REVISED SECTION 02465

POLYMERIC FENDER PILES

## PART 1 GENERAL

### 1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ACI INTERNATIONAL (ACI)

| | |
|---|---|
| ACI 211.1 | (1991; R 2002) Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete |
| ACI 318/318M | (2005; Errata 2005) Building Code Requirements for Structural Concrete |

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM D 1599 | (2005) Resistance to Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings |
| ASTM D 2240 | (2005) Standard Test Method for Rubber Property - Durometer Hardness |
| ASTM D 2310 | (2006) Machine-Made "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe |
| ASTM D 2996 | (2001) Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe |
| ASTM D 4060 | (2007) Abrasion Resistance of Organic Coatings by the Taber Abraser |
| ASTM D 4329 | (2005) Standard Practice for Fluorescent UV Exposure of Plastics |
| ASTM D 570 | (1998; R 2005) Standard Test Method for Water Absorption of Plastics |
| ASTM D 6109 | (2005) Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastic Lumber and Related Products |

| | |
|---|---|
| ASTM D 638 | (2003) Standard Test Method for Tensile Properties of Plastics |
| ASTM D 6662 | (2007) Standard Specification for Polyolefin-Based Plastic Lumber Decking Boards |
| ASTM D 695 | (2002a) Standard Test Method for Compressive Properties of Rigid Plastics |
| ASTM D 746 | (2007) Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact |
| ASTM D 792 | (2000) Density and Specific Gravity (Relative Density) of Plastics by Displacement |
| ASTM D 883 | (2007) Terminology Relating to Plastics |
| ASTM E 84 | (2007b) Standard Test Method for Surface Burning Characteristics of Building Materials |

## 1.2 GLOSSARY

See ASTM D 883 for standard terminology related to plastics.

Extrusion - A manufacturing process where molten polymer is forced through a die of a desired shape, to encapsulate fiberglass reinforced plastic or steel bars, which run continuously throughout the length of the product without joints.

FRP - Fiber reinforced polymer. A polymer matrix, either thermoset or thermoplastic, reinforced with a fiber or other material with a sufficient aspect ratio (length to thickness) to provide a discernable reinforcing function in one or more directions.

GFRP - Glass fiber reinforced plastic. A composite made from fiberglass reinforcement in a plastic (polymer) matrix.

Polymer - Any of numerous natural and synthetic compounds of usually high molecular weight consisting of up to millions of repeated linked units, each a relatively light and simple molecule.

Polymeric Pile - Piling products characterized by the use of polymers, where by (1) the pile strength or stiffness requires the inclusion of the polymer or (2) a minimum of 50% of the weight or volume is derived from the polymer. Polymeric piles may be reinforced by composite design for increased stiffness or strength.

Pultrusion - A continuous process for manufacturing composites that have a cross sectional shape. The process consists of pulling a fiber reinforcing material through a resin impregnation bath and through a shaping die, where the resin is subsequently cured.

Resin - Any of numerous physically similar polymerized synthetics or chemically modified natural resins. Two main types of polymers used for resins include thermoset and thermoplastic materials.

Thermoset Plastics (thermosets) - Refer to a range of polymer materials that once cured do not flow, or melt when heated. Thermoset materials are transformed, through the addition of energy, to a stronger substance. Thermoset materials are usually liquid or malleable prior to curing, and designed to be molded into their final form, or used as adhesive. Thermoset polymer resins can be transformed into plastics or rubbers by cross-linking. A thermoset material cannot be melted and re-molded after it is cured. Thermoset materials are generally stronger than thermoplastic materials. They are also better suited to high temperature applications. They are not easily recyclable like thermoplastics, which can be melted and re-molded. Examples of thermoset plastics include: natural rubber, Bakelite, Urea-Formaldehyde, Melamine, Polyester Resin, and Epoxy Resin.

