COMPLETE REVISION
April 2019

Structural

PIP STS02465
Augered Cast-in-Place Piles
Installation Specification
PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

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Data Forms

- STS02465-D – Augered Cast-in-Place Pile Installation Record (U.S. Customary Units)
- STS02465-DM – Augered Cast-in-Place Pile Installation Record (Metric Units)
1. **Scope**

This Practice describes requirements for furnishing and installing augered cast-in-place (ACIP) piles also called continuous flight auger (CFA) piles. Test piles, pile load tests and pile integrity testing are included and shall be executed in accordance with this specification when required.

2. **References**

Applicable parts of the following 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 will be used herein where appropriate.

2.1 **Industry Codes and Standards**

- **American Concrete Institute (ACI)**
  - ACI 212.3R - *Report on Chemical Admixtures for Concrete*
  - ACI 301 - *Specifications for Structural Concrete*
  - ACI 301M - *Specifications for Structural Concrete (Metric)*
  - ACI 305.1 - *Specification for Hot Weather Concreting*
  - ACI 306.1 - *Standard Specification for Cold Weather Concreting*
- **ASTM International (ASTM)**
  - ASTM A615/A615M - *Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement*
  - ASTM A706/A706M - *Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement*
  - ASTM A722/A722M - *Standard Specification for High-Strength Steel Bars for Prestressed Concrete*
  - ASTM C33/C33M - *Standard Specification for Concrete Aggregates*
  - ASTM C94/C94M - *Standard Specification for Ready-Mixed Concrete*
  - ASTM C150/C150M - *Standard Specification for Portland Cement*
  - ASTM C494/C494M - *Standard Specification for Chemical Admixtures for Concrete*
  - ASTM C618 - *Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete*
  - ASTM C937 - *Standard Specification for Grout Fluidifier for Preplaced-Aggregate Concrete*
  - ASTM C939/C939M - *Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)*
  - ASTM C942 - *Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory*
3. Definitions

constructor: Party responsible for supplying materials, equipment, tools, supervision, and labor for installation of ACIP piles in accordance with contract documents. The term constructor applies 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 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 purchaser and constructor.

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

ageotechnical engineer: Professional engineer responsible for performing geotechnical investigation and/or geotechnical consulting during foundation design, construction of civil works, installation of piling and foundations.

owner: Party who has authority through ownership, lease, or other legal agreement over site, facility, structure or project wherein ACIP piles will be installed.

professional engineer: A licensed engineer, other than engineer of record, qualified to practice in the specialty discipline required for the work described in contract documents.
purchaser: Party who awards contract to constructor. Purchaser may be owner or owner’s authorized agent.

qualified geotechnical representative: Graduate geotechnical engineer, graduate geologist, or geotechnical technician, provided technician has at least ten years of relevant field exploration and logging experience and works under supervision of geotechnical engineer. Geotechnical engineer may also personally fulfill this role.

Quality Assurance (QA) representative: Party retained by purchaser responsible for review of submissions by QC inspector as well as direct observation of the work. Role may be fulfilled by qualified geotechnical representative or geotechnical engineer.

Quality Control (QC) inspector: Party responsible for verifying quality of all materials, installations, and workmanship furnished by constructor. QC inspector is qualified by training and experience and holds certifications or documentation of their qualifications. Unless otherwise specified in contract documents, QC inspector is an independent party retained by constructor.

4. Quality Control/Assurance

4.1 Quality Control

4.1.1 Qualifications

4.1.1.1 ACIP pile constructor including field personnel and QC inspector; geotechnical engineer and qualified geotechnical representative, as well as design team shall be properly qualified. See Sections 5.1 and 5.6 (for equipment).

4.1.1.2 Prior to construction, QC inspector shall become familiar with: project plans and specifications; geotechnical reports, approved installation plan, pre-production test or load test program; automated monitoring system, grout (or concrete) sampling and testing requirements, reinforcing details, pile finishing and cut-off. QC inspector shall review relevant sections of DFI TM-ACIP-2, DFI TM-ACIP-3 and DFI TM-ACIP-4.

4.1.2 Pre-production Program

Indicator and test piles shall be installed as specified to verify soil conditions and pile design parameters, installation equipment and monitoring equipment requirements. See Sections 5.1 and 6.3.

4.1.3 Automated Monitoring

Critical functions shall be continuously monitored: vertical mast force and torque, drill position (depth), drill rotation, grout pressure and grout flow correlated with depth. See Sections 5.4.3 and 5.6.

4.1.4 Continuous Review by Constructor

All aspects of ACIP pile installation shall be continuously reviewed for anomalies which could indicate need for re-drilling, further testing or rejection of piles. See Sections 5.6 and 5.7.
4.2 Quality Assurance

4.2.1 Communications
Project plans and specifications, geotechnical report and local site conditions shall be communicated to all parties. See Sections 5.1, 5.2 and 5.4.

4.2.2 Inspection
The entire installation process shall be continuously monitored, including drilling, grout placement, reinforcing installation and finishing of each pile. All aspects of the installation shall be continuously reviewed for anomalies which could indicate need for re-drilling, further testing or rejection of piles. See Sections 5.1, 5.4, 5.6, 5.7 and 6.1.

4.2.3 Materials Testing
Grout material shall be tested as specified regardless of whether proprietary drilling methods are used. See Section 5.5.

4.2.4 Pile Verification
Selected production piles shall be verified by a program of integrity testing and load testing. See Sections 6.2 and 6.3.

5. Requirements

5.1 General

5.1.1 Constructor shall have a minimum of five years’ experience in successful installation of ACIP piles under similar job and subsurface conditions. Constructor’s supervisor shall have a minimum of five years of method-specific experience and shall be present at all times during installation of the piles. Drilling rig operator assigned to the project shall have a minimum of three years of method-specific experience. QC inspector shall have a minimum of three years of method-specific experience and QC inspector’s qualifications shall be reviewed and approved by geotechnical engineer.

