INTERNATIONAL

Designation: D 6067 – 96$^{\epsilon 1}$

Standard Guide for Using the Electronic Cone Penetrometer for Environmental Site Characterization[1]

This standard is issued under the fixed designation D 6067; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε[1] Note—This standard was corrected editorially in January 2000.

1. Scope

1.1 The electronic cone penetrometer test often is used to determine subsurface stratigraphy for geotechnical and environmental site characterization purposes **(1)**.[2] The geotechnical application of the electronic cone penetrometer test is discussed in detail in Test Method D 5778, however, the use of the electronic cone penetrometer test in environmental site characterization applications involves further considerations that are not discussed.

1.2 The purpose of this guide is to discuss aspects of the electronic cone penetrometer test that need to be considered when performing tests for environmental site characterization purposes.

1.3 The electronic cone penetrometer test for environmental site characterization projects often requires steam cleaning the push rods and grouting the hole. There are numerous ways of cleaning and grouting depending on the scope of the project, local regulations, and corporate preferences. It is beyond the scope of this guide to discuss all of these methods in detail. A detailed explanation of grouting procedures is discussed in Guide D 6001.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.5 This guide is applicable only at sites where chemical (organic and inorganic) wastes are a concern and is not intended for use at radioactive or mixed (chemical and radioactive) waste sites.

1.6 The values stated in either SI units or inch-pound units are to be regarded as standard. Within the text, the inch-pound units are shown in brackets. The values stated in each system are not equivalents, therefore, each system must be used independently of the other.

2. Referenced Documents

2.1 *ASTM Standards:*

C 150 Specification for Portland Cement[3]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[4]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[4]

D 3441 Test Method for Deep, Quasi-Static, Cone and Friction-Cone Penetration Tests of Soil[4]

D 5088 Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites[4]

D 5092 Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers[4]

D 5730 Guide to Site Characterization for Environmental Purposes[5]

D 5778 Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils[5]

D 6001 Guide for Direct Push Water Sampling for Geoenvironmental Investigations[5]

3. Terminology

3.1 *Definitions*—The definitions of terms in this guide are in accordance with Terminology D 653. Terms that are not included in Terminology D 653 are described as follows.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *baseline, n*—a set of zero load readings, expressed in terms of apparent resistance, that are used as reference values during performance of testing and calibration.

3.2.2 *bentonite, n*—the common name for drilling fluid additives and well construction products consisting mostly of naturally occurring sodium montmorillonite. Some bentonite products have chemical additives that may affect water quality analyses.

3.2.3 *cone, n*—the conical point of a cone penetrometer on which the end bearing component of penetration resistance is developed.

3.2.4 *cone resistance*, q_c, *n*— the end bearing component of penetration resistance.

[1] This guide is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Ground Water and Vadose Zone Investigations.

Current edition approved Dec. 10, 1996. Published June 1997.

[2] The boldface numbers in parentheses refer to the list of references at the end of this guide.

[3] *Annual Book of ASTM Standards*, Vol 04.01.

[4] *Annual Book of ASTM Standards*, Vol 04.08.

[5] *Annual Book of ASTM Standards*, Vol 04.09.

3.2.5 *cone sounding*, *n*—a series of penetration readings performed at one location over the entire depth when using a cone penetrometer.

3.2.6 *electronic cone penetrometer*, *n*—a friction cone penetrometer that uses force transducers, such as strain gage load cells, built into a nontelescoping penetrometer tip for measuring within the penetrometer tip, the components of penetration resistance.

3.2.7 *electronic piezocone penetrometer*, *n*— an electronic cone penetrometer equipped with a low-volume fluid chamber, porous element, and pressure transducer for determination of pore pressure at the porous element soil interface.

3.2.8 *end bearing resistance*, *n*—same as cone resistance or tip resistance, q_c.

3.2.9 *equilibrium pore water pressure*, u_o, *n*—at rest water pressure at depth of interest. Same as hydrostatic pressure.

3.2.10 *excess pore water pressure*, $u–u_o$, *n*—the difference between pore pressure measured as the penetratoin occurs, u, and estimated equilibrium pore water pressure, u_o. Excess pore pressure can be either positive or negative.

3.2.11 *friction ratio*, R_f, *n*— the ratio of friction sleeve resistance, f, to cone resistance, q_c, measured with the middle of the friction sleeve at the same depth as the cone point. It is usually expressed as a percentage.

