THIS IS ONE VOLUME OF A SIX VOLUME SET WHICH INCLUDES:

VOLUME I: FIELD OPERATIONS (FO)
VOLUME II: GROUNDWATER (GW)
VOLUME III: GEOTECHNICAL (GT)
VOLUME IV: SURFACE WATER (SW)
VOLUME V: ECOLOGY (EE)
VOLUME VI: AIR (AP)

TABLE OF CONTENTS
FOR VOLUME III: GEOTECHNICAL

Proc. No.	Title	Rev. No.	Effective Date
DCN 91.04	Depth of casing emplacement	1	12/17/91
DCN 91.05	Addition of Grout Ports	1	12/19/91
GT.04	Rotary Drilling and Rock Coring	1	08/30/91
DCN 91.01	Core barrel decontamination	1	10/22/91
DCN 91.02	Clarification of measuring tape decontamination requirements	1	10/29/91
DCN 91.03	Superseded by DCN 91.04	1	12/03/91
DCN 91.04	Clarification of the use of super gel-x	1	12/17/91
GT.05	Plugging and Abandonment of Boreholes	1	08/30/91
DCN 91.01	Surface casing classification	1	10/22/91
GT.06	Monitoring Wells and Piezometer Installation	1	08/30/91
DCN 91.01	Industry Standard is 1 foot into Bedrock	1	10/15/91
DCN 91.02	For the Sitewide Program, Claystone Smearing does not seem to be a problem	1	10/15/91
DCN 91.03	Superseded by DCN 91.06	1	11/08/91
DCN 91.04	Low Alluvial thickness wells	1	11/06/91
DCN 91.05	Superseded by DCN 91.08	1	11/06/91
DCN 91.06	Change in filter pack guidance	1	11/08/91
DCN 91.07	Decontamination for site-wide geological chracterization	1	11/15/91
DCN 91.08	Figure replacement (GT.6-1)	1	11/15/91
DCN 91.09	Sampling with center bit drilling	1	12/03/91

CONE PENETROMETER TESTING

EG&G ROCKY FLATS PLANT	**Manual:**	**5-21000-OPS**
EMD MANUAL OPERATION SOP	**Procedure No.:**	**GT.21, Rev. 0**
	Page:	**1 of 13**
	Effective Date:	**December 20, 1991**
Category 2	**Organization:**	**Environmental Management**

TITLE:
CONE PENETROMETER
TESTING

Approved By:

(Name of Approver)

1.0 TABLE OF CONTENTS

LIST OF FIGURES

2.0 PURPOSE AND SCOPE

This standard operating procedure (SOP) describes procedures that will be used at the Rocky Flats Plant (RFP) to conduct cone penetrometer testing (CPT). This SOP describes personnel responsibilities and qualifications, testing equipment and procedures, and documentation requirements.

3.0 RESPONSIBILITIES AND QUALIFICATIONS

All personnel performing these procedures are required to have the appropriate health and safety training as specified in the site-specific Health and Safety Plan. In addition, all personnel are required to have a complete understanding of the procedures described within this SOP and receive specific training regarding these procedures before CPT begins.

Personnel performing CPT must be highly trained individuals who understand the test characteristics and geology in which they are testing. Field managers will have had previous field experience performing CPT.

4.0 REFERENCES

4.1 SOURCE REFERENCES

The following is a list of references reviewed prior to the writing of this procedure:

A Compendium of Superfund Field Operations Methods. EPA/540/P-87/001. December 1987.

Guidelines For Cone Penetration Test. U. S. Department of Transportation. July 1978.

Meigh, A. C. Cone Penetration Testing (Methods and Interpretation) . Construction Industry Research and Information Association (CIRIA). 1987.

Penetration Testing. Institution of Civil Engineers. 1989.

Robertson, P. K. and Campanella, R. G. Guidelines For Use & Interpretation of the Electric Cone Penetration Test. Hogentogler & Company, Inc. September 1984.

