



Compliance of PIR-A with DFI guidelines

The Deep Foundations Institute “industry standard” guideline “Augered Cast-In-Place Piles Manual” (©2003) gives consensus procedures for proper ACIP installation. (This and the 1994 Inspector’s manual can be obtained through DFI at www.dfi.com). The PIR-A, an “automated monitoring equipment (AME), provides useful information and documentation of pile installation. Comments on PIR-A application follow “quotes” from Manual sections or the Manual’s “Commentary”. **Highlighted text** is our emphasis. This excerpt summary does not relieve the Inspector from understanding proper installation and thorough visual inspection of other items not addressed by the PIR-A, as suggested by these manuals.

- 1.3 The Commentary states, “The **grout volume placed for each increment of depth is the single most important installation control** used during ACIP pile construction. The Pile Contractor’s grout pump and auger equipment operators and the Inspector need to **continually monitor the incremental grout volume being placed.**” The PIR-A measures incremental grout volume.
- 1.5.1f The Manual states, “If specified on the project, submit a description of the automated monitoring equipment (AME) proposed to measure and record drilling progress during the augering phase, and **incremental volume pumped** during the grouting phase. **(A Commentary on AME is provided in Appendix A.)**” The PIR-A totally fulfills all AME requirements.
- 1.5.2 The Manual specifies, “**Records shall be kept for each pile installed. Such records shall as a minimum, include:** project name and number, Pile Contractor, pile location and design pile capacity, pile diameter, tip elevation, drilling ground surface elevation, total and **incremental volume of grout placed**, amount of water (if any) added to the ready mix grout truck at the job site, pile reinforcing steel, and any unusual occurrences during the pile installation.” The Commentary mentions “auger penetration rates in the bearing stratum” (PIR-A records this information automatically) and states “If AME equipment is utilized, the results should be reviewed immediately after pile completion; problems, if detected, should be resolved immediately.” The PIR-A provides a graphical record of incremental volume during grouting and a printout of incremental volume for full pile immediately upon pile completion. **Inspecting PIR-A results immediately means that the pile can be re-drilled and re-grouted while grout is still fluid, and thus resolution costs are minimized.**
- 2.2.2 The Manual specifies “the grout pump shall be calibrated at the beginning of the work to determine the volume of grout pumped per stroke, and should be periodically recalibrated when deemed necessary by the Inspector during the project.” The normal crude barrel “calibration” is inaccurate due to difficulty of obtaining a volume from an integer number of strokes (small number of strokes accentuates this problem), and lack of confining pressure. Barrel must be under filled and reduced volume accurately determined (cannot measure overflow accurately). **The PIR-A (volume measured by high accuracy magnetic flow meter) makes grout pump “calibration” unnecessary.**
- 2.2.3 The Manual states, “Piles may be specified to be installed and monitored during installation to obtain incremental pumped grout volumes using automated monitoring equipment (AME).” The PIR-A measures incremental pumped grout volume.



- 3.4.1 The Commentary states, "Every pile should be checked for plumbness or proper incline prior to the start of drilling by using a hand level (or angle measuring device utilized as part of an AME system), or other approved means." **Pile Dynamics' Angle Analyzer measures inclination.**
- 3.4.4 The Manual specifies, "advance the auger at a continuous rate that prevents removal of excess soil". The PIR-A displays auger's drilling rate and prints drilling times for each incremental depth.
- 3.4.7 The Manual specifies, "Prior to raising the auger, a minimum theoretical initial grout head of ____ feet (____ m) shall be pumped. Positive rotation of the auger shall be maintained at all times during placement of the grout. The rate of grout injection and auger withdrawal shall be coordinated so as to maintain: the minimum grout head at all times, and the total volume of grout to be at least 115 percent of the theoretical volume for each pile depth increment. After grout is flowing at the ground surface from the auger flighting, the rate of grout injection and auger withdrawal shall be coordinated so that there is at least 100 percent of the theoretical volume for each subsequent depth increment. If grout pumping is interrupted for any reason, or discontinued grout or slurry return at the ground surface is observed, the Pile Contractor shall lower the auger at least 5 feet (1.5 m) below the level where the interruption occurred while continuously pumping grout." The operator should **press PIR-A "grout return indicator" when the Inspector first sees grout return at the surface from auger flights.** The required grout ratio is specified by the Engineer. The Contractor may increase the grout ratio. If the grout return depth is consistently substantially deeper than the initial grout head, the initial grout head or grout ratio required may be reduced if so directed by the Engineer.