5.1.2 Constructor shall review data from subsurface investigations and confirm that proposed equipment is suitable for proposed ACIP pile installation program prior to mobilization. Constructor shall provide data from any additional investigations to purchaser.

5.1.3 Constructor shall visit the site before equipment mobilization to identify overhead and horizontal obstructions and to verify that pile installation equipment can access pile locations at the site.

5.1.4 Constructor shall install piles in accordance with the procedure established and proven by a successful pile load test as determined by geotechnical engineer.

5.1.5 Purchaser shall immediately be notified in writing of any situations detrimental to proper and timely completion of work.

5.1.6 Engineer of record, geotechnical engineer, qualified geotechnical representative, or purchaser shall have the right to make inspections and tests at any time. Constructor shall cooperate with purchaser in performance of this work.
5.1.7 Qualified geotechnical representative shall be present during all installation activities. The presence of the qualified geotechnical representative shall in no way relieve constructor of any obligation to perform pile installation, quality control, and record-keeping activities in accordance with contract documents.

5.1.8 Purchaser shall be notified no less than three working days before installation or testing of piles.

5.1.9 Engineer of record, geotechnical engineer, or qualified geotechnical representative shall determine the acceptability of the piles and may reject piles that do not meet all requirements of this Practice.

5.1.10 Rejected piles shall be corrected or replaced as directed by engineer of record. All corrective work shall be performed at no additional cost to purchaser.

5.1.11 Grout test specimens shall be made according to ASTM C109/C109M standard test method.

5.1.12 Installation procedures and equipment shall be same as those used to install test piles. Constructor shall notify purchaser immediately if pile installation procedure and/or equipment are changed for any reason.

5.2 Meetings

5.2.1 Pre-award Meeting

A pre-award meeting, attended by constructor, purchaser, engineer of record, geotechnical engineer, qualified geotechnical representative, QA representative, and QC inspector, shall be held to discuss topics such as the following:

a. Safety requirements
b. Site entry procedures
c. Available subsurface information
d. Underground utility identification and location
e. Survey for elevation and location of piles
f. Grout submittal, delivery, and placement requirements
g. Excavated material disposal
h. Action required if potentially contaminated soil is encountered
i. Requirements for integrity testing, load testing, and inspection
j. Test pile installation and procedures
k. Project pile design plan and specification review
l. Grout pump calibration and computation of required volume based on pump strokes. Use of automated monitoring equipment.
m. Procedures for drilling piles including pile spacing requirements
n. Procedures for grout placement
o. Procedures for re-drilling and re-grouting piles
p. Procedures for installation of reinforcing cages, center reinforcing bars, centralizers, and non-destructive testing access tubes

q. Procedures for finishing pile tops to final grade (topping off or bailing grout below ground surface)

r. Chain of communication for piles not meeting specification requirements

s. Responsibility for required reports

t. Exceptions to specifications, if any, constructor proposes for consideration due to use of proprietary systems or for any other reason

u. Schedule

5.2.2 Pre-construction Meeting

Pre-construction meeting shall be held immediately before start of work. This meeting shall be attended by people assigned to the work who are ultimately responsible for actual field pile installation work. These include the constructor, QC inspector, field superintendent, foremen, operators, installation crew, and grout supplier. Topics addressed shall include those listed above (5.2.1) and shall go into greater detail on actual installation practices (i.e. grout pump installation, rebar spacers, rebar cage handling, and other functional topics). Project specifications shall be reviewed with the construction crew to ensure full understanding of requirements. Purchaser, engineer of record, qualified geotechnical representative, QA representative and geotechnical engineer shall also attend.

5.3 Design of ACIP Piles

Design of ACIP piles will be furnished to constructor in contract documents.

5.4 Submittals

5.4.1 Pre-construction Submittals

The following items shall be submitted to purchaser for approval. Work shall not proceed without approval. Submittals are due at least fourteen calendar days before mobilization begins:

a. Description of pile drilling and pumping equipment to be used on project, including hollow stem auger, drill bit, leads/torque arm, drive box (horsepower, weight, and torque), hydraulic power unit, torque converter, grout pump, and crane(s) to be utilized at site

b. Crane safety inspection report(s)

c. Description of anticipated production in linear feet (meters) of completed piling per rig, per day

d. Proposed grout mix, admixtures, and descriptions of grout components. Grout mix proportioning and compliance verification shall be in accordance with ACI 301 / ACI 301M requirements for grout used in post-tensioned concrete applications, unless otherwise specified in contract documents.

e. Drawings indicating arrangement of pile static load test(s) and all design calculations, as applicable. A professional engineer shall seal the drawings and calculations for testing assembly. Calibrations of load-cell and jack/jack
manometer shall also be included. Calibrations shall be current for project under this contract only and shall be performed within 30 days before equipment is brought to site.

f. Descriptions and calibrations of the dynamic loading equipment and qualifications of the testing technicians, when applicable

g. Permits as required by contract documents

h. Piling plan layout referenced to drawings, including a numbering system capable of identifying each individual pile

i. Certified mill test reports for reinforcing steel, when applicable

j. Complete pile installation procedure in accordance with project specifications, this practice, and DFI manuals referenced above. Procedure shall provide drilling and grouting parameters including auger rotation speed, drilling penetration rate, torque, applied dead weight, grout pressures and grout volume factor range

k. Details of methods to be used for centering reinforcing in piles

l. Written statement that mobilized equipment will be capable of accessing ACIP pile locations and sufficient to install the ACIP piles at required diameter and depth in accordance with contract documents

m. Checked reinforcement bar fabrication drawings showing details of splice length for vertical bars and tie details

n. Drawing and written description of teeth design and material, and picture of rock-cutting bit to be used if applicable

o. Descriptions of automated installation-monitoring equipment and description of monitoring procedures with sample printed output

p. Descriptions of integrity verification testing equipment and procedures and qualifications of testing technician

