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Data Sheet
PIP STS02360-D – Pile and Driving
Equipment Data Sheet (U.S. Customary Units)
PIP STS02360-DM – Pile and Driving
Equipment Data Sheet (SI Units)
1. **Scope**

This Practice describes the requirements for supplying, transporting, handling, installing, and testing driven load-bearing piles. Pile types covered in this Practice are as follows:

a. Steel pipe piles
b. Concrete-filled thin shell piles
c. Steel H-piles
d. Step taper piles
e. Prestressed/precast concrete piles
f. Timber piles

2. **References**

Applicable parts of the following Practices, industry codes and standards, and government regulations shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles are used herein where appropriate.

2.1 **Process Industry Practices (PIP)**

- PIP STS03001 - *Plain and Reinforced Concrete Specification*
- PIP STS02360-D - *Pile and Driving Equipment Data Sheet (U.S. Customary Units)*
- PIP STS02360-DM - *Pile and Driving Equipment Data Sheet (SI Units)*

2.2 **Industry Codes and Standards**

- American Concrete Institute (ACI)
  - ACI 222R - *Protection of Metals in Concrete Against Corrosion*
  - ACI 543R - *Guide to Design, Manufacture, and Installation of Concrete Piles*

- ASTM International (ASTM)
  - ASTM A6/A6M - *Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling*
  - ASTM A36/A36M - *Standard Specification for Carbon Structural Steel*
  - ASTM A53/A53M - *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*
  - ASTM A252 - *Standard Specification for Welded and Seamless Steel Pipe Piles*
  - ASTM A572/A572M - *Standard Specification for High-Strength, Low-Alloy Columbium-Vanadium Structural Steel*
  - ASTM A615/A615M - *Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement*
  - ASTM D25 - *Standard Specification for Round Timber Piles*
3. Definitions

**constructor**: Party responsible for supplying all materials, equipment, tools, supervision, and labor for installation of piles in accordance with contract documents. The term constructor shall apply also to constructor’s subcontractor(s) and vendor(s).

**contract documents**: Any and all documents, including codes, studies, design drawings, specifications, sketches, practices, and data sheets that the purchaser or engineer of record has transmitted or otherwise communicated, either by incorporation or reference, and made part of the legal contract agreement or purchase order between the purchaser and the constructor.

**engineer of record**: Purchaser’s authorized representative with overall authority and responsibility for engineering design, quality, and performance of civil works, structures, foundations, materials and appurtenances described in contract documents. Engineer of record shall be licensed as defined by the laws of the locality in which the work is to be constructed, and be qualified to practice in the specialty discipline required for the work described in the contract documents.

**fabricator**: Party responsible for providing fabricated structural and miscellaneous steel in accordance with contract documents. The term fabricator shall apply also to fabricator’s subcontractor(s) and/or vendor(s).

**geotechnical engineer**: Professional Engineer responsible for performing geotechnical investigation and/or geotechnical consulting during foundation design, construction of civil works, installation of piling and foundations.
inspector: Party responsible for verifying quality of all materials, installations, and workmanship furnished by constructor. Inspector shall be qualified by training and experience and hold certifications or documentation of their qualifications. Unless otherwise specified in contract documents, inspector shall be an independent party retained by purchaser.

manufacturer: Party who produces and warrants the performance of piles, and other materials and/or items provided in accordance with contract documents. Piles and other materials and/or items are manufactured in a controlled process using standard codes, specifications, tests and possibly include shop drawings to assist in proper application, installation and/or use. The term manufacturer shall apply also to manufacturer’s subcontractor(s) and/or vendor(s).

owner: Party who has authority through ownership, lease, or other legal agreement over the site and facility wherein piles are to be installed.

professional engineer: An engineer, other than engineer of record, licensed as defined by the laws of the locality in which piles are to be installed and qualified to practice in the specialty discipline required for the work described in contract documents.

purchaser: Party who awards the contract to constructor, fabricator, manufacturer and/or supplier. Purchaser may be the owner or owner’s authorized agent.

4. Requirements

4.1 Quality Control

4.1.1 Data from subsurface investigation(s) furnished by purchaser shall be reviewed by constructor. Such data shall not be construed to represent subsurface conditions at locations other than the specific boring/sounding location indicated. Additional investigations may be performed at constructor’s own discretion and expense with approval of the engineer of record provided results are reviewed by the owner’s geotechnical engineer.

4.1.2 Intended exposure requirements for piles, e.g., marine, non-marine, freeze-thaw, chemical attack, soil corrosiveness, etc., shall be furnished by engineer of record. Protective coatings or admixtures for piles shall be fit for purposes as required by exposure conditions.

4.1.3 Engineer of record shall be immediately notified in writing of any situations detrimental to proper and timely completion of the work.

4.2 Quality Assurance

4.2.1 An independent testing agency will be retained by purchaser for inspection of all piles and all pile-driving operations.

4.2.2 Testing agency shall furnish inspectors experienced in pile-driving inspection and shall be on site full time during installation of all piles.

