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FIELD PROCEDURES MANUAL
SUBSURFACE INVESTIGATION
METRO RAIL MOS-2
LPE-STUDY

Prepared by:

THE EARTH TECHNOLOGY CORPORATION
3777 Long Beach Boulevard
Long Beach, CA 90807

SEPTEMBER 1988

22444623

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1.0 PROJECT INTRODUCTION

This study is a preliminary geotechnical investigation for the OS-A portion of the Metro Rail. The alignment under study runs north from Vermont/Wilshire along Vermont Avenue, west along Hollywood Boulevard to Highland Avenue, northwest through the Santa Monica Mountains (approximately parallel to the Hollywood Freeway) to Lankershim at Universal City Studio. The general area map is shown in Figure 1.

2.0 PUBLIC RELATIONS

Questions from the public or reporters should be responded to with the following statement:

> The Earth Technology Corporation is performing a subsurface investigation for the Metro Rail Project.
>
> Further questions can be addressed by Mr. Nadeem Tahir of RTD at (213) 972-6439.

We have been directed to answer no other questions regarding this project.

3.0 PROJECT ORGANIZATION AND CONTACT

The overall project organization is presented in Figure 2. Contacts and telephone numbers of key companies and individuals are as follows:

<u>Metro Rail Transit Consultants (MRTC) - Client</u>

- o Dr. James Monsees: Project Manager (213) 612-7050 (office)
- o Mr. Bomi Ghadiali: Project Manager, Field Contact (213) 612-2849 (office)

<u>Earth Technology Corporation - Geotechnical Consultant</u> (213) 595-6611 (office)

- o Dr. G. Ramanjaneya: Principle-In-Charge (714) 842-0353 (home)
- o Dr. Bill Lu: Project Manager (714) 964-0978 (home)

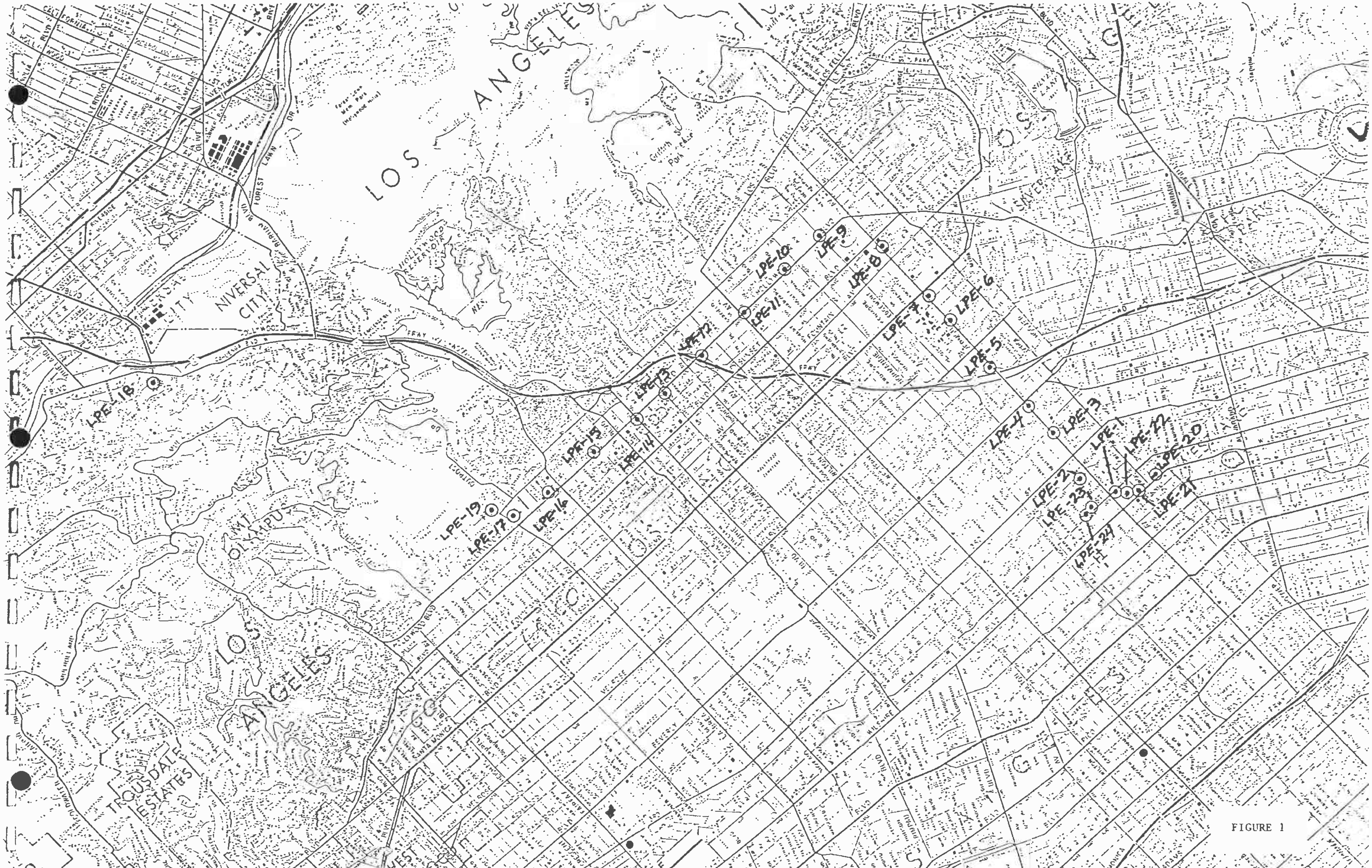
LOS ANGELES
UNIVERSAL CITY
MT OLYMPUS
TROUSDALE ESTATES
LOS ANGELES
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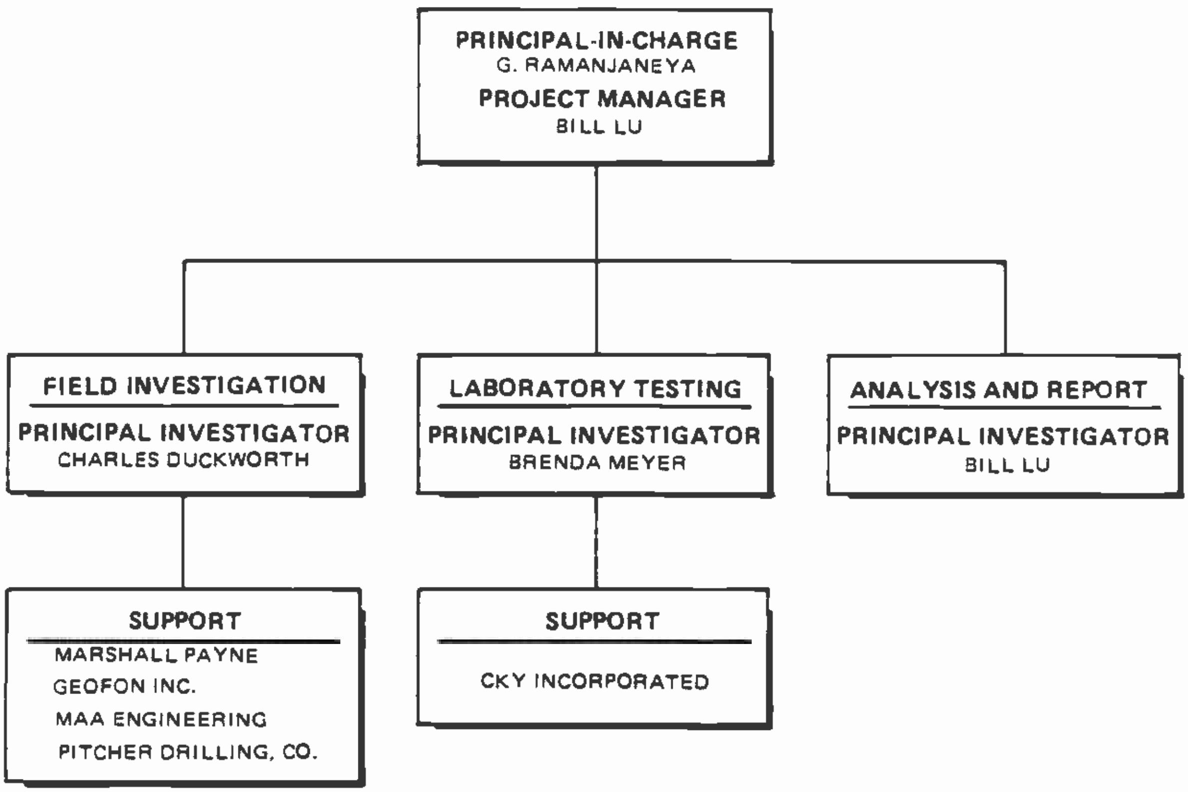
FIGURE 1



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ORGANIZATION CHART

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FIGURE 2

o Mr. Charles Duckworth:	Principle Investigator (Field)	(213) 597-3222 (home)

Geofon, Inc. - Subcontractor

o Mr. Alex Khan:	President	(213) 926-7582 (office)
o Mr. Dan Bush:	Geologist (Boring Logger, Team No. 2 - Primary)	

MAA Engineering Consultants Inc. - Subcontractor

o Mr. Fred Chen: - Registered Geotechnical Engineer G.E. #209	President (Boring Logger, Team No. 1 - Alternate)	(213) 680-4000 (office)

Pitcher Drilling Company - Subcontractor

o Mr. Richard Lake:	President	(415) 328-8910 (office)

Mr. Marshall Payne - Subcontractor, Field Team Leader - Certified Engineering Geologist C.E.G. #367	(Boring Logger Team No. 1 - Primary)	(714) 661-6999
CKY Incorporated - Subcontractor, Environmental Testing		(213) 371-0048

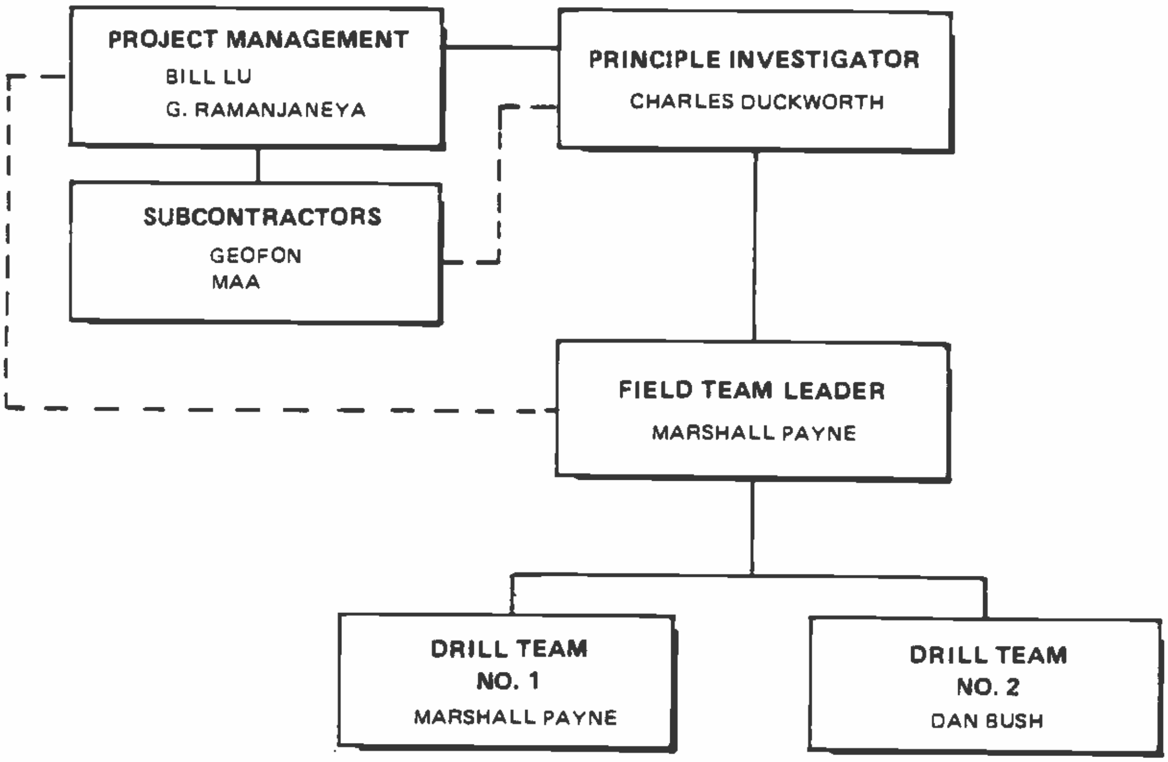
4.0 LINES OF COMMUNICATION

Communication lines for directives and decisions regarding the field investigation work are shown in Figure 3. Communications should occur along indicated "first line" contacts. The "second line" contacts should only be used if the first line is not possible or in emergency cases.

5.0 FIELD INVESTIGATION

The field investigation work consists of drilling rotary-wash borings at predetermined locations along the planned alignment. Borings will be performed primarily within existing street right-of-ways. Prior to work start supplemental documents of drilling permits and boring location maps will be given to

FIELD INVESTIGATION LINES OF COMMUNICATION



EXPLANATION

—— FIRST LINE COMMUNICATION

– – – SECOND LINE COMMUNICATION

The Earth Technology Corporation	PROJECT NO.: 88-429 METRO RAIL-LPE
LINES OF COMMUNICATION	
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each drill team. Piezometers should be at designated borings as shown on the boring location maps.

5.1 PERMITS AND UTILITIES CLEARANCES

Permits from appropriate agencies and land owners will be obtained prior to drilling. Copies of all permits will be given to each drill crew. No boring is to be drilled unless a copy of the permit for that boring is at the drill site. Underground Services Alert (USA) will be notified prior to drilling to coordinate with utility companies for checking that boring locations are clear of utility lines. No boring is to be drilled unless a written confirmation of utility clearance from the principle investigator is at the drill site.

5.2 FIELD EQUIPMENT

The field equipment to be used on the project will consist of the following:

Drill Rig and Support Equipment

- Rotary Wash Rig: Failing 1500
- Mud pump and grouting capability
- Tri-cone auger bit (nominal 6" diameter)
- Water supply truck
- Bentonite drill fluid additive

Sampling Equipment

- Pitcher barrel sampler
- Drive sampler (California type)
- Standard split spoon
- NX rock core barrel
- Rock core boxes
- Foam lined soil sample transport boxes

Monitoring Equipment

- Organic Vapor Analyzer (OVA)

Piezometer Equipment

- PVC casing (threaded, flush), threaded plugs
- Well screen
- Metal locking well cap
- Christie or Pimico box

5.3 GENERAL DRILLING OPERATIONS

- o Arrive at drill site
- o Check location on map, boring no. and permit
- o Establish safety zone around drill site (barricades, delineators, "men-working" signs) as described in Section 5.4
- o If concrete pavement is present, core concrete pavement
- o Advance boring using rotary drilling and install surface casing, if needed
- o Take samples at 5-foot intervals and at significant stratum changes using alternate SPT and California drive sampler or pitcher samplers and in general accordance with the procedures described in Section 5.5.
- o If sound bedrock* is encountered before the planned penetration depth, perform Nx-size rock coring to 10 feet in general accordance with the procedures performed in ASTM D-2113. Terminate the boring after rock coring unless otherwise directed by the principle investigator or Field Team Leader.
- o Refer to appendices A and B for borehole logging procedure.
- o Install peizometers at designated boring locations in accordance with the procedures described in Section 5.6
- o Implement borehole closure procedures in accordance with those specified in Section 5.7

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* For this project bedrock is defined to include sedimentary and volcanic rock of the Topanga Formation

5.4 TRAFFIC CONTROL

Proper traffic control techniques will be needed to minimize risk of traffic accidents and provide adequate safety for the drill crews. Guidelines specified in the Work Area Traffic Control Handbook will be utilized.

Each crew will be equipped with the following traffic control devices:

- o Signs (free standing)
  - Road Work Ahead (C-18, two each)
  - Men at Work (Picturial C-22B)
  - Right Lane Closed (C-20)
- o Delineators (15 each)

Placement of the devices will be as shown in Figure 4.

