

**SECTION 31 62 00**  
**DRIVEN PILES**

SPEC WRITER NOTE: Use this section only  
for NCA projects. Delete text between  
// \_\_\_\_\_ // not applicable to project.  
Edit remaining text to suit project.

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section Includes:
1. Impact driven foundation piles.

**1.2 RELATED REQUIREMENTS**

- A. Surveyor Qualification: Section 01 00 01, GENERAL REQUIREMENTS, Article, PROFESSIONAL SURVEYOR SERVICES.

**1.3 CONTRACT BASIS**

- A. Contract price for piles will be based upon length of piles shown on drawings. Length of piles will be measured from tip to point of cutoff.
1. Adjustment of contract price will be based upon total length of piles placed and not on length of individual piles placed. When total length of completed piles is greater or less than length shown, contract price adjustment will be made according to Clauses of Section 01 00 01, GENERAL REQUIREMENTS as applicable.
  2. No payment will be made for withdrawn, broken or rejected piles, piles out of tolerance, or for portion of pile remaining above cutoff point.
  3. Contract price and time will be adjusted according to Clauses of Section 01 00 01, GENERAL REQUIREMENTS as applicable, when artificial materials that are not shown on drawings are encountered.

**1.4 TOLERANCES**

- A. Install piling with maximum variation of 75 mm (3 inches) of center of any pile from location shown. Piles out of plumb more than 2 percent will not be acceptable.

**1.5 APPLICABLE PUBLICATIONS**

- A. Comply with references to extent specified in this section.
- B. American Concrete Institute (ACI):
1. 318-14 - Building Code Requirements for Structural Concrete and Commentary.
- C. American Welding Society (AWS):

1. D1.1/D1.1M-2015 - Structural Welding Code - Steel.
- D. American Wood Protection Association (AWPA):
1. M4-15 - Standard for the Care of Preservative Treated Wood Products.
  2. U1-15 - User Specification for Treated Wood.
- E. ASTM International (ASTM):
1. A27/A27M-13 - Steel Castings, Carbon, for General Application.
  2. A36/A36M-14 - Carbon Structural Steel.
  3. A148/A148M-15a - Steel Castings, High Strength, for Structural Purposes.
  4. A252-10 - Welded and Seamless Steel Pipe Piles.
  5. A416/A416M-16 - Low-Relaxation, Seven-Wire Steel Strand for Prestressed Concrete.
  6. A572/A572M-15 - High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
  7. A588/A588M-15 - High-Strength Low-Alloy Structural Steel, up to 50 ksi (345 MPa) Minimum Yield Point, with Atmospheric Corrosion Resistance.
  8. A615/A615M-16 - Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
  9. A690/A690M-13a - High-Strength Low-Alloy Nickel, Copper, Phosphorus Steel H-Piles and Sheet Piling with Atmospheric Corrosion Resistance for Use in Marine Environments.
  10. A706/A706M-16 - Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement.
  11. A767/A767M-09 (2105) - Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement.
  12. A775/A775M-16 - Epoxy-Coated Steel Reinforcing Bars.
  13. A884/A884M-14 - Epoxy-Coated Steel Wire and Welded Wire Reinforcement.
  14. A934/A934M-16 - Epoxy-Coated Prefabricated Steel Reinforcing Bars.
  15. A1064/A1064M-16a - Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
  16. C33/C33M-16 - Concrete Aggregates.
  17. C1077-16 - Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation.
  18. D25-12 - Round Timber Piles.
  19. D1143/D1143M-07 (2013) - Deep Foundations Under Static Axial Compressive Load.

20. D3689/D3689M-07 (2013)e1 - Deep Foundations Under Static Axial Tensile Load.
21. D3966/D3966M-07 (2013)e1 - Deep Foundations Under Lateral Load.
22. D4945-12 - High-Strain Dynamic Testing of Deep Foundations.
23. E94-04 (2010) - Radiographic Examination.
24. E164-13 - Contact Ultrasonic Examination of Weldments.
25. E165/E165M-12 - Liquid Penetrant Examination for General Industry.
26. E329-14a - Agencies Engaged in Construction Inspection, Testing, or Special Inspection.
27. E709-15 - Magnetic Particle Testing.

