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NCEL
Technical Note

May 1990

By David E. Pendleton

Sponsored By Naval Facilities Engineering Command

PLASTIC COATINGS AND WRAPS FOR NEW MARINE TIMBER PILING

ABSTRACT The Naval Civil Engineering Laboratory is participating in two long-term studies of the efficacy of plastic coatings and prewraps for timber piling. Full size polyurethane-coated and polyethylene-wrapped piling have been installed in the Port of Los Angeles. In addition, small wood cylinders have been coated with polyurethane and exposed in the marine environment worldwide. All inspection reports indicate no failures of attachment hardware, no adhesion loss, and no visible borer damage to the plastic wrapped or coated wood after more than 5 years of exposure.

NAVAL CIVIL ENGINEERING LABORATORY PORT HUENEME CALIFORNIA 93043-5003

METRIC CONVERSION FACTORS

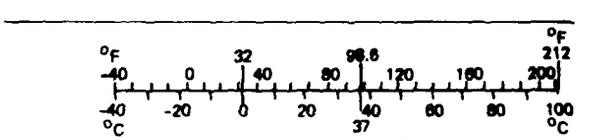
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	*in*
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	*miles*	*mi*
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1,000 kg)	1.1	*short tons*	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	*liters*	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	*cubic feet*	ft^3
m^3	*cubic meters*	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (*then* add 32)	Fahrenheit temperature	°F



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The Naval Civil Engineering Laboratory is participating in two long-term studies of the efficacy of plastic coatings and prewraps for timber piling. Full size polyurethane-coated and polyethylene-wrapped piling have been installed in the Port of Los Angeles. In addition, small wood cylinders have been coated with polyurethane and exposed in the marine environment worldwide. All inspection reports indicate no failures of attachment hardware, no adhesion loss, and no visible borer damage to the plastic wrapped or coated wood after more than 5 years of exposure.

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INTRODUCTION

The wood preservation program at the Naval Civil Engineering Laboratory (NCEL) consists of the development and evaluation of alternative marine timber piling preservation technologies. The program is comprised of two main aspects: (1) chemical preservatives, and (2) barrier systems. Work on chemical preservatives has focused on fumigants and basic zinc sulfate treatments (Refs 1, 2, and 3). Evaluation of barrier systems has previously focused on plastic wrap protection for old, in-place piling (Refs 4 and 5). In 1984, NCEL initiated investigations of plastic coatings and wraps emplaced before the piling are driven. The objective is to determine if plastic barriers are practical alternatives to currently recommended preservatives for new marine timber piling. A summary of these investigations is presented herein. In addition, appendixes are provided that present detailed specifications for test wraps and coatings. These details can provide the basis for the development of Navy specifications for these systems.

NCEL is participating in two long-term studies on the efficacy of plastic coatings and prewraps for timber piling. In both studies, long-term efficacy is evaluated in terms of the resistance of the plastic to borer attack and in terms of coating adherence qualities. In one study, we have supported the preparation and installation of full-size polyurethane (PU)-coated and polyethylene (PE)-wrapped marine piling by the Port of Los Angeles. In a second study, we are participating in an evaluation of PU-coated small wood samples exposed to the marine environment world-wide. The work is being conducted by an International Consortium on Wood Preservation under the direction of Portsmouth Polytechnic near London, England.

EXPERIMENTATION

Full-Size Piling

At the Port of Los Angeles, a series of Douglas-fir piling were prepared and driven in 1984 as part of the fendering system of Berths 174 to 181. The first set of the series consists of 78 untreated, elastomeric PU-coated piling (Figures 1 and 2); the second set consists of 79 creosoted piling wrapped with 20-mil PE; and in the third set are 77 untreated piling wrapped with PE (Figure 3). The specifications for the PE and PU plastics used to wrap or coat the test piling, and the application and installation procedures are listed in Appendix A. This appendix provides PE-wrap and PU-coating specifications for marine timber piling that can provide the basis for minimal Navy specifications for these systems.

All piling were wrapped or coated prior to driving. All pile surfaces were mechanically smoothed to prevent any breaching of the plastic coatings or wraps. The larger checks and cracks of the piles to be coated with PU were filled with a soft polyurethane formulation to allow for a smooth, continuous topcoat. These piles were then covered with a coating of the soft, flexible elastomeric PU formulation followed by an elastomeric PU topcoat that was harder and less flexible. The top 10 feet of the PU-coated piling were left uncoated to facilitate handling while driving. This area was PU coated after driving. The top portions of all PE-wrapped piling remain uncoated and unwrapped. The attachment hardware for the PE wraps consists primarily of aluminum alloy bands and nails. All piling tops are covered by the concrete deck which keeps out the rain thereby avoiding the potential for dry rot. This is especially important for the untreated PE-wrapped piling. In addition, all piling are further protected at the shipside intertidal area by a 150-mil PVC rubber strip to prevent abrasion damage by docking ships (Figure 4).

The first diver inspection report of June 1989 has not yet been officially released but divers revealed that no visible damage had occurred to any of the test piling. No borer attack was evident nor were there any signs of coating adhesion loss or failure of the plastic wrap attachments. Poor performance of several intertidal, 150-mil PVC rubber strips was noted during dockside inspections. The problem was a failure of the aluminum nails and a peeling back of the rubber strips. The problem has been remedied by renailing the rubber strips.

Coated Wood Samples

Members of the International Consortium that is testing PU-coated samples in the marine environment are listed in Table 1. By 1985 each member had exposed a number of cylinders 30 cms long by 4 cms in diameter made of woods commonly used for pilings in the member's regions. The cylinders are exposed in calm waters 1 meter below the low water mark. The wood may or may not contain chemical preservatives, but all were coated with polyurethanes supplied by Grove International, Inc. of Los Angeles. The specifications for these PU coatings (described in detail in Appendix B) are similar to those for the PU-coated full-size piling installed in L.A. Harbor. All PU-coated samples consist of an initial coating of a soft, flexible elastomeric urethane formulation. Some samples have a topcoat of an elastomeric polyurethane that is harder and less flexible. In addition, uncoated samples are emplaced to act as bait for marine borers. Brass eyelets were screwed into the ends of the wood cylinders prior to urethane coat applications to facilitate rope attachments.

NCEL's contribution consists of nine untreated Douglas-fir cylinders. Two samples are completely covered with the bottom coat only; two are coated with the flexible, bottom-coat urethane and the harder topcoat PU; two are covered over half the cylinder surface with the bottom coat PU only; two are covered over half the cylinder surface with bottom and topcoats; and one cylinder is left uncoated. All of our samples are exposed in Sweeper Cove, Adak, Alaska (Figure 5).

Written inspection reports have been infrequent except for those from NCEL (Adak exposures), the United Kingdom, and French Guiana. Annual inspections consist of surface inspections of the coating for

marine borer penetration. In addition, any adhesion loss of the elastomer to the wood is noted. In these inspections to date, it has been reported that no borer damage or adhesion loss has been observed after at least 3 years of exposure. Verbal communication with other members of the consortium has confirmed the fact that there has been no observed damage to any of the PU-coated samples placed in waters around the world. In fact, our PU-coated samples, upon cleaning of fouling organisms, appear to be in pristine condition. In contrast, many of the consortium's (and all of NCEL's) uncoated or half-coated samples have been severely damaged by marine borers (Figure 6).

DISCUSSION

The Navy would benefit from the development and commercial availability of a superior marine timber piling protection system. An ideal system would eliminate all marine borer damage, thus saving up to $25M annually in waterfront maintenance costs. One approach, treatments with biocides (principally creosote), has been extensively employed with limited success for over 150 years. A second approach, plastic barrier systems, has seen little development and use on new piling but is becoming increasingly employed to protect piling already in place. These plastic barriers are typically made of 20- to 30-mil-thick polyvinyl chloride (PVC) or PE. Specifications for materials and installation procedures are provided in Appendix C. (These specifications are included here because many techniques described can also be employed for PE wraps for new piling.) Widespread use of these plastic barriers can virtually eliminate further borer damage to in-place, marine timber piling thus eliminating much of the cost of replacing borer damaged timber piling. It will entail an initial capital cost for plastic installation of about $400 per pile.

A more economical approach is to protect the timber piling with a barrier system before they are installed. The plastic protection will eliminate the need for pressure treatment with a preservative such as creosote. Placing a plastic barrier around piling before driving will also eliminate the need for more costly plastic wrapping after installation. In the past, barrier systems used to protect timber piling from marine borers consisted of a variety of materials from copper sheathing to burlap and tar and were either very expensive, difficult to install, or they rapidly deteriorated in the marine environment. Deterioration of the barrier materials often left the wood beneath exposed to marine borer damage.