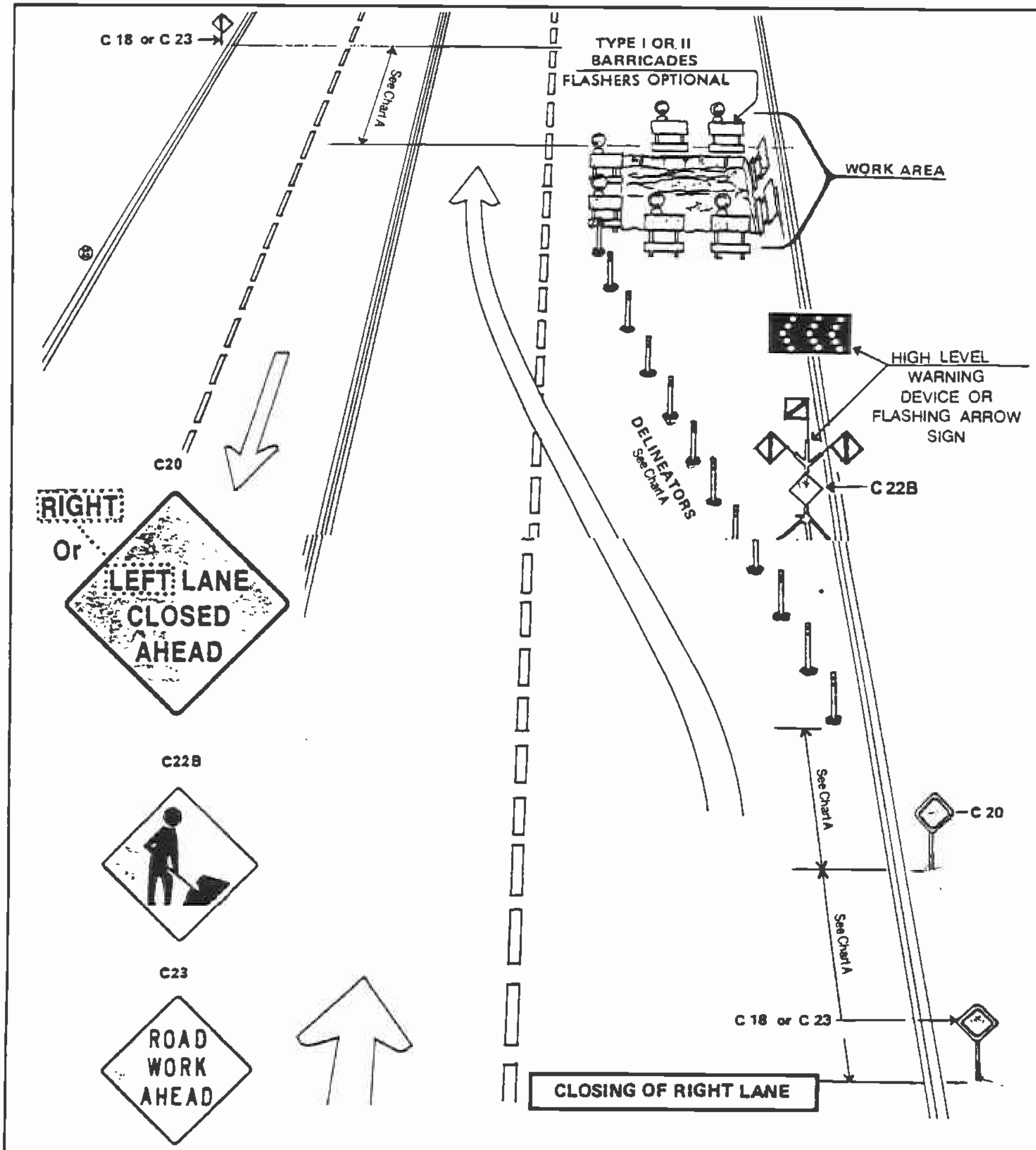
The posting of "No Parking" signs will be coordinated through the Department of Transportation. If automobiles are parked in the posted drill work area, call the principle investigator immediately.

5.5 SAMPLING PROCEDURES

5.5.1 SPT

The equipment and requirements for the SPT will be in general accordance with those specified in the ASTM D1586. (Appendix C). Sampling and testing procedures are as follows:

- o After the boring has been advanced to the desirable sampling depth, clean the bottom of the borehole by removing excessive cuttings
- o Perform a sounding of the borehole using a weighted measuring tape and record the depth on the boring log.
- o Attach the split-spoon sampler to the drill rod and lower it into the borehole
- o Drive the sampler with blows from 140-lb hamper and 30-inch drop height
- o Count and record the number of blows applied in each 6-inch increment until one of the following occurs:



— CHART A —

MINIMUM RECOMMENDED DELINEATOR AND SIGN PLACEMENT

TRAFFIC SPEED	TAPER LENGTH (Each Lane)	DELINEATOR SPACING (Transitions)	DELINEATOR SPACING (Tangent)	SIGN SPACING (Advance of Taper & Between Signs)
25 MPH	150 Ft.	25 Ft.	50 Ft.	150 Ft.
30 MPH	200 Ft.	30 Ft.	60 Ft.	200 Ft.
35 MPH	250 Ft.	35 Ft.	70 Ft.	250 Ft.
40 MPH	350 Ft.	40 Ft.	80 Ft.	350 Ft.
45 MPH	550 Ft.	45 Ft.	90 Ft.	550 Ft.
50 MPH	600 Ft.	50 Ft.	100 Ft.	600 Ft.
55 MPH	700 Ft.	50 Ft.	100 Ft.	700 Ft.

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TRAFIC CONTROL DIAGRAM

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FIGURE 4

- A total of 100 blows has been applied

- There is no observed advance of the sampler during 10 successive blows

- The sample has been advanced 18 inches

o Bring the sampler to surface and record recovered sample length and soil description in accordance with Appendix A

o Take and record the OVA reading of a portion of the sample

o Place representative portions of the sample into a sealable container (or jar)

o Seal and properly label the container for shipment to the laboratory

5.5.2 SAMPLING USING DRIVE SAMPLER

Sampling procedures using drive samplers and thin wall tubes shall be in general accordance with the ASTM D3550 procedure (Appendix C). Sampling procedures are as follows:

o After the boring has been advanced to the desirable sampling depth, clean the bottom of the borehole by removing excessive cuttings

o Perform a sounding of the borehole using a weighted measuring tape and record the depth on the boring log.

o Attach the sampling assembly to the drill rod and lower it into the borehole

o Drive the sampler into bottom of the borehole using a downhole hammer with successive blows until one of the following occurs

- A total of 100 blows has been applied

- There is no observed advance of the sampler during 10 successive blows

- The sampler has been advanced 12 inches or more

o Record blows, hammer weight, drop height, and advance

o Bring the sample to surface, remove the sample and record sample recovery

o Examine the portion of sample in the shoe and/or both ends of the ring sample and record soil description in accordance with Appendix A description

- Take OVA reading of a portion of the sample in the shoe or at the ends of ring sample.

- Place the ring sample into a sealable container

- Seal and properly label the containr for shipment to the laboratory

5.5.3 THIN-WALLED TUBE

The principal investigator or field team leader can decide to take thin-walled tube (Pitcher) sample instead of drive samples. The procedures of taking thin-walled tube samples are similar to the ASTM D1587 procedures (Appendix C) and are described as follows:

- After the boring has been advanced to the desirable sampling depth, clean the bottom of the borehole by removing excessive cuttings

- Perform a sounding of the borehole using a weighted measuring tape and record the depth on the boring log.

- Attach the sampling assembly to the drill rod and lower it into the borehole

- Push the thin-walled tube into soil while the outer core bit reams the hole until 18-inch penetration is obtained or no further advance is feasible

- Slowly extract the sampler, remove the sampling tube, and measure the length of the sample in the tube.

- Remove the disturbed material in the upper end of the tube measure the length again, and seal and cap the upper end of the tube.

- Remove at least one-inch of material from the lower end of the tube and use it for soil description and OVA reading.

- Measure and record overall sample length and seal the lower end of the tube for shipment to the laboratory.

5.6 PIEZOMETER INSTALLATION

Piezometers or ground water monitor wells (GWMW) will be installed in pre-selected borings. GWMW locations along with information on casing depth, screen depth and length will be provided to the drill crews by the principle investigator or the field team leader. The GWMW will be used to obtain data on groundwater levels and to collect water quality samples.

The GWMW equipment will consist of the following:

- o PVC flush threaded casing with rubber O-rings (2-inch diameter)
- o PVC well screen (0.01-inch slots)
- o Sand filter pack (No. 2)
- o PVC threaded plug
- o Aluminum collar and locking well cap
- o Water-tight "pimico" or "christy" box (traffic rated)
- o Bentonite pellets.

Two installation methods are specified. Either methods are acceptable. The principal investigator and/or the field team leader will have the authority to select one of these two methods for GWMW installation.

The first method is to install the GWMW in a specific borehole which has been completely sampled and logged. The procedures are as follows:

- o Thin the drill mud as much as possible

- o Pump from the bottom of the borehole cement and bentonite grout to about 24 feet below the estimated groundwater level (observed from the sampling operation)

- o Place a 2-foot thick bentonite seal by gravity-pouring bentonite pellets

- o Place a 2-foot thick layer of filter sand (No. 2) on top of the bentonite seal

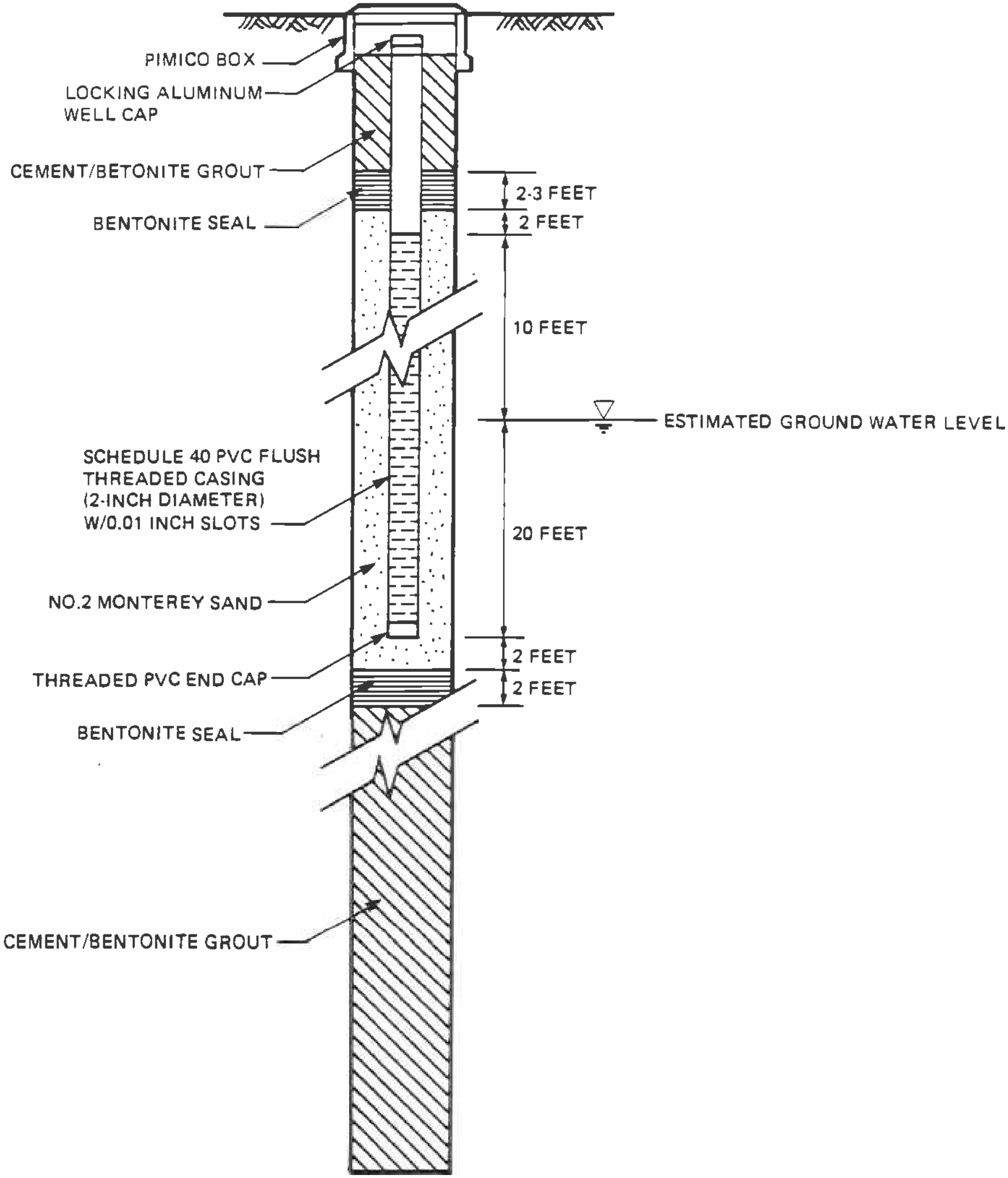
- o Lower PVC casing and screen assembly (shown in Figure 5) to the top of the top of the filter sand layer

- o Place filter sand by gravity to about 2 to 3 feet above the top of the well screen (Figure 5)

- o Place a 2- to 3-foot thick bentonite seal on top of the sand filter by pouring bentonite pellets by gravity

- o Pump cement-bentonite grout from top of the bentonite seal to about 18 inch below the ground surface

- o Install "christy" or "pimico" box (traffic rated) which should be set approximately ½ to 1 inch above grade to prevent surface water ponding.



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PIEZOMETER INSTALLATION SCHEMATIC

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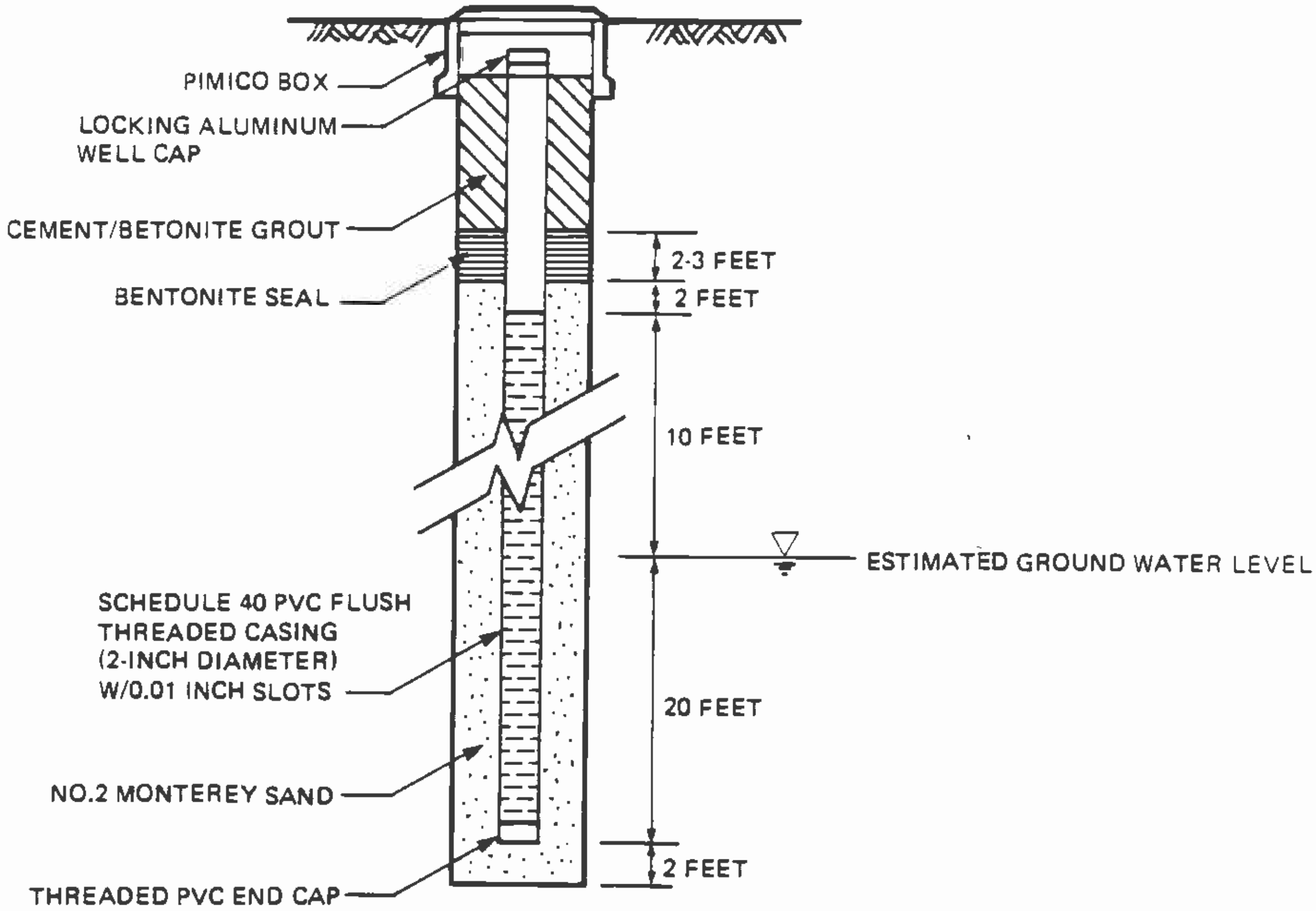
FIGURE 5



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METRO RAIL-LPE

PIEZOMETER INSTALLATION
SCHEMATIC

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FIGURE 6

The second method involves drilling of an adjacent borehole to the depth as shown in Figure 6. Except for the bottom cement/bentonite grout and bentonite seal layer, the GWMW installation procedures are similar to the first method and will not be repeated herein.

5.7 BOREHOLE CLOSURE

At the completion of each non-piezometer boring the borehole will be grouted with a grout mixture of cement and bentonite. The grout is to be pumped from the bottom of the borehole to displace the borehole drill fluid into the mud tank. The end of the grout discharge hose should always remain in the column of grout as it is pumped; grout should not be allowed to flow into the drill fluid. No drilling fluid, grout or water should be discharged onto city streets or private property.

Excess fluids should be pumped into 55-gallon drums. The drums will be taken to storage yard where the drill fluid will be pumped from the drums into a Baker™ Tank.

The grout should be pumped to within 18 inches of the ground surface. In pavement areas the upper 18 inches will be backfilled with asphalt patch or Portland Cement concrete, depending on the type of the existing street pavement surface.