Thermoplastics - Most thermoplastics are high molecular weight polymer chains, mostly joined through weak dispersion forces and more rarely dipole-dipole interactions. Thermoplastic polymers are usually contrasted with thermosetting polymers, which cannot go through melt/freeze cycles. Many thermoplastic materials are addition polymers (chain growth polymers), such as polyethylene and polypropylene.

## 1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02, Shop Drawings

Polymeric piles G

SD-03, Product Data

Polymeric piles G

Include dimensions, material specifications, and method of manufacture.

Manufacturer's Warranty G

Contractor's Warranty G

SD-05 Design Data

Polymeric piles G

Design calculations G

Concrete mix design G

SD-06, Test Reports

Material Test Reports G

Performance Test Data G

Delivery inspection list

Field inspect and submit a verification list of each pile indicating the condition of the polymeric. Do not incorporate materials damaged in transport from plant to site.

SD-07, Certificates

Polymeric piles G

SD-11, Closeout Submittals

Pile records

Submit the close out version of the pile installation records in a type written format within 21 calendar days after completion of installation.

## 1.4 DELIVERY, STORAGE, AND HANDLING

The Contractor shall inspect each pile, upon delivery, for surface damage, cracks, blemishes, scaring and straightness. The condition of each pile shall be recorded and the delivery inspection list shall be submitted to the Contracting Officer. The Contractor shall handle the piles with ropes or nylon slings without dropping, breaking, bruising or penetrating outer surface with tools. Do not use cant dogs, peaveys, hooks or pikepoles. Protect piles from damage. Store piles above the ground on blocking which is shaped or padded and prevent scaring or sagging of the piles. Storage racks shall be arranged to permit air circulation and shall be covered.

## 1.5 BASIS OF BIDS

### 1.5.1 Fender Piles

Base bids on the number, circumference, and length of piles as indicated. Should the total number of piles vary from that specified as the basis for bidding, the Contract price will be adjusted in accordance with Contract Clause entitled "Changes". Adjustment in Contract price will not be made for cutting off piles, for any portion of a pile remaining above the cutoff elevation, or for broken, damaged or rejected piles.

# PART 2 PRODUCTS

## 2.1 PILE CLASSIFICATION

1. Type 5 - Polymeric composite tube with a concrete core.

## 2.2 POLYMERIC PILES

Provide polymeric piles manufactured as specified. Piles shall be provided by Lancaster Composite, P.O. Box 27, Millersville PA, 17551, 717-872-8999, or equal. All polymeric fender piles of the

specified type shall be the product of a single manufacturer. Each pile shall be permanently tagged with the pile's serial number, date of fabrication and manufacturer's name. The stamp or tag shall be placed two to four feet from the top of the pile and shall be visible after installation. The tags shall not be placed on the outer face (berthing side) of the pile. Piles shall be in one piece. Splices will not be permitted, unless approved by the Contracting Officer. All polymeric fender piles shall be delivered to the job site fully fabricated complete with installed inserts for fasteners and ready for installation. Pile diameter shall be as indicated. If pile cut-off is required it shall be accomplished by shortening the pile by removal of the bottom such as to retain installed inserts for fasteners at the correct elevations and in their correct position in the finished structure.

## 2.3 PERFORMANCE REQUIREMENTS

The cross-sectional dimensions of piles shall be as indicated. Wall thickness of polymeric material shall be verified as capable determined on the basis of the ability to perform satisfactorily under the physical loading and environmental conditions imposed and to effectively perform the energy absorption properties desired. The Contractor shall submit the Performance Test Data and Design Calculations to substantiate the performance.

## 2.4 MINIMUM PERFORMANCE CHARACTERISTICS

Each fender pile shall have the minimum following performance characteristics:

1. Compliance with placement in an open ocean environment with storm wave loading producing 4,100 pounds force applied to each fender pile at mid-span with moments based upon a simply supported span condition. Service life based upon fatigue for this loading shall be based upon a minimum 40 years of exposure based upon 15 average seasonal storms (of 2 days duration per storm) producing this loading per year at this location. The Contractor shall provide Calculations performed by a Professional Engineer registered in the State of California demonstrating compliance with this provision.
2. Compliance with loading generated in the fender system by a 100 ton vessel approaching the fender system at a velocity normal to the fender system equal to 1.5 feet per second. The Contractor shall provide Calculations performed by a Professional Engineer registered in the State of California demonstrating compliance with this provision.