The use of plastic coatings or wraps on timber piling has resolved these difficulties. The elastomeric polyurethane coating and the polyethylene wrap can now be applied to untreated timber piling at a cost comparable to biocide pressure treatments. With greater demand, the cost will likely be less than conventional creosote pressure treatments. The plastic materials and attachment hardware are not visibly damaged after 5 years of exposure to the marine environment and provide an effective, continuous barrier to marine borers. The coated piling can apparently be handled and driven with only a modest increase in care to avoid damage to the plastic. In addition, the finished product presents virtually no environmental risk to the marine environment.

Before the Navy fully implements this technology, several developmental stages should be completed. At present we are in the early stages of long-term exposure testing. Confidence in new technologies for marine timber protection systems typically requires at least 20 years of continuous, effective service. In addition to the completion of long-term, exposure testing that demonstrates feasibility, the Navy should develop, concurrently, specifications for materials and installation procedures. It is anticipated that most wrapping and coating of timber piling will be performed by contractors. It is vital that this contracted work be of the highest quality. The appendixes provide a starting point for the development of these specifications. Further development of these specifications is required. Especially important is the development of handling and driving procedures. Changes from current procedures for handling and driving preservative-treated timber piling must be carefully planned and implemented because current procedures have been established for a very long time. Old habits are hard to change.

CONCLUSIONS

1. Plastic barrier systems have been shown to be promising alternatives to conventional chemical preservative treatments for new marine timber piling.

2. There is no visible marine borer damage to polyurethane-coated or polyethylene-wrapped wood after 5 years of marine exposure.

3. No polyurethane adhesion loss is evident after 5 years of marine exposure.

4. Aluminum attachment hardware for polyethylene wraps are intact and remain effective after 5 years of marine exposure.

5. The cost of plastic-coated or wrapped piling is now comparable to conventional, pressure-treated piling and may be less in the future if widely available.

6. Handling and driving care must be greater for plastic-coated piling than for conventionally treated piling.

7. Materials and handling specifications for Navy employment of plastic barrier systems should be developed concurrently with continued long-term marine exposure monitoring.

RECOMMENDATIONS

1. The development of Navy specifications for plastic coatings and wraps for marine timber piling should be predicated on the success of tested systems. At present we are in early stages of long-term exposure testing of these systems. It is strongly recommended, therefore, that we continue at least minimal support for additional periodic inspections of:

(a) Full-size piling precoated with polyethylene or prewrapped with polyethylene at the Port of Los Angeles.

(b) Polyurethane-coated wood samples in Adak, Alaska in cooperation with the International Consortium.

2. It is recommended that the Navy incorporate this technology by developing specifications for plastic prewrapped and precoated timber piling. The appendixes provided herein can provide the basis for these specifications. A pilot program should be developed that demonstrates the efficacy of adapted specifications. The program should be comprised of: (1) the development of Navy specifications, (2) the use of these specifications to treat and install specified prewrapped and precoated piling, and (3) an evaluation of the practicality of adapted specifications.

3. In addition to continued exposure testing and the adaptation of specifications for Navy use, the Navy should develop or evaluate other plastic materials that can be used to precoat or prewrap timber piling. The development of accelerated testing procedures for alternative plastic materials would be useful.

REFERENCES

1. Naval Civil Engineering Laboratory. Technical Note N-1784: Feasibility of alternative chemical preservatives for timber in the marine environment, by D.E. Pendleton. Port Hueneme, CA, May 1988.

2. D.E. Pendleton. "Inspections of experimental piling at Pearl Harbor, Hawaii," in Annual Proceedings of American Wood-Preserver's Association, Minneapolis, MN, May 1988, pp 267-274.

3. Department of Forest Products, Oregon State University. Second Annual Report: Evaluation of methylisothiocyanate, chloropicrin, and vorlex for prevention and control of marine borer attack in Douglas-fir piling, by J.J. Morrell and M.A. Newbill. Corvallis, OR, Aug 1988.

4. Naval Civil Engineering Laboratory. Technical Note N-1773: A comparison of timber piling barrier and chemical preservation annual costs, by D.E. Pendleton and T.B. O'Neill. Port Hueneme, CA, Apr 1987.

5. Naval Civil Engineering Laboratory. Technical Data Sheet 87-06: Polyvinyl chloride (PVC) wraps reduce the cost of maintaining timber piling. Port Hueneme, CA, Jul 1987.

Table 1. Polyurethane Coatings on Wood Samples Exposed in the Sea

	Country/Collaborators	Installation Date	Timbers/Treatments/Sites
1	AUSTRALIA (L.J. Cookson & J.E. Barnacle)	-	*Eucalyptus obliqua* - untreated and PEC 30 white treated. Cairns or Innisfail, Queensland
2	FRENCH GUINA (G.R.Y. Dèon)	November 1985	8 species (See IRG/WP/4121) plus *Ocotea rubra* all untreated. Kourou Harbour
3	GHANA (F.F.K. Ampong)	April 1985 Tema June 1985 Sekondi	*Nauclea diderrichii* - untreated
4	ITALY (Anna Gambetta)	-	*Pinus sylvestris* untreated Follonica
5	Malaysia (West) (K. Daljeet Singh)	-	
6	Malaysia (East) (C. Chan)	-	
7	NEW ZEALAND (D.V. Plackett)	April 1986	*Pinus radiata* sapwood (See IRG/WP/4121). Tauranga Harbour, North Island
8	NIGERIA (E.O. Ademiluyi)	-	
9	NORWAY (F.G. Evans)	June 1985	(See IRG/WP/4121) Trondheimsfjord
10	PAPUA NEW GINUEA (A. Oteng-Amoako)	-	
11	SOUTH AFRICA (W.E. Conradie)	-	
12	UNITED KINGDOM (R.E. Eaton)	July 1985	*Pinus sylvestris* - CCA treated. Bradwell, Essex
13	U.S.A. (Alaska) (D.E. Pendleton)	July 1985	*Pseudotsuga menziesii* Sweeper Cove, Adak
14	U.S.A. (Oregon) (J.J. Morrell)	June 1985 Coos Bay July 1985 Newport	*Pseudotsuga menziesii* - untreated
15	U.S.A. (Panama Canal) (J.D. Bultman)	November 1985	Pine untreated. Naos Island and Ft. Sherman

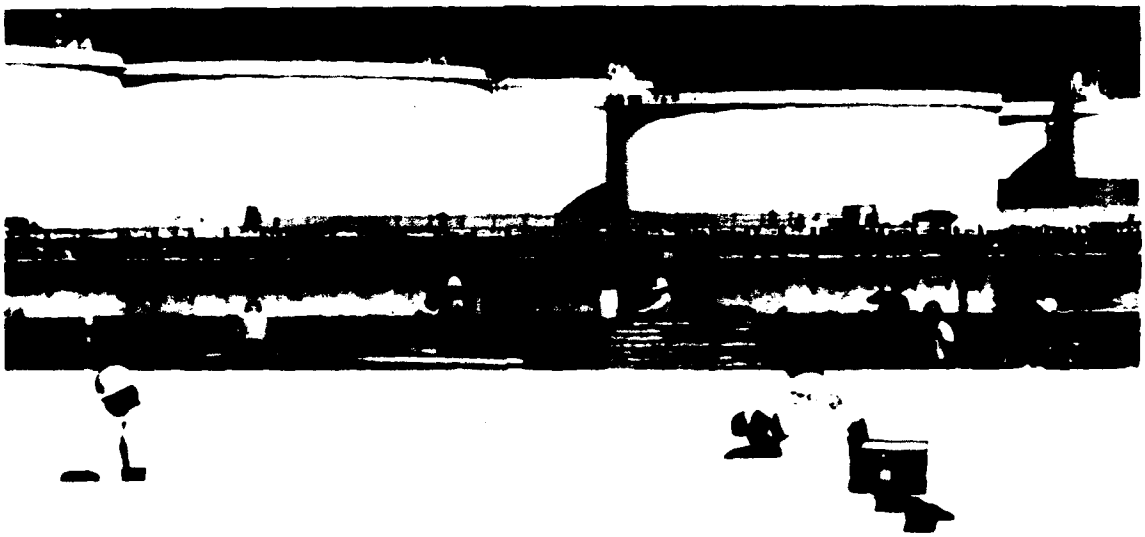

Figure 1. Polyurethane-coated piling prepared on-site for installation at the Port of Los Angeles.