4.2.3 Inspector qualifications including a resume of the inspector to be provided by independent testing agency shall be submitted to engineer of record and owner’s geotechnical engineer for review and approval not less than 14 days before mobilization.
4.2.4 Testing agency shall document driving in accordance with Section 4.3.9, and shall certify that piles and installation are in accordance with this Practice and the contract documents.

4.2.5 Testing agency shall be responsible for pile concrete testing and sampling.

4.2.6 Testing agency shall notify constructor and engineer of record immediately of any observed deviations from this Practice and contract documents.

4.2.7 Engineer of record, purchaser’s inspector and assigned independent testing agencies inspector shall have the right to make additional or independent inspections and tests at any time.

4.2.8 Engineer of record and owner’s geotechnical engineer shall be notified not less than 3 working days before installation or testing of piles.

4.2.9 Readily visible marks shall be provided on all piles at 1-ft (300 mm) intervals and marks shall be numbered every 5 ft (1500 mm) starting at the tip.

4.2.10 Engineer of record, owner’s geotechnical engineer, purchaser’s inspector or assigned independent testing agencies inspector may reject piles that are not in accordance with all requirements of this Practice or contract documents, including piles that are damaged, misplaced, driven improperly, or out of alignment.

4.2.11 Rejected piles shall be corrected as directed by engineer of record or owner’s geotechnical engineer. Correction may include extracting the rejected pile and driving a new pile or additional piles. All corrective work shall be performed at no additional cost to purchaser or owner.

4.3 Submittals

4.3.1 Execution Plan Documentation

The following shall be submitted to the engineer of record and owner’s geotechnical engineer for review not less than 14 days before commencement of mobilization:

a. Procedure for protection, handling, and storage of piles before installation including dunnage/lifting locations and maximum tolerable sweep for each pile size and length

b. Identification and description of equipment for handling and installing piles

c. Completed PIP STS02360-D or PIP STS02360-DM as applicable, with manufacturer’s hammer specification data and recommended operating procedures, including details of any hammer modifications

d. Pile installation procedures, including any pre-drilling and/or jetting equipment and procedures. A copy of a blank pile driving record proposed for use on the project shall be included.

e. Calibration certificates for pressure gauges, current within 6 months, and manufacturer’s calibration of bounce-chamber gauges

f. Pile and pile accessory material certifications
g. Plan of proposed sequence of driving
h. Proposed plan to monitor ground heave for both the ground surface and the newly installed piles
i. Proposed pile acceptance criteria for approval by engineer of record and owner’s geotechnical engineer

4.3.2 Prestressed/Precast Concrete Pile

4.3.2.1 The following shall be submitted to engineer of record and owner’s geotechnical engineer for review not less than 14 days before commencing manufacturing:

a. All design calculations and manufacturing drawings for piles, including, uplift connections and splices, sealed by constructor’s responsible professional engineer

b. A pile driving study including computer analysis of dynamic stresses during pile driving that confirm that tension and compressive stresses during low-resistance and final high-resistance driving are less than allowable stresses for the piles. The range of performance characteristics of constructor’s proposed pile driving hammer, cushion blocks and appurtenances using the proposed pile shall be modeled using a proven, generally-available computer program acceptable to the project engineer of record and geotechnical engineer.

c. Concrete mix design and basis for mix
d. Method of curing
e. Sampling and testing procedures
f. Certified test reports that confirm all materials to be used in manufacture of piles, including strands, wire, cement, aggregates, admixtures, and curing are in accordance with this Practice
g. Procedures for tensioning and detensioning, including equipment descriptions and calibration records
h. Shop drawings

4.3.2.2 Prestress loss calculations and the tensioning records in accordance with PCI MNL-116 shall be submitted to engineer of record and owner’s geotechnical engineer within 7 days after tensioning.

4.3.2.3 Concrete cylinder strength test results for each lot of piles, including strengths at time of prestress transfer, when removed from casting bed, and 28 days after pour shall be submitted to engineer of record and owner’s geotechnical engineer upon completion of pile manufacturing.
4.3.3 Steel H-Pile

The following shall be submitted to the engineer of record and owner’s geotechnical engineer for review not less than 14 days before commencing fabrication:

a. All design calculations and fabrication drawings for piles, including pile shoes, uplift connections and splices, sealed by a qualified, responsible professional engineer.

b. A pile driving study including computer analysis of dynamic stresses during pile driving that confirm that the tension and compressive stresses during low-resistance and final high-resistance driving are less than the allowable stresses for the piles. The range of performance characteristics of constructor’s proposed pile driving hammer, cushion blocks and appurtenances using the proposed pile shall be modeled using a proven, generally-available computer program acceptable to project engineer of record and geotechnical engineer.