3.2.12 *friction reducer*, *n*—a narrow local protuberance on the outside of the push rod surface, placed at a certain distance above the penetrometer tip, which is provided to reduce the total side friction on the push rods and allow for greater penetration depths for a given push capacity.

3.2.13 *friction sleeve resistance*, f_s, *n*—the friction component of penetration resistance developed on a friction sleeve, equal to the shear force applied to the friction sleeve divided by its surface area.

3.2.14 *friction sleeve*, *n*—an isolated cylindrical sleeve section on a penetrometer tip upon which the friction component of penetration resistance develops.

3.2.15 *local friction*, *n*—same as friction sleeve resistance.

3.2.16 *penetrometer*, *n*—an apparatus consisting of a series of cylindrical push rods with a terminal body (end section) called the penetrometer tip and measuring devices for determination of the components of penetration resistance.

3.2.17 *penetrometer tip*, *n*—the terminal body (end section) of the penetrometer which contains the active elements that sense the components of penetration resistance.

3.2.18 *piezocone*, *n*—same as electronic piezocone penetrometer.

3.2.19 *piezocone pore pressure*, u, *n*—fluid pressure measured using the piezocone penetration test.

3.2.20 *push rods*, *n*—the thick walled tubes or rods used to advance the penetrometer tip.

3.2.21 *sleeve friction or resistance*, *n*— same as friction sleeve resistance, f.

3.2.22 *stratigraphy*, *n*—a classification of soil behavior type that categorizes soils of lateral continuity **(4)**.

3.3 *Acronyms:*Acronyms:

3.3.1 *CPT*—Cone Penetration Test.

3.3.2 PPT_u—Piezocone Penetration Test.

3.3.3 *ECP*—Electronic Cone Penetrometer (used when referring to the cone penetrometer).

4. Significance and Use

4.1 Environmental site characterization projects almost always require information regarding subsurface soil stratigraphy. Soil stratigraphy often is determined by various drilling procedures and bore logs. Although drilling is very accurate and useful, the electronic cone penetrometer test may be faster, less expensive, and provide greater resolution, and does not generate contaminated cuttings that may present other disposal problems **(2,3,4,5)**. Investigators may obtain soil samples from adjacent borings for correlation purposes, but prior information or experience in the same area may preclude the need for borings **(1)**.

4.2 The electronic cone penetration test is an in situ investigation method involving:

4.2.1 Pushing an electronically instrumented probe into the ground (see Fig. 1 for a diagram of a typical cone penetrometer). The position of the pore pressure element may vary.

4.2.2 Recording force resistances, such as tip resistance, local friction, and sometimes pore pressure.

4.2.3 Data interpretation.

4.2.4 The most common use of the interpreted data is stratigraphy. Several charts are available. A typical CPT stratigraphic chart is shown in Fig. 2 **(1)**. The first step in determining the extent and motion of contaminants is to determine the subsurface stratigraphy. Since the contaminants will migrate with ground water flowing through the more permeable strata, it is impossible to characterize an environmental site without valid stratigraphy. Cone penetrometer data has been used as a stratigraphic tool for many years. The pore pressure channel of the cone can be used to determine the depth to the water table or to locate perched water zones.

4.2.5 When attempting to retrieve a soil gas or water sample, it is advantageous to know where the bearing zones (permeable zones) are located. Although soil gas and water can be retrieved from on-bearing zones such as clays, the length of time required usually makes it impractical. Soil gas and water samples can be retrieved much faster from bearing zones, such as sands. The cone penetrometer tip and friction data generally can identify and locate the bearing zones and nonbearing zones less than a foot thick. Since the test is run at a constant rate, the pore pressure data can often identify layers less than 20 mm thick.