4.2 INTERNAL REFERENCES

Related SOPs cross-referenced by this SOP are as follows:

- SOP FO.3, General Equipment Decontamination
- SOP FO.4, Heavy Equipment Decontamination.
- SOP FO.15, Photoionization Detectors (PIDs) and Flame Ionization Detectors (FIDs)
- SOP GT.17, Land Surveying
- SOP GT.22, In-Situ Sampling with BAT System

5.0 TESTING PROCEDURES

5.1 GENERAL

CPT provides a way to rapidly measure soil parameters such as bearing, friction, and pore pressure (if a piezometric CPT is used). Electric cone penetrometers have built-in sensors (usually strain gauges) at the tip and sides (sleeve) of the probe that measure penetration resistance and side friction of soils. Typically, tip penetration resistance and sleeve friction are different for clayey soils when compared to granular soils. This makes CPT useful for

identifying sands and gravels versus clays and silts. See Figure GT.21-1 for an example of a CPT log. Four important uses of the CPT data are:

- To identify soils and evaluate subsurface soil profiles
- To interpolate subsurface conditions between control boreholes
- To evaluate soil parameters (i.e., shear strength, etc.)
- To measure soil moisture content

A special rig is used to hydraulically push the CPT tool into the subsurface. Segments of rod are added as the probe is advanced at a constant rate of 0.6-1.0 inches (1.5-2.5 cm) per second. Continuous measurements of the penetration tip resistance and sleeve friction are recorded. These data are transferred through an electrical cable, connected to the CPT probe, to a computerized data acquisition system in the rig. Typically, data is recorded at approximately every 0.4-0.8 inches (1-2 cm) of penetration. The collected data can then be interpreted to provide information on the engineering characterization of the subsurface soils.

CPT may not be successful in soil that contains cobbles, boulders, rock, or other debris. These materials may damage the cone penetrometer (CP) probe or make it impossible for it to penetrate into the material. Sites will be evaluated for these conditions before testing begins to determine if CPT is appropriate. In addition, many projects require conventional borings to supplement CPT.

The following sections give details on equipment and procedures for CPT along with documentation requirements. During CPT, the appropriate personal protective equipment (PPE) as specified in the site-specific Health and Safety Plan will be worn at all times.