4.3.4 Steel Pipe Pile

The following shall be submitted to engineer of record and owner’s geotechnical engineer for review not less than 14 days before commencing fabrication:

a. All design calculations and fabrication drawings for piles, including pile shoes, uplift connections and splices, sealed by the constructor’s qualified, responsible professional engineer.

b. A pile driving study including computer analysis of dynamic stresses during pile driving that confirm that the tension and compressive stresses during low-resistance and final high-resistance driving are less than the allowable stresses for the piles. The range of performance characteristics of constructor’s proposed pile driving hammer, cushion blocks and appurtenances using the proposed pile shall be modeled using a proven, generally-available computer program acceptable to project engineer of record and geotechnical engineer.

4.3.5 Tapered Pile

The following shall be submitted to engineer of record and owner’s geotechnical engineer for review not less than 14 days before commencing fabrication:

a. All design calculations and fabrication drawings for piles, including pile shoes, uplift connections and splices, sealed by a qualified, responsible professional engineer.

b. A pile driving study including computer analysis of dynamic stresses during pile driving that confirm that the tension and compressive stresses during low-resistance and final high-resistance driving are less than the allowable stresses for the piles. The range of performance characteristics of constructor’s proposed pile driving hammer, cushion blocks and appurtenances using the proposed pile shall be modeled using a proven, generally-available computer program acceptable to project engineer of record and geotechnical engineer.
4.3.6 Concrete-Filled Pile

4.3.6.1 The following information shall be submitted to engineer of record and owner’s geotechnical engineer for review not less than 14 days before commencement of mobilization:
   a. Concrete mix design and basis for mix
   b. Sampling and testing procedures
   c. Concrete placement procedures

4.3.6.2 Concrete cylinder strength test results for each lot of piles, including strengths at 7 and 28 days after pour shall be submitted to engineer of record and owner’s geotechnical engineer.

4.3.7 Timber Pile

The following information shall be submitted to the engineer of record and owner’s geotechnical engineer not less than 14 days before installation:

   a. Certificate of treatment for each lot of treated timber piles, showing treatment method and type of preservative and minimum net retention of preservative
   b. An independent report by an independent inspection agency, attesting that piles have been treated with preservative in accordance with this Practice. This agency shall be experienced with wood preservation and is likely different than the installation inspection agency.
   c. A pile driving study including computer analysis of dynamic stresses during pile driving that confirm that tension and compressive stresses during low-resistance and final high-resistance driving are less than allowable stresses for the piles. The range of performance characteristics of constructor’s proposed pile driving hammer, cushion blocks and appurtenances using the proposed pile shall be modeled using a proven, generally-available computer program acceptable to project engineer of record and geotechnical engineer.

4.3.8 Pile Load Test

The following submittals shall be provided to engineer of record and owner’s geotechnical engineer for review not less than 14 days before commencing the test:

   a. Shop drawings of loading apparatus and arrangement of the test and all design calculations, sealed by the constructor’s responsible professional engineer
   b. Current calibrations of load-cell and jack/jack manometer within one year of the planned completion of test

4.3.9 Pile-Driving Record

4.3.9.1 One copy of the proposed pile-driving record form for pile-driving record keeping shall be submitted to engineer of record and owner’s geotechnical engineer for review and approval not less than 14 days prior to beginning installation.
4.3.9.2 During installation, one copy of the completed pile-driving record for each pile shall be submitted to engineer of record and owner’s geotechnical engineer within 3 days of completion of driving. Submitted pile-driving record shall be the hand-written field record completed and signed by the inspector in the field and shall be clearly legible.

4.3.9.3 Pile-driving record shall include but not be limited to the following information:

a. Project name, number, and location
b. Drawing number and structure identification
c. Name of constructor, subcontractors, and suppliers
d. Date of pile installation
e. Pile location, number, and design capacity; location of pile in pile group and location or designation of pile group
f. Pile type, size, and length
g. Design and actual pile cut-off and tip elevations
h. Hammer make, model, stroke, weight, normal operating speed, and rated energy
i. Type, dimension, and condition of cushion or capblock
j. Operating pressure for steam/air hammer and bounce chamber pressure for double-acting diesel hammer
k. Actual operating rate or speed (blows/minute) during final driving
l. Other installation equipment including details on use of pile cushion, follower, mandrels, pre-drilling, and water jet
m. Time for start and finish of driving pile
n. Sequence of pile driving for piles in group
o. Penetration under own weight and penetration under own weight plus weight of hammer
p. Driving data in number of blows per foot from initial to final driving and number of blows per 1 inch (25 mm) for the last 12 inches (300 mm)
q. Splice types and locations
r. Upon termination of the driving of open-end pipe piles, record depth from ground surface outside pile to soil surface inside pipe. Record depth of any clean out if used. Note any water in the pipe.
s. Records of re-striking
t. Interruptions (reason, time, duration, tip elevation)
u. Volume of cast-in-place concrete placed
v. Degree of out-of-axial alignment
w. Deviations from contract documents
x. Weather conditions and temperature
y. Notation of any unusual occurrences during installation or of any observed pile damage
z. Signature and title of inspector recording pile-driving data

4.4 Materials

4.4.1 General

4.4.1.1 All constructor-supplied materials and proprietary items, including piles, splice devices, tip protectors, driving shoes, tension or uplift connectors, etc., shall be subject to engineer of record’s and owner’s geotechnical engineer’s approval and shall be installed in accordance with manufacturer’s instructions.