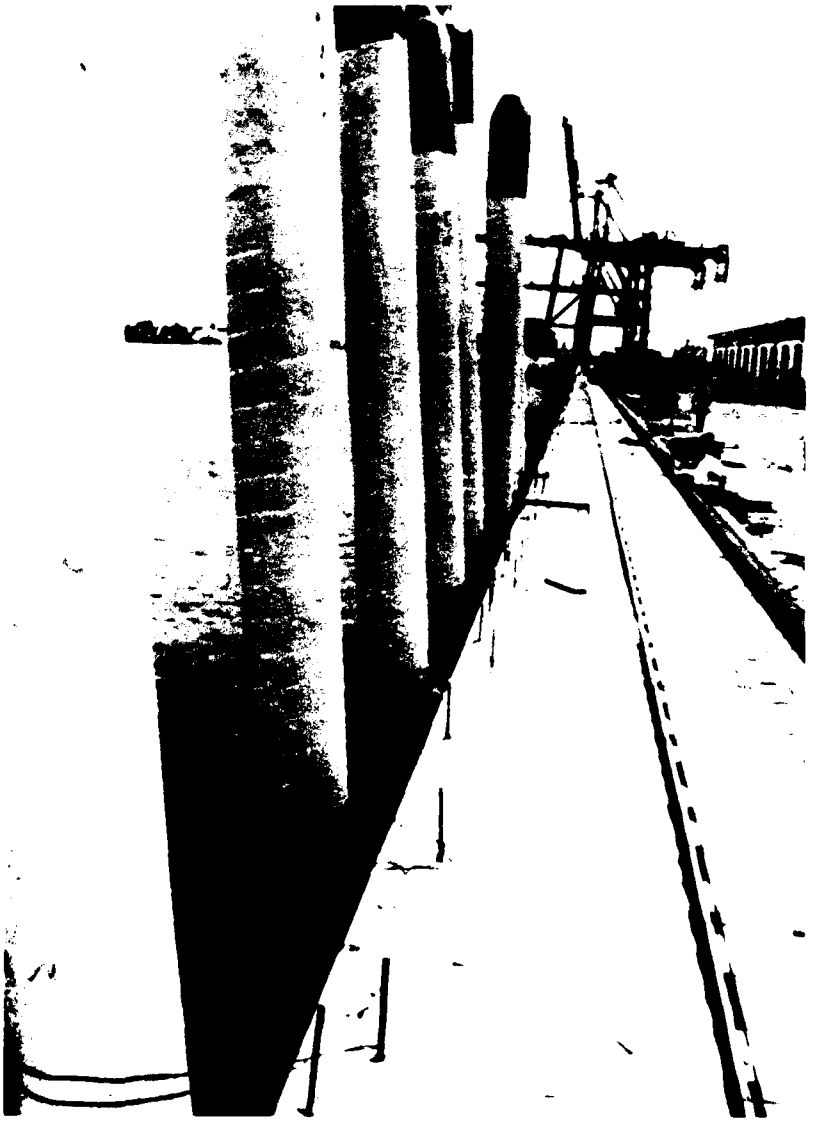

Figure 2. Polyurethane-coated piling during installation at the Port of Los Angeles in 1984.

Figure 3. Polyethylene-wrapped piling prepared on-site for installation at the Port of Los Angeles.

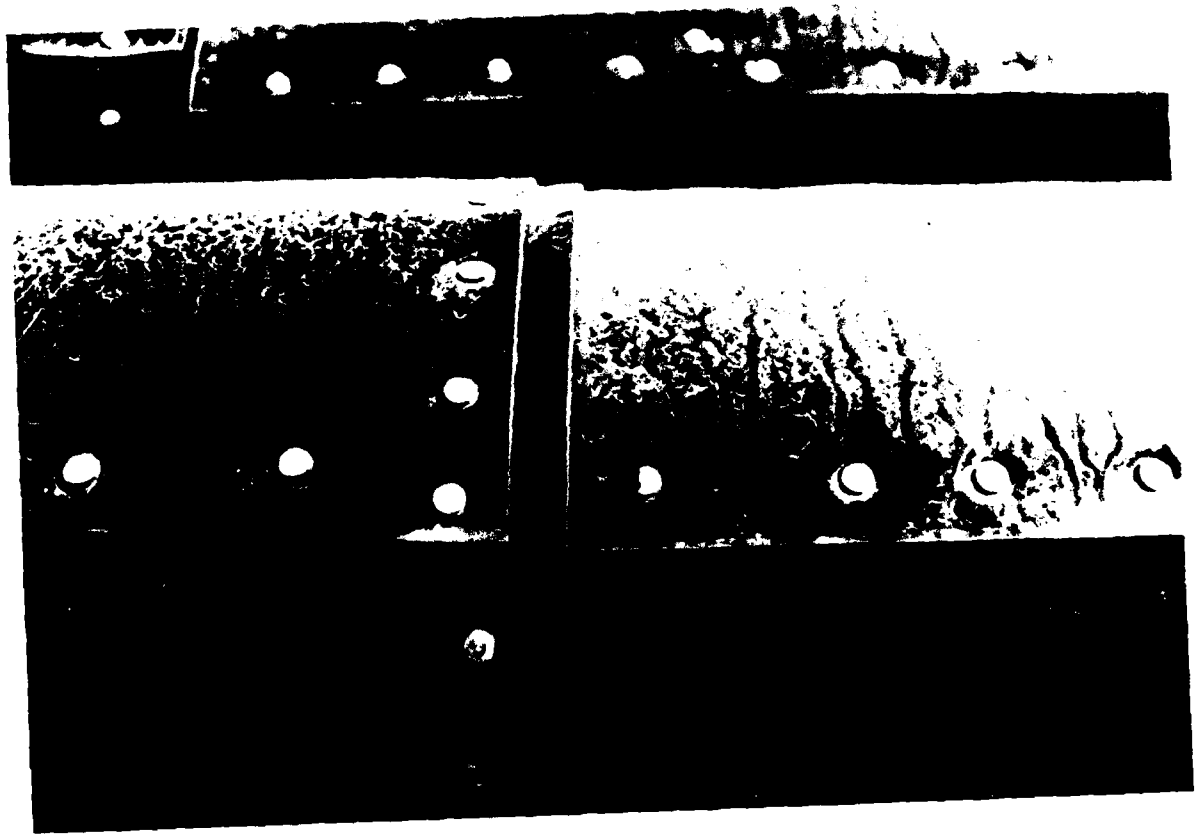

Figure 4. An example of 150-mil polyethylene wraps installed to protect intertidal area of all plastic-coated and wrapped experimental piling at the Port of Los Angeles.

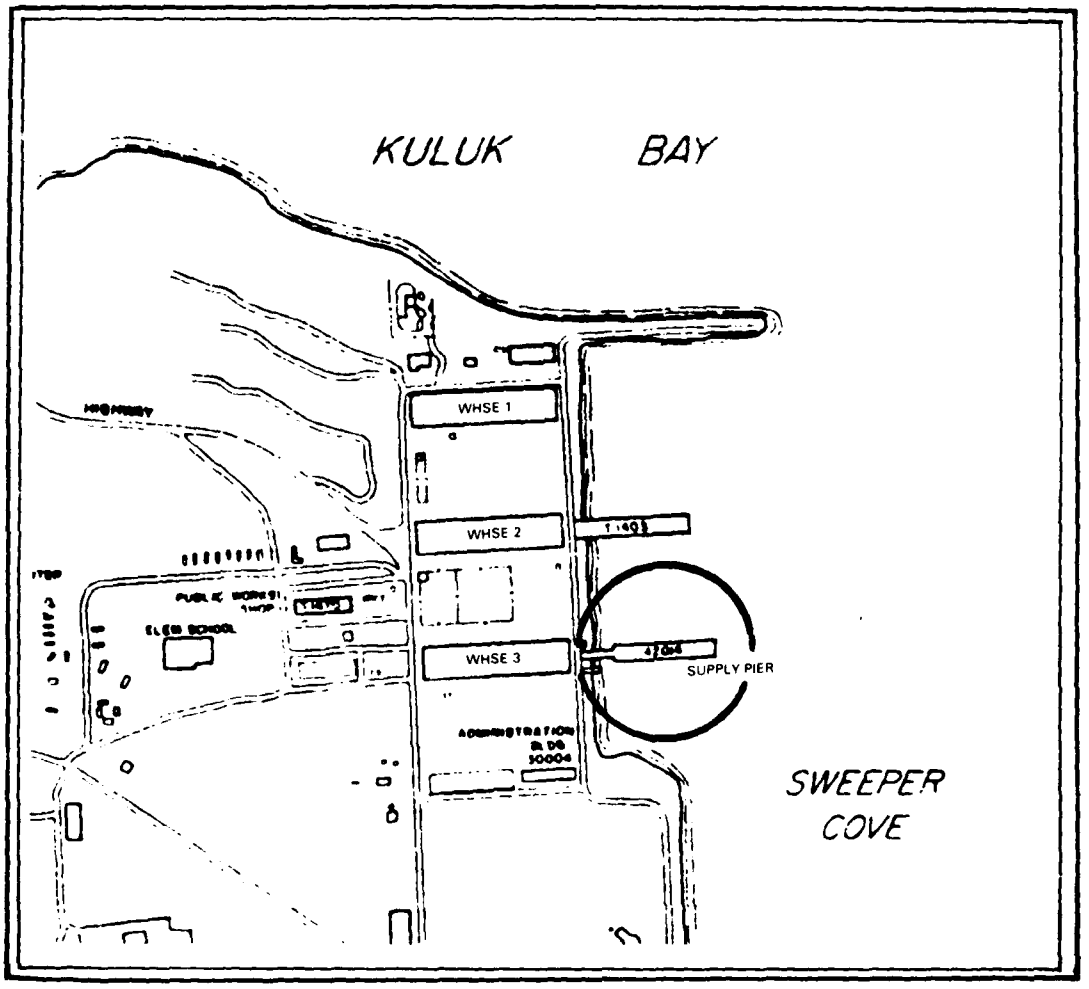

Figure 5. Location of polyurethane-coated wood samples emplaced in Sweeper Cove, Adak, Alaska.