5.4.2 Construction Submittals

5.4.2.1 QC inspector shall prepare a pile installation record using attached data form PIP STS02465-D or PIP STS02465-DM (as applicable) for each pile and provide to qualified geotechnical representative for immediate review. QC inspector shall distribute one copy each to: purchaser, engineer of record, and geotechnical engineer within two working days of installation. QC inspector shall record the following information at a minimum (unless contract documents explicitly allow incremental data to be recorded solely by automated measuring equipment [items w, dd, ee]):

a. Pile number

b. Project name, number, and location

c. Name of constructor

d. Date of installation, weather conditions, and temperature

e. Pile QC inspector’s name and signature
f. Rig: identification number, model number and operator’s name

g. Grout supplier, grout truck number, grout ticket number, time grout was batched, grout truck arrival time on-site, batch volume (load)

h. Amount and type of admixture(s) added to each grout truck on-site

i. Amount of water added to each grout truck on-site

j. Grout mix number, grout sampling time, grout temperature

k. Flow cone time in seconds [Cone orifice diameter is 3/4 inch (20 mm) as required by specification]

l. Grout cube/cylinder sets with time and identification

m. Drawing numbers of pile detail and pile location

n. Design pile diameter

o. Auger diameter (note actual diameter each time measured in field)

p. Auger pitch (note actual pitch each time measured in field; average the measured length between a minimum of six auger flights)

q. Ground surface elevation

r. Pile top elevation (cut-off)

s. Design tip of pile elevation

t. As-built length of pile

u. Alignment of crane leads (vertical or battered with angle)

v. Augering start time (pile excavation began)

w. Number of auger revolutions per 5-ft (1.5-m) increment of pile penetration while drilling down

x. Augering stop time (pile tip elevation reached)

y. Total time of excavation (note in blank space)

z. Depth of pile

aa. Pile tip elevation (subtract depth from ground surface elevation)

bb. Theoretical volume (calculate from auger diameter and depth of pile)

c. Time grout pumping began

d. Grout pump strokes for each 5-ft (1.5-m) increment of pile grout [2-ft (0.6-m) increment if automated monitoring equipment is used]

e. Grout factor per increment (calculate actual/theoretical volume) (Convert pump strokes into quantity of grout placed for each 5-ft (1.5-m) increment of pile versus theoretical quantity of grout [2-ft (0.6-m) increment if automated monitoring equipment is used])

ff. Time grout pumping ceased

gg. Total time of grout placement (note in blank space)
hh. Pump strokes for grout placed to build initial pressure head
ii. Total pump strokes to complete pile
jj. Grout return depth (Auger depth when grout first observed at ground surface)
kk. Overall grout factor (actual grout volume pumped into pile divided by theoretical grout volume; grout factor shall not include grout required to fill lines or auger, nor any excess grout pumped at ground surface.)
ll. Reinforcing steel placed (time, meets drawing requirements, centralizers, etc.)
mm. Elevation of top of steel
nn. Pile top form placed and finished (time)
oo. Any unusual occurrences during pile installation, including loss of ground or loss of grout after completion
pp. Total number of pump strokes to complete pile (actual grout volume)
qq. Grout settlement, description of communication with adjacent piles (if any)
rr. Printed copy of automated measuring and recording equipment output
ss. Confirmation of pile location within specified tolerance

5.4.2.2 Grout compression test results shall be submitted to purchaser within five days of performing test. Engineer of record shall be notified immediately if any test indicates that grout is below the specified strength.

5.4.2.3 Constructor shall submit an electronic spreadsheet that links pile installation records with cube strength values and other test results. Spreadsheet shall be updated daily during ACIP pile installation and on receipt of cube strength or other test results and shall be submitted weekly.

5.4.2.4 Constructor shall submit to purchaser a printed copy of automated measuring and recording equipment output as required by 5.4.3, and shall provide a copy with pile installation record required by 5.4.2.1.

5.4.2.5 QC inspector shall notify constructor immediately of any concerns regarding pile installation and shall document the concern on pile installation record.

5.4.2.6 Geotechnical engineer shall review inspection records within 4 business days of pile installation. Any deficiencies identified in pile installation record shall be resolved; such resolution may include testing as specified by geotechnical engineer.

5.4.3 Automated Instrumentation and Monitoring Submittals

As a minimum the submittal shall contain the following information:

a. Manufacturer and model of equipment and components
b. Description of equipment function  
c. Sample of information and printout provided  
d. Certification that equipment can measure parameters desired by engineer of record and by constructor  
e. Operating manual of equipment  
f. Record of calibration and statement of measurement precision

5.5 Materials

All furnished materials and proprietary items shall be subject to engineer of record’s approval and shall be installed in accordance with contract documents.

5.5.1 Portland Cement

Portland cement shall be in accordance with ASTM C150/C150M with type of cement as specified in contract documents.

5.5.2 Mineral Admixtures

Mineral admixtures, if specified shall be in accordance with ASTM C618, Class C or Class F as specified in contract documents.

5.5.3 Chemical Admixtures

5.5.3.1 Chemical admixtures shall be in accordance with ASTM C494/C494M and ACI 212.3R, and shall be approved by engineer of record.

5.5.3.2 Air entraining admixtures shall not be used.

5.5.3.3 Chemical admixtures that contain chloride shall not be permitted.

5.5.4 Fluidifier

Fluidifier shall be in accordance with ASTM C937.