5.8 BORING STOPPED BEFORE REACHING PLANNED DEPTH

There are two potential situations that the boring may be stopped before reaching the planned depth of penetraiton. These are

1. Situation 1: OVA reading (sample minus background OVA readings) exceeds 10 PPM.

2. Situation 2: Obstruction or other cause to prevents the advancement of boring.

In Situation 1, drilling should be immediately stopped and the hole grouted in accordance with the procedures described in Section 5.7. The field team leader should immediately notify the Principal Investigator when such a situation occurs. The drill rig should then be moved to the next planned boring location to continue the field work.

In Situation 2, the borehole should be grouted and the rig move a few feet to drill a supplementary boring. The supplementary boring should be drilled (without sampling) to the termination elevation of the original borehole and then resume drilling and sampling schedule to the planned final penetration depth. If the supplementary boring fails to reach required depth due to obstruction. The supplementary borehole should be grouted and the field team leader should immediately inform the Principal Investigator.

5.9 STANDBY

Delays due to increment weather or other reasonable causes (such as severe obstruction from people, traffic accident, etc.) or order from MRTC will be considered as standby.

Any standby delays other than those ordered by MRTC should be determined and issued by the Principal Investigator who is also responsible to contact and inform MRTC of such standby delays. The Principal Investigator should decide the next step of action after consultation with MRTC.

APPENDIX A

SOIL LOGGING

A.1 GENERAL

- Boring log must indicate the following information

  - Boring number
  - Project name
  - Project number
  - Location
  - Drilling company and driller's name
  - Name of logger and date
  - Method of drilling and sampling
  - Drill bit type and size
  - Driving weight and average drop

- The following information should be recorded for all soils and samples on the boring log:

  - USCS name and symbol, color, moisture content, degree of cementation
  - Estimated gradation (gravel, sand, fines)
  - Range of particle size and shape for coarse-grained soils
  - Soil consistency
  - Depth at which change in soil type occurs
  - Estimated groundwater level

- Drive, thin-walled tube (Shelby or Pitcher) or Split Spoon samples should be obtained at designated depths as well as at depths of change in soil type. Thin-walled tube samples should be attempted only when moist to saturated soft fine-grained soils are encountered. In general, designated depths are as follows: Typically samples will be taken at 5-foot depth intervals. Drive and Split Spoon samples will alternate ever 5-foot interval.

- The number of blows to drive the drive sampler 12 inches should be recorded. The drive sampler should be driven 12 inches using a down-hole hammer.

- SPT below counts per Section 5.4.1 in the main text.

- Thin-walled tubes should be slowly pushed into the soil then slowly extracted from the boring. Note the drill rig hydraulic pressure gage reading during the sampling push; record the pressure on the boring log.

- Frequent notes should be made regarding rate of advance of drill bit, chattering of the rig, blockage, loss of fluid circulation, etc.

A.2 PROCEDURE FOR COMPLETING BORING LOGS

The procedure for completing the field boring log form is described below. A completed boring log is shown in Table A-1.

Form Heading - Enter the boring number ; project name, date(s), project number; name of drilling company; drill size and method of drilling; driving weight; average drop and time of setup, start, and stop.

Bulk - Fill in the column indicating the depth interval at which bulk sample is obtained.

Core - Fill in the column indicating the depth interval at which drive or Split Spoon sample is obtained.

Sample No. - Enter the sample number to the left of the depth scale. Use the following designations: B-1 for bulk sample, D-1 for drive sample, S-1 for Split Spoon sampler, and P-1 for Pitcher tube.

Tip Depth - Enter the tip depth, in feet, to which the drive sample is driven.

Recovery - Enter the length (in inches) of the sample recovered in the sampler.

Blow Count - Enter the number of blow counts to drive the drive or split Sppon sampler 12 inches.

Moisture - Enter the moisture condition of the soil using the following description:

Dry: No apparent moisture

Damp: Slight moisture content (well below optimum)

Moist: Near optimum moisture content

Wet: Over optimum moisture content

Consistency - Enter the approximate consistency of coarse-grained soils and fine-grained soils using the following description and abbreviations:

Fine-Grained Soils	Characteristic
VS : very soft	Easily penetrated to a few inches by fist
S : soft	Easily penetrated a few inches by thumb
MS : medium stiff	Penetrated a few inches by thumb with effort

ST :	stiff	Readily indented by thumb, but penetrated only with great effort
VST:	very stiff	Readily indented by thumb-nail
H :	hard	Indented with difficulty

Coarse-Grained Soils

VL :	very loose	Will not hold vertical cut
L :	loose	Will hold vertical cut but caves if disturbed
MD :	medium dense	Holds vertical cut, even when disturbed, easily penetrated
D :	dense	Holds vertical cut, difficult to penetrate
VD :	very dense	Impossible to penetrate or excavate

Color - Enter the color of the soil in moist condition using the following abbreviations:

Black:	Blk.	Brown:	Brn.	Blue:	Bl.	Green:	Grn.
Gray:	Gry.	Red:	Rd.	Orange:	Or.	Pink:	Pnk.
Tan:	Tn.	White:	Wh.	Yellow:	Yel.	Light:	LT.
Dark:	DK.						

Note: For multiple and mottled colors use / (slash) such as LT.Br./Grn.

USCS Symbol - Enter the USCS Soils Classification symbol (see Table A-2).

Percent - Enter the visual percentage estimate of gravel, sand and fine.

OVA Reading - Enter the OVA reading in parts per million (ppm). Also indicate location of reading: "H" for Headspace and "B" for top of Borehole.

Description - Enter the predominant soil type (write out fully) such as "Silty Sand" or "Sandy Clay". Also enter other visual descriptions such as:

- o plasticity of fine-grain soils (non-plastic or NP, low, medium, high)
- o grain size of coarse-grain soils (fine, medium, coarse)
- o cementation based on reaction with 10% HCI solution (none, weak, moderate, strong)

The Earth Technology Corporation

SHEET ____ OF ____

FIELD LOG OF BORING NUMBER ____

PROJECT NAME METRO RAIL-LPE

PROJECT NUMBER 88-429-03

DRILLING COMPANY ____

DRILL SIZE: METHOD ____

DRIVING WEIGHT ____ AVERAGE DROP ____

DATE(S) ____ ELEVATION ____

DATUM ____

LOGGED BY ____

WATER LEVEL ____ AFTER ____ HOURS ____

TIME ____ SETUP ____ START ____ STOP ____

SAMPLES

FT.	Bulk	Core	Tip Depth	Recovery	Blowcount	Moisture	Consistency	Color	USCS Symbol	Percent Gr	Percent Sa	Percent Fines	OVA Reading	DESCRIPTION

NOTES ____

Prep By ____ Date ____ Ckd By ____ Date ____ Corr By ____ Date ____ ReChk By ____ Date ____ Appr ____ Date ____

APPENDIX B

ROCK CORE LOGGING

LIST OF EFFECTIVE PAGES

Page No.	Effective Date
1 thru 21	9/1/86
(Appendix) A-1 thru A-3	9/1/86
	9/1/86

Form No.	Effective Date
F-3-1-1A	9/1/86
F-3-1-1B	9/1/86

APPROVED BY:

G. Ramanjaneya 9/9/86

G. RAMANJANEYA DATE
DIRECTOR OF TECHNICAL RESOURCES

Alain Sharp 9/9/86

ALAIN SHARP DATE
QUALITY ASSURANCE MANAGER

Bruce A. Schell 9-10-86

BRUCE SCHELL DATE
PEER REVIEW COMMITTEE CHAIRMAN

CORE LOGGING
PROCEDURE F-3-1

1.0 Purpose

This procedure provides guidelines for lithologic and geotechnical descriptions of rock cores.

2.0 Scope

This procedure establishes generalized requirements for the logging of rock cores. It does not provide guidelines for logging of soils or unconsolidated sediments. The items covered in this procedure are:

2.1 Planning (6.1)
2.2 Procedures (6.2)
2.3 Check and Approval (6.3)

3.0 Definitions

3.1 Rock quality designation (RQD): a core-recovery parameter in which the lengths of all the pieces of intact core greater than twice the diameter are summed and then divided by the total length drilled. RQD is generally expressed as a percentage.

3.2 Technical Representative (Tech. Rep.): The Earth Technology Corporation geologist, engineer or technician assigned to log the core.

3.3 Total core recovery: the summed length of all pieces of recovered core from a cored interval divided by the length drilled and expressed as a percentage.

4.0 References

4.1 Shuri, Frank S., Michael L. Feves, Gary L. Peterson, Kevin M. Foster and Clive F. Kienle, Jr., 1981. Field and In Situ Rock Mechanics Testing Manual, Foundation Sciences, Inc., ONWI-310.

4.2 Brown, E.T. (ed), 1981. "Rock Characterization Testing and Monitoring - ISRM Suggested Methods," Commission on Testing Methods, International Society for Rock Mechanics, pp. 42-52.

4.3 ASCE Task Committee for Foundation Design Manual, 1972. Surface Investigation for Design and Construction of Foundations of Buildings: Part II, Proc. Am. Soc. Civ. Eng., J. Soil Mech. Fnds. Div., SM6.

4.4 Core Logging Committee of the South Africa Section of the Association of Engineering Geologists, 1976. "A Guide to Core Logging for Rock Engineering," Proceedings of the Symposium on Exploration for Rock Engineering, pp. 71-94.

5.0 Equipment

5.1 Measuring tape at least 3 m (10 ft) long, graduated to at least 2.5 mm (0.1 in) shall be used for measuring length along rock cores.

5.2 Hand lens of approximately 10 power magnification for examining rock materials.

5.3 Log forms (F-3-1-1A & B).

5.4 Geologist's rock hammer

5.5 Pocket knife to determine hardness.

5.6 Hydrochloric acid (5% solution) to indicate the presence of carbonate in rock cores.

5.7 V trough as required by project needs to hold retrieved cores during core logging.

5.8 Equipment such as, engineer's scale, straight edge, protractor, clipboard, indelible markers, as required to efficiently log and label the core and perform the field characterization tests.

5.9 Camera, scale, and appropriate identification label or board to show sample number, depths, date, etc., if core phohographs are to be taken.

6.0 Procedures

6.1 Planning

The Project Manager or his designated representative shall issue a Specific Work Instruction (SWI) per procedure QA-2-3 for sample logging. The SWI shall include:

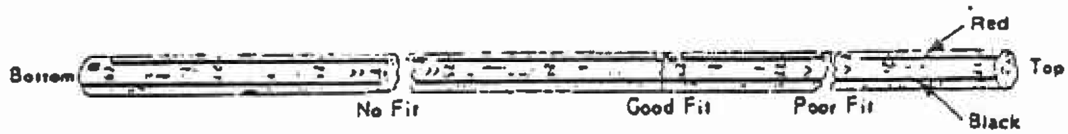
6.1.1 Summary Project Description.
6.1.2 Personnel responsible for logging the core.
6.1.3 Personnel responsible for checking and approving the work.
6.1.4 Schedule.
6.1.5 Data requirements on the logging form.
6.1.6 Additional information as required to perform the work.

These instructions may be included in the SWI issued for Rock Core Drilling Procedure F-3.

6.2 Logging

6.2.1 Carefully remove all core pieces from the core barrel. Clean the core with a cloth and wipe dry.

6.2.2 Assemble the core pieces in the V trough by fitting their ends together. When the core from the entire run is aligned, scribe the core with two reference lines using indelible black and red felt marker pens and a straight edge (the core must be relatively dry to prevent smudging). The lines shall be scribed side by side, parallel to the core axis with black lines to the right and red lines to the left when the core logger is looking toward the top of the core as illustrated below. Mark the depth footage on each core piece, if required by Activity Plan or SWI.



6.2.3 Document the required information in core log form (F-3-1-1A and B). Unless otherwise specified in the SWI (Sec. 6.1).

- o <u>Client</u> - The name of the client.
- o <u>Project Name</u> - The name of the project.
- o <u>Project Number</u> - The Earth Technology project number
- o <u>Coordinates</u> - The location of the top of the borehole in latitude and longitude or township/range designation, if available
- o <u>Hole Number</u> - The designated borehole number.
- o <u>Elevation</u> - The elevation of the borehole, if known.
- o <u>Orientation</u> - The inclination of the boreholes in degrees from horizontal and the bearing in degrees clockwise from north (azimuth) if required by the project.
- o <u>Depth</u> - The maximum depth of the borehole.

- Date Started - The date when drilling was started.
- Date Finished - The date when drilling was completed.
- Water Table - If required by written instructions, the depth of the water table in the borehole measured to ± 0.1 ft (0.03 m) and the date of the reading.
- Core Boxes - The designation of the core boxes used to hold the cores from the borehole.
- Date - The date the core was logged.
- Logging Personnel - The individual(s) logging the core.
- Page Numbers - The first log form for each borehole shall be page 1 (Form F-3-1-1A). Additional log forms are numbered sequentially for each corehole (Form F-3-1-1B). The total number of pages is entered after logging of all cores from the borehole is complete.
- Drilling Rig/ Driller - Type of machine used for drilling and driller's initials.
- Drilling Methods & Fluid - Type of drilling method and drilling fluid used.
- Core Barrel & Bit Data - Type and diameter of core barrel(s) and bit(s) used shall be entered.
- Plus any additional information specified in the SWI (Section 6.1.5)

6.2.4 Core Quality Description and Logging

Elevation and Depth - The elevation of the borehole above mean sea level, if known, and its total depth below the ground surface shall be entered. Elevations and depths shall be recorded on the log where major formational or structural changes occur.

Core Loss Log - Sections of the borehole from which core was successfully recovered are represented by a solid bar in the core loss column. Intervals of core loss (CL) when identifiable are left open and labeled "CL". Otherwise an interval of the appropriate length is left open at the end of each run and labeled "CL-UN" (core loss-unknown depth).

Total Core Recovery - Total Core Recovery for each cored interval shall be entered in the appropriate columns.

Rock Quality Designation (RQD) - The rock quality designation (RQD) is a percentage of core recovered and calculated as the sum of all pieces of intact core greater than twice the diameter, divided by the total length drilled. Pieces shorter than twice the diameter resulting from closer jointing, faulting, or weathering should not be summed. If the core is broken by handling or by the drilling process (i.e., if the fractures clearly are fresh breaks rather than natural discontinuities), the freshly broken pieces shall be fitted together and considered as one piece. The RQD values of individual beds, structural domains, weakness zones, etc., shall be logged separately to indicate any inherent variability and to provide a more accurate picture of the location and width of zones with small RQD value.

Fracture Log - Fractures shall be recorded graphically at the depths and orientations where they occur. Breaks which are clearly a result of drilling or handling (as opposed to natural breaks such as joints) shall be shown with a jagged line and labeled as "MB" (mechanical break). The orientation shall be related to the black core scribe line (Section 6.2.2).

Structural Description - The joints, beds, foliation, shears or gouge zones, etc., shall be described. In general, the size of the feature, geometry, and gouge or coatings or slickensides should be noted, as appropriate. In addition, characteristic discontinuities should be described as to orientation, spacing (Table 1), surface roughness (Table 2), fracture filling material (Table 3), separation and wall strength (Table 4), as listed below.

- Orientation - Fracture planes are described in terms of azimuth and dip. Azimuth is the bearing of the plane projected to a horizontal ordinate scale of 0 to 360°. The strike direction to be recorded is the strike direction relative to the black scribe line if oriented cores are not available. Dip is the angle of the plane relative to horizontal measured normal to the azimuth.
- Spacing - The spacing between discontinuities is measured along the scribe line between adjacent natural discontinuities of one set (discontinuities with similar orientation). Standard terms for describing spacing are listed in Table 1.
- Roughness - Roughness is described qualitatively of the fracture surface. The descriptive terms of Table 2 will be used for discontinuity classification.
- Fracture-Filling Material - All materials occurring between the fracture walls are referred to as fracture filling. Fracture filling includes materials deposited or intruded between the fracture surfaces. The descriptions of fracture-filling material abundance shall use the terms given in Table 3. The filling material (i.e., bentonite, montmorillonite, etc.), stain, or coloration shall be described.

Table 1
Terms for Describing
Spacing of Rock Structures
(after ASCE, 1972)

Spacing	Joint	Bedding and Foliation
Less than 2 in (<50 mm)	Very Close	Very thin
2 in to 1 ft (50 mm to 30 cm)	Close	Thin
1 ft to 3 ft (30 cm to 1 m)	Moderately close	Medium
3 ft to 10 ft (1 m to 3 m)	Wide	Thick
More than 10 ft (<3 m)	Very Wide	Very thick

Table 2

Terms for Describing Roughness

(After CLC of S. Africa Section, 1976)

Classification	Description
Smooth	Appears smooth and is essentially smooth to the touch. May be slickensided.
Slightly Rough	Asperities (undulations) on the fracture surfaces are visible and can be distinctly felt.
Medium Rough	Asperities are clearly visible and fracture surface feels abrasive.
Rough	Large angular asperities can be seen. Some ridges and high angle steps evident.
Very Rough	Near vertical steps and ridges occur on the fracture surface

Table 3

Terms for Abundance of Fracture Filling Materials

(After CLC of S. Africa Section, 1976)

Description	Definition
Clean	No fracture filling material.
Stained	Coloration of rock only. No recognizable filling material.
Filled	Fracture filled with recognizable filling material.