4.2.6 The electronic cone penetrometer test is used in a variety of soil types. Lightweight equipment with reaction weights of less than 10 tons generally are limited to soils with relatively small grain sizes. Typical depths obtained are 20 to 40 m, but depths to over 70 m with heavier equipment weighing 20 tons or more are not uncommon. Since penetration is a direct result of vertical forces and does not include rotation or drilling, it cannot be utilized in rock or heavily cemented soils. Depth capabilities are a function of many factors including:

4.2.6.1 The force resistance on the tip,

4.2.6.2 The friction along the push rods,

4.2.6.3 The force and reaction weight available,

4.2.6.4 Rod support provided by the soil, and

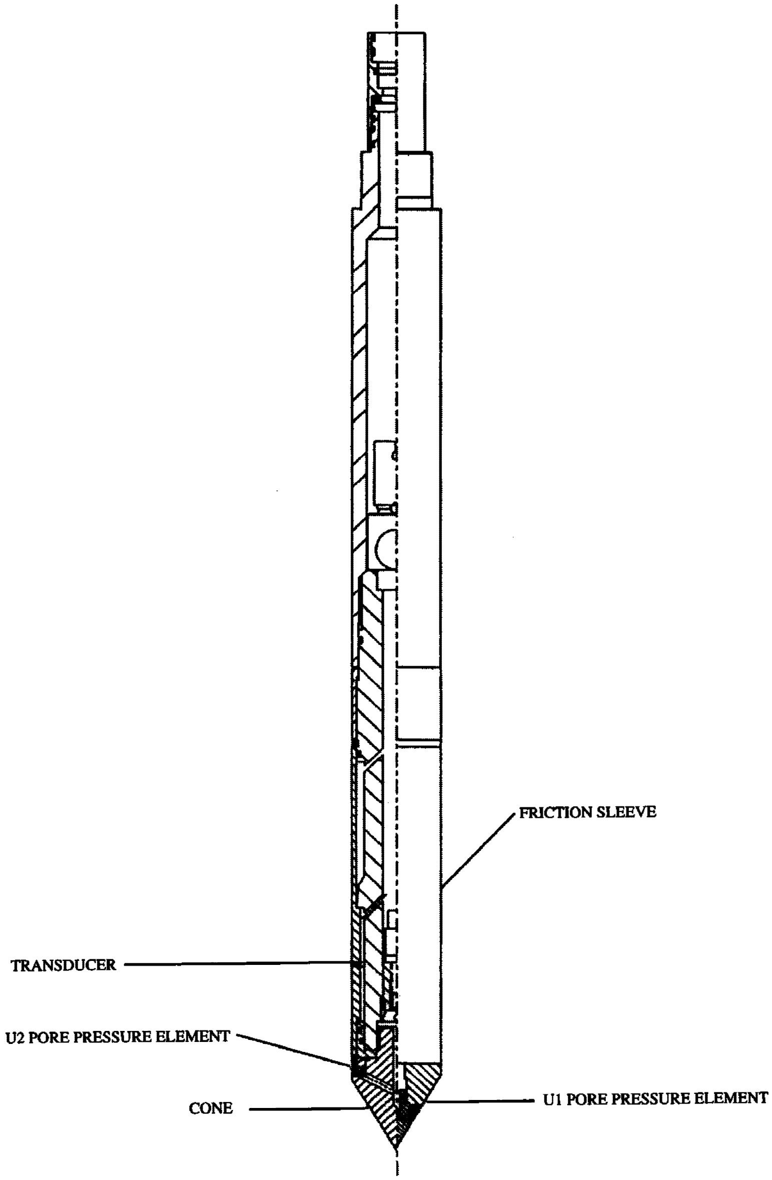


FIG. 1 Electronic Cone Penetrometer

4.2.6.5 Large grained materials causing nonvertical deflection or unacceptable tool wear.

4.2.7 Depth is always site dependent. Local experience is desirable.

4.3 *Pore Pressure Data*:

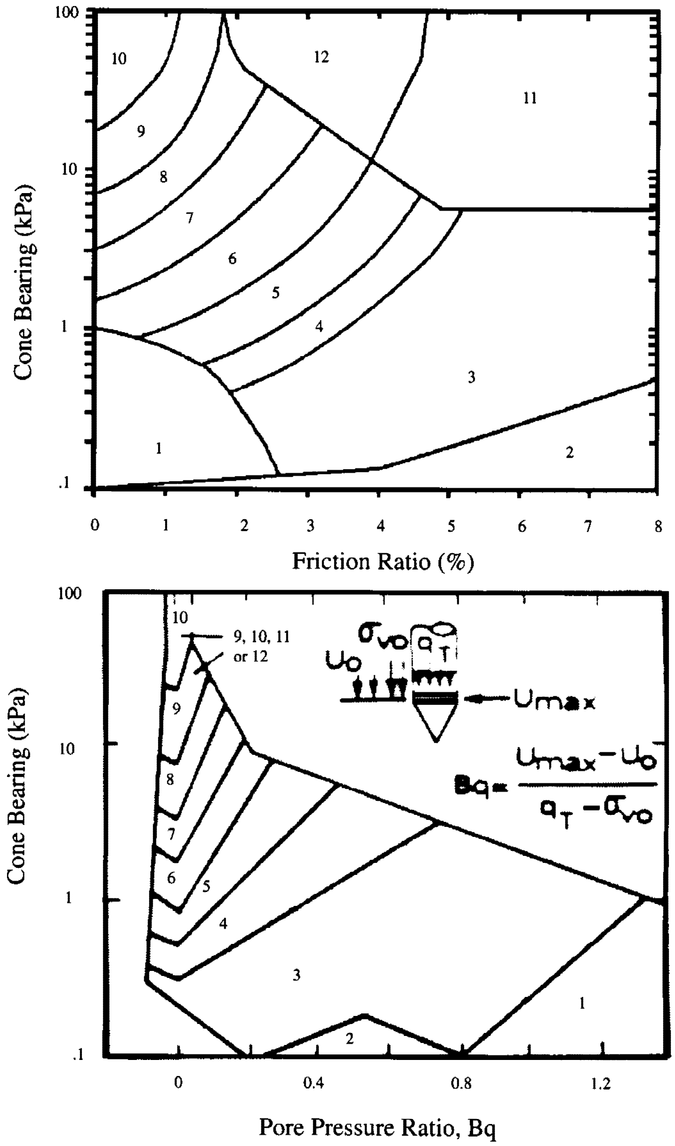
4.3.1 The pore pressure data often is used in environmental site characterization projects to identify thin soil layers that will either be aquifers or aquitards. The pore pressure channel often can detect these thin layers even if they are less than 20 mm thick.

4.3.2 Pore pressure data also is used to provide an indication of relative hydraulic conductivity. Excess pore pressure is generated during an electronic cone penetrometer test. Generally, high excess pore pressure indicates the presence of aquitards, and low excess pore pressure indicates the presence of aquifers. This is not always the case, however. For example, some silty sands and over-consolidated soils generate negative pore pressures if monitored above the shoulder of the cone tip. See Fig. 2. The balance of the data, therefore, also must be evaluated.

4.3.3 In general, since the ground water flows primarily through sands and not clays, modeling the flow through the sands is most critical. The pore pressure data also can be monitored with the sounding halted. This is called a pore pressure dissipation test. A rapidly dissipating pore pressure indicates the presence of an aquifer while a very slow dissipation indicates the presence of an aquitard.

4.3.4 A pore pressure decay in a sand is almost instantaneous. The permeability (hydraulic conductivity), therefore, is very difficult to measure in a sand with a cone penetrometer. As a result, the cone penetrometer is not used very often for measuring the permeability of sands in environmental applications.

4.3.5 A thorough study of ground water flow also includes determining where the water cannot flow. Cone penetrometer pore pressure dissipation tests can be used very effectively to



Zone	Q_c/N	Soil Behavior Type
1)	2	sensitive fine grained
2)	1	organic material
3)	1	clay
4)	1.5	silty clay to clay
5)	2	clayey silt to silty clay
6)	2.5	sandy silt to clayey silt
7)	3	silty sand to sandy silt
8)	4	sand to silty sand
9)	5	sand
10)	6	gravelly sand to sand
11)	1	very stiff fine grained (•)
12)	2	sand to clayey sand (•)

(•) over consolidated or cemented

FIG. 2 Simplified Soil Classification Chart for Standard Electric Friction Cone (Robertson and Campanella 1985)

study the permeability of aquitards.

4.3.6 The pore pressure data also can be used to estimate the depth to the water table or identify perched water zones. This is accomplished by allowing the pressure to equilibrate and then subtract the appropriate head pressure. Due to excess pore pressures being generated, typical pore pressure transducers are configured to measure pressures up to 3.5 MPa [500 psi]. Since transducer accuracy is a function of maximum range, this provides a relative depth to water level accuracy of about ±150 mm. Better accuracy can be achieved if the operator allows sufficient time for the transducer to dissipate the heat generated while penetrating dry soil above the water table. Lower pressure transducers are sometimes used just for the purpose of determining the depth to the water table more accurately. For example, a 175-KPa [25-psi] transducer would provide accuracy that is better than 10 mm. Caution must be used, however, to prevent these transducers from being damaged due to a quick rise in excess pressure.