F. Prestressed Concrete Institute (PCI):

1. MNL-116-99 - Manual for Quality Controls for Plants and Production of Structural Precast Concrete Products.
2. MNL-120 10- PCI Design Manual.

G. Society for Protective Coatings (SSPC):

1. Paint 16 06 (2015) - Coal Tar Epoxy-Polyamide Black (or Dark Red).

**1.6 PREINSTALLATION MEETINGS**

- A. Conduct preinstallation meeting at project site minimum 30 days before beginning Work of this section.

SPEC WRITER NOTE: Edit participant list to ensure entities influencing outcome attend.

1. Required Participants:

- a. Contracting Officer's Representative (COR).
- b. // Architect/Engineer. //
- c. // Inspection and Testing Agency. //
- d. Contractor.
- e. Installer.
- f. // Manufacturer's field representative. //
- g. Other installers responsible for adjacent and intersecting work, including // \_\_\_\_\_ //.

SPEC WRITER NOTE: Edit meeting agenda to incorporate project specific topics.

2. Meeting Agenda: Distribute agenda to participants minimum 3 days before meeting.
  - a. Installation schedule.

- b. Installation sequence.
  - c. Preparatory work.
  - d. Protection before, during, and after installation.
  - e. Installation.
  - f. Terminations.
  - g. Transitions and connections to other work.
  - h. Inspecting and testing.
  - i. Other items affecting successful completion.
3. Document and distribute meeting minutes to participants to record decisions affecting installation.

### 1.7 SUBMITTALS

- A. Submittal Procedures: Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Submittal Drawings:
  - 1. Show fabrication and installation details for proposed piles, including driving points, splices, field-cut holes, and pile caps.
  - 2. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld.
- C. Manufacturer's Literature and Data:
  - 1. For each type of pile product, accessory, and paint.
  - 2. Hammer: Include type, make, maximum rated energy, and rated energy per blow of hammer; weight of striking part of hammer; weight of drive cap; details, type, and structural properties of hammer cushion; and details of follower and jetting equipment.
  - 3. Design Mixes: For each concrete mix. Include revised mix proportions when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
- D. Test Reports: Wave equation analysis report, driving of each pile, pile location plumbness, welding, and static pile test reports.
- E. Certificates:
  - 1. Preservative Treatment of Timber Piles: Certification by treating plant stating type of preservative solution and pressure process used, net amount of preservative retained, and compliance with applicable standards. For waterborne-treated products, include statement that moisture content of treated materials was reduced to levels indicated before shipment to Project site.
  - 2. Welding certificates.
- F. Qualifications: Substantiate qualifications comply with specifications.

1. Installer with project experience list.
  2. Welders and welding procedures.
  3. Testing agency.
- G. Delegated Design Drawings and Calculations: Signed and sealed by responsible design professional.
1. Include arrangement of static pile reaction frame, test and anchor piles, equipment, and instrumentation.
  2. Steel Reinforcement: Comply with ACI 318.

#### **1.8 QUALITY ASSURANCE**

- A. Installer Qualifications:
1. Regularly installed specified products.
  2. Installed specified products with satisfactory service on five similar installations for minimum five years.
    - a. Project Experience List: Provide contact names and addresses for completed projects.
- B. Testing Agency Qualifications: Independent testing agency qualified according to ASTM C1077 and ASTM E329 for testing indicated and approved by COR.
- C. Welding and Welding Procedures Qualifications: AWS D1.1/D1.1M.
- D. Delegated Design: Professional engineer licensed in State where project is located.

#### **1.9 DELIVERY**

- A. Deliver piles to Project site in quantities and times to ensure continuity of installation.

#### **1.10 STORAGE AND HANDLING**

- A. Store and handle pile to prevent damage.
- B. Protect pile coatings and touch up coating damage before driving piles.
- C. Protect structures, underground utilities, and other construction from damage caused by pile driving.

#### **1.11 FIELD CONDITIONS**

- A. Existing Conditions: Evaluate and implement geotechnical report.

