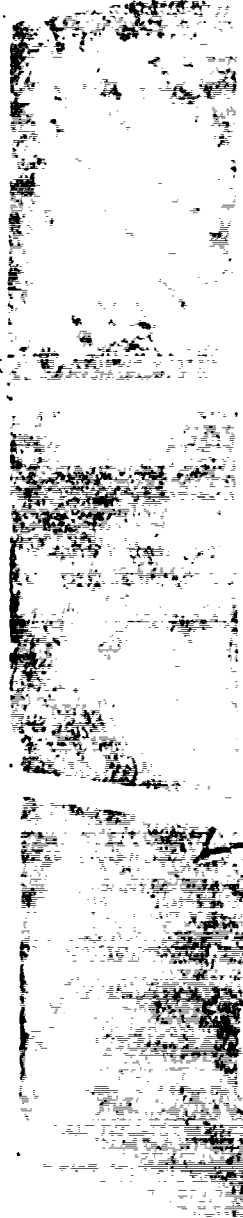
1

10

9

7

3



7

8



PHOTO 1 TEST AFTER 100 H. R. EXPOSURE

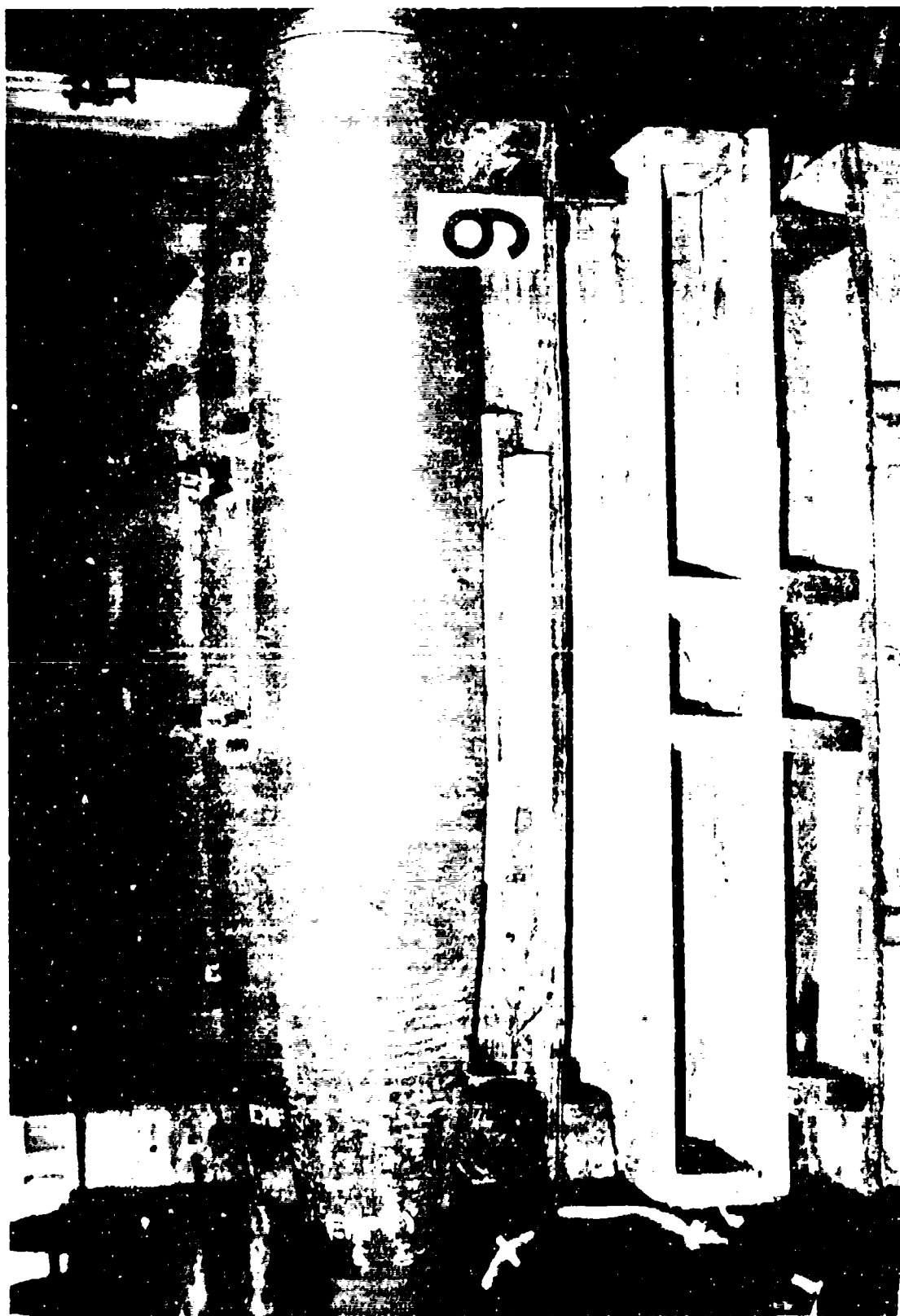
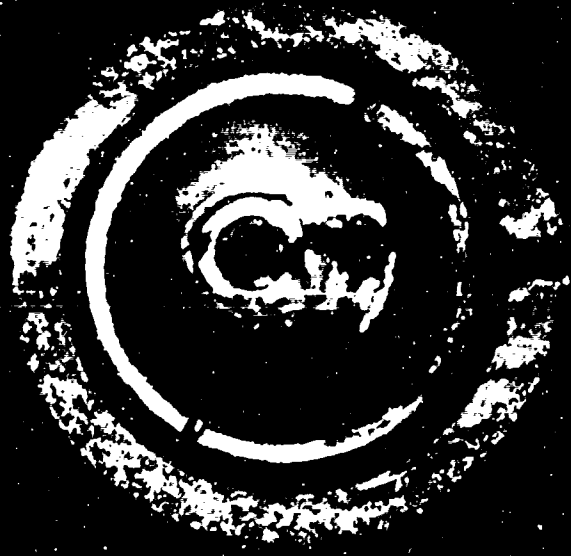