Table 4

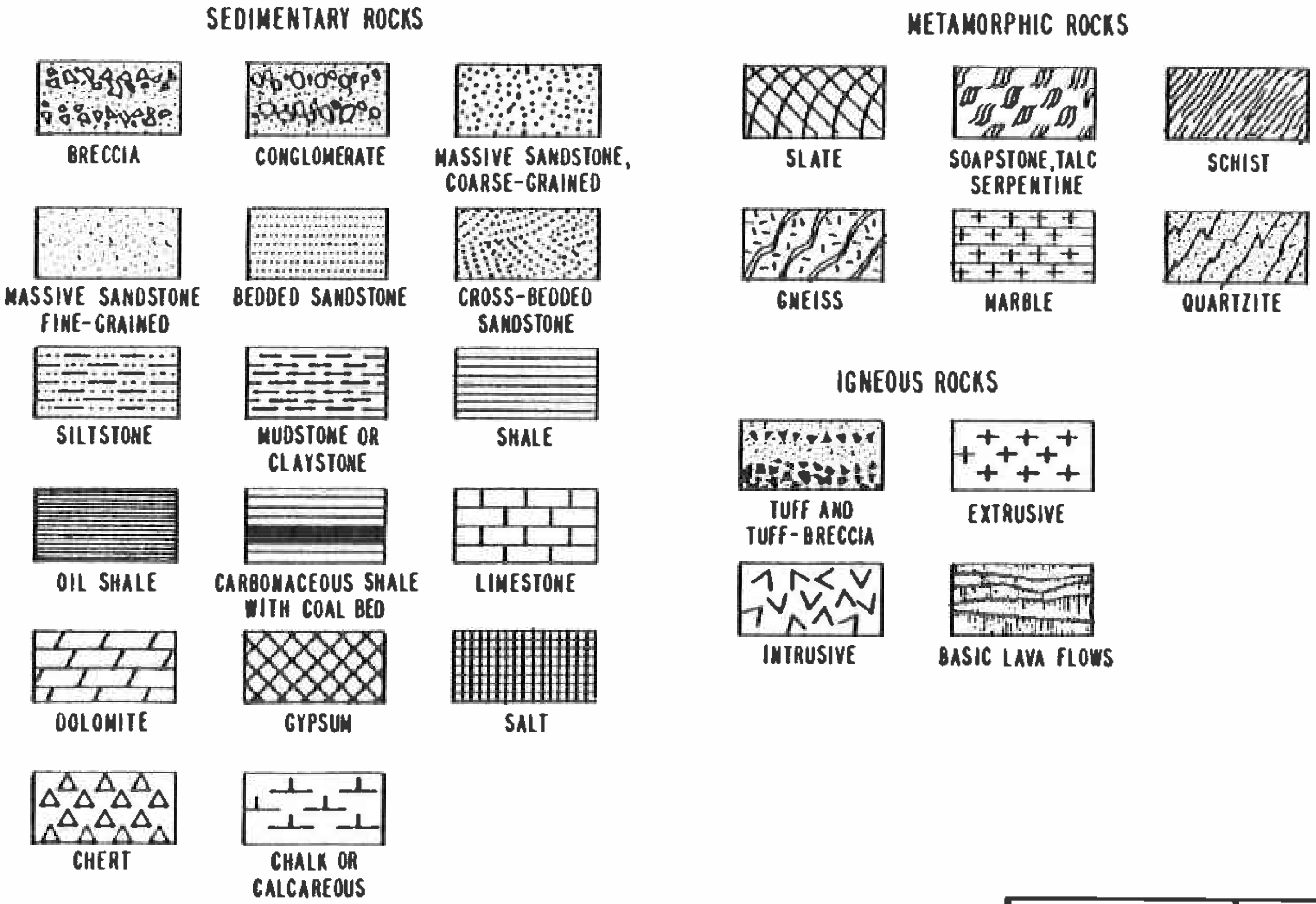
Terms for Separation of Fracture Walls

(After CLC of S. Africa Section, 1976)

Description	Separation of Wall (mm)
Closed	0
Very narrow	0 - 0. 1
Narrow	>0.1 - 1.0
Wide	>1.0 - 5.0
Very wide	>5.0

- Separation - Separation is the distance between fracture walls. If the separation is measurable, the terms in Table 4 shall be used.
- Wall Strength - Wall strength can be assessed either by Schmidt hammer testing of rigidly clamped core pieces or point-load testing across the core diameter. This is optional data and shall be performed as required by the project.
- Lithic Symbol - The lithic symbol is a graphic representation of the rock type. The symbols to be used are shown in Figure 1. Symbols for rock types not shown in Figure 1 may be specified by written instructions (SWI), as required by the project.
- Lithic Description - A standard macroscopic petrologic description of the rock shall be recorded for each rock type encountered. Variation of materials within a formation shall be noted at the appropriate depth (Form F-3-1-1A and B). The description shall include, as a minimum, the following information for each rock type encountered.
  - Rock type
  - Depth interval
  - Mineral composition
  - Color
  - Texture
  - Hardness
  - Weathering
  - Abundance and type of fossils
  - Any unusual or pertinent aspects (voids, inclusions, etc.).

Rock Type and Depth Interval - Rock type will be identified and recorded using the classification system given in Appendix A. Mineralogic composition and the estimated



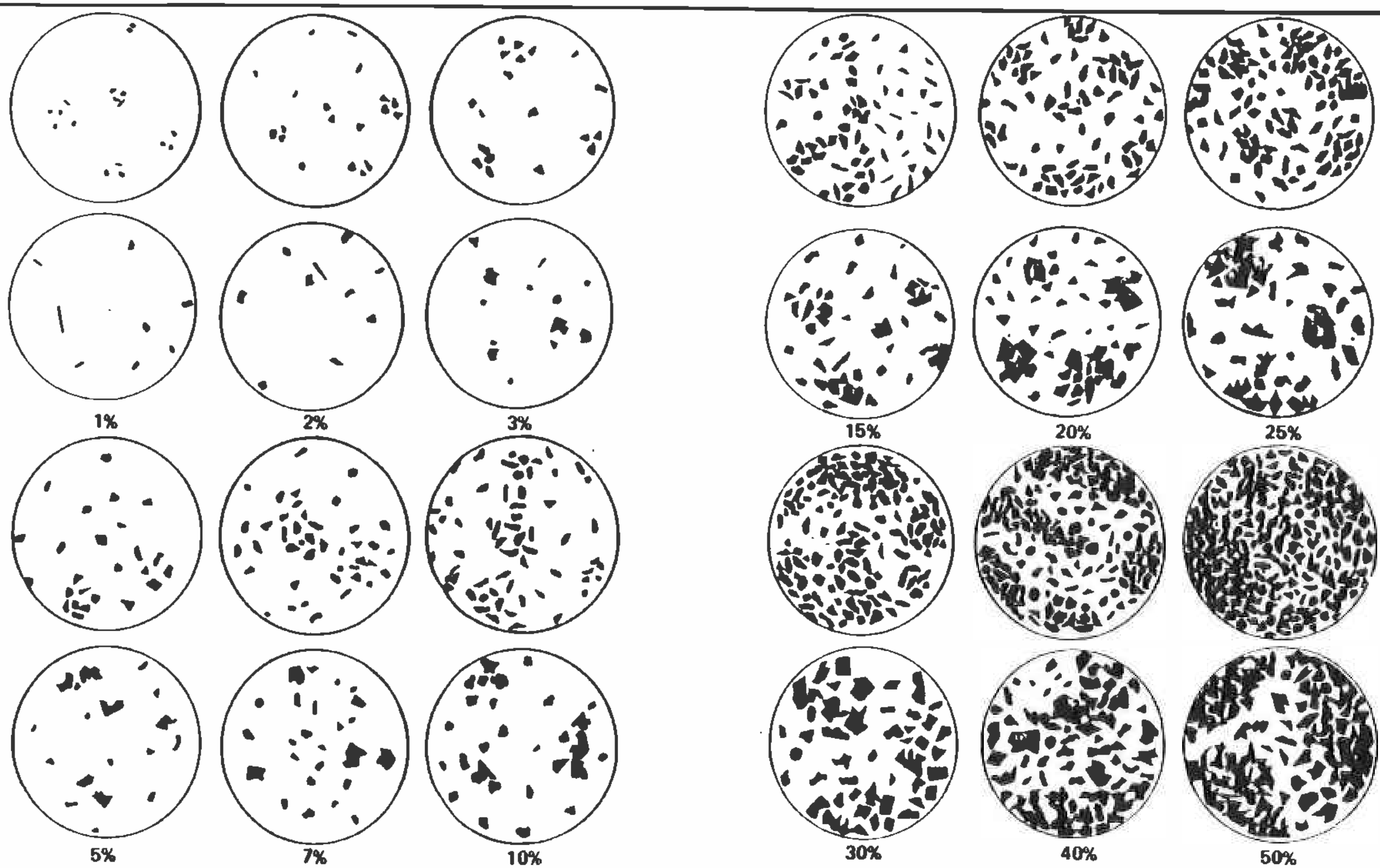
The Earth Technology Corporation	Field Procedure F 3 1
Standard Lithic Symbols	
Figure 1	

mineral percentages shall be recorded along with applicable color, textural information, and approximate percentages of important components (Figure 2).

Color - Colors are to be included in the description, with the use of the Munsell Color Chart recommended where pertinent. In many rock types, rock texture may give rise to an ill-defined or variable color. In these cases, the color of dominant minerals or the overall ground mass shall be described and the abundant colors of secondary minerals should be described separately.

Description of the rock texture, voids inclusions, etc. - Texture is a function of the size, shape, and arrangement of the grains or crystals of a rock. The most noticeable textural feature is grain/crystal size. The grain-size classification given on Table 5 which is based on visual identification shall be used. A grain/crystal size range and mode (most abundant size) should be given for the very coarse-grained rocks. For sedimentary rocks, roundness and sphericity are important textural parameters; roundness refers to the sharpness and angularity of corners of grains and fragments as shown in Figure 3. Sphericity refers to the degree the grains approximate a sphere as illustrated in Figure 3. For igneous and metamorphic rock, crystal face relationships are described according to the classifications shown on Table 5. Additional textural information shall include nature and filling of voids and grain interstices and specifics on rock fabric (i.e., porphyritic or glassy for igneous rock) as required for the project.

Hardness - Hardness shall be described as detailed on Table 6. Hardness shall indicate the overall rock condition and not that of individual minerals.



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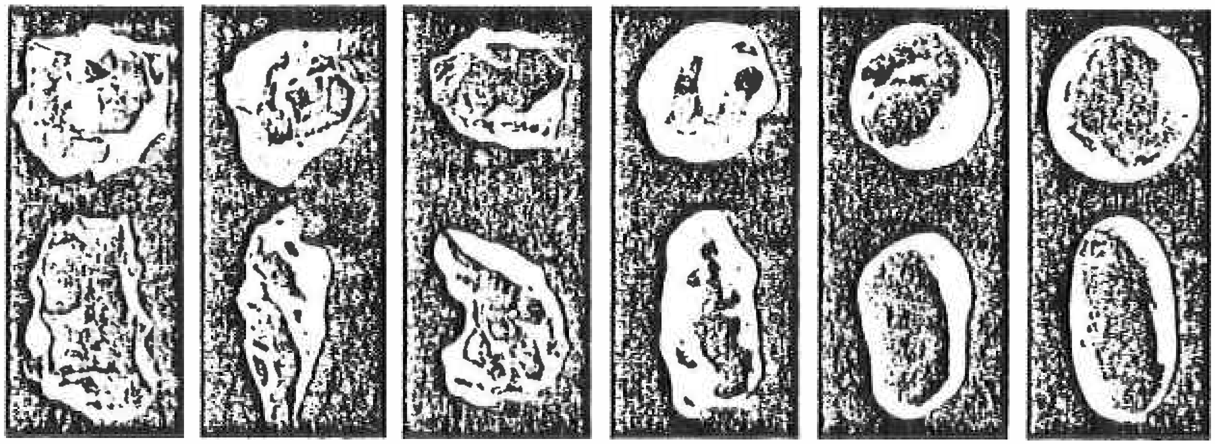
Field Procedure F-3-1

Charts for Estimating Percentage Composition of Rocks and Sediments

Figure 2

DEGREES OF ROUNDNESS



(After Powers, 1955)

The Earth Technology Corporation	Field Procedure F-3-1
Roundness and Sphericity	
Figure 3	

Table 5

Grain Size Classification

Description	Size (mm)	Recognition	Equivalent Soil Type
Sedimentary Rock			
Very fine grained	<0.06	Individual grains/crystals cannot be seen with a hand lens	Clays & Silt
Fine grained	0.06 - 0.2	Just visible as individual grains/crystals under hand lens	Fine sand
Medium grained	0.2 - 0.6	Grains/crystals clearly visible under hand lens, just visible to the naked eye	Medium sand
Coarse grained	0.6 - 2.0	Grains/crystals clearly visible to naked eye	Coarse sand
Very coarse grained	>2.0	Grains/crystals measureable	Gravel
Igneous and Metamorphic Rock			**Rock Description**
Fine grained	<1.0	Grains difficult to recognize without hand lens	Aphanitic
Medium grained	1.0 - 5.0	Observable without hand lens	Phaneritic
Coarse grained	>5.0	Easily distinguished	Phaneritic

Table 6

Engineering Hardness Classification for Description of Rock
(after ASCE, 1972)

Designation	Description
VH	Very Hard - Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows from a hammer or geologist's pick.
H	Hard - Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
MH	Moderately Hard - Can be scratched with knife or pick. Gouges or grooves to 6.4 mm (1/4 in) deep can be excavated by hard blow of point of geologist's pick. Hand specimens can be detached by moderate blow.
M	Medium - Can be grooved or gouged 1.6 mm (1/16 in) deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 25 mm (1 in) maximum size by hard blows of the point of geologist's pick.
S	Soft - Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size (50 to 75 mm) by moderate blows of pick point. Small, thin pieces can be broken by finger pressure.
VS	Very soft - Can be carved with knife. Can be excavated readily with point of pick. Pieces of 25 mm (1 in) or more in thickness can be broken by finger pressure. Can be scratched readily by fingernail.

<u>Weathering</u> - The degree of weathering of the rock shall be described according to the classifications in Table 7. The interval over which the description applies shall be indicated by arrows in the weathering description column.

- <u>Tests and Remarks</u> - The logger shall enter any remarks concerning unusual or noteworthy conditions such as loss of drilling fluids or large voids and note any test intervals, such as packer or point load tests. The photograph roll and photograph numbers may be entered in this column.

6.3 Photography

If required by the SWI (Sec 6.1) color print photographs or slides of the core and specific features may be required to support observations made during logging. If required by a SWI or Activity Plan, each photograph should contain:

- borehole or corehole identification number
- a graphic scale
- top of core noted
- project and name and number
- footage (depth)

6.4 Check and Approval

6.4.1 The completed core log form shall be checked and signed by assigned personnel according to procedure QA-5.

6.4.2 The log shall be reviewed and approved by assigned personnel according to procedure QA-5.

Table 7

Rock Weathering Descriptions

(Shuri et al, 1981)

Designation	Description
I	Fresh: no visible sign of weathering
II	Faintly weathered: weathering limited to the surface of major discontinuities
III	Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material
IV	Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable
V	Highly weathered: weathering extends throughout rock mass and the rock material is partly friable
VI	Completely weathered: rock is wholly decomposed and in a friable condition but the rock texture and structure are preserved
VII	Residual soil: a soil material with the original texture, structure, and mineralogy of the rock completely destroyed

7.0 Records

7.1 SWI

7.2 Rock Core Log Data Sheet (F-3-1-1)

7.3 Approval cover sheets (Form QA-5-1)

7.4 Photographs

The Earth Technology Corporation

ROCK CORE LOG

Client	Project	Project No.
Hole Location	Hole No.	Elevation
Hole Angle	Bearing	Depth
Started	Finished	Core Boxes No. of

Depth Water Table	On (Date)	Logged By	Date

Drill Rig/Driller	Drilling Methods & Fluid	Core Barrel/Bit Data
Checked by	Date	Page No. of

Elevation	Depth	Core Loss Log	Total Core Recovery	R. Q. D.	Fracture Log	Structural Description	Lithic Symbol	Lithic Description	Weathering	Tests and Remarks

The Earth Technology Corporation

ROCK CORE LOG

Client	Project	Project No.
Hole Location	Hole No.	Elevation
Checked by	Date	Page No.

Elevation	Depth	Core Loss Log	Total Core Recovery	R. Q. D.	Fracture Log	Structural Description	Lithic Symbol	Lithic Description	Weathering	Tests and Remarks

APPENDIX C

ASTM STANDARDS

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D 2488; 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.

1. Scope

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils.

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (See Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.5 The values stated in inch-pound units are to be regarded as the standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terms and Symbols Relating to Soil and Rock[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2487 Test Method for Classification of Soils for Engineering Purposes[2]

3. Definitions

3.1 Except as listed below, all definitions are in accordance with Terms and Symbols D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:

Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and

Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1 *clay*—soil passing a No. 200 (75-μm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.2 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.6 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-μm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-μm) sieve.