### 2.4.1 Flexural Strength

Test Procedures shall be per ASTM D 6109 except as modified herein:

Specimens Tested

A minimum sample size of five specimens shall be tested to determine the flexural properties of the fender pile type.

Allowable Flexural Strength

The Allowable Flexural Strength (Ma) of the pile is given as the Nominal Flexural Strength Mn, divided by the General Adjustment Factor, Ga. The Nominal Flexural Strength, Mn, of the pile is product of the mean value minus one standard deviation at 3 percent strain (Fb @ 3%strain) and the section modulus S, of the pile. The General Adjustment Factor, Ga, which accounts for end use and the duration of the tests, is given as 3.0.

Ma=Mn/Ga and Mn=(Fb @ 3%strain) x S

Laterally-loaded piles shall be cycled five times to the lesser of 1.0 percent strain or 30 percent of failure.

2.4.2 Flexural Stiffness

The Design Flexural Stiffness, (EI) of the pile is the product of the Modulus of Elasticity (E) of the pile and the Moment of Inertia (I)of the gross section of the pile. The Modulus of Elasticity (E), is the average value of the Chord Modulus at 1% strain determined in accordance with ASTM D 6109. A factor of safety of 2 shall be used for flexure.

2.5 SIZE TOLERANCES

2.5.1 Circular Piles

The tolerance against the specified diameter shall be plus or minus 3 percent. The maximum eccentricity (out of roundness) at any cross-section is e=0.2 when calculated as follows:

e=(square root of ($a^2$-$b^2$)) divided by a; where 2a = major diameter and 2b = minor diameter.

2.6 MATERIALS

2.6.1 Physical Properties

The physical properties for each type of material shall be as follows: The Contractor shall submit Material Test Reports, as applicable, for each type of material.

Physical Properties of Polymeric Material

| Property | Type 5 |
|---|---|
| Density<br>ASTM D 792<br>$lb/ft^3$ | 140 min. |
| Water<br>Absorption<br>ASTM D 570<br>at 24 hours | < 3% |
| Brittleness<br>ASTM D 746<br>at $-40^0F$ | No Break |
| Hardness<br>ASTM D 2240<br>Shore D | 89 |

| | |
|---|---|
| Ultraviolet ASTM D 4329 Change in Shore D Durometer Hardness after 500 hours Exposure | 89 |
| Weatherability ASTM D 6662 Change in Flexural Modulus and Strength after 2000 hours Exposure | <or= 10 |
| Flame Spread Rating ASTM E 84 | <or= 200 |
| Abrasion ASTM D 4060 Weight loss Wear Index: 2.5-3.0 Cycles: 10,000 | n/a |
| Compressive Modulus ASTM D 695 psi, minimum | 50,000 |
| Tensile Properties ASTM D 638 psi, minimum | 60,000 |
| Tensile Strength Circumferential ASTM D 1599 psi, minimum | 35,000 |
| Fiber Percent by Volume minimum | 50 |

| | |
|---|---|
| Fiber Percent by Weight minimum | 68 |
| Laminate Void Content percent | -2 |