**1.12 WARRANTY**

SPEC WRITER NOTE: Always retain construction warranty. FAR includes Contractor's one year labor and material warranty.

- A. Construction Warranty: FAR clause 52.246-21, "Warranty of Construction."

**PART 2 - PRODUCTS****2.1 SYSTEM PERFORMANCE**

- A. Delegated Design: Prepare submittal documents including design calculations and drawings signed and sealed by registered design professional, licensed in state where work is located.
  1. Minor deviations to details shown on drawings to accommodate manufacturer's standard products may be accepted by COR when deviations do not affect design concept and specified performance.

**2.2 PILES**

- A. General: Friction end-bearing piles of capacity specified. Provide // timber // steel H // steel pipe // cast-in-place concrete // prestressed concrete // piles.
- B. Timber Piles: One piece with uniform taper from butt to tip conforming to ASTM D25. Provide unused, clean, and peeled round timber piles treated according to AWPA U1 and fresh-headed and shaped to fit driving head.
  1. Timber Pile Shoes: Size and type most suitable for driving condition. Saw off tops of timber piles in horizontal plane. Treat cutoffs and damaged pile surfaces as specified in AWPA M4.
  2. Strapping: 32 mm (1.25 inch) wide, 0.78 mm (0.031 inch) thick, cold rolled, heat-treated steel; painted and waxed.
  3. Spud piles or bored holes are acceptable to penetrate highly resistant strata laying near surface.
  4. Submit signed certificate stating that preservative treatment of timber piles delivered to site complies with structural and environmental requirements, including name and address of contractor, project locations, quantity of piles and date or dates of shipments, name of preservative used and retention in kilograms per cubic meter (pounds per cubic foot) of wood treated.

## C. Steel H Piles:

SPEC WRITER NOTE: Adjust steel type to project requirements.

1. Carbon Steel: ASTM A36/A36M. Grade 60.
2. High-Strength, Low-Alloy, Columbium-Vanadium Steel: ASTM A572/A572M.
3. High-Strength, Low-Alloy, H-Pile Steel: ASTM A690/A690M.
4. High-Strength, Low-Alloy, Structural Steel: ASTM A588/A588M.
5. Driving Points: One-piece driving point, fabricated from steel castings from one of the following for full bearing of web and flange of pile tip. Cast driving point with integral tapered cutting wedges and with top alignment curbs to encase web and flanges of pile:
  - a. Carbon-Steel Castings: ASTM A27/A27M.
  - b. High-Strength Steel Castings: ASTM A148/A148M.
6. Splice Plates: Manufacturer's standard units, matching H pile material, fabricated to encase web and part of each flange.
7. Paint: SSPC-Paint 16; self-priming, two-component, coal-tar epoxy polyamide, // black // red // manufacturer's standard color //.
8. Piles may be driven in single length or may be field spliced. Do not splice piles less than 7500 mm (25 feet) in length. Maximum one splice is permitted in any pile under 12 000 mm (40 feet) long. Splices to maintain alignment and position of pile sections and develop full strength of pile in bearing and minimum 50 percent of pile in bending. Butt-weld splices at flanges and web. Drive piles so that driving stress does not exceed 90 percent of minimum yield strength.

## D. Steel Pipe Piles:

SPEC WRITER NOTE: Adjust steel type and concrete strength to project requirements.

1. Pipe Steel: ASTM A252, seamless or welded. Grade 60.
2. Install piles with either open or closed ends. Close ends with forged or cast steel conical point continuously welded to pipe. Minimum wall thickness of open-ended pipe to be 6 mm (0.25 inch) for diameter less than 350 mm (14 inches) and 10 mm (0.375 inch) for diameters greater than 350 mm (14 inches). Minimum wall thickness of concrete filled pipe piles installed with closed ends to be 2.5 mm

(0.10 inch). Minimum outside diameter to be 250 mm (10 inches) for open-ended pipe piles and 200 mm (8 inches) for pipe piles installed with closed ends.