5.5.5 Water

Water shall be in accordance with ASTM C94/C94M.

5.5.6 Fine Aggregates

Fine aggregates shall be in accordance with ASTM C33/C33M.

5.5.7 Grout

5.5.7.1 Grout shall be in accordance with ASTM C94/C94M. Grout shall be a mixture of portland cement, fine aggregates, mineral admixtures (if specified), chemical admixtures, fluidifier, and water, proportioned and mixed to produce a grout capable of being pumped.

5.5.7.2 Grout shall be capable of maintaining the solids in suspension.

5.5.7.3 Grout shall have a minimum 28-day compressive strength of 4,000 psi (28 MPa), unless otherwise specified in contract documents.

5.5.7.4 Grout materials shall be accurately measured to meet design proportions. Total water in the grout mix shall not exceed design quantity in approved grout mix submittal.
5.5.7.5 Addition of water or admixtures on site shall be in strict accordance with procedure approved by the engineer of record.

5.5.7.6 Grout shall be mixed at site for a minimum of two minutes at maximum revolution rate unless site-added admixtures require a longer mixing time. Maximum holding time from batch plant shall be two hours, and maximum temperature of grout at time of placement shall be 100°F (32°C).

5.5.7.7 Grout shall be protected from low temperatures in accordance with ACI 306.1 and from high temperatures in accordance with ACI 305.1.

5.5.7.8 Grout mix shall be assigned a mix number to be included on the grout delivery tickets for identification purposes.

5.5.7.9 Testing

a. Grout test cubes shall be prepared, cured, and tested in accordance with ASTM C942 and ASTM C109/C109M, as applicable.

b. A set of at least six 2-inch (50-mm) cubes shall be prepared for every 5-hour interval (or portion thereof) during which a rig is installing piles. During daily installation operations of 8 to 10 hours prepare two sets of grout cubes from different grout trucks for each pile installation rig. If extended hour daily operations are used, no more than four sets of cubes per rig should be prepared in a 24-hour day unless directed by QC inspector.

c. At least two sets of six grout cubes per set shall be prepared for each test pile. These cubes will be tested as follows: two cubes at seven days, two cubes at fourteen days, two cubes at twenty-eight days, two cubes on the same day the pile load test is conducted, and four cubes held in reserve.

d. Each set of six cubes made during production installation shall be tested as follows: two cubes at seven days, two cubes at twenty-eight days, and two cubes held in reserve.

e. Flow rate of grout shall be tested each time cubes are made to measure workability/consistency. Time inconsistencies shall be noted on installation record. Flow cones shall be in accordance with ASTM C939/C939M, except that cone shall be modified to provide a 3/4-inch (20-mm) opening.

f. Grout flow rates shall be between ten and twenty-five seconds.

g. Flow cone shall be provided by QC inspector.

h. QC inspector shall inform constructor if the grout does not meet time, temperature, and consistency requirements for placement. It is constructor’s responsibility to reject delivered grout.

5.5.8 Reinforcing Bars

5.5.8.1 Reinforcing bars shall be in accordance with ASTM A615/A615M Grade 60 (420) or ASTM A706/A706M Grade 60 (420), as specified in contract documents.
5.5.8.2 High-strength reinforcing bars shall be in accordance with ASTM A722/A722M, as specified in contract documents.

5.5.8.3 Ties shall be of materials compatible with reinforcing bars.

5.6 Equipment

5.6.1 Automated Instrumentation, Monitoring and Recording

5.6.1.1 Automated monitoring equipment instrumentation shall be used to monitor pile installation. Minimum specified grout ratio or volume per unit pile length measurement shall be clearly displayed to guide constructor and purchaser during pile installation. Automated instrumentation and monitoring equipment shall be provided in accordance with requirements of this specification for all pile installations except those installed using limited access/low-overhead equipment.

5.6.1.2 Digital records shall be made of all acquired data and made available to purchaser and purchaser’s representatives. The electronic data shall be furnished in spreadsheet, raw data and plot formats.

5.6.1.3 Data shall include grout pressure and grout volume versus both depth and time and shall include angle of pile installation.

5.6.1.4 Automated instrumentation and monitoring equipment shall be calibrated to ensure recording data within +/-3% tolerance of the quantity measured--whether volume, length, pressure or torque--at the start of work and every month thereafter.

5.6.1.5 Display device(s) shall be supplied for data monitoring by constructor and purchaser during installation of each pile for depth increments not to exceed 2 ft (0.6 m). Alternatively, operator can provide an immediate printout of pile details for field evaluation to determine if re-drilling is necessary.

5.6.1.6 Provide printer on site to document results of pile installation immediately following completion of each pile in accordance with Section 5.4.2.4.

5.6.1.7 Measurements made by automated measuring and recording equipment shall include as a minimum:

a. Auger rotation and hydraulic torque for every 2-ft (0.6-m) increment, or less, of pile advancement during drilling process, and during placement of grout or concrete (if auger is rotated during this placement)

b. Volume of grout or concrete placed versus depth of outlet orifice for every 2-ft (0.6-m) increment, or less, of pile placed

c. Average maximum and minimum pump stroke pressures at ground level for every 2-ft (0.6-m) increment, or less, of pile placed

d. Average maximum and minimum pump stroke pressure at or near auger head for every 2-ft (0.6-m) increment, or less, of pile placed, if directed by engineer of record
e. Additionally, purchaser may also specify that crowd force (downward thrust on auger) measurements be made at every 2-ft (0.6-m) increment, or less, of pile advancement during drilling process.

5.6.2 Gear Box and Power Unit

5.6.2.1 Driver shall provide a minimum of 20,000 ft-lb (27 kN-m) of torque and a minimum of 4,000 lb (18 kN) of crowd force (dead weight). Power unit shall provide a minimum of 200 hp (150 kW).