4.4 For a complete description of a typical geotechnical electronic cone penetrometer test, see Test Method D 5778.

4.5 This guide tests the soil in situ. Soil samples are not obtained. The interpretation of the results from this guide provides estimates of the types of soil penetrated. Investigators may obtain soil samples from adjacent borings for correlation purposes, but prior information or experience in the same area may preclude the need for borings.

4.6 Certain subsurface conditions may prevent cone penetration. Penetration is not possible in hard rock and usually not possible in softer rocks, such as claystones and shales. Coarse particles, such as gravels, cobbles, and boulders may be difficult to penetrate or cause damage to the cone or push rods. Cemented soil zones may be difficult to penetrate depending on the strength and thickness of the layers. If layers are present which prevent direct push from the surface, rotary or percussion drilling methods can be employed to advance a boring through impeding layers to reach testing zones.

5. Apparatus

5.1 Most apparatus required is discussed in Test Method D 5778. When using the electronic cone penetrometer test for environmental site characterization purposes, however, other items often are necessary.

5.2 *Safety Equipment*—Environmental site characterization often involves exposure to potentially hazardous substances. Detection equipment to determine oxygen content and the presence of combustible or toxic materials may be required. Numerous air monitors are available to detect harmful situations, such as the lack of oxygen, excess carbon monoxide or carbon dioxide, the presence of methane, or other combustible gasses. Other devices, such as flame-ionization or photoionization detectors and LELs can be used to monitor vapors form the rods or the hole, or both, to forewarn the operators of potential contamination. Operator protective equipment, such as breathing apparatus and bodily protection, also may be required.

5.3 *Laboratory Equipment*—The electronic cone penetrometer often is used in conjunction with sampling devices and field laboratory equipment (see Guide D 6001). Since many cone penetrometer systems are deployed from enclosed, air conditioned, and heated trucks, these vehicles can also be used as a mobile laboratory. This unique capability provides rapid on-site analysis. First, the cone penetrometer data eliminates most guess work in determining where to retrieve samples. Second, the on-site laboratory analysis can provide important information, such as where to retrieve subsequent samples and avoids many unnecessary samples. On-site laboratory instruments range from simple portable devices, such as photoionization devices, to sophisticated gas chromatographs and mass spectrometers (GC-MS). This approach often is called Expedited Site Characterization.

5.4 *Steam Cleaning Equipment*—When the push rods are withdrawn from the ground, they may be contaminated by toxic, combustible, or corrosive compounds. If this is the case, the push rods will need to be steam cleaned. Many dedicated purpose systems have built in chambers that automatically steam clean the rods while they are being withdrawn from the ground and before they enter the vehicle. A typical diagram of an automatic decon assembly is shown in Fig. 3.

5.4.1 *Steam Cleaner/High-Pressure Washer*— Portable or trailer-mounted for cleaning the rods after grouting, with appropriate hoses for connection to the steam cleaning unit.

5.4.2 *Personal Protective Equipments*, such as boots, gloves, glasses, and so forth.

5.4.3 *Water Trough Cleaning Tub*, for cleaning grout rods and containing grey water.

5.4.4 *Shotgun Bristle Brush*, for cleaning inside of cone or grout rods.

5.5 *Grouting Equipment*—When multiple ground water aquifers have been penetrated, grouting the hole closed after the test is completed may also be required to prevent cross contamination of one aquifer by another. A detailed explanation of grouting procedures is discussed in guide D 6001. The equipment required includes, but may not be limited to the following:

5.5.1 *Expendable Grout Tips for the Grout Rods*—These tips should be conical in shape and have an outside diameter larger than the grout rods. Tip size will be varied to enlarge the hole and to reduce friction on the push rods.

5.5.2 *Suitable Small-Diameter Grout Rods*— These rods may be steel or PVC. The type and size depends on the capability of being pushed back down the same CPT hole.

5.5.3 *Grout Line Connector Assembly*™ his assembly is screwed into the top of the grout rods. A pressure fitting may be required if gravity placement is unacceptable and pressure is required to force grout down the rods. Since this fitting must be attached and unattached many times it may be preferable to have a quick-connect coupling.