Physical Properties of Polymeric Material

| Property | Type 5 |
|---|---|
| Density ASTM D 792 $kg/m^3$ | 2,200 min. |
| Water Absorption ASTM D 570 at 24 hours | < 3% |
| Brittleness ASTM D 746 at $-40^0C$ | No Break |
| Hardness ASTM D 2240 Shore D | 89 |
| Ultraviolet ASTM D 4329 Change in Shore D Durometer Hardness after 500 hours Exposure | 89 |
| Weatherability ASTM D 6662 Change in Flexural Modulus and Strength after 2000 hours Exposure | <or= 10 |
| Flame Spread Rating ASTM E 84 | <or= 200 |

| | |
|---|---|
| Abrasion<br>ASTM D 4060<br>Weight loss<br>Wear Index:<br>2.5-3.0<br>Cycles:<br>10,000 | n/a |
| Compressive Modulus<br>ASTM D 695<br>kPa, minimum | 340,000 |
| Tensile Properties<br>ASTM D 638<br>kPa, minimum | 410,000 |
| Tensile Strength Circumferential<br>ASTM D 1599<br>kPa, minimum | 240,000 |
| Flexural Properties<br>ASTM D 6109, except as modified herein<br>psi, minimum | 300,000 |
| Fiber Percent by Volume minimum | 50 |
| Fiber Percent by Weight minimum | 68 |
| Laminate Void Content percent | -2 |

2.6.2 Not used

2.6.3 Type 5 Polymeric Piles

2.6.3.1 Polymeric Composite Tube

The polymeric composite pile shall be comprised of material which provides the tube strength. The polymeric material shall be "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin). The tube shall be manufactured in accordance with ASTM D 2996 and ASTM D 2310.

2.6.3.2 Outer Surface

The entire outer surface is to be provided a protective barrier as well as wear and impact resistance and shall be comprised of a suitable, high impact, marine grade coating. It shall provide an ultraviolet and chemical resistant barrier of at least (0.03 inch) 0.75 mm thickness and be of a black opaque color.

2.6.3.3 Inner Surface

The inner surface shall be comprised of a pure polymeric liner layer of at least (0.025 inch)0.64 mm thickness for alkalinity resistance. The inner surface shall be roughened or wrinkled to provide adhesion of the inner shell to the concrete fill.

2.6.3.4 Concrete Fill

The concrete fill shall be secured and engaged within the polymeric composite tube and act compositely. The concrete fill shall have a minimum 28-day compressive strength of 6,000 psi. Core concrete shall be expansive in nature and must set to a permanent positive stress, with a minimum outward expansion of 20 psi. Submit a concrete mix design certifying that the proportioning of the mix is in accordance with ACI 211.1 or ACI 318/318M for specified strength. Mix design shall be based upon aggregate data which has been determined by laboratory tests during the last twelve months. All material to be provided by an approved batch plant.

## 2.7 PILE FINISHING

### 2.7.1 Polymeric Pile Protection

The entire exterior surface of the polymeric piles shall have an abrasion resistance less than 0.5g per ASTM D 4060. The pile shall be protected by encasement in an abrasion resistant polymer. The protective encasement shall extend full length of the pile.

### 2.7.2 Surface Condition

The pile surface exhibiting roughness or corrugations due to manufacturing processes, shall not have depressions or projections greater than 3/8 inch and less than 9 $in^2$ in surface area. The surface of the pile shall contain no cracks or splits, in any orientation.

### 2.7.3 Pile Tops

The tops of the polymeric piles shall be encapsulated in polymeric material.

## 2.8 SOURCE QUALITY CONTROL

### 2.8.1 Plant Inspection

The Contracting Officer reserves the right to perform plant inspection of the polymeric pile manufacturing process. Provide the Contracting Officer with a minimum 2-week advance notice, indicating the date manufacturing is to start, and tests that are to be conducted. Allow the Contracting Officer unlimited access to the plant and inspection privileges for each facet of the manufacturing process.

2.8.2 Curing

2.8.2.1 Type 5 Polymeric Piles

Concrete filled piles shall be filled with concrete prior to placement. Support the pile to prevent sag during concrete placement and curing. The Type 5 polymeric piles shall cure a minimum of one week prior to placement of the concrete fill. Piles shall be moved to curing table within 20 minutes of wet concrete placement. Do not handle or transport piles for seven days or until concrete has reached 2,500 psi strength. Place piles after full strength has been obtained or after 28 days of curing.