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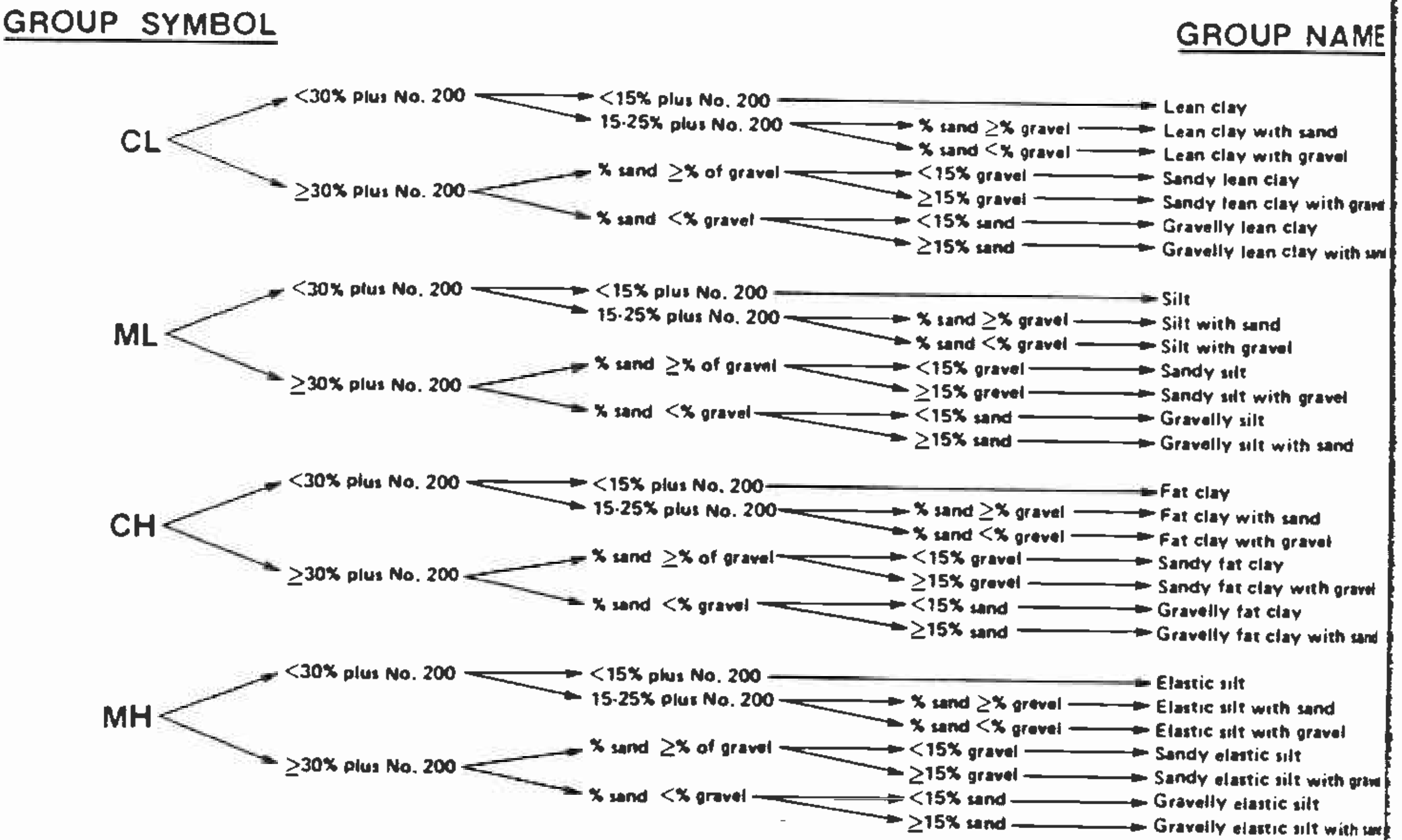
[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved Oct. 3, 1984. Published December 1984. Originally published as D 2488 – 66 T. Last previous edition D 2488 – 69 (1975).

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



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)

fine—passes a No. 40 (425-µm) sieve and is retained on a No. 200 (75-µm) sieve.

3.1.7 *silt*—soil passing a No. 200 (75-µm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

4. Summary of Practice

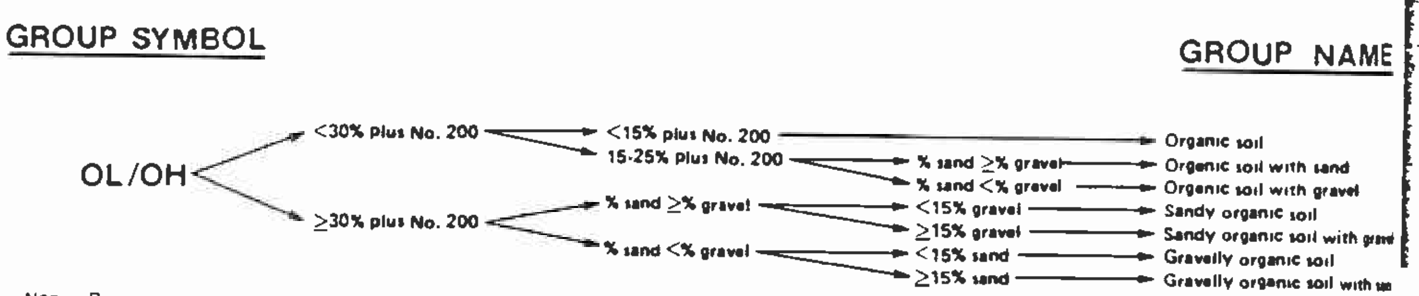
4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Figs. 1a and 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols.*

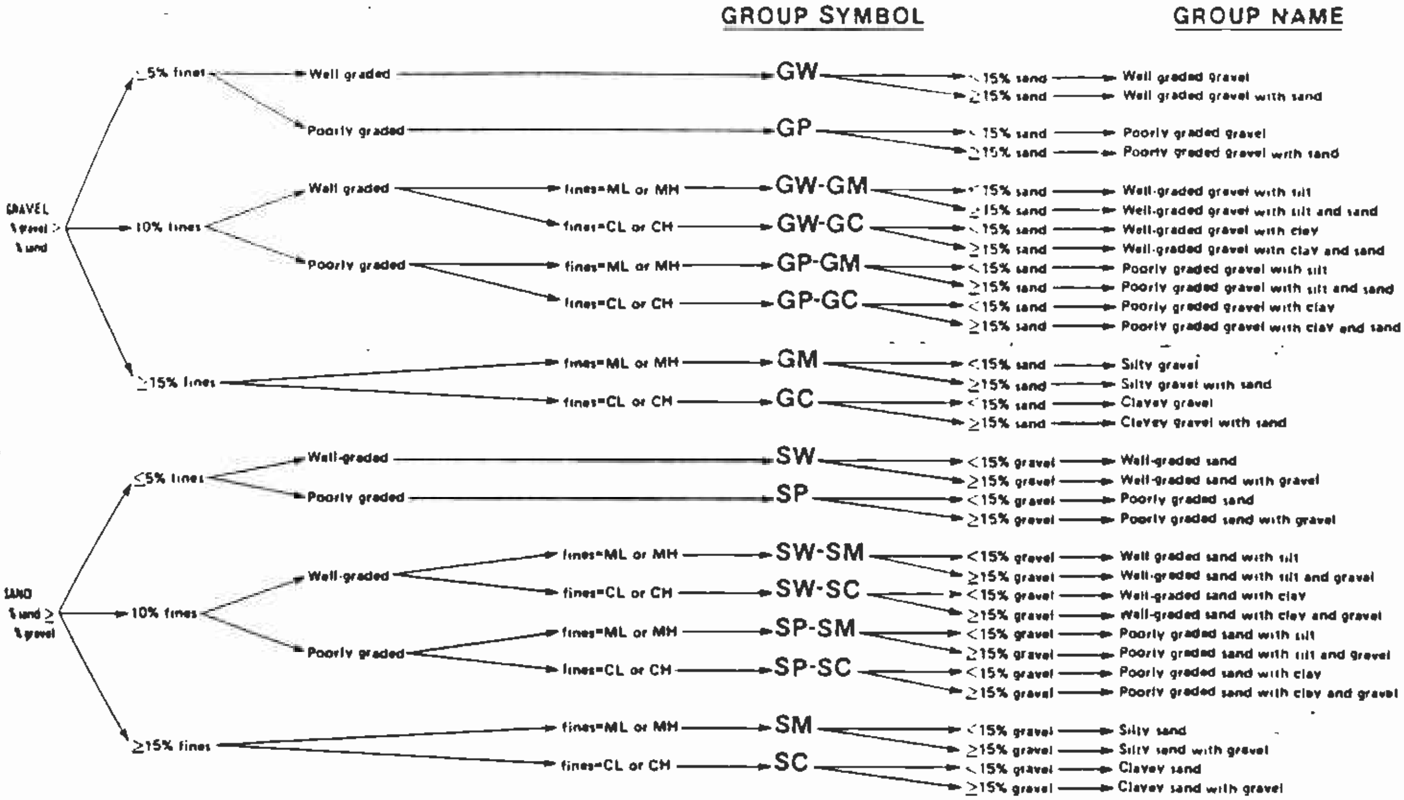
Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

6. Apparatus

6.1 *Required Apparatus:*

6.1.1 *Pocket Knife or Small Spatula.*

6.2 *Useful Auxiliary Apparatus:*

6.2.1 *Small Test Tube and Stopper* (or jar with a lid)

6.2.2 *Small Hand Lens.*

7. Reagents

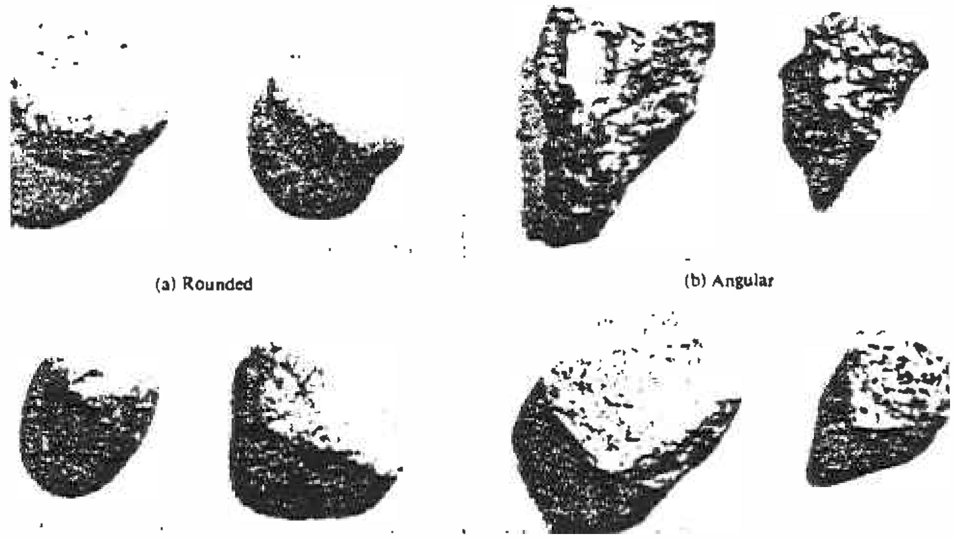
7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.



(a) Rounded (b) Angular

(c) Subrounded (d) Subangular

FIG. 3 Typical Angularity of Bulky Grains

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 5—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 6—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (⅜ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

NOTE 7—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceeding schedule.

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

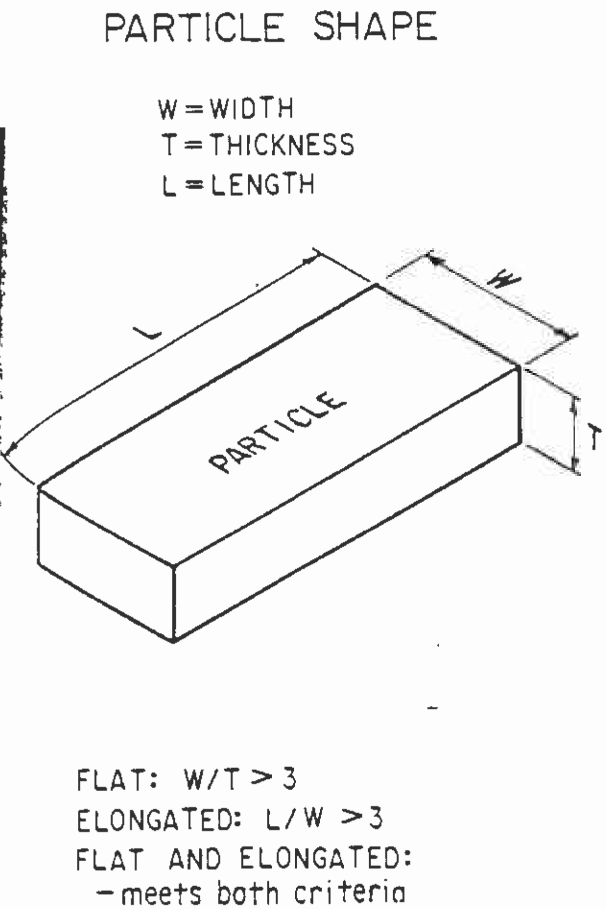


FIG. 4 Criteria for Particle Shape

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

ample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Consistency

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼ in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.7. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the

TABLE 6 Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 8—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 9—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

TABLE 8 Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength:*

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 10—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy:*

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness:*

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

14.7 *Identification of Inorganic Fine-Grained Soils:*

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 11—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

14.8 *Identification of Organic Fine-Grained Soils:*

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 12—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Figs. 1a and 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group namd. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Figs. 1a and 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

15. Procedure for Identifying Coarse-Grained Soils (Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A ⅛-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

TABLE 12 Identification of Inorranic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 13—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 14—Other examples of soil descriptions and identification are given in Appendixes X1 and X2.

NOTE 15—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %

Few—5 to 10 %

Little—15 to 25 %

Some—30 to 45 %

Mostly—50 to 100 %

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information only; therefore, a precision and bias statement is not applicable.

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incorporated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % fines; "Poorly Graded Gravel with Sand (GP)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

Designation: D 1586 – 84

Standard Method for Penetration Test and Split-Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 1586; 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.

This method has been approved for use by agencies of the Department of Defense and for listing in the DOD Index of Specifications and Standards.

1. Scope

1.1 This method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative soil sample and a measure of the resistance of the soil to penetration of the sampler.

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For a specific precautionary statement, see 5.4.1.

1.3 The values stated in inch-pound units are to be regarded as the standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 2487 Test Method for Classification of Soils for Engineering Purposes[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

3. Descriptions of Terms Specific to This Standard

3.1 *anvil*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2 *cathead*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.3 *drill rods*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.4 *drive-weight assembly*—a device consisting of the hammer, hammer fall guide, the anvil, and any hammer drop system.

3.5 *hammer*—that portion of the drive-weight assembly consisting of the 140 ± 2 lb (63.5 ± 1 kg) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.6 *hammer drop system*—that portion of the drive-weight assembly by which the operator accomplishes the lifting and dropping of the hammer to produce the blow.

3.7 *hammer fall guide*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.8 *N-value*—the blowcount representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.9 ΔN—the number of blows obtained from each of the 6-in. (150-mm) intervals of sampler penetration (see 7.3).

3.10 *number of rope turns*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.11 *sampling rods*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

3.12 *SPT*—abbreviation for Standard Penetration Test, a term by which engineers commonly refer to this method.

4. Significance and Use

4.1 This method provides a soil sample for identification purposes and for laboratory tests appropriate for soil obtained from a sampler that may produce large shear strain disturbance in the sample.

4.2 This method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate SPT blowcount, or *N*-value, and the engineering behavior of earthworks and foundations are available.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitably clean open hole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions.

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used in conjuction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

5.1.2 *Roller-Cone Bits*, less than 6.5 in. (162 mm) and

[1] This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

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

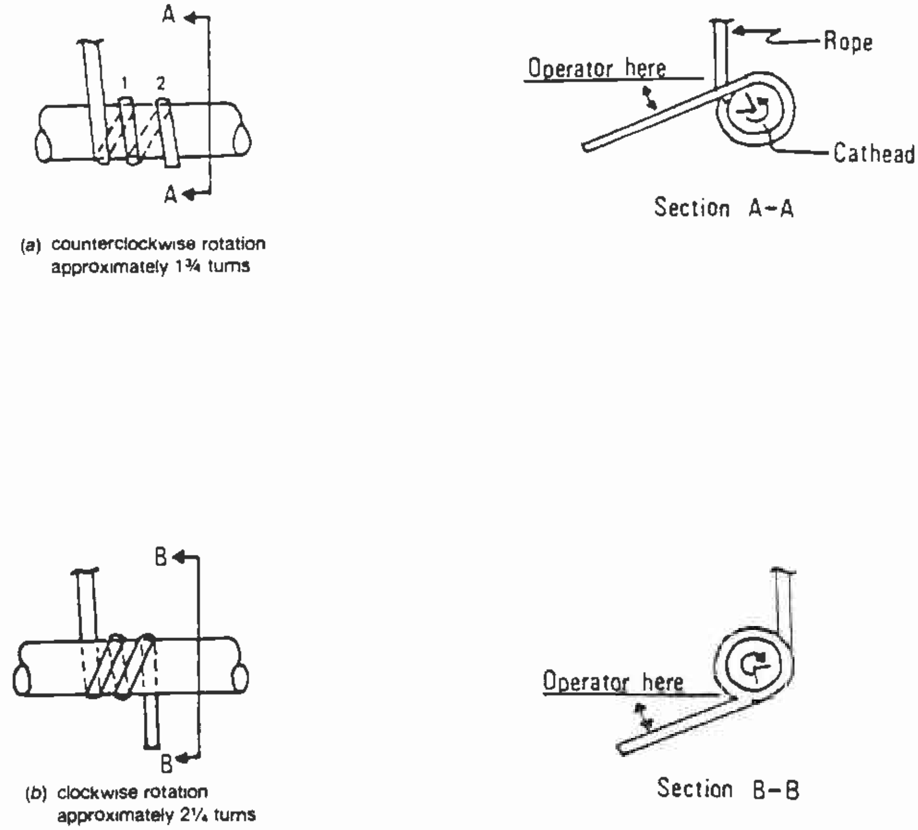


FIG. 1 Definitions of the Number of Rope Turns and the Angle for (*a*) Counterclockwise Rotation and (*b*) Clockwise Rotation of the Cathead

greater than 2.2 in. (56 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the boring. The inside diameter of the hollow-stem augers shall be less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used if the soil on the side of the boring does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod which has an outside diameter of 1⅝ in. (41.2 mm) and an inside diameter of 1⅛ in. (28.5 mm).