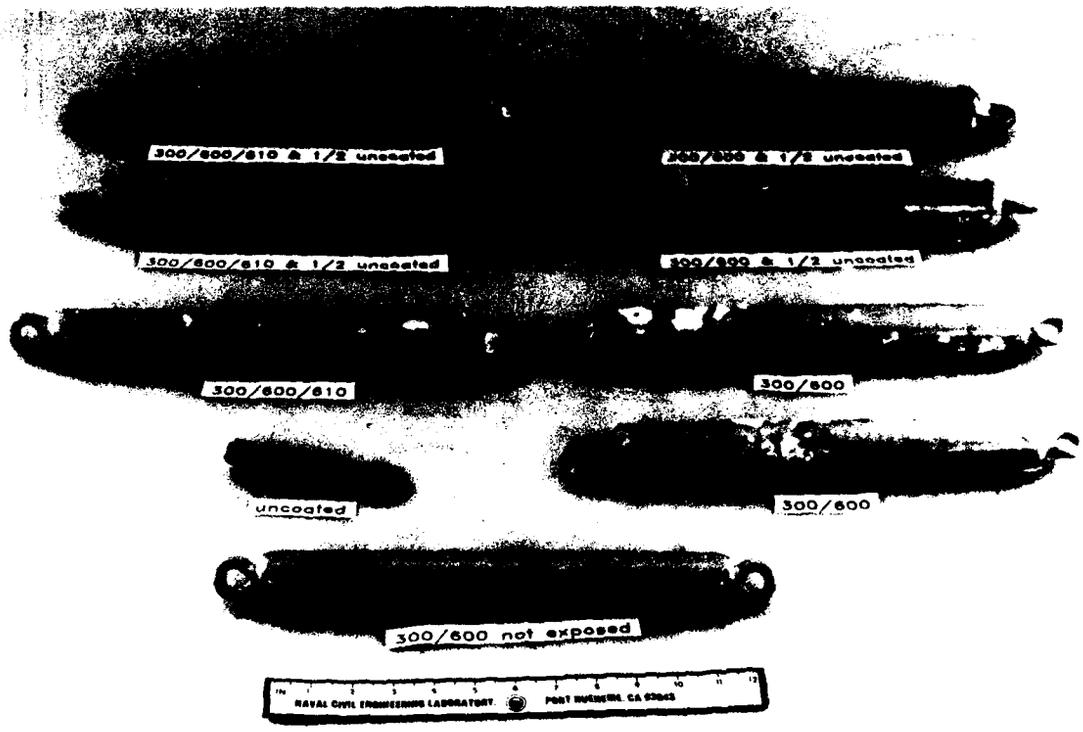

Figure 6. Polyurethane-coated wood samples after 3 years of exposure at Adak, Alaska; soft fouling organisms were removed to show condition of plastic barriers.

Appendix A

PORT OF LOS ANGELES SPECIFICATIONS FOR POLYETHYLENE-WRAPPED AND POLYURETHANE-COATED TIMBER PILING

PART 1 - GENERAL

1.1 WORK INCLUDED

A TIMBER PILES consists of furnishing transportation, supervision, labor, equipment and materials for the installation of timber piles in accordance with the Drawings and Specification.

1.2. REFERENCE STANDARDS

A Applicable Standards:

1 American Society for Testing and Materials (ASTM):

ASTM D 25	Specification for Round Timber Piles
ASTM D 638	Test Method for Tensile Properties of Plastics
ASTM D 746	Test Methods for Brittleness, Temperature of Plastics and Elastomers by Impact
ASTM D 790	Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM D 882	Test Methods for Tensile Properties of Thin Plastic Sheeting
ASTM D 1238	Test Methods for Flow Rates of Thermo-Plastics by Extrusion Plastometer
ASTM D 1505	Test Methods for Density of Plastics by the Density-Gradient Technique
ASTM D 1693	Test Method for Environmental Stress - Cracking of Ethylene Plastics
ASTM D 1894	Test Method for Static and Kinetic Coefficients of Friction of Plastic Film and Sheeting
ASTM D 2103	Specification for Polyethylene Film and Sheeting

2 American Wood-Preservers Association: (AWPA)

AWPA C-18	Standard for Pressure Treated Material in Marine Construction
AWPB MP-2	Standard for Marine Piling Pressure Treated with Creosote for Use in Marine Waters

3 Federal Specifications:

FS L-P-378	Plastic Sheet and Strip Thin Gauge, Polyolefin

B Reference Specifications (RS):

Section 205-1 Timber Piles
Section 305-1 Pile Driving
Section 204-2 Treatment with Preservatives

1.3 SUBMITTALS

A The Contractor shall submit to the Engineer, prior to the shipment of piles, proof of the grade of pile and of the treatment per AWPA and AWPB.

B The Contractor shall submit to the Engineer the manufacturer's certification that aluminum fasteners are of appropriate alloy grade.

C The Contractor shall submit to the Engineer for approval a list of equipment, and the methods and procedures for the driving of piles.

D The Contractor shall submit to the Engineer for approval a schedule and sequence of pile driving.

PART 2 - PRODUCTS

2.1 PILES

A 70 timber piles shall be creosote-treated piles with polyethylene sheet wrapping. 70 timber piles shall be untreated piles with polyethylene sheet wrapping. The piles shall conform to ASTM D 25.

2.2 EQUIPMENT

A Conform to RS Section 305-1.2.

2.3 HANDLING

A Conform to RS Section 204-2.5. Piles shall not be handled in a manner that will result in damage to the outer surface of the pile and its wrapping.

2.4 PILE MATERIALS

A Conform to RS Section 205-1, except that the minimum pile circumference shall be as shown on the Drawings.

2.5 PILE WRAP

A Polyethylene for Wrapping Pilings: Polyethylene sheeting shall be formulated to provide maximum resistance to long-term exposure to marine organisms, rot, and decay of timber piles. The sheeting shall be black in color, smooth, and free of wrinkles, pinholes and other irregularities. The polyethylene sheeting must also meet the following requirements:

1 Resin Virgin polyethylene--no reprocessed resin

Property	Value	Test Method
Thickness	20 mils	ASTM D 2103, Para 7.9
Density	0.917 - 0.931	ASTM D 1505
Carbon Black	2.0% minimum	
Free shrink	MD 15-20% TD 0-7%	Fed. Spec L-P-378
Coefficient of friction, U_K	0.4 to 0.6	ASTM D 1894
Heat sealing properties	Normal	
Melt index, grams/10 minutes	0.2 - 0.4	ASTM D 1238
Tensile strength psi	MD 1400 min. TD 1500 min.	ASTM D 882
Elongation, percent	MD 300 min. TD 300 min.	ASTM D 882
Yield, sq. in per lb of material	1351 - 1677	

Property	Value	Test Method
Roll width, ft.	5.5 center fold 11.0 ± 0.1 open	
Roll length, ft.	150 + 5-0	
Roll weight, lb.	141 - 183	

2 Mechanical fasteners, 2-inch aluminum screw grip nails fitted with neoprene grommet to be approved by Engineer. Aluminum nails shall be 5056 alloy; other aluminum accessories shall be 5052 alloy.

B Polyethylene Wearing Surface:

1 150 mil extra high molecular weight polyethylene sheets 12 feet in length meeting the following criteria:

Property	Value	Test Method
Density	0.950 gm/cc	ASTM D 1505
Melt flow condition F	Less than 9 gm/10 min	ASTM D 1238
Environmental stress, cracking resistance, condition B, F-50	1,000 hours	ASTM D 1693
Tensile strength (2 in/min)	3,600 psi	ASTM D 638
Elongation (2 in/min)	650%	ASTM D 638
Brittleness (°F)	Temperature less than 180°	ASTM D 746
Flexural modules	175,000 psi	ASTM D 790

2 Mechanical fasteners, 3-inch aluminum screw grip nails and fitted with neoprene grommet to be approved by the Engineer. Aluminum nails shall be 5056 alloy; other aluminum accessories shall be 5052 alloy.

2.6 APPLICATION

A General: Creosoted piles shall be creosoted in accordance with AWPA C18. Creosoted piles shall conform with AWPB MP-2.

B Lengths: The pile lengths shall be sufficient to achieve the design depth and allow for cut-off of unsound timber pile due to damage in driving.