4.4.1.2 Concrete shall be in accordance with PIP STS03001. Additional requirements for concrete to be used in PCPS piles are presented in Section 4.4.2.

4.4.1.3 Welding

1. Welding shall be in accordance with AWS D1.1/D1.1M.
2. Welding filler metal shall be in accordance with AWS D1.1/D1.1M, Section 3.3 with electrode strength of 58 ksi (400 MPa) minimum yield strength and 70 ksi (482 MPa) minimum tensile strength.
3. E60XX electrodes may be used for tack welding.
4. Welding procedures and individual welders shall be qualified in accordance with AWS D1.1/D1.1M.
5. Qualification records shall be made available to engineer of record and owner’s geotechnical engineer for review.

4.4.1.4 Splicing

1. Splices shall provide true alignment of total pile.
2. Splices shall be capable of transmitting all driving forces and all intended service loads.
3. Spliced piles receiving concrete fill shall be watertight after driving to prevent increasing the water/cement ratio and loss of strength. Such piles shall have water and debris removed before concrete fill is placed.

4.4.2 Prestressed/Precast Concrete Piles

4.4.2.1 Design and manufacture of concrete piles shall be in accordance with PCI JR-382, PCI MNL-116, and ACI 543R.

4.4.2.2 For prestressed concrete piles, pile manufacturer’s mix design can be used with approval of engineer of record and owner’s geotechnical engineer.
4.4.2.3 Pile materials shall be the following types:

a. Concrete shall be minimum 5000 psi (35 MPa) 28-day compressive strength concrete meeting the requirements of PCI JR-382, PCI MNL-116, and ACI 543R. The maximum aggregate size shall be 3/4 inch (20 mm).

b. Pre-stressing strand shall be in accordance with recommendations of ACI 543R for materials, handling, and placement in forms.

c. Deformed reinforcing bars and smooth steel reinforcing shall be in accordance with recommendations of ACI 543R for materials, handling, and placement in forms.

d. Embedded metals and strands shall be protected from corrosion as recommended by ACI 222R.

4.4.2.4 Transportation, handling, and storage shall be in accordance with PCI JR-382. Lift points shall be plainly marked and lift direction shall be shown.

4.4.2.5 Each pile shall be clearly labeled with pile number assigned at the casting yard to correlate quality control data.

4.4.3 Steel H-Piles

4.4.3.1 Pile material shall be in accordance with ASTM A36/A36M or ASTM A572/A572M Grade 50, HP shapes in accordance with ASTM A6/A6M.

4.4.3.2 Splices shall be either of the following types:

a. Full-penetration butt welds using backup plates or back gouging

b. H-pile splicer sleeves, fillet welded to pile web in accordance with contract design drawings, and full-penetration butt-welded to pile flanges. Each flange of upper pile section shall be bevelled, leaving 1/8 inch (3 mm) of metal for weld backing.

4.4.4 Steel Pipe Piles

4.4.4.1 Pipe material shall be welded or seamless steel pipe in accordance with ASTM A53/A53M, Grade B, Type E or Type S, or ASTM A252, Grade 2.

4.4.4.2 Concrete fill, if required, shall be in accordance with PIP STS03001 and a minimum of 4000 psi (28 MPa) 28-day compressive strength.

4.4.4.3 Tip closures shall be either of the following types:

a. ASTM A36/A36M steel plate welded to beveled pipe end and making a watertight enclosure. Diameter shall not exceed pipe outside diameter.

b. Proprietary weldless drive points with tapered swage and making a watertight joint to pipe. Diameter shall not exceed pipe outside diameter.

4.4.4.4 Drive shoes shall be hardened steel, inside cutting type, within outside diameter of pipe.
4.4.4.5 Splices shall be full-penetration butt welds or proprietary self-sealing, mechanical splices.

4.4.5 Tapered Piles

4.4.5.1 Shell Material

1. Shell material shall be minimum 9-gauge 0.14955-inch (3.75 mm) thickness. Shells may be corrugated or smooth tapers. Shell may change to uniform diameter steel pipe pile as determined by constructor’s professional engineer.

2. Welded or seamless steel pipe in accordance with ASTM A252, Grade 1 is an alternate shell material.

3. Increase in diameter at each transition shall not exceed 1 inch (25 mm).

4. Shells and joints shall be tight after driving to allow water and debris removal to facilitate placement of concrete fill. This prevents increasing the water/cement ratio and loss of strength.

4.4.5.2 Concrete core shall be in accordance with PIP STS03001 and constructed with the following materials:

   a. Minimum 4000 psi (28 MPa) 28-day compressive strength concrete

   b. Reinforcing bars, when required, shall be in accordance with ASTM A615/A615M minimum.