The Commentary suggests initial grout heads from 5 to 15 ft. "**Initial Grout head**" is defined as an equivalent height for the nominal diameter of **grout volume** to be pumped prior to beginning auger withdrawal. The Commentary explains that after the initial grout return "**the Contractor should continue pumping grout while removing the auger until the auger tip reaches the surface... [as] this grout ... has the greatest chance of being contaminated with soil and should not be used in the pile..**"

The Commentary states , "The most desirable precautions that are available in the construction of ACIP piles are to: pump the specified initial grout head prior to withdrawal of the auger, maintain grout pumping while installing the required incremental grout volume as the auger is being withdrawn, and observing grout return when the auger's depth below the ground surface is equal to or greater than the specified initial grout head. **The observation of these three conditions are the most useful quality control tools that can be utilized in ACIP pile construction.**" The PIR-A records these three conditions.

- 3.4.8 The Manual specifies that if the incremental grout volume is "less than specified... in any five foot increment" then "the auger shall be lowered 5 ft or to the bottom of the pile if that is less, followed by the controlled auger withdrawal while maintaining grout injection." **Since the PIR-A provides information to the operator during grouting, the operator has the information to correctly install the pile the first time (or if a problem occurs to reauger the pile below the defect depth while the grout is still fluid).** While the manual mentions a "five foot increment", this is due to traditional visual inspection methods, which are less precise. With higher accuracy depth determination, **PDI recommends a 2 ft increment length.**



- 3.4.9 The Commentary says, "The auger may be either withdrawn continuously or in small increments. These discrete lift increments should be limited to at most 12 inches (300 mm)" **The PIR-A has both "continuous" and "discrete lift" increment modes of operation.**
- 3.8 The Manual specifies "The Architect / Engineer will evaluate pile installation data obtained by the Inspector, grout sampling / testing data provided by the Testing Agency, and any supplemental information provided by the Geotechnical Engineer and determine the acceptability of the completed piles. The Architect / Engineer will notify the Pile Contractor if a pile is not in conformance with the specifications." **Pile acceptance is assigned to the Architect/Engineer. The PIR-A printout should normally be part of this acceptance criterion and should therefore be transmitted in a timely manner to the approving authority.** The on-site Inspector's visual information should also be considered.

Appendix A: Commentary on Automated Monitoring Equipment (AME) for ACIP Piles says, " The AME should have the following components:

- Display Unit ... should be mounted in the cab to provide immediate feedback to the crane operator, particularly during the critical grouting phase to verify minimum grout volume per depth increment...
- Depth Sensor... should record pile depth (referenced to ground elevation) to confirm pile length...
- Magnetic Flow Meter (MFM)... to be installed in the grout line near the crane to measure grout volume pumped within accuracy of 2%...
- Field Printer... to record a hard copy of results for each pile. One copy of printed results should be provided to the Inspector or Architect/Engineer immediately following completion of each pile...

"The MFM and Depth Sensor should be sufficient to determine **the volume pumped per unit depth increment** (which is typically displayed graphically as a bar chart to the crane operator). The minimum grout ratio should be clearly displayed as a guide to aid the operator during pile installation." The PIR-A meets all these requirements. **The PIR-A liability is limited solely to documenting the drilling phase and determination of grout volume pumped per depth increment. Any further liability is specifically declined by Pile Dynamics, Inc.**

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