- a. Allowable Design Unit Stresses: 0.33 f'c average cross-sectional area of pile. For pipe sections 6 mm (0.25 inch) or more in thickness, 35 percent of minimum specified yield strength is permitted on full steel area. Minimum specified yield strength not be assumed to be greater than 250 MPa (36,000 psi) for computation purposes.
- b. Driving: Drive piles to required penetration without distortion, damage or not exceeding driving stress 90 percent of minimum specified yield strength. Provide tip reinforcement and steel caps as required. Establish and maintain axial alignment of leads and pile before and during driving.
  - 1) Drive piles in single length or splice with continuous butt weld. Space splices minimum 6000 mm (20 feet) in sections below upper splice. Provide watertight shell, splices and end closures. Square cut shell driving surfaces.
  - 2) Do not drive pile within 3000 mm (10 feet) in granular soil and 6000 mm (20 feet) in cohesive soil of any pile in which concrete has been placed, until 24 hours after concrete placement.
3. Concrete: ACI 318 for specified concrete mix. Provide 125 mm (5 inch) slump, plus or minus 25 mm (1 inch). Provide maximum coarse aggregate 19 mm (0.75 inch), per ASTM C33/C33M.
4. Reinforcement:

SPEC WRITER NOTE: Adjust reinforcement  
type to project requirements.

- a. Reinforcement Bars: ASTM A615/A615M, Grade 60; deformed.
- b. Low-Alloy-Steel Reinforcing Bars: ASTM A706/A706M.
- c. Galvanized Reinforcing Bars: ASTM A767/A767M, with Class II zinc coating, hot-dip galvanized after fabrication and bending, as follows:
  - 1) Steel Reinforcement: ASTM A615/A615M, Grade 60, deformed.
- d. Epoxy-Coated Reinforcing Bars: ASTM A775/A775M.
- e. Plain Steel Wire: ASTM A1064/A1064M.
- f. Deformed-Steel Wire: ASTM A1064/A1064M.



g. Epoxy-Coated-Steel Wire: ASTM A884/A884M.

5. Filling Casings: Do not place concrete in any pile in a group until entire group is driven. Pile interior clean and approved by COR before placing concrete. Place concrete using funnel or hopper. Place no concrete through water, except with COR written approval. Proportions of concrete so placed and method of placing to be approved by COR.

E. Cast-in-Place Concrete Piles:

SPEC WRITER NOTE: Adjust steel type and  
concrete strength to project  
requirements.

1. Allowable Design Stresses: 0.33 f'c on average cross-sectional area of pile. For computation purposes, assumed f'c cannot exceed 30 MPa (4000 psi). For casing thickness less than 2.5 mm (0.10 inch), no stress is permitted. For casing thickness 2.5 mm (0.10 inch) or more, less than 1.7 mm (0.067 inch) for protection, 35 percent of minimum specified yield strength is permitted. Minimum specified yield strength cannot be assumed to be greater than 250 MPa (36,000 psi) for computation purposes.
2. Provide uniformly tapered, step tapered, or cylindrical casings, or a combination of these, and laterally corrugated, spirally corrugated, longitudinally fluted or plain. Only one combination permitted throughout project.
  - a. Uniform-Taper: Provide 200 mm (8 inches) minimum nominal diameter at tip. Increase diameter from tip to cut-off following standard taper.
  - b. Step-Taper: Provide 220 mm (8 5/8 inches) minimum nominal diameter at tip. Increase diameter from tip to cut-off, in standard increments.
  - c. Constant-Section: Provide 300 mm (12 inches) minimum nominal diameter.
  - d. Casing to be watertight. Splices to be watertight and develop entire casing strength.
  - e. Close casing tip by continuously welding tip closure.
  - f. Replace non-watertight or damaged casings.
  - g. Do not drive casing within 3000 mm (10 feet) in granular soil and 6000 mm (20 feet) in cohesive soil of any pile in which

concrete has been placed, until 24 hours after concrete placement.

3. Concrete: ACI 318, for specified concrete mix. Provide 125 mm (5 inches) slump, plus or minus 25 mm (1 inch). Provide maximum coarse aggregate 25 mm (1 inch).
4. Reinforcement:

SPEC WRITER NOTE: Adjust reinforcement type to project requirements.