4.4.5.3 Tip closures shall conform to mandrel tip, be watertight after pile is driven and be either of the following types:

   a. ASTM A36/A36M steel plate, seal welded to shell end

   b. Shop-formed hemispherical steel, boot welded to shell tip

   c. For proprietary thin shell, watertight manufactured type tip closures compatible with manufacturer’s shell system

4.4.5.4 Splices shall be either of the following types:

   a. For steel pipe, splices in accordance with Section 4.4.4.5

   b. For proprietary thin shell, watertight manufactured splice device compatible with manufacturer’s shell system

4.4.6 Timber Piles

4.4.6.1 Timber materials shall be in accordance with ASTM D25 for “clean-peeled” round timber piles, and have minimum allowable design strength of 1200 psi (8.3 MPa) compression parallel to grain in accordance with ASTM D2899.

4.4.6.2 Depending on the application specified in contract documents, timber piles shall be of the following species:

   a. Piles subject to land or freshwater service: southern pine, ponderosa pine, or Douglas fir
b. Piles subject to marine (brackish or seawater) service: southern pine or Pacific Coast Douglas fir

4.4.6.3 Depending on pile type specified in contract documents, minimum diameters shall be in accordance with the following requirements:

a. Friction piles shall have a butt circumference of 41 inches (1040 mm) minimum (approximately 13-inches (330 mm) diameter) and a minimum tip circumference in accordance with ASTM D25, Tables X1.2 and X1.3.

b. End-bearing piles shall have a tip circumference of 25 inches (630 mm) minimum (approximately 8 inches (200 mm) diameter) and a minimum butt circumference in accordance with ASTM D25, Table X1.4 and X1.5.

4.4.6.4 Pressure Treatment, Care, and Field Repair

1. Treatment shall be in accordance with AWPA T1, AWPA U1 and Use Category defined in contract documents.

2. All treated piles shall be permanently branded to identify treating company and year of treatment.

3. Care and handling of piles shall be in accordance with AWPA M4.

4. Treatment of field cuts caused by handling, cut-offs, installation of uplift connections, and any other daps or holes shall be in accordance with AWPA M4.

4.4.6.5 Strapping

1. Strapping shall be high-tensile steel straps, a minimum of 1-1/4 inch (30 mm) wide, having 5100-pounds (22.5 kilonewtons) minimum tensile strength.

2. Strapping shall be secured with crimped seals that develop 80% of strap strength.

3. Two straps shall be installed (after pressure treatment for treated piles), one at 18 inches (450 mm) and the other at 24 inches (600 mm) from butt.

4.5 Execution

4.5.1 General

4.5.1.1 Piling materials, labor, tools, supervision, equipment, and supplies necessary for transporting and installing driven piles shall be provided in accordance with the contract documents and this Practice.

4.5.2 Handling and Storage

4.5.2.1 Piling materials shall be delivered to the job site in good condition.

4.5.2.2 Piling materials shall be handled and stored in a manner that avoids damage to or excessive stresses on these materials.
4.5.2.3 Stored pile materials shall be placed on sufficient dunnage to prevent contact with ground and to keep deflection of stored piles within tolerable limits.

4.5.2.4 Lifting cables, ears, or other connections used in transportation shall be removed to prevent reducing friction capacity as pile is driven. Locations where lifting cables, ears, or connections were attached shall be treated to prevent corrosion and infiltration of water.

4.5.3 Equipment

4.5.3.1 Hammers

1. Piles shall be driven with power impact hammers capable of installing the piles to the specified capacity, resistance, and minimum depth.

2. Vibrating hammers or drop hammers shall not be used.

3. Piles driven with faulty equipment shall be subject to rejection by engineer of record and owner’s geotechnical engineer. Cost of removal or installation of additional piles shall be borne by the constructor.

4. For an air/steam hammer, a calibrated pressure gauge shall be provided.

5. For a double-acting diesel hammer, a calibrated bounce-chamber gauge shall be provided.

6. Gauges on the hammer side of all valves shall be positioned so that gauges can be easily observed by inspecting personnel. Gauges shall not be greater than 100 feet (30 meters) of hose away from the hammer intake.

7. Open-ended (single-acting) diesel hammers shall be equipped with a device to permit inspecting personnel to visually determine hammer stroke at all times during pile driving.

8. Hammers shall not be operated at less than the speed and stroke length specified by the manufacturer.

4.5.3.2 Leads

1. Fixed leads shall be provided.

2. Leads shall be held firmly in position by stiff braces.

3. Axis of the leads, hammer, and pile shall coincide. Swinging or spud type leads shall be used only with approval of engineer of record and owner’s geotechnical engineer.
4.5.3.3 Cushioning

1. Hammer cushions or capblocks shall be provided in either of the following configurations:
   a. Aluminum and micarta discs stacked alternately in a steel housing and with a steel plate at the top and bottom of the stack.
   b. One-piece hardwood capblock, with grain parallel to the pile axis and enclosed in a close-fitting steel housing. Satisfactory driving criteria shall be established with this capblock, and a new capblock shall not be used during the final driving of any pile.

2. Cap blocks made from other materials shall be used with approval of engineer of record and owner’s geotechnical engineer.