PHOTO #22 SPECIMEN NO. 9. 1,000 HR. EXPOSURE: WHITE CORROSION PRODUCTS CAN REDUCE
LEDGIBILITY OF MARKINGS



2

OP FIRES — SAVE LIVES —
A RULE TO CALL RESCUE — 117

SPECIMEN NO. 2. 500 HR. EXPOSURE: AN EXAMPLE OF INA

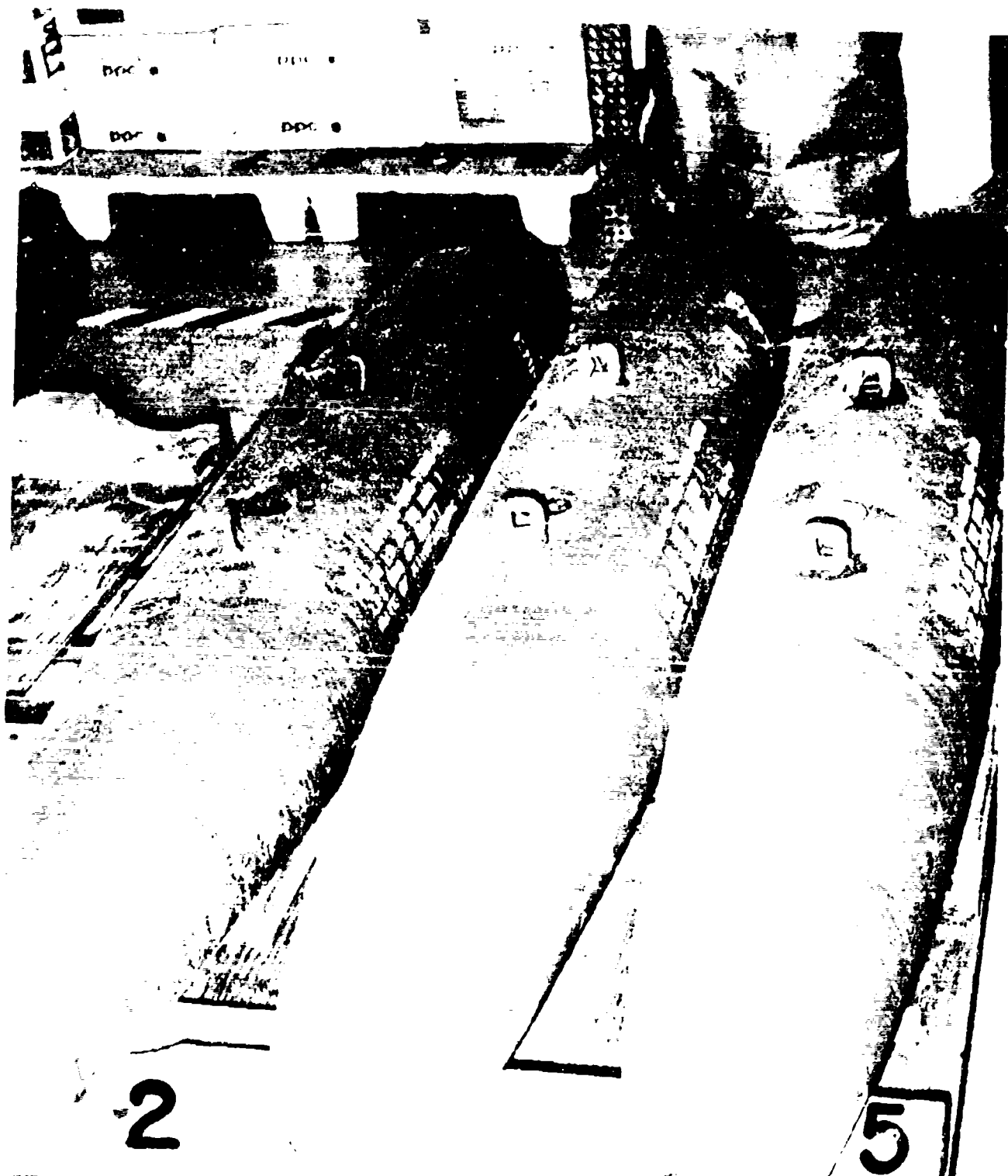