- a. Reinforcing bars: ASTM A615/A615M, Grade 60, deformed.
- b. Cold drawn bar for spirals, ASTM A1064/A1064M.
- c. Fabrication:
  - 1) Detail and fabricate according to ACI 318.
  - 2) Provide centralizers minimum every 9000 mm (30 feet) along length of reinforcement with minimum 2 centralizers per pile.
5. Filling Casings: Do not place concrete in any pile in a group until entire group is driven. Pile interior to be clean and approved by COR before placing concrete. Place concrete using funnel or hopper. Place no concrete through water, except with COR written approval. Proportions of concrete so placed and method of placing to be approved by COR.

F. Prestressed Concrete Piles:

SPEC WRITER NOTE: Adjust size, steel type and concrete strength to project requirements.

1. Prestressed Concrete: MNL-120 and MNL-116, except as specified.
2. Prestressed Concrete Piles: 300 mm (12 inches) square and reinforced as detailed.
3. Reinforcement:

SPEC WRITER NOTE: Adjust reinforcement type to project requirements.

- a. Reinforcing Bars: ASTM A615/A615M, Grade 60; deformed.
- b. Low-Alloy-Steel Reinforcing Bars: ASTM A706/A706M.
- c. Galvanized Reinforcing Bars: ASTM A767/A767M, with Class II zinc coating, hot-dip galvanized after fabrication and bending, as follows:
  - 1) Steel Reinforcement: ASTM A615/A615M, Grade 60.

- d. Epoxy-Coated Reinforcing Bars: ASTM A775/A775M or ASTM A934/A934M, as follows:
    - 1) Steel Reinforcement: ASTM A615/A615M, Grade 60, deformed.
  - e. Plain Steel Wire: ASTM A1064/A1064M.
  - f. Deformed-Steel Wire: ASTM A1064/A1064M.
  - g. Epoxy-Coated-Steel Wire: ASTM A884/A884M, Class A coated.
4. Concrete: Minimum ultimate compressive strength of 35 MPa (5,000 psi) at 28 days. Concrete mix to contain minimum 10 sacks of cement per cubic meter (7.5 sacks of cement per cubic yard) and maximum 20 L (5.0 gallons) of water per sack of cement, including surface moisture in aggregates. Maximum aggregate size shall be 25 mm (1 inch). Provide 50 mm to 100 mm (2 to 4 inches) slump range. Concrete may be steam cured.
  5. Prestressing Reinforcement: 7-wire stress relieved strands with 1700 MPa (250,000 psi) ultimate tensile strength conforming to ASTM A416/A416M.
    - a. Spiral Reinforcement: ASTM A615/A615M reinforcing steel ASTM A1064/A1064M cold drawn wire.
  6. Pile Accessories:
    - a. Pile Shoes: Minimum 25 mm (1 inch) thick of carbon-steel plate matching pile tip shape.
    - b. Pile Splices: Carbon-steel plates or castings that develop continuous pile strength at splice location.
  7. Compressive Cylinder Strength: Minimum 25 MPa (3,500 psi) at prestressing force transfer. Neither shipment from plant site nor driving will be permitted until full compression cylinder strength is reached.
  8. Initial tension in 11 mm (7/16 inch) strands, before release, to be 84 kN (18,900 pounds) per strand. Provide lifting devices on piles at points shown on drawings.
  9. COR reserves right to inspect, either part-time or full-time, operations at prestressing plant.
  10. Ensure that pile driving stresses do not exceed 0.85 f'c-effective prestress in compression and effective prestress in tension.