C Splicing: No splicing will be permitted.

D Pile Wrap:

1 Pile shall be wrapped in polyethylene before installation. This wrap shall cover the pile between the elevations of (-) 49 feet and (+) 8 feet with respect to MLLW.

a The wrap shall be uniform and continuous throughout the length of pile, resulting in a smooth, wrinkle-free, airtight fit. All joints shall be overlapped a minimum of 4 inches and a maximum of 8 inches to provide a continuous seal.

b Mechanical fasteners shall be used to secure the longitudinal joint. Fasteners shall be spaced a minimum of two inches on center and a maximum of one inch from all edges. If deformations, buckles, or wrinkles occur between fasteners, additional fasteners shall be used to produce a flush joint.

2 An outer wearing surface shall then be applied as tightly as possible using mechanical fasteners. This covering shall extend form elevation (-) three feet to elevation (+) nine feet. The pile shall be wrapped with the wearing surface prior to driving. If driving conditions prohibit proper positioning of the pile, the Engineer may allow the wearing surface to be applied after driving.

a The wearing surface shall be wrapped around the pile resulting in a smooth, wrinkle-free fit.

b Mechanical fasteners shall be used to secure the longitudinal joint. Joints shall be overlapped a minimum of 2 inches and a maximum of eight inches. (Thus, the width of wearing surface used will depend upon the circumference of pile used.) Fasteners shall be spaced a minimum of 4 inches on center. If deformations, buckles or wrinkles occur between fasteners, additional fasteners shall be used to produce a flush joint. The maximum gap between wearing surface and pile shall be 1/4 inch.

c Transverse joints will not be allowed.

d After driving, the longitudinal joint of the wearing surface shall be on the land-side face of the pile.

PART 3 - EXECUTION

3.1 INSTALLATION

A General: Piles are to be driven to the depth shown on the Drawings.

B Markings: Before driving, piles shall be marked in order that tip elevations may be read from the exposed ends.

C Driving: Conform to RS Section 305-1.4. Jetting timber piles will not be permitted. Timber piles shall be driven after the rock dike is in place and fitted with a pointed steel driving shoe.

D Pile Cut-Off: Piles shall be cut off as required in order to fit into the concrete pocket. Once piles are cut off, the cut surfaces shall be thoroughly treated per AWPA C-18.

3.2 DAMAGED PILES

A Piles that are broken, cracked, or splintered during pile driving operations shall be removed and replaced with a new timber pile at the Contractor's expense. The location of replacement piles shall be approved by the Engineer.

POLYURETHANE COATING:

Polyurethane shall be a one-component, moisture-curing, elastomeric, polyether-base resin with the properties listed below. The base coat shall be Pacific Polymer's Elasto-Deck 5001 and the topcoat shall be Pacific Polymer's Elasto-Glaze 6001AL. Base and topcoat shall be supplied as a "system" by the same manufacturer.

PROPERTY	VALUE FOR BASE COAT	VALUE FOR TOPCOAT	TEST METHOD
Tensile Strength, 75°F	800-1000 psi	3500 psi	ASTM D 412
Elongation, 75°F	600-800%	175%	ASTM D 412
Viscosity, 75°F	2800-3000 cps	1500 cps	Brookfield #4 Spindle, 20 rmp

PROPERTY	VALUE FOR BASE COAT	VALUE FOR TOPCOAT	TEST METHOD
Adhesion to Wood	300 psi	300 psi	LAHD TT-1
Drying Time (10 mils dry film)	24 hrs. max.	4 hrs. (tack-free)	
Fire Test	Class B	Class B	ASTM E 108-58
Hardness (Shore A)	80-85	95-100	ASTM D 2440
% Solids (by weight)	80% min.	65% min.	
Resistance to Abrasion	--	0.4 grams (max.)	Tabor H-18 Wheel, 1000 cycles
Water Absorption	--	1/2% max.	ASTM D 471
Tear Resistance	--	300 lb/in.	ASTM D 624
Permeability	--	0.01 perm.-in.	ASTM E 96

APPLICATION:

Lengths: The pile lengths shall be sufficient to achieve the design depth and allow for cut-off of unsound timber pile due to damage in driving.

Splicing: No splicing shall be permitted.

EXECUTION

INSTALLATION:

General: - Piles are to be driven to the depth shown on the Drawings.

Markings: - Before driving, piles shall be marked in order that tip elevations may be read from the exposed ends.

Driving: - Conform to RS Section 305-1.4. Jetting timber piles will not be permitted. If timber piles are driven after the rock dike is in place, a driving shoe shall be used.

Pile Cut-Off - Piles shall be cut off at an angle of 15° to 20° from the horizontal sloping toward the water. Once piles are cut off, the cut surfaces shall be thoroughly treated in accordance with RS Section 204-2.3 for creosoted piles and a polyurethane coating 50 mils thick for polyurethane-coated piles.

Polyurethane Coating

- Untreated timber piles shall be prepared for coating in accordance with the following:

  a. Protrusion in excess of 1/8" from surface of piles, such as splinters or rough surfaces, must be removed so that no "snags" exist.

  b. Cracks, checks and kerfs wider than 1/8" shall be chaulked with a urethane sealant (compatible with coating) to provide a uniform surface.

  c. Cracks, checks and kerfs wider than 1/4" shall be filled with a "backer-rod" or suitable material approved by the Engineer.

- Application of coating shall be as follows:

  a. Material shall be applied in conformance with the manufacturer's recommendations.

  b. The base coat shall have a cured uniform thickness of 35 miles (±5 mils). The topcoat shall have a cured uniform thickness of 15 mils (+5 mils -0 mils). Total thickness of coating shall be 50 mils (+5 mils, -0 mils).

  c. The timber pile from its tip to 10 feet from the tip need not be coated.

Appendix B

PRODUCT DATA FOR POLYURETHANE COATINGS APPLIED TO SMALL WOOD TEST CYLINDERS

PRODUCT NAME: GS-300 elastomeric urethane coating, liquid applied, with CHEMPRO.*

MANUFACTURER: GROVE INTERNATIONAL, INC.
826 North Lake Street
Burbank, California 91502
Telephone - (818) 840-8826
TWX# 910-498-2748

PRODUCTION DESCRIPTION: GS-300 is a single-component, moisture-cured modified polyurethane coating. GS-300 forms a continuous, flexible, seamless membrane on vertical or horizontal surfaces which provides positive waterproofing. Its toughness and flexibility enables the membrane coating to bridge hairline cracks, should they occur. We recommend the use of GS-14 Primer at a rate of 325 to 350 square feet to the gallon.

USE: To provide a water barrier membrane for concrete slab construction on roofs, parking decks, patios, malls, and other bridges and for use on exterior foundation walls, planter boxes, subway structures, tunnels, and other areas where waterproof membrane is required.

ADVANTAGES: GS-300 is cold applied and ready to use from the factory container. The product can be sprayed, rolled, or troweled to vertical or horizontal surfaces.

TECHNICAL DATA AND APPLICABLE STANDARDS:

Weight/Gallon	10.4 lb
%NVM	81
Viscosity	220-2800 cps
Drying Time (depending on temperature and humidity	10-24 hours
Fire Test	
ASTM Class B E-108-58	
Hardness, Shore A	72
Adhesion, Concrete	excellent
Wood	excellent
Tensile Strength	
ASTM D-412	800-1000 psi
Elongation	
ASTM D-412, Percent	600-800%

*CHEMPRO is a select blend of proprietory adhesion promoters that provide superior wetting and adhesion.

INSTALLATION:

Preparatory Work. All surfaces must be structurally sound, clean, and free of visible moisture, grease, dirt, and corrosion. Remove all fresh asphalt, resin-base curing compounds, or loose paint. Use compressed air to remove dust and dirt prior to applying the waterproofing membrane.

Joint & Crack Preparation. Fill contraction and expansion joints with compressible rod, such as butyl or ethafoam, to within 1/2 inch of the surface. Fill the balance of the joint with MC-100 Mono-Calk joint sealant. All cracks 1/16 inch and larger shall be caulked. The following day, strip coat with a preparatory coat of GS-300. Any expansion and contraction joints should be primed and sealed.

APPLICATION: GS-300 coating can be applied by air or airless spray, a roller, or a notched trowel. Minimum coverage is 3 gallons per 100 square feet. Vertical surfaces will require two or three coats to obtain proper thickness. Horizontal surfaces will require two coats. Since the coating bonds to itself, applications may be performed at intervals providing the edge of previously applied material is cleaned and the edges are lapped at least 6 inches.

COVERAGE: Minimum coverage of 3 gallons per 100 square feet is recommended. Vertical surfaces may require three or more coats to obtain proper thickness.

INSPECTION AND TESTING: The wet film thickness shall be checked at frequent intervals to ascertain 50 mils minimum thickness is obtained. Inspect all applied surfaces and eliminate all voids or holidays.