NOTE 1—Recent research and comparative testing indicates the type rod used, with stiffness ranging from "A" size rod to "N" size rod, will usually have a negligible effect on the *N*-values to depths of at least 100 ft (30 m).

5.3 *Split-Barrel Sampler*—The sampler shall be constructed with the dimensions indicated in Fig. 2. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The use of liners to produce a constant inside diameter of 1⅜ in. (35 mm) is permitted, but shall be noted on the penetration record if used. The use of a sample retainer basket is permitted, and should also be noted on the penetration record if used.

NOTE 2—Both theory and available test data suggest that *N*-values may increase between 10 to 30 % when liners are used.

5.4 *Drive-Weight Assembly:*

5.4.1 *Hammer and Anvil*—The hammer shall weigh 140 ± 2 lb (63.5 ± 1 kg) and shall be a solid rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting a free fall shall be used. Hammers used with the cathead and rope method shall have an unimpeded overlift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged.

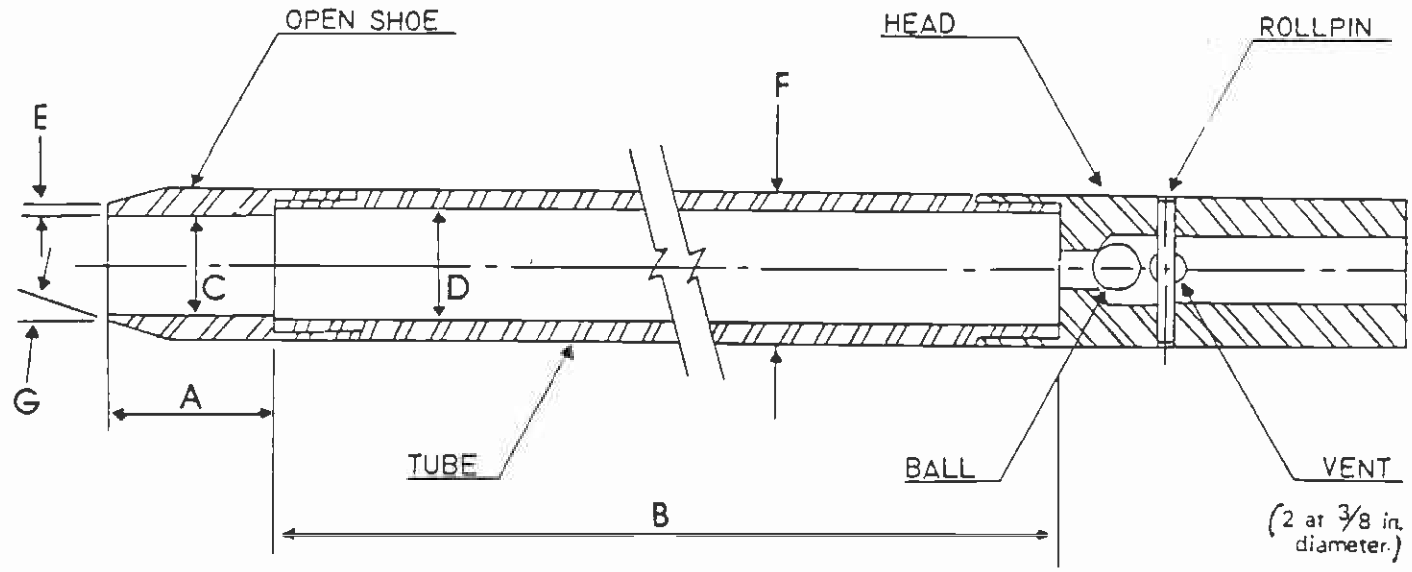
NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic, or automatic hammer drop systems may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 *Accessory Equipment*—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The boring shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and lo-



A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 − 0.00 in. (38.1 ± 1.3 − 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 − 0.00 in. (50.8 ± 1.3 − 0.0 mm)
G = 16.0° to 23.0°

The 1½ in. (38 mm) inside diameter split barrel may be used with a 16-gage wall thickness split liner. The penetrating end of the drive shoe may be slightly rounded. Metal or plastic retainers may be used to retain soil samples.

FIG. 2 Split-Barrel Sampler

cations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 mm) or less in homogeneous strata with test and sampling locations at every change of strata.

6.2 Any drilling procedure that provides a suitably clean and stable hole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures have proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable borings. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the boring below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a boring with bottom discharge bits is not permissible. It is not permissible to advance the boring for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the boring or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the boring has been advanced to the desired sampling elevation and excessive cuttings have been removed, prepare for the test with the following sequence of operations.

7.1.1 Attach the split-barrel sampler to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the boring and apply a seating blow. If excessive cuttings are encountered at the bottom of the boring, remove the sampler and sampling rods from the boring and remove the cuttings.

7.1.4 Mark the drill rods in three successive 6-in. (0.15-m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 6-in (0.15-m) increment.

7.2 Drive the sampler with blows from the 140-lb (63.5-kg) hammer and count the number of blows applied in each 6-in. (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 6-in. (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 18 in. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.3 Record the number of blows required to effect each 6 in. (0.15 m) of penetration or fraction thereof. The first 6 in. is considered to be a seating drive. The sum of the number of blows required for the second and third 6 in. of penetration is termed the "standard penetration resistance," or the "*N*-value." If the sampler is driven less than 18 in. (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 6-in. (0.15-m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 1 in. (25 mm), in addition to the number of blows. If the sampler advances below the bottom of the boring under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lb (63.5-kg) hammer shall be accomplished using either of the following two methods:

7.4.1 By using a trip, automatic, or semi-automatic hammer drop system which lifts the 140-lb (63.5-kg) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 25 mm) unimpeded.

7.4.2 By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM, or the approximate speed of rotation shall be reported on the boring log.

7.4.2.3 No more than 2¼ rope turns on the cathead may be used during the performance of the penetration test, as shown in Fig. 1.

NOTE 4—The operator should generally use either 1¾ or 2¼ rope turns, depending upon whether or not the rope comes off the top (1¾ turns) or the bottom (2¼ turns) of the cathead. It is generally known and accepted that 2¾ or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be maintained in a relatively dry, clean, and unfrayed condition.

7.4.2.4 For each hammer blow, a 30-in. (0.76-m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

7.5 Bring the sampler to the surface and open. Record the percent recovery or the length of sample recovered. Describe the soil samples recovered as to composition, color, stratification, and condition, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 6-in. (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel.

8. Report

8.1 Drilling information shall be recorded in the field and shall include the following:

8.1.1 Name and location of job,
8.1.2 Names of crew,
8.1.3 Type and make of drilling machine,
8.1.4 Weather conditions,
8.1.5 Date and time of start and finish of boring,
8.1.6 Boring number and location (station and coordinates, if available and applicable),
8.1.7 Surface elevation, if available,
8.1.8 Method of advancing and cleaning the boring,
8.1.9 Method of keeping boring open,
8.1.10 Depth of water surface and drilling depth at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,
8.1.11 Location of strata changes,
8.1.12 Size of casing, depth of cased portion of boring,
8.1.13 Equipment and method of driving sampler,
8.1.14 Type sampler and length and inside diameter of barrel (note use of liners),
8.1.15 Size, type, and section length of the sampling rods, and
8.1.16 Remarks.

8.2 Data obtained for each sample shall be recorded in the field and shall include the following:

8.2.1 Sample depth and, if utilized, the sample number,
8.2.2 Description of soil,
8.2.3 Strata changes within sample,
8.2.4 Sampler penetration and recovery lengths, and
8.2.5 Number of blows per 6-in. (0.15-m) or partial increment.

9. Precision and Bias

9.1 Variations in *N*-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent borings in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.3 The variability in *N*-values produced by different drill rigs and operators may be reduced by measuring that part of the hammer energy delivered into the drill rods from the sampler and adjusting *N* on the basis of comparative energies. A method for energy measurement and *N*-value adjustment is currently under development.

Standard Practice for Thin-Walled Tube Sampling of Soils[1]

This standard is issued under the fixed designation D 1587; 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.

This practice has been approved for use by agencies of the Department of Defense and for listing in the DOD Index of Specifications and Standards.

1. Scope

1.1 This practice covers a procedure for using a thin-walled metal tube to recover relatively undisturbed soil samples suitable for laboratory tests of structural properties. Thin-walled tubes used in piston, plug, or rotary-type samplers, such as the Denisón or Pitcher, must comply with the portions of this practice which describe the thin-walled tubes (5.3).

NOTE 1—This practice does not apply to liners used within the above samplers.

2. Referenced Documents

2.1 *ASTM Standards:*

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D3550 Practice for Ring-Lined Barrel Sampling of Soils[2]

D4220 Practices for Preserving and Transporting Soil Samples[2]

3. Summary of Practice

3.1 A relatively undisturbed sample is obtained by pressing a thin-walled metal tube into the in-situ soil, removing the soil-filled tube, and sealing the ends to prevent the soil from being disturbed or losing moisture.

4. Significance and Use

4.1 This practice, or Practice D 3550, is used when it is necessary to obtain a relatively undisturbed specimen suitable for laboratory tests of structural properties or other tests that might be influenced by soil disturbance.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment may be used that provides a reasonably clean hole; that does not disturb the soil to be sampled; and that does not hinder the penetration of the thin-walled sampler. Open borehole diameter and the inside diameter of driven casing or hollow stem auger shall not exceed 3.5 times the outside diameter of the thin-walled tube.

5.2 *Sampler Insertion Equipment,* shall be adequate to provide a relatively rapid continuous penetration force. For hard formations it may be necessary, although not recommended, to drive the thin-walled tube sampler.

5.3 *Thin-Walled Tubes,* should be manufactured as shown in Fig. 1. They should have an outside diameter of 2 to 5 in. and be made of metal having adequate strength for use in the soil and formation intended. Tubes shall be clean and free of all surface irregularities including projecting weld seams.

5.3.1 *Length of Tubes*—See Table 1 and 6.4.

5.3.2 *Tolerances,* shall be within the limits shown in Table 2.

5.3.3 *Inside Clearance Ratio,* should be 1 % or as specified by the engineer or geologist for the soil and formation to be sampled. Generally, the inside clearance ratio used should increase with the increase in plasticity of the soil being sampled. See Fig. 1 for definition of inside clearance ratio.

5.3.4 *Corrosion Protection*—Corrosion, whether from galvanic or chemical reaction, can damage or destroy both the thin-walled tube and the sample. Severity of damage is a function of time as well as interaction between the sample and the tube. Thin-walled tubes should have some form of protective coating. Tubes which will contain samples for more than 72 h shall be coated. The type of coating to be used may vary depending upon the material to be sampled. Coatings may include a light coat of lubricating oil, lacquer, epoxy, Teflon, and others. Type of coating must be specified by the engineer or geologist if storage will exceed 72 h. Plating of the tubes or alternate base metals may be specified by the engineer or geologist.

5.4 *Sampler Head,* serves to couple the thin-walled tube to the insertion equipment and, together with the thin-walled tube, comprises the thin-walled tube sampler. The sampler head shall contain a suitable check valve and a venting area to the outside equal to or greater than the area through the check valve. Attachment of the head to the tube shall be concentric and coaxial to assure uniform application of force to the tube by the sampler insertion equipment.

6. Procedure

6.1 Clean out the borehole to sampling elevation using whatever method is preferred that will ensure the material to be sampled is not disturbed. If groundwater is encountered, maintain the liquid level in the borehole at or above ground water level during the sampling operation.

6.2 Bottom discharge bits are not permitted. Side discharge bits may be used, with caution. Jetting through an open-tube sampler to clean out the borehole to sampling elevation is not permitted. Remove loose material from the center of a casing or hollow stem auger as carefully as possible to avoid disturbance of the material to be sampled.

NOTE 2—Roller bits are available in downward-jetting and diffused-

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

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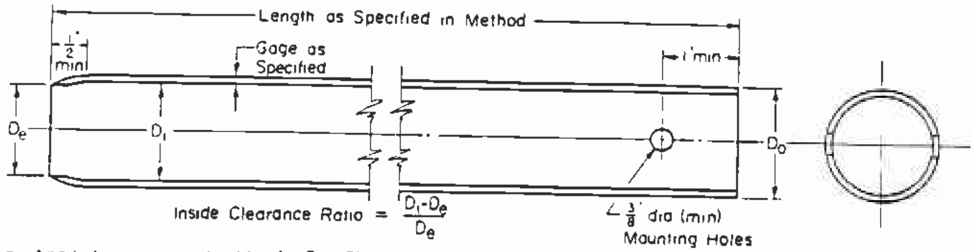
[2] *Annual Book of ASTM Standards,* Vol 04.08.



NOTE 1—Minimum of two mounting holes on opposite sides for 2 to 3½ in. sampler.
NOTE 2—Minimum of four mounting holes spaced at 90° for samplers 4 in. and larger.
NOTE 3—Tube held with hardened screws.
NOTE 4—Two-inch outside-diameter tubes are specified with an 18-gage wall thickness to comply with area ratio criteria accepted for "undisturbed samples." Users are advised that such tubing is difficult to locate and can be extremely expensive in small quantities. Sixteen-gage tubes are generally readily available.

Metric Equivalents

in.	mm
⅜	6.77
½	12.7
1	25.4
2	50.8
3½	88.9
4	101.6

FIG. 1 Thin-Walled Tube for Sampling

TABLE 1 Suitable Thin-Walled Steel Sample Tubes[A]

Outside diameter:			
in.	2	3	5
mm	50.8	76.2	127
Wall thickness:			
Bwg	18	16	11
in.	0.049	0.065	0.120
mm	1.24	1.65	3.05
Tube length:			
in.	36	36	54
m	0.91	0.91	1.45
Clearance ratio, %	1	1	1

[A] The three diameters recommended in Table 1 are indicated for purposes of standardization, and are not intended to indicate that sampling tubes of intermediate or larger diameters are not acceptable. Lengths of tubes shown are illustrative. Proper lengths to be determined as suited to field conditions.

TABLE 2 Dimensional Tolerances for Thin-Walled Tubes

Size Outside Diameter	Nominal Tube Diameters from Table 1[A] Tolerances, in. 2	3	5
Outside diameter	+0.007 −0.000	+0.010 −0.000	+0.015 −0.000
Inside diameter	+0.000 −0.007	+0.000 −0.010	+0.000 −0.015
Wall thickness	±0.007	±0.010	±0.015
Ovality	0.015	0.020	0.030
Straightness	0.030/ft	0.030/ft	0.030/ft

[A] Intermediate or larger diameters should be proportional. Tolerances shown are essentially standard commercial manufacturing tolerances for seamless steel mechanical tubing. Specify only two of the first three tolerances; that is, O.D. and I.D., or O.D. and Wall, or I.D. and Wall.

jet configurations. Downward-jetting configuration rock bits are not acceptable. Diffuse-jet configurations are generally acceptable.

6.3 Place the sample tube so that its bottom rests on the bottom of the hole. Advance the sampler without rotation by a continuous relatively rapid motion.

6.4 Determine the length of advance by the resistance and condition of the formation, but the length shall never exceed 5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clays.

NOTE 3—Weight of sample, laboratory handling capabilities, transportation problems, and commercial availability of tubes will generally limit maximum practical lengths to those shown in Table 1.

6.5 When the formation is too hard for push-type insertion, the tube may be driven or Practice D 3550 may be used. Other methods, as directed by the engineer or geologist, may be used. If driving methods are used, the data regarding weight and fall of the hammer and penetration achieved must be shown in the report. Additionally, that tube must be prominently labeled a "driven sample."

6.6 In no case shall a length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3 in. for sludge-end cuttings.

NOTE 4—The tube may be rotated to shear bottom of the sample after pressing is complete.

6.7 Withdraw the sampler from the formation as carefully as possible in order to minimize disturbance of the sample.

7. Preparation for Shipment

7.1 Upon removal of the tube, measure the length of sample in the tube. Remove the disturbed material in the upper end of the tube and measure the length again. Seal the upper end of the tube. Remove at least 1 in. of material from the lower end of the tube. Use this material for soil description in accordance with Practice D 2488. Measure the overall sample length. Seal the lower end of the tube. Alternatively, after measurement, the tube may be sealed without removal of soil from the ends of the tube if so directed by the engineer or geologist.

NOTE 5—Field extrusion and packaging of extruded samples under the specific direction of a geotechnical engineer or geologist is permitted.
NOTE 6—Tubes sealed over the ends as opposed to those sealed with expanding packers should contain end padding in end voids in order to prevent drainage or movement of the sample within the tube.