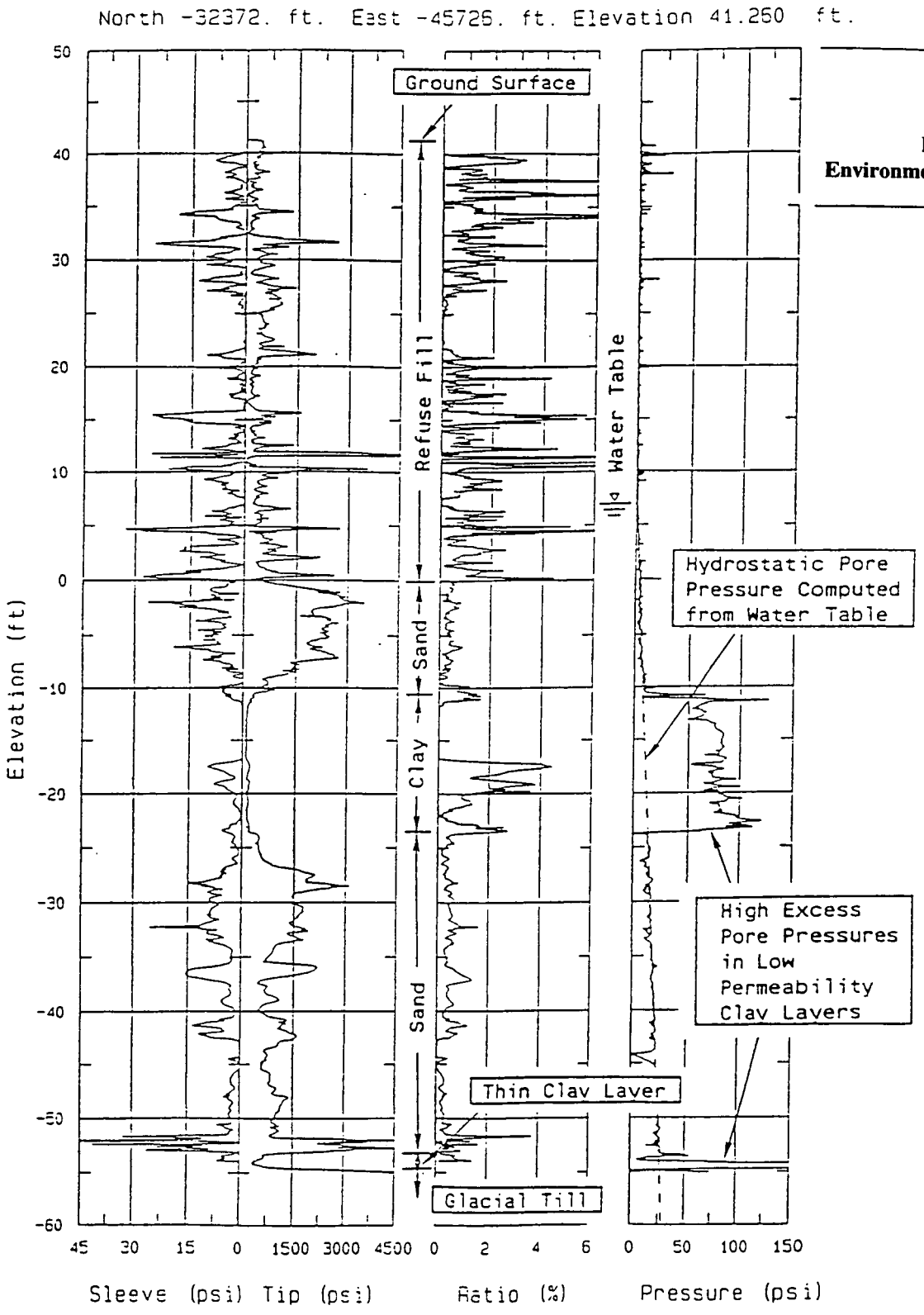


FIGURE GT.21-1 TYPICAL DATA FROM THE CONE PENETROMETER

FROM: Applied Research Associates, Inc.

5.2 EQUIPMENT

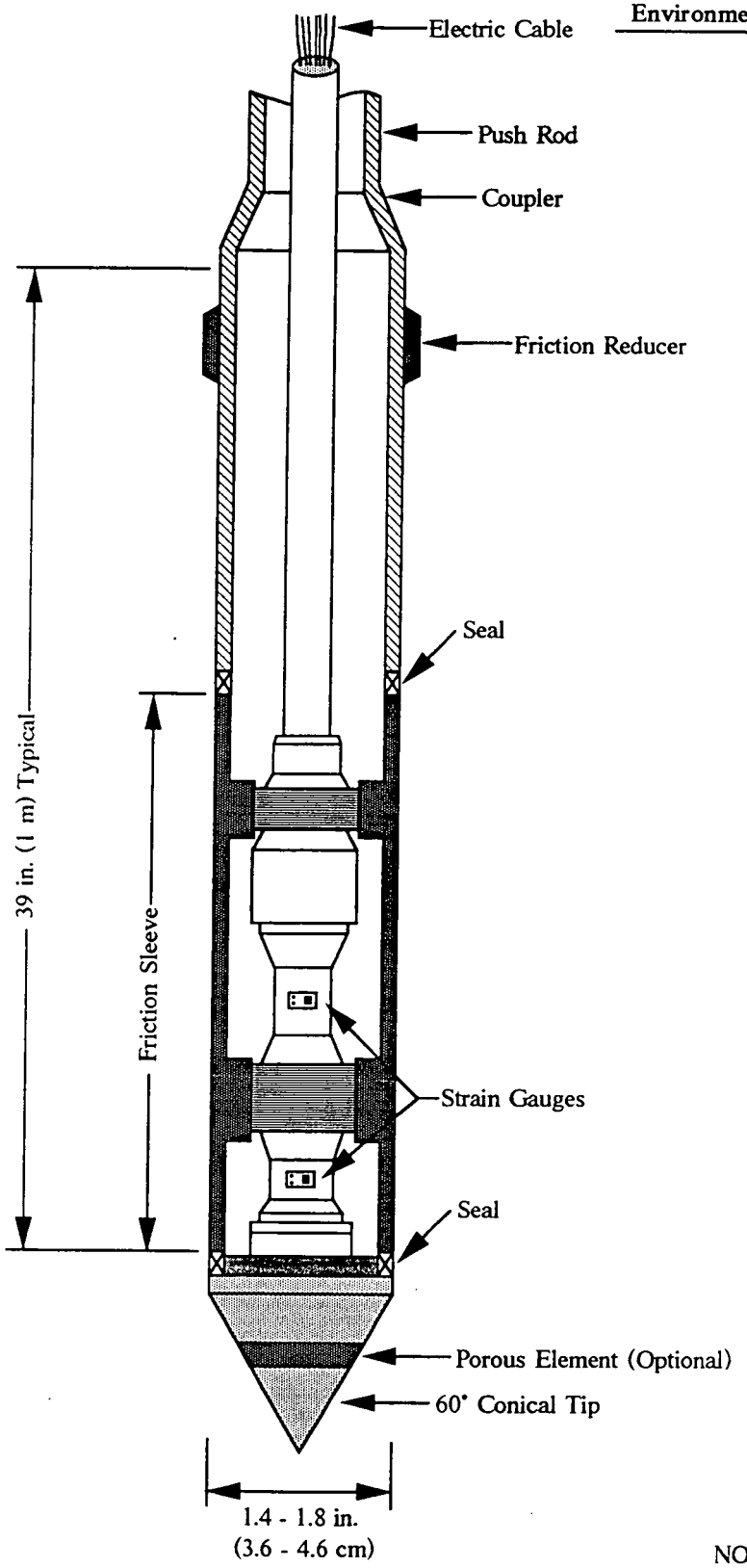
The following is a list of equipment that will be needed for cone penetrometer testing:

- Rig equipped for CPT
- CPT rods
- CPT electric probe
- High-pressure steamer/sprayer
- Long-handled bristle brushes
- Wash and rinse tubs
- Phosphate-free lab-grade detergent (e.g., Liquinox)
- Distilled water
- Plastic sheeting
- Sample locations (map and/or list)
- Appropriate health and safety equipment
- Log book

5.3 CPT PROBE AND RIG

The CPT probe is composed of a 1.4 inch-1.8 inch (3.6 cm-4.6 cm) diameter probe with a conical point. Most CP probes are 1.4 inches (3.6 cm) in diameter. Typically, electric cone penetrometers have strain gauges that measure penetration resistance and side friction of soils. The continuous data from the strain gauges is transferred electronically through a cable, connected to the probe, to a computerized data acquisition system in the CPT rig. See Figure GT.21-2 for a schematic diagram of an electric CP.

Electric Cone Penetrometer



NOT TO SCALE

Figure GT.21-2

A friction reducer or coupling is usually placed approximately 1.0 ft-3.3 ft (30 cm-100 cm) behind the cone tip (see Figure GT.21-2). The purpose of the friction reducer is to increase the hole diameter in order to reduce soil contact against the cone rods. This makes the CP easier to push into the subsurface. Typically, a 2-inch long steel tube is welded (and chamfered to 30°) over the cone rod as a friction reducer.

CPT rods used to hydraulically push the CPT probe into the subsurface are made of high-tensile steel with special tapered threads. They are usually 1.4 in (3.6 cm) outside diameter and 0.6 inches (1.6 cm) inside diameter. A standard push rod is 3.3 ft (1 m) in length. Rods smaller in diameter than the cone base may be used, but there must be a minimum length of 39 inches (1 m) of rod immediately above the cone that is the same diameter as the cone (see Figure GT.21-1).

Rigs outfitted with a hydraulic jacking system are utilized to push the cone penetrometer into the subsurface. The rigs are usually specially built, but an anchored drill rig or trailer-mounted setup can also be used. There are light, medium, and heavy rigs depending on the thrust required. This SOP addresses CPT with medium and heavy rigs. The CPT rigs are often mounted in heavy duty trucks that are ballasted to a total dead weight of approximately 15 metric tons (150 kN). Screw anchors are then utilized to develop the extra reaction to reach the maximum thrust of approximately 20 metric tons (200 kN), if needed. The rigs are usually separated into push and data acquisition workspaces.

5.4 PROCEDURE

Before testing, sites will be located, numbered, and identified using stakes (or spray paint on paved surfaces). Refer to SOP GT.17, Land Surveying, for more information regarding site location procedures.

After test sites have been located, an exclusion zone will be established according to the project Health and Safety Plan, and the CPT rig will be set up. The procedure for conducting CPT at a specific location is as follows:

1. Decontaminate the rig and downhole equipment. See SOP FO.3, General Equipment Decontamination, and SOP FO.4, Heavy Equipment Decontamination for specific details regarding decontamination.

2. Set up the rig to obtain a thrust direction as close to vertical as possible. The maximum acceptable deviation from vertical is 2%.

3. Advance the CPT probe and add CPT rods connected hand-tight as the probe advances. The electrical cable used to transfer data to the surface will be continuous, and it will be prethreaded through the push rods before the test begins.

4. Monitor the breathing zone of the CPT rig for volatile organic compounds (VOCs) during testing. See SOP FO.15, Photoionization Detectors (PIDs) and Flame Ionization Detectors (FIDs), for more information regarding the use of monitoring instruments.

5. Check the computer data acquisition system before CPT begins and also during testing to ensure that it is working properly.

6. Advance the hole at a continuous rate of 0.6-1.0 inches (1.5-2.5 cm) per second to the desired depth.

7. Record the appropriate readings/measurements at every 0.4-0.8 inches (1-2 cm) of penetration using the computer data acquisition system (Note: readings should be taken at regular intervals, and the interval between readings shall never exceed 7.9 inches or 20 cm).

8. Review and evaluate field plot(s) of tip/sleeve resistance to ensure data quality.

9. When the test is complete, pull the CPT out of the subsurface. If the rig is equipped for it, the hole will be grouted from the bottom as the rods are withdrawn.