3. Wood chips, small wood blocks, wood shavings, wire rope, or other materials with high-elastic properties shall not be used for capblocks.

4. For prestressed concrete piles, a pile cushion shall be provided that is appropriate for pile and hammer and approved by engineer of record and owner’s geotechnical engineer.

4.5.3.4 Mandrel

1. A compatible expanding, internal mandrel shall be used for driving all thin shell and step taper piles.

2. The mandrel shall maintain a positive grip on the pile.

4.5.3.5 Follower

A follower shall be used only with approval of engineer of record and owner’s geotechnical engineer.

4.5.4 Installation

4.5.4.1 General

1. Piles shall be driven to the indicated lines, grades, and capacities required by the contract documents.

2. A driving cap or helmet shall be used to prevent damage to pile heads during driving. Loose inserts in cap shall not be permitted.

3. Pile shall be held securely in proper position and alignment while driving.

4. Hammer impacts shall be delivered concentrically and in direct alignment with pile. Forcing pile laterally or bending pile shall be avoided.

5. Piles shall not be driven closer than 20 feet (6 meters) from concrete that has been in place less than 3 days.

6. Piles shall be driven continuously, without interruption, to the final tip elevation.
7. A discontinuous driving operation shall be referred to engineer of record and owner’s geotechnical engineer for resolution.

8. Sudden resistance to pile driving by underground obstructions shall be brought to engineer of record and owner’s geotechnical engineer’s attention for resolution.

9. If required by contract documents, uplift connectors shall be installed.

10. If top of a pile is damaged during driving, damaged portion shall be cut off.

11. A damaged pile shall be brought to the attention of engineer of record and owner’s geotechnical engineer for resolution. If required by engineer of record and owner’s geotechnical engineer, a new length shall be spliced to the undamaged pile before resumption of driving.

12. Piles in large groups shall be driven from inside toward the outside.

13. Piles shall not be driven beyond depth of penetration required.

14. Piles shall not be driven until the earthwork within the area has been completed to specified grade.

15. If measured driving stresses in piles are deemed excessive by engineer of record and owner’s geotechnical engineer, the driving energy transmitted to the pile shall be decreased by reducing the energy output of the hammer or by using additional cushions.

4.5.4.2 Tolerances

1. Pile heads, at cut-off elevation, shall be within 3 inches (75 mm) in any horizontal direction of the position shown in contract documents.

2. Pilings shall be cut off square, true, and level.

3. Cut-off tolerance shall be within 1 inch (25 mm) of required elevations shown in the contract documents.

4. Vertical piles shall be plumb within 2% of pile length.

5. The maximum deviation from required axial alignment of battered piles shall be within 4% of pile length.

4.5.4.3 Pre-drilling

1. Pilot holes shall be drilled when authorized by engineer of record and owner’s geotechnical engineer.

2. Pilot holes shall be subject to modification by engineer of record and owner’s geotechnical engineer based on the results of initial driving operations and analysis of driving data.

3. Pilot holes shall not be drilled greater than the least dimension of pile minus 2 inches (50 mm).

4. Pre-drilling shall be terminated at least 5 feet (1500 mm) above pile tip elevation.
5. All spoils shall be promptly removed from work area and disposed as directed by the purchaser.

4.5.4.4 Jetting

1. Jetting shall be used when authorized by engineer of record and owner’s geotechnical engineer.

2. Jetting procedures shall be submitted for approval by engineer of record and owner’s geotechnical engineer.

3. All jet water shall be controlled, treated if necessary, and disposed of in a manner acceptable to engineer of record and owner’s geotechnical engineer.

4.5.4.5 Pile Heave

1. Heave and displacement of each pile shall be recorded after all piles in a group have been driven.

2. Piles that heave more than 1/4 inch (6 mm) shall be re-driven to their original elevation.

4.5.4.6 Cutoff

1. Sufficient pile length shall be provided above cut-off elevations so that any portion of pile damaged during driving can be cut off.

2. Piling shall be cut off neatly and squarely at required elevation in accordance with Section 4.5.4.2.3.

3. Cut-off lengths shall be disposed of off the property.

4.5.4.7 Driving Criteria and Capacity Evaluation

1. Pile-driving criteria, specifying the minimum acceptable blows per foot and refusal criteria, shall be in accordance with contract documents.

2. Driving criteria shall be subject to modification by engineer of record and owner’s geotechnical engineer based on analysis of initial and ongoing driving results.

3. Any modification of driving criteria shall not result in additional cost to purchaser.

4. Piles shall be driven to minimum tip elevation in accordance with contract documents.

5. Driving shall be continued beyond minimum tip elevation until pile-driving criteria are met or until maximum pile penetration depth is reached.

6. Penetration short of specified minimum tip elevation shall be permitted only if, in the opinion of engineer of record and owner’s geotechnical engineer, additional pile driving may damage the pile.