5.5.4 *Foot Clamps/Retraction Jack*, for holding and manually extracting rods.

5.5.5 *Hoisting Plug*, for holding rods by overhead rope or cable.

5.5.6 *Grout Mixing Equipment*—Grouting quantities for cone holes are small with only 20 to 60 L [5 to 15 gal] of grout required for filling. In many cases grout mixing in small tubs with mechanical agitation devices are acceptable.

5.5.7 *Cement*, see Specification C 150. Either Type I or Type II cements are acceptable. Cement should be supplied in sacks.

5.5.8 *Bentonite*, powdered high-yield sodium montmorillonite or prehydrated bentonite. The bentonite should not contain any particular additives.

5.5.9 *Potable Water*, for mixing grout. As long as an acceptable supply of drinking water is found, the chemical analysis may not be required.

5.5.10 *Mixing Tubs*, 40 to 60-L [10 to 15-gal] plastic mixing tubs with rope handles (for mixing grout if an automatic mixer is not used).

5.5.11 *Drill-Powered Mixing Paddles*, for mixing grout in tubs by hand. Using a hand-powered drill with a stem equipped with blades for mixing.

5.5.12 *Platform Scale*, for weighing mixture proportions.

5.5.13 *Personal Protective Equipment*, eye protection from splashes of grout.

5.5.14 *Flexible Nylon*, reinforced 13 or 10-mm [½ or ⅜-in.] outside diameter tubing, for feeding grout by gravity into the grout rods.

5.5.15 *Depth-Graduated Tape*, for measuring grout levels in rods.

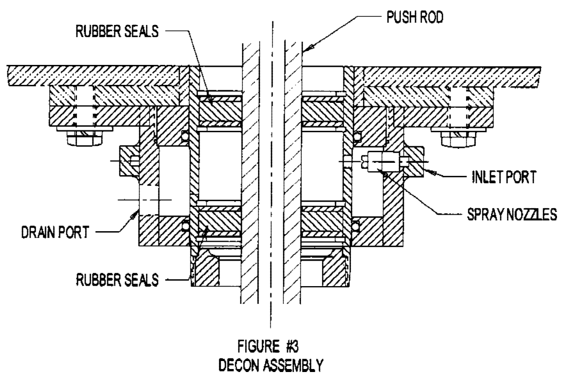


FIG. 3 Decon Assembly

6. Reagents and Materials [6]

6.1 In addition to the substances described in Test Method D 5778, the following may be necessary:

6.2 *Water*—A significant amount of water may be required for decontamination purposes. This water may become contaminated and need to be evaluated and properly disposed.

6.3 *Cleaning Agents*—Cleaning of the push rods and cone penetrometer requires a detergent, such as alconox, or solvent, such as hexane. Some contaminants cannot be removed by standard methods as described in Practice D 5088. The operating personnel must be aware of the anticipated contaminants and fully understand the required cleaning procedures. Recognize that some cleaning agents, particularly solvents such as hexane, also are hazardous substances. Regional protocol and regulations influence the selection of cleaning agents.

6.4 *Grout*—Various types of bentonite and cement often are required to seal the hole at the end of the sounding. Regional regulations and protocol dictate exactly what grout materials will be required. Usually, the bentonite used is powdered and the cement is portland, though sometimes ultrafine cement is used if it is to be pumped through a small tube. See 5.5.

7. Hazards

7.1 Environmental site characterization can present numerous hazards to equipment and personnel. It is the responsibility of everyone involved with the environmental site characterization project to understand fully all potential hazards.

[6] *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

NOTE 1—**Warning:** Hazards to personnel include, but are not limited to, fire; toxicity; heat exhaustion; local vegetation, such as poison ivy; local animals, such as snakes, or simply accidents due to the cumbersome aspects of safety equipment. A complete understanding of the OSHA 40-h safety course and the Health and Safety Plan[7] is required.

NOTE 2—**Caution:** Hazards to equipment include, but are not limited to, fire or chemical attack. Seals for the cone penetrometer must be compatible with the local contaminants.

8. Procedure

8.1 The first step of any environmental site characterization project is to understand fully safety issues, such as the Health and Safety Plan, and having the area cleared and marked for utilities. A proper Health and Safety Plan addresses the aspects that apply specifically to the cone penetration operation and not just to drilling.