5.6.2.2 Drill rig shall be capable of advancing auger of specified diameter to specified embedment within bearing strata without soil mining. Constructor shall provide equipment with adequate torque and crowd force as required to install ACIP piles in accordance with contract documents and this Practice. Constructor shall provide to purchaser specifications and evidence that equipment can and has been used to install piles similar to those specified and in similar conditions.

5.6.2.3 For low-overhead piles see Section 5.7.8.

5.6.3 Augering Equipment

5.6.3.1 Augers shall be continuous flight, hollow stem with an opening at bottom of the auger head below the part of the head containing teeth.

5.6.3.2 Auger flighting shall be continuous without gaps or breaks and shall be uniform in diameter within a tolerance of 3% of that specified in contract documents.

5.6.3.3 Pitch of the auger flighting shall not exceed 9 inches (225 mm).

5.6.3.4 Intermediate stabilizing guide(s) shall be provided for augers longer than 40 ft (12 m).

5.6.3.5 For hanging lead rigs, piling leads shall be prevented from rotating by a stabilizing arm or by firmly placing bottom of the leads into ground or by other means approved by engineer of record.

5.6.3.6 Leads or mast shall be clearly marked on both sides at 1-ft (0.3-m) intervals to facilitate measurement of auger penetration. Marks on the leads shall be labeled with numerals every 5 ft (1.5 m) such that QC inspector can easily determine final drill depth and grout return depth. Constructor shall position equipment such that QC inspector can clearly see the marks while standing on grout line near grout pump.

5.6.3.7 Rig shall be equipped so that auger withdrawal can be accomplished at a slow, continuous rate.

5.6.3.8 Equipment furnished shall be capable of installing piles at least 10 ft (3 m) longer than that required for specified length piles.

5.6.3.9 If logs of soil borings indicate that timber logs, cobbles, or other minor obstructions will be encountered before reaching required pile depth, then a rock-cutting bit shall be supplied and used.
5.6.4 Pumping Equipment

5.6.4.1 Pumping equipment used in pumping and handling the grout shall be adequate to meet requirements of this Practice and contract documents and shall allow placement of a homogeneous grout of required consistency through the auger to depth required.

5.6.4.2 Pump hoppers shall be provided with a 3/4-inch (20-mm) screen to exclude oversize lumps from creating a blockage.

5.6.4.3 Positive displacement pump capable of at least 350-psi (2,400-kPa) displacement pressure at the pump shall be provided.

5.6.4.4 Pump pressure gauge shall be provided and in clear view of the operator.

5.6.4.5 Pump shall be calibrated on site prior to installation of first pile and after modifications are made to pumps or other equipment or after a significant change in grout return depth. Onsite pump calibration shall be completed by recording number of pump strokes required to fill at least 75% of a 55-gallon (200-liter) barrel or other accurately known volume container of similar size with grout. Container shall be measured and actual grout volume shall be computed when container is not completely filled at an even number of grout pump strokes. QC inspector shall observe calibration and provide documentation to engineer of record.

5.6.4.6 Digital or mechanical grout pump stroke counter shall be provided. Constructor shall have at least one spare pump counter available onsite and shall maintain pump stroke counter in operating condition at all times.

5.6.5 Mixing and Transportation Equipment

5.6.5.1 Mixing and transportation equipment used in preparing and handling grout should be adequate to meet requirements of this Practice and contract documents and should produce a homogeneous grout of required consistency.

5.6.5.2 Mixing plant equipment may be central mix or transit mix batch plant. Plant must be calibrated to produce grout required.

5.6.5.3 Transit trucks must be capable of continuously agitating grout to maintain consistency.

5.7 Execution

5.7.1 General

5.7.1.1 Piling materials, labor, tools, supervision, equipment, and supplies necessary for installing ACIP piles shall be furnished in accordance with contract documents and this Practice.

5.7.1.2 Sufficient quantity of grout to complete a pile shall be available at site or in transit before pile installation begins. No open holes are permitted.

5.7.2 Construction Tolerances

5.7.2.1 Pile centers shall be located within a tolerance of +/- 3 inches (75 mm) of locations shown in contract documents unless a lesser tolerance is provided therein.
5.7.2.2 Vertical piles shall be plumb within 2% of pile length.

5.7.2.3 Battered piles shall be aligned to within 4% of pile length based on specified batter.

5.7.2.4 Reinforcing cages or center bars shall have a minimum of 3 inches (75 mm) clearance from the wall of augered hole.

5.7.2.5 Finished top of pile shall be no more than 1 inch (25 mm) above nor 3 inches (75 mm) below cut-off elevation, and extension of reinforcing above cut-off elevation shall not be less than as shown on contract documents.

5.7.3 Adjacent Piles

5.7.3.1 Piles shall not be placed within six pile diameters, center to center, of adjacent piles containing grout that has set for less than twelve hours.

5.7.3.2 Approximate time of initial set shall be determined by QC inspector. However, for purposes of drilling adjacent piles, initial set time shall not be taken as less than given above.

5.7.4 Installation Procedures

5.7.4.1 Pile length, drilling criteria, and installation procedures of production piles may be modified by engineer of record from information obtained during installation of probe piles, reaction piles, test piles, and pile load tests.

5.7.4.2 Production piles shall be installed with same equipment and identical procedures used for installation of probe piles and test piles.

5.7.4.3 Drilling shall advance at a continuous rate appropriate for the soil conditions until required depth or refusal is reached.

5.7.4.4 Oversight shall be provided by an experienced QC inspector to prevent excessive rotation of the auger, which can cause loss of ground in running sands.