10. If the rig is not equipped to grout up the hole, screen the open hole for volatile organic compounds (VOCs) after the CP has been pulled out of the ground. See SOP FO.15 for more information regarding the use of monitoring equipment.

11. Grout the hole up if it has not already been completed by the rig. PVC pipe may be used if the hole did not collapse. If the hole collapsed, hollow CPT rods and a sacrificial tip will be used. The PVC pipe or CPT rods will be pushed to the bottom of the hole. Grout will then be pumped to the bottom of the hole as the CPT rods or PVC pipe are withdrawn.

If CPT testing is used at landfill sites or other sites where heavy debris (i.e., concrete, wood, etc.) may be present, special care will be taken. Readings will be monitored closely as the CP is pushed into the ground in order to recognize debris. If debris is encountered, the CP will be pulled out of the ground, and the hole will be grouted up. The CP system will then be offset (See Section 5.5 for minimum offset distances), and a new site will be tested. This procedure will be repeated until the desired depth is reached.

If lubricants are required for down-hole equipment, only pure vegetable oil will be used. If gas and/or liquid samples are to be taken, the sampling procedures will be carried out according to SOP GT.22, In Situ Sampling With BAT System.

The thrust used for CPT testing is approximately 10-20 metric tons (100 kN-200 kN). In soft soils, however, a thrust as low as 2 metric tons (20 kN) may be sufficient. The test rods may buckle if a thrust of greater than 20 metric tons (200 kN) is applied. Generally, in most uncemented soils, a thrust capacity of 10 metric tons (100 kN) will handle more than 90% of CPT to 98 feet (30 m) depth.

5.5 CALIBRATION AND CHECKS

The CPT probe will be checked before a test begins and between test holes to ensure that its dimensions and surface roughness are within acceptable limits. The test system will also be calibrated as needed, and the calibration will be documented. Specifically, the load cells will be calibrated according to manufacturer specifications and industry standards at least every three months.

Before performing CPT, the straightness of the push rods will be checked. The bottom five push rods will be particularly checked by rotating them to see if they wobble. If a wobble is noticeable, the push rod(s) will not be used.

CPT will not be performed within 3.3 ft (1 m) of an existing CPT site. In addition, CPT will not be performed within 10 ft (3 m) of an uncased or unfilled borehole.

6.0 DECONTAMINATION

All equipment including the rig, probe, rods, etc. will be decontaminated before arrival at the work site. Between test holes, all down-hole equipment will be decontaminated. Decontaminated equipment will be placed on new plastic or racks until it is used. CPT rigs will be decontaminated when moved out of a work area or when they become unusually dirty as a result of site or testing conditions, at the discretion of the site or project manager. See SOP FO.3, General Equipment Decontamination, and SOP FO.4, Heavy Equipment Decontamination, for specific details regarding decontamination.

7.0 DOCUMENTATION

All information required by this SOP will be documented on the Cone Penetrometer Testing Form (Form GT.21A) and/or the CPT log. The Cone Penetrometer Testing Form will be filled out for each day of testing at a given location and, in situations where more than one test hole is completed per day per rig, at least one form will be completed per test hole. The Cone Penetrometer Testing Form will include the following information and have space for comments and documentation of general observations:

- Project name and number
- Date
- Site location/identification and coordinates
- Weather
- Testing company and personnel
- Equipment descriptions (i.e., rig, probes, etc.)
- Environmental monitoring results
- Grouting details
- End-of-day status (i.e., partially complete, complete, etc.)

- Comments/observations

Any additional comments and/or observations will be recorded with black permanent ink in a bound log book with consecutively numbered pages.

All final CPT logs should have headers. At a minimum, the header should include the following information:

- Project name and number
- Date
- Site location/identification
- Elevation and depth reference
- Testing company and operator
- Equipment information
- Total depth

CONE PENETROMETER TESTING FORM

Project Number: _____ Date: _____

Project Name: _____

Site Location/Identification: _____

Coordinates: _____North (Y) _____East (X)

Weather Conditions: _____

Testing Company: _____

Testing Team Leader: _____

Testing Team Member: _____

Testing Team Member: _____

Rig Type: _____

Cone Type and Size: _____

Total Depth: _____

Grouting Details: _____

End-of-Day Status: _____

HIGHEST ENVIRONMENTAL MONITORING RESULTS

Organic Vapors: _____ _____ _____
Value Units Instrument Used

Comments: _____

_____

_____

_____

_____

Completed By: _____
Print Name Date Signature

Contractor: _____