2.9 Ultrahigh Molecular Weight Polyethylene (UHMWPE) Rubbing Surface

2.9.1 General

a. Materials including additives shall be traceable by original lot number.

b. Materials used shall be FDA approved or otherwise harmless to marine life.

c. Fabricated form shall be virgin resin.

2.9.2 Resin

a. ASTM D 4020. Virgin resin shall be homopolymer of ethylene and have an intrinsic viscosity (IV) between 22.0 and 28.0 dl/g.

b. No reprocessed resin shall be used.

c. Resin shall be oil and moisture free (0.2 percent weight maximum).

2.9.3 Composition and Fabricated Form

a. Resin shall comprise a minimum 95.0 percent by weight concentration in the formulation.

b. The finished form shall maintain ultraviolet stability for a minimum of 25 years and be free of saltwater or petroleum product leachable materials.

c. No unfused areas or light patches greater than 300 micrometers (No. 50 sieve) shall be in the final fabricated form.

d. The fabricated form shall have the following properties:

| | |
|---|---|
| Density (ASTM D 792) | 57.5-58.7 lb/cu.ft |

| | |
|---|---|
| Tensile Strength (ASTM D 638M) | |
| Ultimate, minimum | 31.7 MPa |
| Ultimate Elongation, minimum | 250 percent |
| Impact Strength (ASTM D 256) | |
| Test Method A, Izod | Non-break for all five determinations in sample |
| Hardness (ASTM D 2240), minimum | Shore D 65 |
| Coefficient of Friction (ASTM D 1894) | |
| Kinetic, maximum | 0.13 |
| Static, maximum | 0.20 |
| Water Absorption (ASTM D 570) | Nil |
| Abrasion Index (relative to steel = 100), maximum | 10 |
| Density (ASTM D 792) | 0.92-0.94 g/cc |
| Tensile Strength (ASTM D 638) | |
| Ultimate, minimum | 4600 psi |
| Ultimate Elongation, minimum | 250 percent |
| Impact Strength (ASTM D 256) | |
| Test Method A, Izod | Non-break for all five determinations in sample |
| Hardness (ASTM D 2240), minimum | Shore D 65 |
| Coefficient of Friction (ASTM D 1894) | |
| Kinetic, maximum | 0.13 |
| Static, maximum | 0.20 |
| Water Absorption (ASTM D 570) | Nil |
| Abrasion Index (relative to steel = 100), maximum | 10 |

e. Color shall be black.

## 2.10 MANUFACTURER'S WARRANTY

In addition to the Manufacturer's standard one year warranty, the Manufacturer shall warranty all polymeric piles to be free from defects in materials and workmanship for a period of ten years. The Contracting Officer has the right to require complete replacement of any pile with material or workmanship defects. The Manufacturer shall cover all costs related to the repair or replacement of the defective piles. All costs includes materials cost, transportation cost, construction cost, and any other costs necessary to result in a complete fully installed repair or replacement installation. This warranty

need not cover repairs required as a result of normal wear and tear, misuse, mishandling, extreme weather or other acts of God, failure to perform routine maintenance, non-recommended or improperly executed alterations by anyone other than the Manufacturer, tampering, loading of the pile beyond its rated capacity, improper installation, or other use inconsistent with Manufacturer's specifications.

## 2.11 CONTRACTOR'S WARRANTY

The Contractor shall warranty all polymeric piles to be free from defects in materials caused by mishandling prior to installation and improper installation for a period of ten years. The Contracting Officer has the right to require complete replacement of any pile deemed by the Contracting Officer to have defects due to mishandling or improper installation. The Contractor shall cover all construction costs related to the repair or replacement of the defective piles.

# PART 3 EXECUTION

## 3.1 INSTALLATION

### 3.1.1 Type 5 Polymeric Piles

#### 3.1.1.1 On Site Storage

Piles shall be stored and continually supported in a manner which minimizes creep, saddling and sag.