5.7.4.5 If refusal is reached before the required depth, purchaser shall be notified immediately.

5.7.4.6 Auger refusal is defined as a rate of auger penetration of less than 1 ft (0.3 m) per minute of drilling with maximum torque and weight applied to auger using equipment approved by purchaser.

5.7.4.7 Plug shall be provided in the bottom of auger during drilling to prevent entry of soil or water into hollow stem of the auger.

5.7.4.8 When auger reaches specified depth, auger may be raised 6 to 12 inches (150 to 300 mm), and grout pumping shall begin.

5.7.4.9 After grout pressure builds up as calculated by the required volume to fill pump line, auger tube and provide a minimum of 5 ft (1.5m) of grout above auger tip, auger shall be re-drilled to the previously established tip elevation.

5.7.4.10 Grout head of at least 5 ft (1.5 m) shall be continuously maintained above injection point during withdrawal of auger. If 5 ft (1.5 m) grout
head is not observed by grout return to the ground surface, constructor shall re-drill and re-grout pile to the full depth.

5.7.4.11 Auger shall be withdrawn at a smooth, continuous rate. If auger jumps upward during withdrawal, if grout pressure decreases, or if grouting is interrupted for any reason, auger shall be reinserted to 5 ft (1.5 m) below tip depth of the auger when the interruption occurred or to the bottom of pile, whichever is less, and rate of withdrawal shall be decreased to prevent further jumping or pressure decreases.

5.7.4.12 Auger shall be rotated clockwise slowly during withdrawal.

5.7.4.13 Counter-clockwise rotation shall not be permitted.

5.7.4.14 A minimum of 115% of the theoretical grout volume shall be placed in each 5-ft (1.5-m) increment of pile, unless another minimum grout factor is selected by geotechnical engineer on the basis of field test piles.

5.7.4.15 After grout is flowing at ground surface from auger flighting, the rate of grout injection and auger withdrawal shall be coordinated so that grout constantly flows at surface and theoretical volume is placed in each subsequent depth increment.

5.7.4.16 If any 5-ft (1.5-m) increment is deficient, pile shall be reinstalled by advancing auger 10 ft (3 m) below the deficient grout interval or to bottom of the pile, whichever is less, and pile shall be re-grouted using a reduced rate of auger withdrawal.

5.7.4.17 Piles shall be completely grouted and protected at termination of each day’s operation. No pile shall be left partly completed overnight.

5.7.4.18 Reinforcing steel shall be in accordance with contract documents, shall be placed while grout is still fluid, and shall have centering fins, spacers, or other devices to assure minimum grout cover as shown on drawings. If cover is not shown on the drawings, a minimum of 3 inches (75 mm) of grout cover shall be provided.

5.7.4.19 Tops of pile grout shall be manually screened clean of dirt and debris before insertion of reinforcing.

5.7.4.20 Reinforcing cages or bars shall be clean before insertion into pile grout.

5.7.4.21 Reinforcing cages or bars shall be cooled with a water spray before being inserted into grout.

5.7.4.22 Reinforcing steel shall fall into place by gravity, except that it may be pushed steadily a maximum of 4 ft (1200 mm) into the pile using minimal force, provided it remains centered in the pile and does not deform.

5.7.4.23 Reinforcing cages, bars, or access tubes shall not be disturbed or shaken for a minimum of twelve hours after grout placement.

5.7.4.24 If reinforcing steel cannot be placed to design elevation, reinforcing steel shall be removed and pile shall be re-drilled to full depth. Cost for reinstalling pile shall be borne by constructor.
5.7.4.25 Methods to facilitate proper centering of steel cages or tension reinforcing installed in piles shall be approved by engineer of record.

5.7.4.26 Reinforcing cages shall be tied in a manner that the cage shall retain specified shape and all reinforcing elements shall maintain specified positions throughout installation of cage.

5.7.4.27 Centralizer devices shall be spaced no more than 20 ft (6 m) apart on vertical cages or bars and no more than 10 ft (3 m) apart on battered cages or bars.

5.7.4.28 Field bar bends shall be limited to 90-degree bends and limited to #7 bars (#22 metric bars) or smaller.

5.7.4.29 If welding steel reinforcing bars is specified in contract documents, it shall be in accordance with *AWS D1.4/D1.4M*.

5.7.4.30 Observe tops of completed piles to note any grout subsidence for period before initial set occurs.

5.7.4.31 Grout subsidence shall be handled by topping off piles with additional grout provided pile grout has not achieved initial set.

5.7.4.32 Grout subsidence greater than 1 ft (0.3 m) shall be avoided by increasing distance between installations of adjacent piles, or alternating pile locations and/or requiring grout to set for a longer time.

5.7.4.33 Additional grout shall only be placed prior to initial set of grout in pile to avoid formation of a cold joint at the pile top.

5.7.4.34 Grout mix design, delivery ticket, grout density tests and installation notes shall be reviewed to determine if there are problems with grout.

5.7.5 **Spoils Handling**

5.7.5.1 Spoils including excess grout and soil returned to surface by augers shall be kept clear of pile location by prompt removal.

5.7.5.2 Spoil shall be minimized by controlling speed of auger withdrawal and rate and volume of grout pumped during auger withdrawal.

5.7.5.3 Remove and dispose of spoils as directed by purchaser.

5.7.5.4 Comply with any restrictions on disposal, and transport spoils to disposal area provided.

5.7.5.5 Promptly inform purchaser if contaminated soil is suspected.

5.7.6 **Obstructions**

5.7.6.1 If obstructions causing auger refusal are encountered above desired tip elevation, pile shall be completed to refusal depth in accordance with contract documents.

5.7.6.2 Pile installation records shall be immediately sent to geotechnical engineer and engineer of record for evaluation.