8.2 Upon arrival at the site, review the definition of the project to determine if any safety issues have been overlooked. If any unanticipated hazardous situation exists, notify the proper authorities immediately. An exclusion zone around the vehicle must be established to prevent unauthorized entry in the area. Appropriate flagmen, warning signs, cones, and street markings is required if the work is near a street or parking lot.

8.3 Regulations and safety specifications often are generic in nature and are intended to cover a wide variety of environmental site characterization projects. It is possible that one or more of these procedures could be counterproductive or even present an alternative hazard. If this is the case, notify the appropriate authorities immediately.

8.4 All cleaning, grouting, and safety equipment must be in good working order and fully prepared before starting each cone penetration test.

8.5 Perform the electronic cone penetrometer test in accordance with Test Method D 5778. Calibrate the cone penetrometer in accordance with Test Method D 5778, as well. Note any variances to the test due to environmental conditions.

8.6 Monitor the pore pressure dissipation. If monitoring is done, the cone should be saturated fully in accordance with the manufacturer's recommendations. The data acquisition system should begin timing automatically the dissipation the instant the rod motion is stopped.

8.7 During the extraction process, monitor for volatile organic compounds with a PID or FID at the top of rods and in the breathing zone and note readings in the scientific notebook. Take wipe samples as required in the health and safety plans. If any chemical constituent exceeds safe limits, as determined by the health and safety plan, respirators or other appropriate action will be required in the breathing zone. Use double gloves at all times while handling rods.

8.8 During disassembly of rods, if there is any free water within the rod column, these rods must be treated carefully. Check free water with an FID or PID. If this water registers PID readings or appears discolored, remove the end rods in the string from the cone truck or cleaned appropriately.

8.9 Clean the equipment according to predetermined appropriate methods. Inspect the equipment regularly for chemical attack and seal deterioration. First, externally clean and dry the cone. This will help prevent contaminants from intruding during disassembly for a more thorough cleaning. If only limited contamination exists and no cleaning is required, store the penetrometer in plastic or foil, and do not handle the penetrometer without protective gloves. The O-rings in the cone may need to be inspected or changed, or both, after every sounding. Change the O-rings if they appear to be swollen, stuck to the metal surfaces, or spongy. If they appear to be deteriorating rapidly, use a more impervious compound. O-ring deterioration may cause erroneous friction data. A different compound, however, also may alter the data.

8.10 Normally, the dirt seals in the joints around the sleeve jacket contain only a minor amount of soil (less than 1 g) such that there is usually no concern for cross contamination between sounding sites. In cases where cleaning is required, the soil and fluids that the cone was exposed to may be considered contaminated; therefore, take the following measures to clean and decontaminate the cone.

8.11 Contamination will only be present on the cone body and the seals around the piezo element and friction sleeve. Place a protective cap over the electrical connector. Wash the cone with a brush and warm water and nonphosphate detergent, such as Alconox, and rinse with deionized water. Repeat as necessary to remove any visible soil from o-ring and quad-ring areas. O-rings, quad-rings, and piezo elements will be discarded during disassembly.

8.12 After pore pressure soundings, the pore pressure element may require special attention. Whereas, in geotechnical cone penetrometer tests, the elements can be used more than one time. In environmental tests, the elements may need to be replaced and discarded after each test if the material has been chemically degraded.

8.13 Grout the holes closed according to the appropriate predetermined method. A complete discussion of grouting holes resulting from direct push tools is discussed in Guide D 6001. Reentry grouting is the most common method of grouting **(6)**. The grout rod could be a PVC pipe, a plastic tube, or another steel pipe, depending on how well the hole stays open. A grout rod will follow the path of least resistance and often can be pushed to the complete depth of the original CPT hole. This method is simple and usually very effective.

8.14 There are several methods of grouting during rod retraction without reentry. The following discussion is intended to discuss advantages and disadvantages of each method. Not all methods are discussed, but most methods include the following principles.

8.14.1 Grouting through the CPT push rod is possible. The grout can be pumped down the rod and out special ports near or at the cone tip. Pumping the grout inside the rod smears grout on the inside of the rod and on the signal cable. The extra cleaning time often makes this method impractical. The grout also can be pumped down an inner tube inside the rod. This usually requires a thinner grout mix to flow through a thin tube or it requires a larger tube with a larger diameter push rod requiring additional force to push.