### 3.1.2 Preexcavation

#### 3.1.2.1 Not used.

### 3.1.3 Installation of Piles

#### 3.1.3.1 Driving of piles is prohibited.

Piles shall not be installed by use of pile driving.

#### 3.1.3.2 Piles shall be installed in predrilled holes prefilled with concrete.

Piles shall be installed into 3 foot diameter predrilled holes prefilled with concrete by use of similar methods specified for use installing structural piles supporting the pier. Such similar methods include use of casing to be removed to achieve maintaining open holes for preplacement of concrete.

#### 3.1.3.3 Tolerances in Placement of Piles.

Piles shall be placed in the locations indicated. Each fender pile, at its contact with the design seafloor elevation indicated in the construction documents, shall be placed a maximum of 0.25 inch per foot of free pile length in feet above the average soil contact line at each pile in a direction parallel to the pier face and 0.125 inch per foot of the free pile length in a direction perpendicular to the pier face. Remove and replace with new piles those damaged, mislocated, placed below the design cutoff, or placed out of alignment or out of tolerance.

3.1.4 Not used

3.1.5 Pile Cut-Off

Each polymeric pile provided shall be a minimum of 3 feet longer than the specified length to allow cut-off to the precise length required to allow for minor variations in the pile length from the top of rock at the seabed floor. Cut off shall be performed by shortening the pile by removal of excess material from the bottom of pile with a smooth level cut using pneumatic tools, sawing, or other suitable methods per the polymeric pile Manufacturer's recommendations. Excess pile length shall not be removed from the top of the pile, this is to maintain pre-placed fasteners in their correct elevation and position in the final structure. Use of explosives for cutting is not permitted. Pile ends at cut-off shall be level and sound. The Contractor shall cut off piles at no additional cost to the Government.

3.1.6 Fastening

Fasten the polymeric piles to the existing pier as indicated on Contract Drawings.

3.2 FIELD TREATMENT

3.2.1 Polymeric Work

Field treat cuts, bevels, notches, refacing and abrasions made in the field in accordance with the Manufacturer's recommendations. The tops of the piles shall be covered with polymeric material matching the Manufacturer's polymeric materials in all respects.

3.3 FIELD QUALITY CONTROL

3.3.1 Inspections

Inspect piles when delivered and immediately before placement. Secure piles in their proper alignment.

When Government inspections result in product rejection, the Contractor shall promptly segregate and remove rejected material from the premises. The Government may also charge the Contractor an additional cost of inspection or testing when prior rejection makes reinspection or retesting necessary.

3.3.1.1 Straightness

Each pile shall be measured for straightness prior to placement by placing a straight line from the center of the top to the center of the tip. The line shall lie entirely within a (10 inch) 250 mm diameter circle centered at the centerline of the pile, when it is suspended from the head. The piles shall also be free of short crooks that deviate more than (2½ inch)64 mm from straightness in any (20 feet)6 meter length. Piles not meeting with criteria shall be rejected.

3.3.1.2 Cracks and Defects

Each pile shall be inspected for cracks and defects prior to placement. After the piles are installed and all connections to the structure are completed, each pile shall again be inspected for cracks and defects. The Contractor shall notify the Contracting Officer of any cracking or other defects observed, and

await direction. The Contracting Officer may reject any piles with defects. The Contractor shall be responsible for all costs incurred for complete removal of rejected piles and complete replacement of the rejected piles.

3.3.2 Pile Installation Inspection

The Contractor shall perform special inspection of the pile installation. The Contractor shall employ approved Special Inspectors subject to the review and approval of the Contracting Officer.

3.3.3 Pile Records

For each pile, keep a record of complete installation including the precise predrilled length in rock, the volume of concrete preplaced for installation of each pile, the precise elevation of the bottom of the predrilled hole for installation of the pile, the precise elevation of the seabed floor at each pile location, and any unusual occurrence during installation of the pile.

-- End of Section --