5.7.6.3 Additional adjacent piles shall be installed as directed by geotechnical engineer and engineer of record.
5.7.7 Termination (Pile Cut-Off)

5.7.7.1 Piles shall be cut off by removing fresh grout from the top of the pile or by cutting off hardened grout down to final cut-off point.

5.7.7.2 Adding grout to raise pile cut-off elevation after pile has reached its initial set shall not be permitted.

5.7.7.3 Sleeves or casings shall be placed around pile top if pile cut-off elevation is above surrounding ground surface elevation.

5.7.7.4 Reinforcing steel cages or central bar shall be supported to prevent settling below planned elevation.

5.7.8 Low-Overhead ACIP Piles

5.7.8.1 All preceding sections of this Practice shall be also be applicable for limited access/low-overhead ACIP piles except as modified by this section.

5.7.8.2 Additional pre-construction submittals shall be provided for limited access/low-overhead ACIP piles:

a. Sketches showing envelope dimensions of the low-overhead rig. Envelope shall be dimensioned from center of augered cast-in-place pile and shall allow for overall height, horizontal width on either side of pile, and horizontal length in front and in back of pile. Envelope shall allow for any movement of rig during installation and during auger addition and withdrawal.

b. Reinforcement shop drawings that include all splice details for reinforcement bar/cage for low-overhead ACIP piles

5.7.8.3 Additional construction submittals shall be provided for limited access/low-overhead ACIP piles:

a. Description of number, diameter, length and construction of auger sections used in each pile

b. Description of number, diameter, length and connections of center bar and cage sections used in each pile

5.7.8.4 Drive gearbox shall have a minimum of 20,000 ft-lb (27 kN-m) of torque and a minimum of 2,000 lb (9 kN) of crowd force (dead weight). Equipment with greater torque and weight shall be provided as required to install limited access/low-overhead ACIP piles in accordance with contract documents and this Practice.

5.7.9 Probe, Reaction, and Test Piles

5.7.9.1 Probe (or indicator piles), reaction, and test piles shall be furnished and installed in accordance with contract documents.

5.7.9.2 Probe, reaction and test piles shall be installed with same pile installation equipment and in compliance with procedures specified for installation of production piles.

5.7.9.3 Probe piles are installed to determine suitability of equipment and ability to install ACIP piles in site soil and stratigraphy. Probe piles
may be unreinforced unless intended as part of a foundation. Probe piles may be used as reaction piles if reinforced.

5.7.9.4 Reaction piles shall be installed around a test pile to furnish reaction load to test jack. Reaction piles are normally tension piles and shall be reinforced the complete length of pile.

5.7.9.5 Reaction piles shall be installed before test piles with close observation of all installation procedures used in normal production.

5.7.9.6 Test piles shall be installed with close observation of all installation procedures used in normal production.

6. Inspection, Testing and Acceptance

6.1 Inspection

6.1.1 QC inspector shall prepare pile installation record required in 5.4.2 above and detailed in data form PIP STS02465-D or PIP STS02465-DM (as applicable) for all piles installed.

6.1.2 During ACIP pile installation, QC inspector shall be alert for any problems which can reduce load carrying capacity of an ACIP pile and note on the pile installation record.

6.1.3 QC inspector shall conduct grout tests described above and note on the pile installation record.

6.1.4 QC inspector shall observe automated instrumentation and monitoring system measuring elements of installation process and obtain a copy of printout. QC inspector shall collect copies of printout and attach to the pile installation record.

6.1.5 QC inspector shall observe that drilling advances at a continuous rate appropriate for soil conditions until required depth or refusal is reached. If refusal is reached before the required depth, purchaser shall be notified immediately. Auger refusal is defined as a rate of auger penetration of less than 1 ft (0.3 m) per minute of drilling with maximum torque and weight applied to auger.

6.1.6 QC inspector shall verify that all items on inspection sheet shown in data form PIP STS02465-D or PIP STS02465-DM (as applicable), or similar form are completed in detail for each ACIP pile.

6.2 Integrity Verification

6.2.1 ACIP pile integrity verification shall be by low strain impact integrity testing in accordance with ASTM D5882, by single or cross-hole logging in accordance with ASTM D6760, by thermal integrity profiling in accordance with ASTM D7949, or a combination of these methods, as specified in contract documents.

6.2.2 Constructor shall grind two or more smooth flat spots on top of each ACIP pile selected for low strain testing as designated by purchaser.

6.2.3 Constructor shall provide and install tubes suitable for single or cross-hole logging as directed by purchaser. Tubes shall be filled with clean water immediately after placement and kept full until after completion of testing. Tube may also be used for pile toe tell-tale access during load test.
6.2.4 Constructor shall provide and install materials required for thermal integrity profiling as specified in contract documents.

6.2.5 All probe, test and reaction piles shall be tested using one of the integrity verification methods listed above, as specified in contract documents. Production piles shall be tested at a frequency specified in contract documents.

6.2.6 Constructor shall provide access and assistance to testing agency technician conducting the integrity testing.

6.3 Load Testing

6.3.1 Test piles shall be installed at locations shown in contract documents. If specified by purchaser, production piles shall be selectively tested as directed.

6.3.2 Pile load tests shall be performed in accordance with ASTM D1143/D1143M (“Compression Test”), ASTM D3689 (“Tension Test”), ASTM D3966/D3966M (“Lateral Load Test”), or ASTM D4945 (“Dynamic Load Test”) as specified by purchaser in contract documents. If multiple tests on the same pile are specified, tests shall be conducted in the following order; Compression, Tension, Dynamic, then Lateral.

6.3.3 All materials and equipment required for performing and monitoring the static or dynamic load test in accordance with appropriate specification shall be provided.