### 2.3 DRIVING EQUIPMENT

- A. Pile Hammer: Capable of developing ultimate pile capacity considering hammer impact velocity, ram weight, stiffness of hammer and pile cushions, cross section, length, and total weight of pile and character

of subsurface material to be encountered. // Use same pile hammer, operating at same rate and in same manner, as that used for driving test piles. //

1. Obtain required hammer driving energy, except for diesel hammers, by use of heavy ram and short stroke with low impact velocity.
  2. At final driving, operate pile hammer according to manufacturer's recommendations for driving either end bearing piles or friction piles.
  3. At final driving, operate diesel powered hammers at rate recommended by manufacturer for hard driving.
- B. Pile Cushions: Laminated, ring-shaped of 25 mm (1 inch) hardwood or 19 mm (3/4 inch) plywood, minimum 152 mm (6 inches) thick, cut to fit pile head.
1. Increase pile cushion thickness to suit pile size and length, character of sub-surface material to be encountered, hammer characteristics, and required driving resistance.
- C. Hammer Cushions: Aluminum and Micarta disks alternatively stacked in steel housing or suitable polymer as indicated by hammer manufacturer.
- D. Leads: Fixed or rigid-type pile-driver leads to hold pile along full length firmly in position and in axial alignment with hammer. Extend leads within 600 mm (24 inches) of elevation at which pile enters ground.

### **PART 3 - EXECUTION**

#### **3.1 PREPARATION**

- A. Survey: Lines and levels established and pile locations staked by Registered Professional Land Surveyor or Registered Civil Engineer, specified in Section 0100 01, GENERAL REQUIREMENTS.

SPEC WRITER NOTE: Specify load test and/or formula method to determine pile capacity as required by Design Engineer. Design Engineer will determine formula.

#### **3.2 STATIC PILE TESTS**

- A. Verify design pile lengths and confirm design load capacity of piles using static pile tests.
1. Provide test piles 1500 mm (60 inches) longer than production piles.
  2. Base actual pile length on results of static pile tests.
- B. Pile Tests:

1. Axial Compressive Static Load Test: ASTM D1143/D1143M.
  2. Axial Tension Static Load Test: ASTM D3689/D3689M.
  3. Lateral Load Test: ASTM D3966/D3966M.
- C. Equip each test pile with two telltale rods, according to ASTM D1143/D1143M, for measuring deformation during load test.
- D. Drive test piles at locations indicated to tip elevation below final cutoff elevation equal to pile length specified as basis of bid, or to refusal, whichever occurs first. Piles are considered driven to refusal when 5 blows of hammer are required to produce a total penetration of 6 mm (0.25 inch) or less:
1. Allow minimum seven days after driving test piles before starting pile testing.
- E. Provide pile reaction frame, anchor piles, equipment, and instrumentation with sufficient reaction capacity to perform tests. Notify COR minimum 48 hours in advance of performing tests. On completion of testing, remove testing structure, anchor piles, equipment, and instrumentation:
1. Number of Test Piles: Two single piles, or as directed by COR.
- F. Driving Test Piles: Use test piles identical to those required for project and drive with appropriate pile-driving equipment operating at rated driving energy to be used in driving permanent piles.
- G. Test Pile Driving Records: Prepare driving records for each test pile, compiled and attested to by qualified professional engineer. Include same data as required for driving records of permanent piles.
- H. Test piles that comply with requirements, including location tolerances, // may // may not // be used at production pile locations.

### 3.3 ALLOWABLE LOAD ON PILES

- A. Maximum Axial Capacity of Vertical Pile: Allowable axial load applied concentrically in direction of its axis. Limit structural strength of piles by allowable unit stresses specified.
- B. Maximum allowable capacity of piles to be established by driving control test piles in locations shown on drawings and conducting load tests.
1. Drive no foundation piles until test reports of test piles, as required by // ASTM D1143/D1143M // ASTM D3689/D3689M // ASTM D3966/D3966M // are received and written approval is given by COR.

2. Conduct load tests as specified in // ASTM D1143/D1143M // ASTM D3689/D3689M // ASTM D3966/D3966M //, standard loading procedure. Single pile load test to be twice design load.