7.2 Prepare and immediately affix labels or apply markings necessary to identify the sample. Assure that the markings labels are adequate to survive transportation and storage.

8. Report

8.1 The appropriate information is required as follows:

8.1.1 Name and location of the project,

8.1.2 Boring number and precise location on project,

8.1.3 Surface elevation or reference to a datum,

8.1.4 Date and time of boring—start and finish,

8.1.5 Depth to top of sample and number of sample,

8.1.6 Description of sampler: size, type of metal, type of coating,

8.1.7 Method of sampler insertion: push or drive,

8.1.8 Method of drilling, size of hole, casing, and drilling fluid used,

8.1.9 Depth to groundwater level: date and time measured,

8.1.10 Any possible current or tidal effect on water level,

8.1.11 Soil description in accordance with Practice D 2488,

8.1.12 Length of sampler advance, and

8.1.13 Recovery: length of sample obtained.

9. Precision and Bias

9.1 This practice does not produce numerical data; therefore, a precision and bias statement is not applicable.

Designation: D 3550 – 84

Standard Practice for Ring-Lines Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 3550; 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.

1. Scope

1.1 This practice covers a procedure for using a ring-lined barrel sampler to obtain representative samples of soil for identification purposes and other laboratory tests. In cases where it has been established that the quality of the sample is adequate, this practice provides shear and consolidation specimens that can be used directly in the test apparatus without prior trimming. Some types of soils may gain or lose significant shear strength or compressibility, or both, as a result of sampling. In cases like these, suitable comparison tests should be made to evaluate the effect of sample disturbance on shear strength and compressibility.

1.2 This practice is not intended to be used as a penetration test; however, the force required to achieve penetration or a blow count, when driving is necessary, is recommended as supplemental information.

1.3 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 1586 Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

3. Significance and Use

3.1 This practice is used where soil condition and resistance to advance of the sampler do not permit the use of a thin-wall tube (Practice D 1587) and where the formation does not require diamond coring (Practice D 2113).

4. Apparatus

4.1 *Drilling Equipment*—Any drilling equipment may be used that provides a reasonably clean hole before insertion of the sampler and that does not disturb the soil to be sampled. However, in no case shall a bottom-discharge bit be permitted. Side-discharge bits are permissible.

4.2 *Drive Weight Assembly*—Any drive weight assembly that will provide penetration in the range from 1 to 20 blows per foot (65 blows per metre) may be used. Whenever possible, soils are to be sampled by pushing instead of driving (see Section 5).

4.3 *Ring-Lined Barrel Sampling Assembly*—This shall consist of a shoe, sampler, and waste barrel, as shown in Fig. 1.

4.4 *Ring-Lined Sampler*—Test specimens shall be obtained using a suitable one piece or split sampling barrel lined on the inside with removable rings. These rings shall be thin-walled and shall conform to the size requirements of the particular laboratory test determinations employed. They shall fit snugly inside the sampler with no discernible free play in any direction. The sampler may be sectionalized to allow end-to-end make up of sections as necessary. Each section shall be designed so that addition or removal of sections will not loosen, permit movement, or otherwise adversely affect retention of the rings within the sampler. The sampler and rings shall be free of bumps, dents, scratches, rust, dirt, and corrosion.

NOTE 1—It is recommended that the sampler contain at least six rings in order to provide samples for a variety of tests.

4.5 *Waste Barrel*—A waste barrel that can be removed from the sampler in the field shall be provided to contain space for disturbed soil originally at the bottom of the hole. The length of the waste barrel shall be at least three times its interior diameter, and the inside diameter shall be the same, or slightly larger than, the inside diameter of the rings.

4.5.1 An attachment, check valve, and one or more vents is required. The design of these items is optional.

4.6 *Shoe*—The shoe shall be machined as shown in Fig. 1. The inside of the assembled shoe and ring-lined sampler shall be smooth, straight, and uniform. The thin-walled extension of the shoe shall be 2 to 4 in. (51 to 102 mm) in outside diameter and made of any materials of adequate strength and resistance to corrosion. The length of the thin-walled extension shall be equal to three times the diameter of its opening, but shall not exceed 8 in. (203 mm). The inside clearance ratio shall be between 0.5 and 3.0 %. (See Fig. 1 for inside clearance ratio formula.) The wall thickness of the thin-walled extension shall conform to Table 1.

4.6.1 The thin-walled extension of the shoe shall be perfectly round. Shoes that have become out-of-round for any reason shall not be used. If the thin-walled extension of the shoe deforms during sampling, the sample obtained shall not be used for tests, such as shear strength, where soil disturbance is a factor.

NOTE 2—The thin-walled extension of the shoe is not suitable for stiff or gravelly soils. In cases such as these, a shoe similar to the type specified

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

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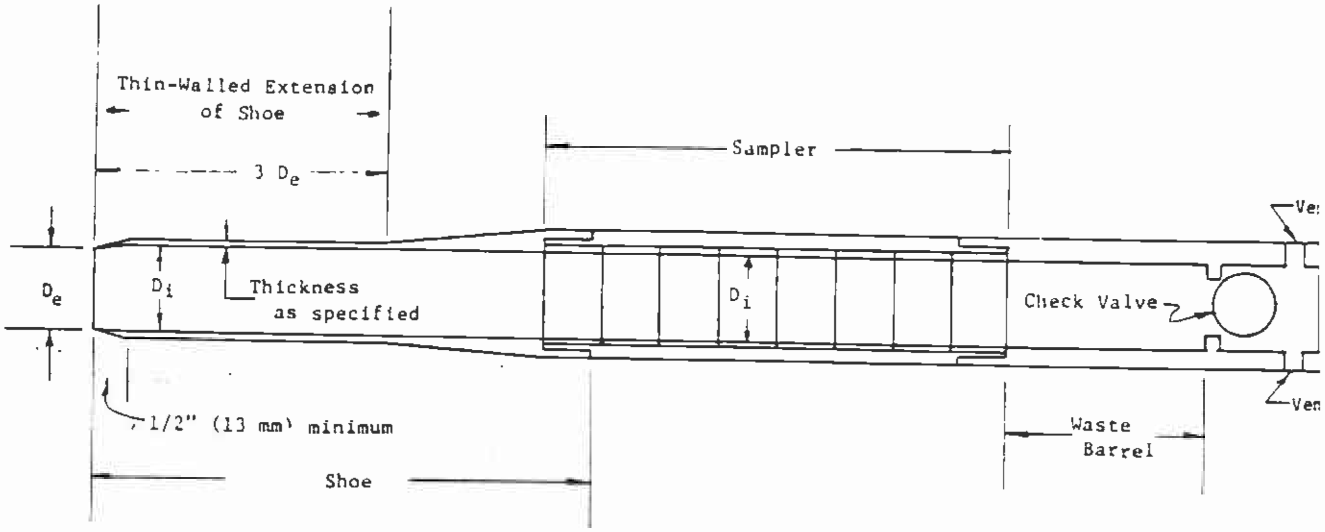
[2] *Annual Book of ASTM Standards*, Vol 04.08.



NOTE 1—Inside clearance ratio = $(D_i - D_e)/D_e$

NOTE 2—Dimensional tolerance of D_i = ±0.003 in. (±0.08 mm)

FIG. 1 Ring-Lined Barrel Sampling Assembly

in Method D 1586 is required for penetration. The use of this type of shoe, however, may result in excessive disturbance of the soil so that it is no longer suitable for shear or consolidation determinations, or both.

4.7 *Sample Extractor*—Specimen-filled rings shall be removed from the sampler by pressing them out or alternatively by the use of a split barrel. The extractor disk shall be at least 0.5 in. (13 mm) thick and shall bear solidly against the sample rings at all points. It shall slide easily inside the sampler barrel without jamming and without free play.

4.8 *Containers for Specimen-Filled Rings*—These shall be snug fitting, tightly sealed (watertight), rigid containers that will not permit movement of the specimen-filled rings inside. They shall be noncorrosive.

4.9 *Miscellaneous Equipment*—This includes a pipe vise, pipe wrenches, spatulas, cleaning brushes, buckets, rags, data sheets, transporting boxes, etc. Water must be available for cleaning the equipment.

5. Procedure

5.1 Clean the hole to sampling elevation using whatever method is preferred that will ensure that the material to be sampled is not disturbed. In saturated sands and silts, withdraw the drill bit slowly to prevent loosening of the soil around the hole. When casing is used, it shall not be driven below sampling elevation. Water or drilling liquid within the boring must be maintained at all times at or above the natural ground water level; it is preferable to keep the hole filled.

5.2 Keep a careful record of drill penetration and sampler depth to ensure that the soil being sampled is the original soil at the bottom of the hole and is not contaminated by soil falling down from the sides of the hole. If there is any significant tendency for soil to fall from the sides of the hole to the bottom, use water, drilling mud, or casing, as necessary, in order to prevent this from happening. The process of jetting through an open-tube sampler and then sampling when the desired depth is reached shall not be permitted. The use of bottom-discharge bits shall not be allowed.

5.3 Assemble the sampling assembly and lower it carefully into the hole. With the cutting edge of the shoe resting bottom of the hole and the water level in the boring ground water level or above, push the sampling assemb the soil by a continuous and rapid motion without im twisting. Push the assembly in far enough so that all cu sludge, and soil disturbed by drilling are in the waste however, in no case push the assembly farther than th length of the shoe, sampler, and waste barrel. Take ca none of the sample is lost due to improper operation check valve.

5.4 When the soils are so hard that they cannot be trated by pushing, using generally acceptable field proce and where recovery by pushing in sands is poor, use a d hammer to drive the sampling assembly. In such a record the hammer weight, height of drop, and num blows.

5.5 Carefully disassemble the sampling assembly in s manner as to minimize soil disturbance as much as pos Trim the soil flush with the ends of the sampling barrel. remove the specimen (consisting of soil plus rings). Sli container over the specimen-filled rings and cap both Be certain that there is no movement of the specimen- rings inside the container and that the specimen was disturbed while being removed from the barrel and plac the container. Label the container in a suitable mann the soil in the bottom end ring does not protrude from ring after removing the shoe, do not use the soil in the bo ring for tests other than soil classification and moisture tent. If the top ring or rings contain voids, depression any material other than the soil which is being sampled not use the soil in this ring (or rings) for any purpose w soever. The filling of depressions in the end rings with a tional soil shall not be permitted. Discard samples that ap to be disturbed or questionable.

5.6 Examine the soil remaining in the shoe for struct consistency, color, and condition. Record these observat and include them in the report (see 6.1.8).

NOTE 3—The soil remaining in the shoe is relatively undisturbed therefore may be suitable for a variety of laboratory tests.

Data obtained in each boring shall be recorded in the nd shall contain the following:

1 Name and location of job,

2 Date of boring and times of start and finish,

3 Boring number and location,

4 Surface elevation, if available,

5 Sample number and depth,

6 Method of advancing sampler, penetration, and re- engths,

7 Description and size of sampler,

8 Description of soil (see Practice D 2488),

9 Thickness of layer,

6.1.10 Depth to water table or depth of overlying water and time of reading,

6.1.11 Size of casing, depth of cased hole,

6.1.12 Type of drilling equipment—description,

6.1.13 Names of personnel: crewman, field engineer, technician, etc.,

6.1.14 Weather conditions, and

6.1.15 General remarks.

7. Precision and Bias

7.1 This practice does not produce numerical or repeatable data and therefore a precision and bias statement is not applicable.

Designation: D 2113 – 83 (Reapproved 1987)

Standard Practice for Diamond Core Drilling for Site Investigation[1]

This standard is issued under the fixed designation D 2113; 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.

1. Scope

1.1 This practice describes equipment and procedures for diamond core drilling to secure core samples of rock and some soils that are too hard to sample by soil-sampling methods. This method is described in the context of obtaining data for foundation design and geotechnical engineering purposes rather than for mineral and mining exploration.

2. Referenced Documents

2.1 *ASTM Standards:*

D 1586 Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 3550 Practice for Ring-Lined Barrel Sampling of Soils[2]

3. Significance and Use

3.1 This practice is used to obtain core specimens of superior quality that reflect the in-situ conditions of the material and structure and which are suitable for standard physical-properties tests and structural-integrity determination.

4. Apparatus

4.1 *Drilling Machine*, capable of providing rotation, feed, and retraction by hydraulic or mechanical means to the drill rods.

4.2 *Fluid Pump or Air Compressor*, capable of delivering sufficient volume and pressure for the diameter and depth of hole to be drilled.

4.3 *Core barrels*, as required:

4.3.1 *Single Tube Type, WG Design*, consisting of a hollow steel tube, with a head at one end threaded for drill rod, and a threaded connection for a reaming shell and core bit at the other end. A core lifter, or retainer located within the core bit is normal, but may be omitted at the discretion of the geologist or engineer.

4.3.2 *Double Tube, Swivel-Type, WG Design*—An assembly of two concentric steel tubes joined and supported at the upper end by means of a ball or roller-bearing swivel arranged to permit rotation of the outer tube without causing rotation of the inner tube. The upper end of the outer tube, or removable head, is threaded for drill rod. A threaded connection is provided on the lower end of the outer tube for a reaming shell and core bit. A core lifter located within the core bit is normal but may be omitted at the discretion of the geologist or engineer.

4.3.3 *Double-Tube, Swivel-Type, WT Design*, is essentially the same as the double tube, swivel-type, WG design, except that the WT design has thinner tube walls, a reduced annular area between the tubes, and takes a larger core from the same diameter bore hole. The core lifter is located within the core bit.

4.3.4 *Double Tube, Swivel Type, WM Design*, is similar to the double tube, swivel-type, WG design, except that the inner tube is threaded at its lower end to receive a core lifter case that effectively extends the inner tube well into the core bit, thus minimizing exposure of the core to the drilling fluid. A core lifter is contained within the core lifter case on the inner tube.

4.3.5 *Double Tube Swivel-Type, Large-Diameter Design*, is similar to the double tube, swivel-type, WM design, with the addition of a ball valve, to control fluid flow, in all three available sizes and the addition of a sludge barrel, to catch heavy cuttings, on the two larger sizes. The large-diameter design double tube, swivel-type, core barrels are available in three core per hole sizes as follows: 2¾ in. (69.85 mm) by 3⅞ in. (98.43 mm), 4 in. (101.6 mm) by 5½ in. (139.7 mm), and 6 in. (152.4 mm) by 7¾ in. (196.85 mm). Their use is generally reserved for very detailed investigative work or where other methods do not yield adequate recovery.

4.3.6 *Double Tube, Swivel-Type, Retrievable Inner-Tube Method*, in which the core-laden inner-tube assembly is retrieved to the surface and an empty inner-tube assembly returned to the face of the borehole through the matching, large-bore drill rods without need for withdrawal and replacement of the drill rods in the borehole. The inner-tube assembly consists of an inner tube with removable core lifter case and core lifter at one end and a removable inner-tube head, swivel bearing, suspension adjustment, and latching device with release mechanism on the opposite end. The inner-tube latching device locks into a complementary recess in the wall of the outer tube such that the outer tube may be rotated without causing rotation of the inner tube and such that the latch may be actuated and the inner-tube assembly transported by appropriate surface control. The outer tube is threaded for the matching, large-bore drill rod and internally configured to receive the inner-tube latching device at one end and threaded for a reaming shell and bit, or bit only, at the other end.

4.4 *Longitudinally Split Inner Tubes*—As opposed to conventional cylindrical inner tubes, allow inspection of, and access to, the core by simply removing one of the two halves. They are not standardized but are available for most core barrels including many of the retrievable inner-tube types.

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

Current edition approved June 24, 1983. Published August 1983. Originally published as D 2113 – 62 T. Last previous edition D 2113 – 70 (1976).

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

4.5 *Core Bits*—Core bits shall be surface set with diamonds, impregnated with small diamond particles, inserted with tungsten carbide slugs, or strips, hard-faced with various hard surfacing materials or furnished in saw-tooth form, all as appropriate to the formation being cored and with concurrence of the geologist or engineer. Bit matrix material, crown shape, water-way type, location and number of water ways, diamond size and carat weight, and bit facing materials shall be for general purpose use unless otherwise approved by the geologist or engineer. Nominal size of some bits is shown in Table 1.

NOTE 1—Size designation (letter symbols) used throughout the text and in Tables 1, 2, and 3 are those standardized by the Diamond Core Drill Manufacturers' Assoc. (DCDMA). Inch dimensions in the tables have been rounded to the nearest hundredth of an inch.

4.6 *Reaming Shells,* shall be surface set with diamonds, impregnated with small diamond particles, inserted with tungsten carbide strips or slugs, hard faced with various types of hard surfacing materials, or furnished blank, all as appropriate to the formation being cored.

4.7 *Core Lifters*—Core lifters of the split-ring type, either plain or hard-faced, shall be furnished and maintained, along with core-lifter cases or inner-tube extensions or inner-tube shoes, in good condition. Basket or finger-type lifters, together with any necessary adapters, shall be on the job and available for use with each core barrel if so directed by the geologist or engineer.

4.8 *Casings:*

4.8.1 *Drive Pipe or Drive Casing,* shall be standard weight (schedule 40), extra-heavy (schedule 80), double extra-heavy (schedule 160) pipe or W-design flush-joint casing as required by the nature of the overburden or the placement method. Drive pipe or W-design casing shall be of sufficient diameter to pass the largest core barrel to be used, and it shall be driven to bed rock or to firm seating at an elevation below water-sensitive formation. A hardened drive shoe is to be used as a cutting edge and thread protection device on the bottom of the drive pipe or casing. The drive shoe inside diameter shall be large enough to pass the tools intended for use, and the shoe and pipe or casing shall be free from burrs or obstructions.