CLEANING: Clean equipment with GS-9900 Cleaner or a solvent such as Xylol or MEK. Carefully discard all solvent soaked rags. Keep away from open flame. Clean hands before eating since material is harmful if swallowed. Use mild cleaner such as Boraxo or Gre-Solvent.

PRECAUTIONS: People who have sensitive skin should wear protective gloves while applying. Mix and apply these coatings in well ventilated areas while observing normal safety precautions. These materials have a shelf life of 6 months in an unopened container.

AVAILABILITY: GS-300 is available through the home office.

COLOR: Monterey Sand, Cliff Grey, and other colors on request.

MAINTENANCE: If maintenance is necessary, cut the section to be removed in a round or oval shape and repair as stated in application.

PRODUCT WARRANTY: Every reasonable precaution is taken in the manufacture of all products and compiling of data to assure that they shall comply with Grove's exacting standards. To the best of our knowledge, information given is correct and the products as sold are satisfactory for the purpose proposed by Grove.

However, no guarantee of results using these products and data is given because every possible variation in the methods of their use or conditions under which they are applied cannot be anticipated. The only obligation of either seller or manufacturer shall be to replace any defective material.

TECHNICAL SERVICES: Technical assistance can be obtained by contacting:

GROVE INTERNATIONAL, INC.
826 North Lake Street
Burbank, California 91502
Telephone - (818) 840-8826
TWX# 910-498-2748

PRODUCT NAME: GS-600-A Aliphatic, one part, moisture-cured elastomeric urethane top coating, with CHEMPRO.*

MANUFACTURER: GROVE INTERNATIONAL, INC.
826 North Lake Street
Burbank, California 91502
Telephone - (818) 840-8826
TWX# 910-498-2748

PRODUCTION DESCRIPTION: GS-600-A is a ready to use, liquid-applied elastomeric polyurethane coating. It is primarily used as a topcoat/utility surface over a GS-300 elastomeric urethane base coat where superior weathering, wear resistance, and protection against many chemicals is desired. GS-600-A also offers excellent ultraviolet resistance.

USE: GS-600-A is recommended as a topcoat in Grove's GS-300 elastomeric urethane base coat. GS-600-A is lower in viscosity, and harder and higher in tensile strength than GS-300. Because of its better weather, chemical, and abrasion resistance, GS-600-A is used for topcoat and exposed applications such as waterproofing dams, reservoirs, pipes, concrete roofs, pedestrian and vehicular decks, pipe conduits, and similar structures.

ADVANTAGES: No mixing or priming is necessary. GS-600-A has excellent adhesive properties and, combined with its great toughness, makes the ideal wearing surface. The tight molecular structure makes GS-600-A resistant to sunlight and many chemicals from oil and gasoline acids. The product becomes tack free in 2 to 8 hours. The solids content of the coating is 63 percent, therefore two coats will achieve 15 to 20 mils minimum dry coat working surface.

Repairs, if necessary, are easily accomplished when GS-300 is used initially, topcoated with GS-600-A. Wipe with MEK to insure tack and apply immediately.

*CHEMPRO is a select blend of proprietory adhesion promoters that provide superior wetting and adhesion.

PRECAUTIONS: When using urethane elastomers, adequate protective measures should be taken:

1. Use in well ventilated area and avoid breathing vapor.
2. Wash hands before eating or smoking.
3. Avoid contact with eyes, skin, and clothing.
4. Use protective gloves and goggles.

In case of skin contact, wash immediately with isopropanol, followed by soap and water. In case of eye contact, flush with clear water immediately and get medical attention as soon as possible.

Do not install GS-600-A to a thickness greater than 35 mils without obtaining manufacturer specific instruction.

PRIMING: Priming is accomplished by use of GS-300 base coat.

COLORS: Standard colors: grey, tan and off-white, other colors on special order.

PACKAGING: 5-gallon pails, 55-gallon drums

TECHNICAL DATA:

% Solids (NVM) By Weight	63%
% Solids (NVM) By Volume	45%
Viscosity (Brookfield, #4 Spindle, 20 RPM, 75°F	1000 cps
Tack Free Time 8 to 10 mils dry film	2-8 hours depending on temperature and humidity
Cure Time-Full Cure 8 to 10 mils dry film	36-96 hours depending on temperature and humidity
Hardness, Shore A at 75°F	97 ± 2
Tear Resistance at 75°F	300 psi
Tensile Strength at 75°F	3500 psi
Elongation at 75°F (extended at 2" per minute)	125%

INSTALLATION: Allow the base GS-300 to dry a minimum of 24 hours before applying GS-600-A. (Note: If more than 36 hours pass before GS-600-A is to be applied, wipe the base coat with MEK to clean the surface).

In coating steel structures for petroleum or marine use, sandblast to near white and apply GS-14 primer.

We recommend three base coats of GS-300 and two coats of GS-600-A topcoat where severe conditions exist.

COVERAGE: Normally, 3 gallons of GS-300 and 1-1/2 gallons of GS-600-A per 100 square feet are used for most applications. Applications subject to more severe environments use 3-1/2 gallons of GS-300 and 2 gallons of GS-600-A per 1,100 square feet. One cured coat is 12 mils of GS-300 and 7-1/2 to 8 mils of GS-600-A.

COATING APPLICATION: Grove's Elastomeric Urethane coating can be applied by air or airless spray, a roller, or a notched trowel. Spray guns recommended are equivalent to:

Air--De Vilbiss, Model JGA-A502-777E

Airless--Grayco's Airless Hydra Mastic Unit, Model 226-176 with 0.040 tip. Grayco's Bulldog (30 to 1 ratio) pump 100 psi.

Airless equipment can spray up to 2 gallons per minute.

CURE RATE: The cure rate of Grove's Elastomeric Urethane coating is dependent on relative humidity, temperature, and thickness of application. At 70°F and 50 percent R.H., a fairly good cure is obtained of 30 mils film within 24 hours. Thicker applications require longer cure time. Moisture and higher temperature accelerates the cure rate.

PAINTING: After 24 hours cure, GS-600-A topcoat can be painted with acrylic emulsion paint without interfering with final curing process.

CLEANING: Tools and equipment should be cleaned prior to curing of the product with methylene chloride, methyl ethyl ketone. Cured material can be removed by generous soaking in E-Z Strip manufactured by Cal-Tek Industries, Los Angeles, CA.

HANDLING INSTRUCTIONS: Theoretically, it only takes a 3/4 pint of water to cure an entire 55-gallon drum of the coating. It is easily understood therefore, that when a container is opened the moisture from the air starts the curing process.

The entire contents of a container once opened should be used promptly (within a day or two). The product can be preserved longer if the container is flushed with Nitrogen and sealed thoroughly. Another method is to place a polyethylene film on top of the material so that no air can reach the material. If a top skin develops it may be removed and the balance of the material used without affecting its physical properties.

If the product has thickened slightly in storage, it may be thinned with Xylene to proper consistency. Do not use more thinner than necessary. About 3 percent by volume is the maximum amount recommended. Low temperature will increase viscosity. Do not use thinner if thickness is due to low temperature. Use a suitable type of heater to raise the temperature of material to 70°F to 90°F. It takes a considerable period of time to raise the temperature of a drum material, so it is always best to store the material at room temperature.

AVAILABILITY: GS-600-A is available by contacting the home office.

PRODUCT WARRANTY: Every reasonable precaution is taken in the manufacture of all products and compiling the data to assure that they shall comply with Grove's exacting standards. To the best of our knowledge, information given is correct and the products as sold are satisfactory for the purpose proposed by Grove.

However, no guarantee of results using these products and data is given because every possible variation in the methods of their use or conditions under which they are applied cannot be anticipated. The only obligation of either seller or manufacturer shall be to replace any defective material.

MAINTENANCE: No maintenance should be necessary.

See page 1 -- ADVANTAGES should repairs be required.

TECHNICAL SERVICES: Technical assistance can be obtained by contacting:

GROVE INTERNATIONAL, INC.
826 North Lake Street
Burbank, California 91502
Telephone - (818) 840-8826
TWX# 910-498-2748

PRODUCT NAME: GS-610, single component high performance polyurethane coating generally used as a topcoat on GS-300, with CHEMPRO.*

MANUFACTURER: GROVE INTERNATIONAL, INC.
826 North Lake Street
Burbank, California 91502
Telephone - (818) 840-8826
TWK# 910-498-2748

PRODUCT DESCRIPTION: GS-610 is a single component liquid-applied moisture curing polyurethane coating, based on an aliphatic (nonyellowing) isocyanate with a polycaprolactone backbone. The system is available in colors which are unaffected by solar radiation. Mechanical properties are also relatively unaffected over extended periods of exterior exposure.

APPLICATION: GS-610 can be sprayed by airless equipment, airspray, brush or roller at a thickness of 2 to 10 mils (800-160 square feet/gallon).