7. If pile-driving criteria are not met, or penetration to minimum tip elevation is not reached, engineer of record and owner’s geotechnical engineer shall determine any remediation required.
4.5.4.8 Rejected Piles

1. Piles that are not in accordance with this Practice, including piles that are damaged, broken, misplaced, driven improperly or out of alignment shall be rejected.

2. Rejected piles shall be corrected as directed by engineer of record and owner’s geotechnical engineer.

3. Corrective action may include extracting rejected piles and driving new piles or driving additional piles.

4. All corrective work shall not result in additional cost to purchaser.

4.5.4.9 Pipe Piles

1. Piles shall be covered during the interval between driving and placement of concrete.

2. Concrete shall not be placed until effect of ground heave and displacements can no longer be measured.

3. Concrete shall not be placed in a pile that is within 20 ft (6 meters) of another pile that is being driven.

4. Concrete shall not be placed until after piles have been inspected and approved.

5. Concrete shall not be placed until pile is free of all foreign matter and contains not more than 2 inches (50 mm) of water.

6. Concrete shall be placed with a funnel hopper centered directly over the pile. A concrete pump truck with hose may be used in lieu of funnel hopper and tremie pipe.

7. Bottom opening of hopper shall not be larger than one-half diameter of reinforcing steel cage or one-half pile diameter if there is no cage.

8. Concrete shall not be permitted to hit reinforcing steel or side of pile during placement.

9. A tremie pipe shall be substituted for hopper if required to prevent concrete from hitting reinforcement or pile side.

10. If a tremie pipe is used, pipe opening shall be kept submerged under rising top surface of deposited concrete.

11. Concrete shall be placed continuously until pile is full.

12. Piles with a buckle or other deformation that reduces the inside diameter by 10% or more shall be rejected.
4.5.4.10 Precast and Prestressed Concrete Piles

1. For precast and prestressed concrete piles, if anchor/dowel holes have been provided for uplift connection or other purposes, the holes shall be protected to prevent dirt or other substances from contaminating the holes before grouting.

2. The installation of concrete piles should follow recommendations of ACI 543R.

4.5.5 Pile Capacity Testing

4.5.5.1 Pile-Driving Analyzer (PDA)

1. If PDA’s are required, engineer of record and owner’s geotechnical engineer, shall retain and pay for an agency to perform pile-driving analyzer monitoring. Constructor shall promptly provide assistance without cost to agency.

2. Access and assistance shall be provided by constructor to enable testing agency to expeditiously perform required instrumentation and monitoring.

3. Appropriate power sources shall be provided for monitoring as required.

4. Transducers, cables, or equipment associated with dynamic monitoring shall be protected from damage.

5. Personnel to help attach transducers to pile head and manage cables during pile lifting and installation shall be provided by constructor to testing agency. Testing agency shall provide instructions in the details of this work.

6. In accordance with engineer of record and owner’s geotechnical engineer’s instructions, selected piles shall be re-instrumented and re-tapped for dynamic monitoring not less than 72 hours after end of initial driving.

7. A cold hammer shall not be used for re-tapping. The hammer shall be warmed before re-tapping by applying at least 20 blows to another pile.

8. Dynamic monitoring, including attaching and detaching instrumentation and actual testing, shall be accommodated at no additional cost to purchaser.

4.5.5.2 Static Pile Load Test

1. Engineer of record and owner’s geotechnical engineer shall retain and pay for an independent agency to perform static pile load testing.

2. Access and assistance shall be provided by constructor to enable testing agency to expeditiously perform required instrumentation and monitoring.

3. Purchaser shall retain a geotechnical engineer to approve, direct, and document load test(s).
4. Neither installation nor testing of reaction piles nor commencement of load testing shall be performed without approval and presence of purchaser’s geotechnical engineer.

5. Test and reaction piles shall be provided and installed by constructor at the location specified in contract documents.

6. Requirements for driving test and reaction piles shall be same as those for production piles.

7. Test and reaction piles shall be driven with same equipment to be used to drive production piles.

8. Test and reaction piles that are correctly located and installed and tested without damage and that meet all requirements of this Practice may be used as production piles if approved by engineer of record and owner’s geotechnical engineer.

9. Reaction frames and reaction piles shall be designed and installed on approval of engineer of record.

10. Loading tests on piles selected by engineer of record and owner’s geotechnical engineer shall be performed in accordance with the following standards for the type of test shown:
   a. Compression - ASTM D1143/D1143M
   b. Tension - ASTM D3689
   c. Lateral - ASTM D3966/D3966M

11. A load-cell and/or jack/manometer system designed for use in field conditions shall be provided. Jack and manometer shall be calibrated together as a system.

12. Manometer measuring the jack pressure shall have a range of 135% minimum to 300% of the specified allowable pile capacity.

13. A single jack shall be used to apply required load unless authorized by engineer of record and owner’s geotechnical engineer to use a pair of jacks.

14. An operator experienced in pile load testing and a laborer to operate equipment throughout duration of test shall be provided.

15. Suitable enclosure of test arrangement shall be provided to ensure complete weather protection for reference beams and for personnel conducting the test. Necessary power source, lights, and heating for the enclosure shall also be provided.