C. Approval Criteria: Allowable design capacity of test piles to be one-half of load that results in lesser of the following two values:

1. Gross settlement of maximum 25 mm (1 inch), provided load-settlement curve shows no sign of failure.
2. Settlement minimum the value of 's', where:

metric	in-lb
$s = (4 + 8d)/1000 + \blacksquare$ (meters)	$s = 0.15 + d/10 + \blacksquare$ (feet)
where d = diameter of piles (meters)	where d = diameter of piles (feet)
$\blacksquare$ = elastic deformation of the pile (meters) as determined by test pile for that area of foundation, when driven, using equivalent make and model of pile hammer and same operation of hammer, with regard to speed, height or fall, stroke, and pressure.	$\blacksquare$ = elastic deformation of the pile (feet) as determined by test pile for that area of foundation, when driven, using equivalent make and model of pile hammer and same operation of hammer, with regard to speed, height or fall, stroke, and pressure.

- D. Additional load tests, increase in production pile length or number, and/or modifications to the pile cap may be required if the test pile fails load test.
- E. Additional load test costs to evaluate installation discrepancies is Contractor's responsibility.
- F. COR may require group load tests up to 150 percent of maximum allowable capacity of any pile group. If tests disclose that bearing capacity of group is lower than required, retesting will be at Government expense. Retesting performed to evaluate installation discrepancies is Contractor's responsibility.

SPEC WRITER NOTE: Substitute formulas to suit project.

- G. Pile Capacity during Driving: Capacity of single piles not in clusters to be minimum number specified. Determine pile capacity during

installation by the following formulas, modified according to data obtained by load test:

1. For piles with capacities of 36 metric tons (40 tons) or less.

	metric	in-lb
For Single-Acting Hammers:	$R = 166.7 WH$ $S + 2.5 P/W$	$R = 2WH$ $S + 0.1 P/W$
For Double-Acting Hammers:	$R = 166.7 E$ $S + 2.5 P/W$	$R = 2E$ $S + 0.1 P/W$

- H. Where: R is the allowable static pile load in Newtons (pounds).
- I. W is the weight of the striking part of the hammer in Newtons (pounds).
- J. H is the effective height of fall in meters (feet).
- K. E is the actual energy delivered by the hammer per blow in Newton meters (foot pounds).
- L. S is the average net penetration in mm (inches) per blow for last five blows after the pile has been driven to a depth where successive blows have produced approximately equal net penetration for a minimum distance of last 75 mm (3 feet).
- M. P is the weight of the pile in pounds. If P is less than W, P/W shall be taken as unity.
- N. Dynamic pile stresses not to exceed stresses mentioned above.

SPEC WRITER NOTES: Use 9491 Newton meters  
(7000 foot pounds) for timber piles only.

1. For piles that have design capacity greater than 36 metric tons (40 tons), wave equation analysis to be used to determine driving criteria. Wave equation analysis to include final set criteria and driving stresses in pile during installation. Submit wave equation analysis results before start of test program.

### 3.4 INSTALLATION

- A. Order of Driving: Install piles in order and with sufficient spacing to prevent distortion or injury to piles already in place.
1. Hammer Capacity: Minimum // 9491 // 20338 // Newton meters (// 7000 // 15000 // foot pounds) energy per blow.

2. Before beginning pile -driving, submit hammer data, including cap-block arrangement, weight and length of stroke of striking parts of hammer, number of operating blows per minute, piston area, and effective piston pressure to be maintained to COR for approval.
  3. Do not begin pile-driving operations until earthwork fills have been completed or excavations have reached an elevation of 150 to 300 mm (6 to 12 inches) above bottom of footing or pile cap.
  4. Provide proper anvil and cushion to prevent pile butt damage.
  5. Cap or cushion block to consist of one solid block of hardwood of proper shape and dimensions to fit hammer. Block grain to be parallel to pile axis. If laminated materials are used, strength of such materials to be equal to or greater than hardwood. Continuous or frequent introduction of materials to cushion hammer blows will not be permitted.
  6. Do not use wood chips, small blocks, shavings, or similar materials to cushion hammer blow.
  7. Driving piles through overburden without COR prior approval will not be permitted.
  8. Drilling, spudding, or jetting is acceptable only when approved by COR and performed at no additional cost to the Government. Methods employed will be subject to COR approval. Final 1500 mm (5 feet) of pile penetration must be obtained with hammer alone.
  9. Predrilling: Provide pre-excavated holes for piles driven within 4500 mm (15 feet) of existing structures or underground utilities, to depths indicated on drawings. Drill hole diameter less than the largest cross-section dimension of pile.
    - a. Firmly seat pile in predrilled hole by driving with reduced energy before starting final driving.
  10. Heaved Piles: Redrive heaved piles to tip elevation at least as deep as original tip elevation with driving resistance at least as great as original driving resistance.
- B. Drive foundation piles to bearing stratum and driving resistance established by test piles. If allowable capacity is not obtained in bearing stratum, drive piles deeper until required driving resistance is obtained. Penetration of all piles in a group should not vary more than 3000 mm (10 feet) unless approved by COR.
- C. Make no penetration measurements for purpose of determining resistance to driving when pile heads are damaged to extent that may affect