4.8.2 *Casing*—When necessary to case through formations already penetrated by the borehole or when no drive casing has been set, auxiliary casing shall be provided to fit inside the borehole to allow use of the next smaller core barrel. Standard sizes of telescoping casing are shown in Table 2. Casing bits have an obstruction in their interior and will not pass the next smaller casing size. Use a casing shoe if additional telescoping is anticipated.

4.8.3 *Casing Liner*—Plastic pipe or sheet-metal pipe may be used to line an existing large-diameter casing. Liners, so used, should not be driven, and care should be taken to maintain true alignment throughout the length of the liner.

4.8.4 *Hollow Stem Auger*—Hollow stem auger may be used as casing for coring.

4.9 *Drill Rods:*

4.9.1 *Drill Rods of Tubular Steel Construction* are normally used to transmit feed, rotation, and retraction forces from the drilling machine to the core barrel. Drill-rod sizes that are presently standardized are shown in Table 3.

4.9.2 Large bore drill rods used with retrievable inner-tube core barrels are not standardized. Drill rods used with retrievable inner-tube core barrels should be those manufactured by the core-barrel manufacturer specifically for the core barrel.

4.9.3 *Composite Drill Rods* are specifically constructed from two or more materials intended to provide specific properties such as light weight or electrical nonconductivity.

4.9.4 *Nonmagnetic Drill Rods* are manufactured of nonferrous materials such as aluminum or brass and are used primarily for hole survey work. Some nonmagnetic rods have left-hand threads in order to further their value in survey work. No standard exists for nonmagnetic rods.

4.10 *Auxiliary Equipment,* shall be furnished as required by the work and shall include: roller rock bits, drag bits, chopping bits, boulder busters, fishtail bits, pipe wrenches, core barrel wrenches, lubrication equipment, core boxes, and marking devices. Other recommended equipment includes:

TABLE 1 Core Bit Sizes

Size Designation	Outside Diameter		Inside Diameter	
	in.	mm	in.	mm
RWT	1.16	29.5	0.375	18.7
EWT	1.47	37.3	0.905	22.9
EWG, EWM	1.47	37.3	0.845	21.4
AWT	1.88	47.6	1.281	32.5
AWG, AWM	1.88	47.6	1.185	30.0
BWT	2.35	59.5	1.750	44.5
BWG, BWM	2.35	59.5	1.655	42.0
NWT	2.97	75.3	2.313	58.7
NWG, NWM	2.97	75.3	2.155	54.7
2¾ × 3⅞	3.84	97.5	2.69	68.3
HWT	3.89	98.8	3.187	80.9
HWG, . . .	3.89	98.8	3.000	76.2
4 × 5½	5.44	138.0	3.97	100.8
6 × 7¾	7.66	194.4	5.97	151.6

TABLE 2 Casing Sizes

Size Designation	Outside Diameter		Inside Diameter		Threads per in.	Will Fit Hole Drilled with Core Bit Size
	in.	mm	in.	mm		
RW	1.144	36.5	1.19	30.1	5	EWT, EWG, EWM
EW	1.81	46.0	1.50	38.1	4	AWT, AWG, AWM
AW	2.25	57.1	1.91	48.4	4	BWT, BWG, BWM
BW	2.88	73.0	2.38	60.3	4	NWT, NWG, NWM
NW	3.50	88.9	3.00	76.2	4	HWT, HWG
HW	4.50	114.3	4.00	101.6	4	4 × 5½
PW	5.50	139.7	5.00	127 0	3	6 × 7¾
SW	6.63	168.2	6.00	152.4	3	6 × 7¾
UW	7.63	193.6	7.00	177.8	2	. . .
ZW	8.63	219.0	8.00	203.2	2	. . .

TABLE 3 Drill Rods

Size Designation	Rod and Coupling Outside Diameter		Rod Inside Diameter		Coupling Bore, Threads		
	in.	mm	in.	mm	in.	mm	per in.
RW	1.09	27.7	0.72	18.2	0.41	10.3	4
EW	1.38	34.9	1.00	25.4	0.44	11.1	3
AW	1.72	43.6	1.34	34.1	0.63	15.8	3
BW	2.13	53.9	1.75	44.4	0.75	19.0	3
NW	2.63	66 6	2.25	57.1	1.38	34.9	3
HW	3.50	88.9	3.06	77.7	2.38	60.3	3

core splitter, rod wicking, pump-out tools or extruders, and hand sieve or strainer.

5. Transportation and Storage of Core Containers

5.1 *Core Boxes.* shall be constructed of wood or other durable material for the protection and storage of cores while enroute from the drill site to the laboratory or other processing point. All core boxes shall be provided with longitudinal separators and recovered cores shall be laid out as a book would read, from left to right and top to bottom, within the longitudinal separators. Spacer blocks or plugs shall be marked and inserted into the core column within the separators to indicate the beginning of each coring run. The beginning point of storage in each core box is the upper left-hand corner. The upper left-hand corner of a hinged core box is the left corner when the hinge is on the far side of the box and the box is right-side up. All hinged core boxes must be permanently marked on the outside to indicate the top and the bottom. All other core boxes must be permanently marked on the outside to indicate the top and the bottom and additionally, must be permanently marked internally to indicate the upper-left corner of the bottom with the letters UL or a splotch of red paint not less than 1 in.[2] Lid or cover fitting(s) for core boxes must be of such quality as to ensure against mix up of the core in the event of impact or upsetting of the core box during transportation.

5.2 Transportation of cores from the drill site to the laboratory or other processing point shall be in durable core boxes so padded or suspended as to be isolated from shock or impact transmitted to the transporter by rough terrain or careless operation.

5.3 Storage of cores, after initial testing or inspection at the laboratory or other processing point, may be in cardboard or similar less costly boxes provided all layout and marking requirements as specified in 5.1 are followed. Additional spacer blocks or plugs shall be added if necessary at time of storage to explain missing core. Cores shall be stored for a period of time specified by the engineer but should not normally be discarded prior to completion of the project for which they were taken.

6. Procedure

6.1 Use core-drilling procedures when formations are encountered that are too hard to be sampled by soil-sampling methods. A 1-in. (25.4-mm) or less penetration for 50 blows in accordance with Method D 1586 or other criteria established by the geologist or engineer, shall indicate that soil-sampling methods are not applicable.

6.1.1 Seat the casing on bedrock or in a firm formation to prevent raveling of the borehole and to prevent loss of drilling fluid. Level the surface of the rock or hard formation at the bottom of the casing when necessary, using the appropriate bits. Casing may be omitted if the borehole will stand open without the casing.

6.1.2 Begin the core drilling using an N-size double-tube swivel-type core barrel or other size or type approved by the engineer. Continue core drilling until core blockage occurs or until the net length of the core barrel has been drilled in. Remove the core barrel from the hole and disassemble it as necessary to remove the core. Reassemble the core barrel and return it to the hole. Resume coring.

6.1.3 Place the recovered core in the core box with the upper (surface) end of the core at the upper-left corner of the core box as described in 5.1. Continue boxing core with appropriate markings, spacers, and blocks as described in 5.1. Wrap soft or friable cores or those which change materially upon drying in plastic film or seal in wax, or both, when such treatment is required by the engineer. Use spacer blocks or slugs properly marked to indicate any noticeable gap in recovered core which might indicate a change or void in the formation. Fit fracture, bedded, or jointed pieces of core together as they naturally occurred.

6.1.4 Stop the core drilling when soft materials are encountered that produce less than 50 % recovery. If necessary, secure samples of soft materials in accordance with the procedures described in Method D 1586, Practice D 1587, or Practice D 3550, or by any other method acceptable to the geologist or engineer. Resume diamond core drilling when refusal materials as described in 6.1 are again encountered.

6.2 Subsurface structure, including the dip of strata, the occurrence of seams, fissures, cavities, and broken areas are among the most important items to be detected and described. Take special care to obtain and record information about these features. If conditions prevent the continued advance of the core drilling, the hole should be cemented and redrilled, or reamed and cased, or cased and advanced with the next smaller-size core barrel, as required by the geologist or engineer.

6.3 Drilling mud or grouting techniques must be approved by the geologist or engineer prior to their use in the borehole.

6.4 *Compatibility of Equipment:*

6.4.1 Whenever possible, core barrels and drill rods should be selected from the same letter-size designation to ensure maximum efficiency. See Tables 1 and 3.

6.4.2 Never use a combination of pump, drill rod, and core barrel that yields a clear-water up-hole velocity of less than 120 ft/min.

6.4.3 Never use a combination of air compressor, drill rod, and core barrel that yields a clear-air up-hole velocity of less than 3000 ft/min.

7. Boring Log

7.1 The boring log shall include the following:

7.1.1 Project identification, boring number, location, date boring began, date boring completed, and driller's name.

7.1.2 Elevation of the ground surface.

7.1.3 Elevation of or depth to ground water and raising or lowering of level including the dates and the times measured.

7.1.4 Elevations or depths at which drilling fluid return was lost.

7.1.5 Size, type, and design of core barrel used. Size, type, and set of core bit and reaming shell used. Size, type, and length of all casing used. Description of any movements of the casing.

7.1.6 Length of each core run and the length or percentage, or both, of the core recovered.

7.1.7 Geologist's or engineer's description of the formation recovered in each run.

7.1.8 Driller's description, if no engineer or geologist is present, of the formation recovered in each run.

7.1.9 Subsurface structure description, including dip of strata and jointing, cavities, fissures, and any other observations made by the geologist or engineer that could yield information regarding the formation.

7.1.10 Depth, thickness, and apparent nature of the filling of each cavity or soft seam encountered, including opinions gained from the feel or appearance of the inside of the inner tube when core is lost. Record opinions as such.

7.1.11 Any change in the character of the drilling fluid or drilling fluid return.

7.1.12 Tidal and current information when the borehole is sufficiently close to a body of water to be affected.

7.1.13 Drilling time in minutes per foot and bit pressure in pound-force per square inch gage when applicable.

7.1.14 Notations of character of drilling, that is, soft, slow, easy, smooth, etc.

8. Precision and Bias

8.1 This practice does not produce numerical data: therefore, a precision and bias statement is not applicable.

NOTE 2—Inclusion of the following tables and use of letter symbols in the foregoing text is not intended to limit the practice to use of DCDMA tools. The table and text references are included as a convenience to the user since the vast majority of tools in use do meet DCDMA dimensional standards. Similar equipment of approximately equal size on the metric standard system is acceptable unless otherwise stipulated by the engineer or geologist.

APPENDIX D

EXCAVATION PERMIT

USE TYPEWRITER OR BALL POINT PEN — PRESS FIRMLY — PRINT ONLY

DISTRIBUTION: 1. WHITE—ISSUING OFFICE 2. GREEN—PERMITTEE 3. WHITE—CONTRACT ADMIN. 4. BLUE—ACCOUNTING 5. YELLOW—STREET MAINTENANCE

ENG. 3.652 (Rev. 3-82)
City of Los Angeles
DEPT. OF PUBLIC WORKS
Bureau of Engineering

APPLICATION/PERMIT FOR EXCAVATIONS

SEE REVERSE SIDE FOR SPECIAL REQUIREMENTS

IN OR ADJACENT TO PUBLIC STREETS
UNDER CHAPTER 6, ARTICLE 2, LOS ANGELES MUNICIPAL CODE

THIS PERMIT NOT VALID UNLESS REGISTER VALIDATED OR RECEIPT SHOWN

JOB ADDRESS: HOLLYWOOD BLVD.; VERMONT AVE. & OTHER LOCATIONS	RECEIPT NO. 9/15/88 A V 25.00 53; 9/15/88 A V 1.00; CH... ; 9/15/88 731 CH 26.00
PROPERTY OWNER/CONTRACTOR/AGENT FOR: THE EARTH TECHNOLOGY CORP	
MAIL ADDRESS: 3777 LONG BEACH BLVD.	
CITY OR TOWN: LONG BEACH, CA	
ZIP CODE: 90807-3309 / TELEPHONE: (213) 595-6611	
PURPOSE OF EXCAVATION: SOIL BORING (22-HOLES)	STATE O.I.S. PERMIT NO.
WORK ORDER NO: 10002064 / LIAB. INS. C.A. NO.: 012729 / INSURANCE EXPIRES: 10/1/88	
"A" PERMIT NO.: 8851-1184 / SURETY BOND C.A. NO.: / MISC. RECEIPT NO.: 51618	
ARE STREETS NOW BEING IMPROVED? ☐ YES ☑ NO / WAIVER REC. NO.: / MISC. CASH BOND NO.: 21364	
PLAT FILED? ☑ YES ☐ NO / REPORT NO.:	

EXCAVATION SIZE AND TYPE

Item	At $	Lin. Ft.	$
CONC. CURB			
CONC. WALK			
CONC. GUTTER			
PAVEMENT			
DIRT	MINIMUM FEE		25.00
ROCK & OIL			
TOTAL SPECIAL DEPOSIT			
SPECIAL INSPECTION — HOURS / AT / PER HOUR / DAY: TIME CHARGE TO W.O. 1000206			W.O.
TESTING — RELATIVE COMPACTION ___ AT ___ EA.			
STANDARD DENSITY ___ AT ___ EA.			
PLAN CHECK			
TOTAL SPEC. INSP., etc.			
TOTAL AMOUNT — SURCHARGE			1.00
TOTAL AMT.			$ 26.00

NOTICE TO PERMITTEE

PERMIT MUST BE ON JOB AT ALL TIMES.

THIS PERMIT EXPIRES 6 MONTHS FROM ISSUANCE UNLESS WORK HAS COMMENCED LAMC 62.02.

KEEP SIDEWALKS AND GUTTERS CLEAR.

NOTIFY FIRE AND POLICE DEPT. 48 HOURS BEFORE STARTING WORK.

INSPECTION IS REQUIRED

See instructions 8 and 9 on back

I hereby agree to observe all requirements of the Municipal Code of the City of Los Angeles, all amendments thereto, and any special requirements made part of this permit.

x Charles K. Duckworth

PRINT NAME: CHARLES K. DUCKWORTH

JOB ADDRESS: HOLLYWOOD BLVD.; VERMONT AVE. & OTHER LOCATIONS

BY ______ BUREAU OF ENGINEERING ______ DATE

STREETS AFFECTED: HOLLYWOOD BLVD.; VERMONT AVE. NEW HAMPSHIRE; VINE & ETC

SPECIAL INSPECTION NO. E 8

SPECIAL DEPOSIT PERMIT NO. E 8851-0180

ENG. 3.668 (R. 2-80)
City of Los Angeles
Dept. of Public Works
Bureau of Engineering

CLASS "A" APPLICATION/PERMIT

CONT. AD.
INSPECTOR COPY

For the Construction of Curbs, Driveways, Sidewalks and other Structures in Public Streets

APPLICANT/PERMITTEE: THE EARTH TECHNOLOGY CORPORATION

ADDRESS: 3777 LONG BEACH BLVD.

CITY: LONG BEACH, CA ZIP CODE: 90807-3307 TELEPHONE: (213) 595-6611

I hereby agree to observe all requirements of the Municipal Code of the City of Los Angeles, all amendments thereto, and any special requirements made a part of this permit.

X [signature] Date 9-15-88

RECEIPT NUMBER

9/15/88 A FA 35.00
9/15/88 A V 1.00 33
CH 88511184 ACCT#
9/15/88 730 CHI 36.00-

NOTE: Dimensions may be obtained from City Records—Plan No.

WRITTEN BY: VIC S. LIMBO VALIDATION TIME: 9/15/88

	FRONTAGE STREET		INTERSECTING STREET	
Curb face to front edge of walk	FT.	IN.	FT.	IN.
Width of sidewalk	FT.	IN.	FT.	IN.
Back edge of walk to property line	FT.	IN.	FT.	IN.
Curb face to property line	FT.	IN.	FT.	IN.
Height of Curb face (Subject to field check)		IN.		IN.

JOB ADDRESS: HOLLYWOOD BLVD., VERMONT AVE.; VINE & OTHER LOCATION LOCATOR CODE: PERMIT NUMBER: A-8851-1184

WORK DESCRIPTION OR REMARKS: PERMANENT RESURFACING IN ACCORDANCE WITH THE LATESTS EDITIONS OF STANDARD SPECS FOR PUBLIC WORKS CONST.; SUPPLEMENTS, ADDENDUM, AND STD. PLAN S-610
REFERENCE: SDEP E-8851-0180
TIME CHARGE TO W.O. 1000206

STD. PLAN NUMBER		ITEM	QUANTITY	UNIT	RATE	FEE
		CONC. CURB		LIN. FT.		$
DRIVEWAYS		CONC. GUTTER		SQ. FT.		
Case No.		CONC. DRIVEWAY		SQ. FT.		
W =		CONC. SIDEWALK		SQ. FT.		
Y =						
X =				MINIMUM FEE		35.00
a =				MIN. SURCHARGE		$1.00
t =		SKETCH ATTACHED		TOTAL FEE		$ 36.00

JOB ADDRESS: HOLLYWOOD BLVD. VERMONT AVE. & OTHER LOCATION LOCATOR CODE: PERMIT NUMBER: A-8851-1184