[7] Follow NIOSH/OSHA Pocket Guide to Chemical Hazards, NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards, and NIOSH/OSHA Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities available from U.S. Dept. of Health and Human Services, Centers for Disease Control, U.S. Government Printing Office.

8.14.2 It is possible to grout during rod retraction by pushing an expendable ring under the friction reducer. The cone penetrometer would be pushed through a reservoir of grout, dragging the grout down the annular area of the expendable ring. The expendable ring drops off the end when the rods are retracted allowing the grout to fill the hole from the bottom up. The ring increases the hole size, however, requiring additional push force. The outside of the push rods will need to be cleaned of the grout, but this may take less time than cleaning the inside of reentry rods.

8.14.3 It is possible to grout during rod retraction by pushing a casing over the push rod, withdrawing the push rod, and then routing through the open casing. This, too, requires a larger hole, but is often used in soft soils where the outer casing also can provide lateral rod support for the CPT rod.

8.14.4 In some cases, it is possible to simply grout the hole by pouring grout into the open hole. This is normally only permitted if the hole does not extend into the water table.

9. Report

9.1 Where possible, the data and calibration reports should conform to the guides and information described in Test Method D 5778.

9.2 Include information that may alter the cone penetrometer data.

9.2.1 Chemical attack of seals may cause failure and leaks or high friction if the seals become sticky. If alternate seals are used to prevent this from happening, document this information since different seal types have different friction characteristics that may affect the data.

9.2.2 The data obtained by the electronic cone penetrometer test is assumed to pertain to normal soils. This may not be the case, necessarily, in environmental site characterization projects. Report the presence of known tar, waste, debris, landfill deposits, and so forth, that are not normally deposited soils. For example, oily and greasy soils have less local friction, and landfills may have voids and numerous items that are not soils. Voids will be indicated by zero tip and friction values and should be identified as such so the engineer does not think the data indicates depth counter problems. Some landfill items can be identified by sound. The breaking of metal objects or timbers, or both, produces distinct noises that can be identified and noted in the report.

9.3 The cone penetrometer process is a valuable method for deploying alternative sensors. An in-depth discussion of alternative sensors is beyond the scope of this guide. Report the type of sensor and data from the sensor. Report the location and physical shape of the sensor since this may affect the cone penetrometer data. Include a complete description of the sensor technology, equipment, and procedures.

9.4 As indicated in 8.8, include the grouting procedure and anomalies.

10. Keywords

10.1 cone penetrometer; cone penetrometer test; direct push; explorations; ground water; penetration tests; piezocone; soil investigations; soundings; water sampling; well point

REFERENCES

(**1**) Manchon, R. G., “Introduction to Cone Penetrometer Testing and Ground Water Samplers,” Workshop presented at the Fifth National Outdoor Action Conference on Aquifer Restoration, Ground Water Monitoring and Geophysical Methods, IT Corp., Martinez, CA, May 1991.

(**2**) Auxt, J. A., and Wright, D. E., “Environmental Site Characterization in the United States Using the Cone Penetrometer,” *Proceedings of CPT ’95—International Symposium on Cone Penetration Testing*, Vol 2, 1995, pp. 387–392.

(**3**) Lutennegger, A. J., and DeGroot, D. J., “Techniques for Sealing Cone Penetrometer Holes,” *Canadian Geotechnical Journal*, Vol 32, No. 5, pp. 880–891.

(**4**) Smolley, M., and Kappemyer, J., “Cone Penetrometer Tests and Hydropunch Sampling—An Alternative to Monitoring Wells for Plume Detection,” *Proceedings of the Hazmacon 1989 Conference*, April 18–20, 1989, Santa Clara, CA, pp. 71–80.

(**5**) Strutynsky, A., and Bergen, C., “Use of Piezometric Cone Penetration Testing and Penetrometer Ground Water Sampling for Volatile Organic Contaminant Plume Detection,” *Proceedings of the National Water Well Association Petroleum Hydrocarbons Conference*, Oct. 31–Nov. 2, 1990, Houston, TX, pp. 71–84.

(**6**) Berzins, N. A.,“ Use of the Cone Penetration Test and BAT Ground Water Monitoring System to Assess Deficiencies in Monitoring Well Data,” *Proceedings of the National Ground Water Association Outdoor Action Conference* , 1992, pp. 327–341.