6.3.4 Test and reaction piles shall be installed, and load tests shall be performed, only in the presence of qualified geotechnical representative.

6.3.5 Compression test piles and tension test piles shall be equipped with a telltale or strain gauges approved by geotechnical engineer or as shown in contract documents.

6.3.6 A load cell and jack system designed for use in field conditions shall be provided. Jack and pressure measurement device shall be calibrated together as a system.

6.3.7 Pressure measuring system measuring jack pressure and load cell shall have a minimum range of 300% of specified pile design capacity.

6.3.8 A single jack shall be used to apply required load unless purchaser authorizes use of a pair of jacks.

6.3.9 Operators experienced in pile load testing and laborers to operate equipment throughout duration of test shall be provided.

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

6.3.11 Load testing shall begin after grout has achieved its specified strength as determined by grout cube tests, unless a longer time is specified to allow soil set-up on completed pile.

6.3.12 Compression and tension tests shall be performed in accordance with specified in ASTM D1143/D1143M and ASTM D3689 using the “Quick Load Test Method,” with the following modifications:

a. Test load shall be to the lesser of three times design load or failure
b. Each load increment shall be 10% to 15% of design load

c. Each load increment shall be held for ten minutes

d. Loading shall be continuous without intermediate unload/reload cycle

e. Unloading increments shall be a minimum of four approximately equal steps

6.3.13 Dynamic load testing procedures shall be submitted by constructor to purchaser for review and approval by engineer of record. Engineer of record will determine ratio of dynamic tests to conventional compression or tension tests.

6.4 Rejected Piles

Engineer of record will determine if ACIP piles shall be required to be removed and replaced at constructor’s expense, or other remedy required, in the following circumstances:

6.4.1 Piles judged unacceptable after post-installation integrity testing

6.4.2 Piles judged inadequate after verification load testing

6.4.3 Piles judged out of compliance based on QC inspector’s records and/or automated measuring equipment results

6.4.4 Piles out of specified position tolerance

6.4.5 Piles where grout/concrete strength or volume is inadequate

6.4.6 Piles with a defect in reinforcing or observed physical defect
# Augered Cast-In-Place Pile Installation Record

**U.S. Customary Units**

**Data Sheet**

**Assoc. Pip**

**STS02465**

**STS02465-D**

**Page 1 of 1**

**April 2019**

**Pile No.:**

**Meet Spec.?**

**Project:**

**Date:**

**Area:**

**Contractor:**

**Inspector:**

**Rig:**

**Weather:**

**Operator:**

**DWG Nos. - Pile Location/Pile Detail:**

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<th>Batch Time</th>
<th>Arrival Time</th>
<th>Load (YD³)</th>
<th>Fluidifier Units</th>
<th>Water Added On Site (GAL)</th>
<th>GROUT SAMPLING/TESTING MIX NO.</th>
<th>GROUT CUBE/CYLINDERS</th>
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<th>Re-Grouting Summary</th>
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**Center Steel Placed (Time):**

**Center Steel Description:**

**Center Steel Centralizers:**

**Pipe Or Gauges:**

**Cage Steel Placed (Time):**

**Cage Description:**

**Cage Centralizers:**

**Top Of Steel Elev. (FT):**

**GROUT LOSS (IN)/REFERENCE:**

**GROUT LOSS (IN)/REFERENCE:**

**Volume (FT³/FT):**

**Pump Calibration:**

**Pump Primed?**

**Pump Top Cleaned?**

**Weather Protection?**

**Steel Placement Problem?**

**Pile Top Cleaned?**

**Other Problems?**

**Volume Strokes/5 FT (100%):**

**Volume Strokes/5 FT (130%):**

**No.**

**Date**

**Revision Description**

**By**

**APVD.**
### AUGERED CAST-IN-PLACE PILE INSTALLATION RECORD

**METRIC UNITS**

**ASSOC. PIP**  
STS02465  
DATA SHEET  
STS02465-DM  
AUGERED CAST-IN-PLACE PILE INSTALLATION RECORD  
(AUGERED CAST-IN-PLACE PILE INSTALLATION RECORD)  
(METRIC UNITS)

**PAGE 1 OF 1**  
APRIL 2019

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**PILE DATA**

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<th>AUGER ROTATIONS</th>
<th>PUMP STROKES</th>
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### INITIAL INSTALLATION SUMMARY

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### RE-GROUTING SUMMARY

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**AUGER DIA. (mm):**  
1.5 to 0

**AUGER PITCH: (mm):**  
3 to 1.5

**GROUND ELEV. (m):**  
4.5 to 3

**PILE TOP ELEV. (CUTOFF) (m):**  
6 to 4.5

**DESIGN TIP ELEV. (m):**  
7.5 to 6

**AS-BUILT LENGTH (m):**  
9 to 7.5

**ALIGNMENT:**  
10.5 to 9

**AUGERING (TIME):**  
12 to 10.5

---

**CENTER STEEL DESCRIPTION:**

**CENTER STEEL CENTRALIZERS:**

**PIPE OR GAUGES:**

**CAGE STEEL DESCRIPTION:**

**CAGE CENTRALIZERS:**

**TOP OF STEEL ELEV. (m):**

---

**GROUT LOSS (mm)/REFERENCE:**

**GROUT CUBE/CYLINDERS**

---

**PUMP COUNTER @ START/STOP:**

**AUTOMATED MONITORING:**

**WEATHER PROTECTION:**

**STEEL PLACEMENT PROBLEM:**

**OTHER PROBLEMS:**

---

**VOLUME (m³):**

**PUMP CALIBRATION:**

**MIN. INITIAL STROKES:**

**STROKES/1.5 m (100%):**

---

**NO.**

**DATE**

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**REVISION DESCRIPTION**

**BY**

**APVD.**