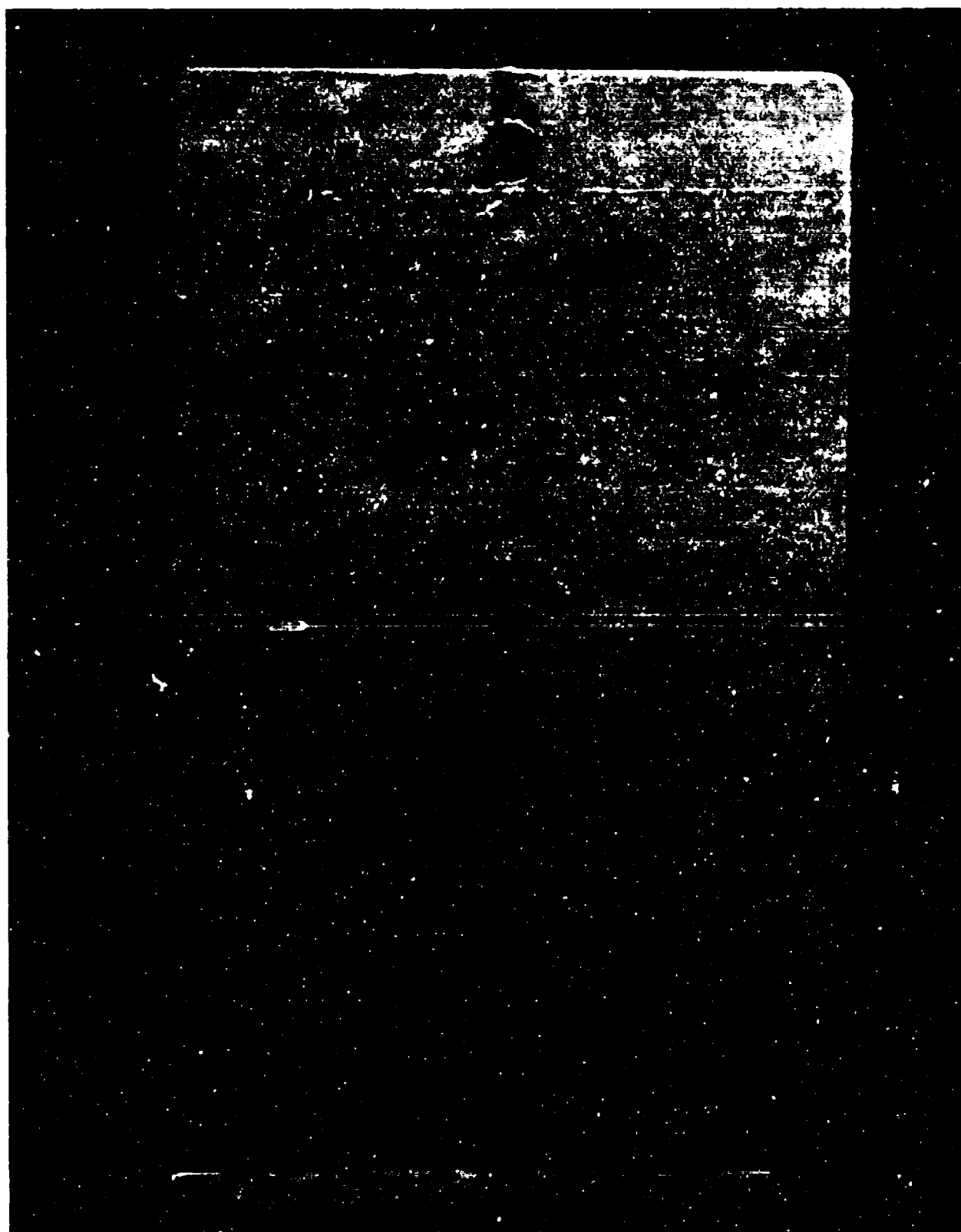


PHOTO #25 SPECIMEN NOS. 2, 3, AND 5 500HR. EXPOSURE: SPECIMEN NO. 3 PROVIDED
GOOD CORROSION RESISTANCE BUT INADEQUATE TOP COAT COMPATIBILITY



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