TYPICAL CURE: Rate of cure is dependent upon temperature relative humidity, and mil thickness. Between 3 - 9 mils at 55 RH and 70^{o}F - 20 hours to touch, 12 hours to completely cure.

*CHEMPRO is a select blend of proprietory adhesion promoters that provide superior wetting and adhesion.

TECHNICAL DATA:

Viscosity, centipoises ASTM D2393	800 cps
Tensile Strength, ASTM D412	5200 psi
Elongation, ASTM D412	100%
Abrasion Resistance CS-17 1000 grams (tabor) 1000 cycles	22 mg
Hardness, Shore A	98
Percent Solids (by weight)	60%
Weight per gallon	9.8 lb

Values listed are typical of clear resin only. Quantities of color pigments may reduce these values in proportion to the pigment loading.

The values shown are typical and are not recommended for specification purposes unless practical tolerances or limitations are established with our laboratory.

Representations made are believed to be valid; however, the seller makes no warranty of any kind concerning the use of this product.

STORAGE: All packaging includes a dry nitrogen blanket in the head space above the liquid. This blanket supplies an inert environment, free of atmospheric moisture to prevent surface skinning of the product.

Storage temperature should be above 70°F but no greater than 100°F. Ideal temperature range is 70 to 90°F.

Department of the Navy
Naval Facilities
Engineering Command

NAVFAC
SPECIFICATION
TSM-B10a
October 1973
Superseding TSM-B10

Appendix C

NAVFAC TYPE SPECIFICATIONS FOR INSTALLATION OF FLEXIBLE PLASTIC BARRIERS ON MARINE BORER DAMAGED WOOD BEARING PILES

Type Specifications shall not be referenced but are to be used as manuscripts in preparing project specifications. APPROPRIATE CHANGES AND ADDITIONS AS MAY BE NECESSARY AND AS REQUIRED BY THE NOTES MUST BE MADE. Number in parentheses --e.g., "(2)" -- in right-hand margin refer to corresponding notes at end of specification.

SECTION INSTALLATION OF FLEXIBLE PLASTIC BARRIER ON MARINE-BORER DAMAGED WOOD BEARING PILES

.1 Scope. This section includes the installation of flexible plastic barriers on marine-borer damaged wood bearing piles, complete.

.2 Applicable documents. The following specifications and standards of the issues listed in this paragraph (including the amendments, addenda, and errata designated), but referred to hereinafter by basic designation only, form a part of this specification to the extent required by the references thereto. (See paragraph entitled "Specifications and Standards" in Section 1A for additional information.)

.2.1 Federal Standards

Fed-Std-191 Textile test methods

.2.2 Non-Government documents.

.2.2.1 American Society for Testing and Materials.

D543-___ Method of test for resistance of plastics to chemical reagents.

D****** Stiffness of plastics by means of a cantilever beam.

D792-___ Methods of test for specific gravity and density of plastics by displacement.

D882-___ Methods of test for tensile properties of thin plastic sheeting.

D1004-___ Method of test for tear resistance of plastic film and sheeting.

D1203-___ Methods of test for loss of plasticizer from plastics (activated carbon methods).

D1204-___ Method for measuring changes in linear dimensions for non-rigid thermoplastic sheeting or film.

D1564-___ Methods of testing slab flexible urethane foam.

.3 General requirements. Flexible plastic barrier installation shall be in accordance with the materials and application techniques required by the specifications.

.3.1 Materials shall be delivered in the manufacturers' original unbroken packages or containers which shall be labeled plainly with the manufacturers' names and brands.

.3.1.1 Polyvinyl chloride sheet shall be used as the barrier. It shall be new, seamless, nonrigid, domestic, virgin homopolymer material. The sheet shall be uniform throughout; free from dirt, oil, and other foreign matter and commercially free from cracks, creases, bubbles, pits, tears, holes, and any defect that may affect its service. The plasticizer system shall be such as to insure stability and adequate resistance of the barrier to fungal and bacterial degradation. Suitable stabilizers shall be incorporated into the resin to impart durability. The use of water-soluble compounds ingredients is prohibited. A black pigment shall be dispersed to produce an even color which is fade-resistant in sunlight. The barrier shall be of width ample to encircle each pile and allow for a minimum of 1-1/2 revolutions of the pole pieces for final fastening. The thickness of the sheet shall be 0.030 inch with a plus tolerance of 0.005 inch and no minus tolerance, and the sheet shall conform to the following mechanical and physical requirements as tested by reference ASTM Standards:

Property	Requirement	Test Method
Tensile Strength:		
Machine direction	2,500 psi, min.	D882, Method A
Transverse direction	2,000 psi, min.	D882, Method A

Property	Requirement	Test Method
Elongation	300% both directions	D882
Volatility	1.5% man. weight loss	D1203
Graves Tear	300 lb/in	D1004
Shrinkage	5% max. (30 mins. at 212°F)	D1204
Specific Gravity	1.20 - 1.35	D792

(a) Water extraction shall be determined in accordance with ASTM D543, Method I, using sea water as the reagent, except that the specimens shall be dried for 6 hours at 70°C (158°F), 1 hour at 100°C (212°F), and overnight at the conditioning temperature before reweighing. The weight loss shall be not more than 0.75 percent.

(b) Flexibility test shall be in accordance with ASTM D747. A stiffness value of 2100 psi ± 10% is acceptable.

(c) Fungal degradation shall be determined in accordance with Method No. 5760 of Federal Test Method Standard No. 191, using a quantitative evaluation. The tensile strength of the exposed specimens, in both the machine and transverse directions, shall be no more than 20% below the tensile strength of unexposed specimens determined in accordance with ASTM D882, Method A.

.3.1.2 Intertidal seals shall consist of 0.75-inch by 3-inch flexible polyether-type polyurethane foam conforming to the requirements of the following tests:

Tests	Requirements
(a) Density (ASTM D1564, Sec. 68-73)	1.85-2.1 lb/ft^3
(b) Indentation-load-deflection (ASTM D1564, Method "A"; Sec. 19-25)	42 ± 4
(c) Compression Set (ASTM D1564, Sec. 12-18) 50% constant deflection - set based upon original thickness	10% maximum
(d) Steam autoclave (ASTM D1564, Condition "B"; Sec. 5-11)	

Tests	Requirements
(e) Compression-load-deflection loss (ASTM D1564, Sec. 32-37)	±12%
(f) Tension (ASTM D1564, Sec. 81-87):	
Tensile strength	15 lb/inch^2, Min.
Tensile elongation	200% Min.
(g) Tear resistance (ASTM D1564, (Sec. 74-80)	2.0 lb/inch Min.

.3.1.3 Bands shall be 0.030- to 0.032-inch by 1-inch aluminum alloy 5052, H - 34 work hardened. They shall be of sufficient length to completely encircle the pile over the seal area and provide for an additional 18 inches, minimum, for the strapping operation.

.3.1.4 Nails shall be of two types:

(a) Type I shall be aluminum alloy 5056 roofing nail with screw shank, 0.150-inch minimum diameter, 1-1/2 inches long with 1/2-inch minimum head diameter, and equipped with a 3/32-inch flat neoprene washer.

(b) Type II shall be aluminum alloy 5056 straight 0.215-inch minimum diameter shank common nail, 4 inches long, with 13/32-inch minimum diameter flat head.

.3.1.5 Pole pieces shall be kiln dried, select heart grade Apitong, clear, straight grain, pitch free, and without slash, knots, splits, checks, or any other defects. It shall be milled to a half-round section approximately 1 inch in diameter. The length of each pole piece shall be 2 feet shorter than the length of the barrier wrap to be applied in order to provide a 12-inch-long polyvinyl chloride skirt at each end.

.3.1.6 Creosote seal membrane shall be 0.006-inch-thick polyethylene film sufficiently wide to encircle the pile with a 6-inch minimum overlap.

.3.1.7 Test sticks shall be untreated rough pine or Douglas Fir, 3/8 inch thick, 2 inches wide, and 12 inches shorter than the barrier.

.3.1.8 Hydraulic grouting mortar shall be a nonshrinking type of grouting mortar with a minimum compressive strength of 1,500 psi. An approved standard commercial grouting mortar may be used. The approved product shall be delivered to the site of the work in the original sealed containers, each bearing the trade name of the material and the name of the manufacturer.

.3.2 Assembly of the modular units.

.3.2.1 Polyvinyl chloride barrier sections are to be fabricated in modular lengths not to exceed 16-foot lengths to conform with the pile taper for the full barrier length. All barrier assemblies shall be

provided with a horizontal 2-inch-wide by 12-inch-long white painted mark on the outside of the wrap. Markings are to be 3 feet from the bottom of the sheet. These marks are to be used as a reference for determining the actual length of the lap joints of modular sections and also the depth of mud seals. The length of the barrier assembly shall also be stenciled on the outside of the wrap at the midsection. This is to expedite the OICC's determination of the actual net lengths of barrier installed.