16. Compression testing shall begin 5 to 30 days after initial driving of pile or as permitted by engineer of record and owner’s geotechnical engineer.

17. Tension testing shall begin 10 to 30 days after initial driving of pile or as permitted by engineer of record and owner’s geotechnical engineer.
18. Pile shall not be subject to any loading before starting the test.

19. Pile tests shall be performed in accordance with Quick Load Test Method specified in ASTM D1143/D1143M or ASTM D3689.

20. Test pile loading and unloading shall be performed in accordance with the following procedure:
   a. Pile shall be loaded in not less than 20 equal increments applied every 10 minutes to a maximum load of 300% of specified pile capacity.
   b. Each load level shall be accurately maintained.
   c. If loading increment becomes too large, the load shall not be released. Load level shall be recorded, the reading shall be taken at this load level, and the next loading increment shall be made correspondingly smaller.
   d. Within each load level, simultaneous readings of movements and load at 3, 6, and 10 minutes after start of loading shall be recorded.
   e. After the maximum test load has been maintained for 10 minutes, pile shall be unloaded in 5 approximately equal decrements of load every 5 minutes. Movements and load for each load level at the end of each 5-minute period shall be recorded.
   f. Movement gauges shall continue to be recorded at 10-minute intervals for at least 30 minutes after completely unloading pile.

21. If requested by engineer of record and owner’s geotechnical engineer, a quick pile reloading test shall be performed immediately after first test is completed. Reloading test shall require fewer load increments and will be completed in approximately 2 hours.

22. Evaluation of tests shall be sole responsibility of engineer of record and owner’s geotechnical engineer.
Hammer Components:
- Manufacturer: ___________________________  Model No.: ___________________________
- Hammer Type: ___________________________  Serial No.: ___________________________
- Manufacturer's Maximum Rated Energy: ________ FT-LBS
- Stroke at Maximum Rated Energy: ________ FT
- Range in Operating Energy: ________ TO ________ FT-LBS
- Range in Operating Stroke: ________ TO ________ FT
- Ram Weight: ________ LBS
- Modifications: ___________________________

Striker Plate:
- Weight: ________ LBS  Diameter: ________ IN
- Thickness: ________ IN

Hammer Cushion:
- Material #1: ___________________________  Name: ___________________________
- Material #2 (for Composite Cushion): ___________________________
- Area: ________ IN²  Material #1: ___________________________
- Area: ________ IN²  Material #2: ___________________________
- Thickness/Plate: ________ IN  Thickness/Plate: ________ IN
- No. of Plates: ___________________________
- Total Thickness of Hammer Cushion: ________ IN

Helmet Weight: ________ LBS

Pile Cushion:
- Material: ___________________________
- Area: ________ IN²  Thickness/Sheet: ________ IN
- No. of Sheets: ___________________________
- Total Thickness of Pile Cushion: ________ IN

Pile:
- Type: ___________________________
- Diameter of Cross Sectional Width: ________ IN
- Cross Sectional Area: ________ IN²  Weight/FT.: ________ LBS
- Wall Thickness: ________ IN  Taper: ___________________________
- Ordered Length: ________ FT
- Design Load: ________ TONS
- Ultimate Pile Capacity: ________ TONS
- Description of Splice: ___________________________
- Driving Shoe/Closure Plate Description: ___________________________

No.  Date  Revision Description  By  APVD
### PILE AND DRIVING EQUIPMENT (SI UNITS)

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**HAMMER COMPONENTS:**

- **MANUFACTURER:**
- **MODEL NO.:**
- **SERIAL NO.:**
- **STROKE AT MAXIMUM RATED ENERGY:**
- **RANGE IN OPERATING ENERGY:**
- **RANGE IN OPERATING STROKE:**
- **RAM WEIGHT:**
- **MODIFICATIONS:**

**STRIKER PLATE:**

- **WEIGHT:**
- **DIAMETER:**
- **THICKNESS:**

**HAMMER CUSHION:**

- **MATERIAL #1 NAME:**
- **MATERIAL #2 (FOR COMPOSITE CUSHION) NAME:**
- **AREA:**
- **THICKNESS/PLATE:**
- **NO. OF PLATES:**
- **TOTAL THICKNESS OF HAMMER CUSHION:**

**HELMET WEIGHT:**

**PILE CUSHION:**

- **MATERIAL:**
- **AREA:**
- **THICKNESS/SHEET:**
- **NO. OF SHEETS:**
- **TOTAL THICKNESS OF PILE CUSHION:**

**PILE:**

- **DIAMETER OF CROSS SECTIONAL WIDTH:**
- **CROSS SECTIONAL AREA:**
- **WEIGHT/FT.:**
- **WALL THICKNESS:**
- **TAPER:**
- **ORDERED LENGTH:**
- **DESIGN LOAD:**
- **ULTIMATE PILE CAPACITY:**
- **DESCRIPTION OF SPLICE:**
- **DRIVING SHOE/CLOSURE PLATE DESCRIPTION:**

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