measured penetration nor immediately after fresh cushion block has been inserted under striking part of hammer. Make measurements with minimum interruption of driving.

- D. If, during driving of any pile, previously driven piles show signs of heaving, redrive disturbed piles to their original driving resistance, at no additional cost to the Government.
- E. Remove soil that heaves during or after driving to maintain grades. Do not place concrete in empty casing until all driving and re-driving has been completed within radius in which driving of adjacent pile casings may result in heaving.
- F. Clean out steel pipe pile by removing soil and debris from inside pile before placing steel reinforcement.
- G. Withdraw damaged or defective piles and piles that exceed driving tolerances; install new piles within driving tolerances. Fill holes left by withdrawn piles as directed by COR.
  - 1. Rejected piles may be abandoned and cut off as directed by COR.
  - 2. Leave rejected piles in place and install new piles in locations as directed by COR.
  - 3. Fill holes left by withdrawn piles that will not be filled by new piles using cohesionless soil material such as gravel, broken stone, and gravel-sand mixtures. Place and compact in lifts not exceeding 1800 mm (72 inches).
- H. Cut off tops of piles square with pile axis and at required elevations.

### **3.5 DESIGN MODIFICATIONS**

- A. Where piles are installed exceeding specified tolerances for plumb or location, foundation design will be analyzed by COR and, if necessary, redesigned by the COR. Costs for analysis, redesign, and remediation will be Contractor's responsibility.
- B. Additional piles and pile cap modifications necessitated by redesign to be provided at no additional cost to the Government.
- C. Provide specified type of pile and casing of gauges necessary to install satisfactory pile foundation. Conversion from one type of pile to another, or from lighter to heavier casing gauges will be at no additional cost to the Government.

### **3.6 FIELD QUALITY CONTROL**

- A. Surveyor: After all piles are driven and installed, Registered Professional Land Surveyor or Registered Civil Engineer will make field

survey of completed piling work. Submit drawing to COR showing actual pile locations with respect to planned pile locations and indicating plumbness of piles.

- B. Reports: Submit report in quadruplicate to COR, for each pile, detailing diameter or cross section, length, make and model of hammer, driving time, blows per minute, number of blows per 300 mm (blows per foot) in last 1500 mm (5 feet) of penetration, number of blows for each 25 mm (blows for each inch) during final 150 mm (6 inches) of penetration, and any other pertinent information.
- C. High-Strain Dynamic Monitoring: Perform and report according to ASTM D4945 during initial driving and during restriking on // 12 percent // 15 percent // of single piles.
- D. Low-Strain Integrity Measurement: Perform and report for each pile.
- E. Weld Testing: In addition to visual inspection, test and inspect welds according to AWS D1.1 and the inspection procedures listed below, at testing agency's option. Correct deficiencies in Work that test reports and inspections indicate do not comply with the drawings and specifications.
  - 1. Liquid Penetrant Inspection: ASTM E165/E165M.
  - 2. Magnetic Particle Inspection: ASTM E709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
  - 3. Radiographic Inspection: ASTM E94, minimum quality level "2-2T."
  - 4. Ultrasonic Inspection: ASTM E164.

### 3.7 CLEANING

- A. Remove and dispose of all withdrawn piles and cutoff pile sections, debris from excavations, and any material not to remain as part of construction off the project site in legal manner.
- B. Clean project site at frequent intervals with no material obstructing easy access of equipment and personnel.

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