.3.2.2 Pole pieces shall be stapled to each vertical edge of the polyvinyl chloride barrier in such a manner that a 12-inch horizontal PVC skirt will be formed at the top and bottom of the unit. The stapling shall start by installing two staples at each end of the sheet, then installing staples on 2-inch centers for the first 12 inches, then on 6-inch centers.

.3.2.3 Modular units to be installed in the intertidal zone shall be polyurethane foam strips stapled at 3-inch intervals, 1/2 inch extension over the top and bottom edges of the unit. These foam strips are not required on modular units to be installed below extreme low tide.

.3.3 Installation.

.3.3.1 Number and lengths of piles to be wrapped shall be determined by the OICC. Barrier wraps shall extend from a point 24 inches above the highest point of borer attack to a point 36 inches below the lowest anticipated low tide, or to an elevation furnished by the OICC based upon a recent diver's inspection. Bids shall be based on the total length of installed plastic barriers.

.3.3.2 Cleaning and surface preparation. The entire surface of each pile shall be thoroughly cleaned for the entire length that is to be covered by the barrier. This cleaning does not require the removal of surface growths from cavities or other indentations that do not come in contact with the plastic barrier; but does require removal of all surface projections such as nails, bolts, large splinters, fouling organisms, and other surface conditions that would either penetrate the plastic or cause undue deformation. Cleaning operations may be done manually or with mechanized equipment. It is not necessary to remove minor surface bumps or other similar uneveness, provided these are smooth, as the plastic material has sufficient elasticity to pass over these surface defects without interfering with the snugness of the overall length. Any depressions of longitudinal cracks in the piles at the top and bottom terminations of the wraps that make it difficult or impossible to attain an effective seal shall be filled with a hydraulic mortar or other material approved by the OICC, necessary to obtain the "tightness" or seal specified hereinafter.

.3.3.3 Creosoted piling to be wrapped with a polyvinyl chloride barrier shall first be covered with a 0.006-inch polyethylene seal membrane between the pile surface and the polyvinyl chloride barrier. The polyethylene membrane shall be wide enough to encircle the pile with

a minimum 6-inch overlap. The edges of the creosote seal shall be stapled to the pile at 12-inch vertical intervals, and at 3-inch intervals along the top and bottom edges.

.3.3.4 Intertidal seals shall be installed wherever borer attack has occurred in the intertidal zone. They shall extend from a point 24 inches above the highest point of borer attack to a point 36 inches below the lowest anticipated low tide, or to an elevation furnished by the OICC based upon a recent diver's inspection. The OICC will provide the Contractor with a list of piles requiring intertidal seals. The intertidal seal shall be installed first to ensure a bottom seal against the wood pile rather than on the surface of the submerged wrapped section, thus reducing the possibility of a pumping action during tidal changes. The barrier shall be installed by encircling the pile with the fabricated unit (previously assembled with attached Apitong pole pieces), socketing the pole pieces at the bottom of the wrap, matching the pole pieces together with the top plastic sleeve and ratchet, rotating the pole pieces a minimum of 1-1/2 revolutions to wind up the surplus sheet, and bringing the assembly into sufficient circumferential tension to provide an intimate contact of the sheet with the pile for the full barrier length. After the wrap is fastened in final position, the foam seal shall extend 1/2 inch over the top and bottom edges of the unit to prevent the formation of a water "pool" where borers could live during tidal changes. The foam shall be tightly compressed to approximately 1/8-inch thickness by the application of 0.030- to 0.032-inch by 1-inch 5052 aluminum-alloy bands. The bands shall be placed around the wrap directly over the top and bottom seal areas. An aluminum-alloy clip shall be installed at the overlap, and the band shall be drawn tight with a strapping ratchet tool. A Type II nail shall be driven through the clip after the tightening operation. At least four Type I nails shall be driven through the band along its circumference to further seal the wrap to the pile. Additional nails are to be driven wherever uneven pile surfaces require closer nail spacing to ensure a tight seal. The top and bottom foam seals are to be in continuous, compressed, pressure contact with the pile surface for the full circumference. This closure must be sufficiently tight so that it will not be possible to insert an object the size of a hacksaw blade under or past the seal without the use of force or damaging the barrier. Wherever it is necessary to extend upward the lengths of intertidal wraps now in position, where full coverage of attacked area has not been previously provided, the design of the extensions shall be the same as the original wrap (i.e., with pole pieces, skirts, and foam seals on each end). The designs are as follows:

2-foot minimum length, with 12-inch pole pieces and 6-inch skirts at each end.

3-foot with 24-inch pole pieces and 6-inch skirts at each end.

4-foot or longer pole pieces, 2 feet shorter than wrap, with 12-inch skirts at each end.

.3.3.5 Overlapping units below the tidal unit shall be installed as in paragraph __.3.3.4, but without foam seals and aluminum-alloy bands. Where it is necessary to employ more than one modular unit to encapsulate a given length of pile, each section shall overlap the one below by not less than 12 inches. Payment will be made on the basis of 12-inch overlaps. Any overlap that is longer than 12 inches will be at the Contractor's expense. Skirts of 12-inch minimum length shall be provided at the top and bottom of the pole pieces. All top and bottom skirts shall be permanently fastened with a minimum of five nails to insure a tight closure.

.3.3.6 Nailing of pole pieces, skirts, lap joints, and bands is required to insure a permanently tight enclosure. Pole pieces shall be fastened with Type II nails on 3-foot center, with the top and bottom nails 8 inches in from the ends of the pole pieces. Top and bottom skirts and lap joints shall be secured with five Type I nails to insure a tight closure.

.3.3.7 Mud line seal shall be required where marine-borer attack is found to extend 4 feet, or less, above the mud line. The soil around the base of the pile shall be excavated so that the barrier can extend a depth of 15 inches, plus or minus 6 inches, below the mud line, measured at the low side of the pile. After installation of the barrier, all excavated areas shall be backfilled to the original mud line with soil or hydraulic grouting mortar.

.3.3.8 Hydraulic grouting mortar shall be used in locations where it is dangerous, or impractical, to move rocks surrounding the piling in order to install the plastic barrier below the mud line. After installation of the barrier above the mud line, hydraulic grouting mortar shall be applied by hand packing, tremie, pumping, or by pouring grout into a suitable form or sleeve encircling the pile. The grout shall penetrate interstices of the rock surrounding the pile at the mud line and extend at least 6 inches above the bottom of the barrier to provide a positive seal.

.3.3.9 Test sticks shall be provided with each plastic barrier. The test stick shall be inserted vertically behind the barrier and next to the pile surface in the area adjacent to the pole pieces. The condition of the test sticks can be determined by feeling them through the barrier, tapping them with a hammer for signs of borer attack, or by complete removal.

.4 Quality assurance provisions.

.4.1 Sampling. Complete testing shall be performed on samples taken from the beginning, middle, and end of each production run of the polyvinyl chloride sheeting, and certified results of these tests shall be supplied to the Government.

.4.2 Documentary evidence. The Contractor shall furnish documentary evidence that all materials used in installing the flexible plastic barriers meet the appropriate requirements of this specification.

.4.3 Responsibility for inspection. The Contractor shall be responsible for the inspection of all phases of the barrier installation as specified herein. The Government reserves the right to perform or check any of the inspections where such inspections are deemed necessary to assure compliance to prescribed requirements.

NOTES ON THE USE OF THIS SPECIFICATION

1. The installation of flexible plastic barriers is recommended on wood piles that, after a thorough inspection by a qualified diver, reveal a 10 to 15 percent reduction in cross-sectional area from the destructive effect of marine borers.

2. Paragraph .2 Applicable documents. The current edition designation of all documents shall be inserted in this paragraph. The current issue of NAVFAC P-34, "Specifications Used in Contracts for Public Works" and industry document indices should be consulted. It is not necessary to include addresses where documents may be obtained; however, it may be desirable to do so for documents that are not well known.

3. Paragraph .3. The installation of flexible plastic barriers on marine-borer damaged piling is a patented process. Only Marine Barriers, Inc., P.O. Box 1533, 330 Descanso Avenue, Avalon, California 90204, or its licensees can manufacture and supply the fabricated units. Drawings showing design and installation details are available from Marine Barriers, Inc., or its licensees. Also available are outlines of special techniques to expedite the installation of the plastic barriers.

4. Paragraph .3.3.3. Polyvinyl chloride will have a tendency to soften and lose strength in the presence of free creosote. Therefore, the use of polyethylene seal membrane is recommended in relatively new creosoted piles and in those piles where leaching of the creosote has not progressed sufficiently to remove it from the surface.

5. Paragraph .3.3.4. Delete entire paragraph, as well as other references to intertidal seals, where borer attack has not occurred in the intertidal zone.

6. Paragraphs .3.3.7 and .3.3.8. The use of mud line seals and hydraulic grouting mortar shall be determined by the OICC after Government diver's inspection. Delete paragraph when not applicable.

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