

**FIELD PROCEDURE FP 6-7**  
**PACKAGING AND SHIPMENT OF FIELD SAMPLES**

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## 1.0 PURPOSE

The purpose of this procedure is to define the requirements necessary for sample packaging and information on chain-of-custody records used in sample transfer.

## 2.0 SCOPE

This procedure applies to the packaging, shipping and documentation of samples being transferred from the field to the laboratory for analysis. Specifically, this document outlines shipping and sample documentation procedures that are in accord with the U.S. Department of Transportation (DOT). This procedure is applicable to all samples taken from uncontrolled hazardous substance sites for analysis at laboratories away from the site; however, this procedure does not take precedence over region-specific or site-specific requirements for chain-of-custody.

## 3.0 REQUIREMENTS

Careful packaging, shipping and documentation are necessary to insure that all samples received are undamaged and authentic.

## 4.0 REFERENCES

4.1 HAZWRAP, July 1990. *Quality Control Requirements for Field Methods*, DOE/HWP-69/R1.

4.2 HAZWRAP, July 1988. *Requirements for Quality Assurance of Analytical Data*, DOE/HWP-65, Rev. 0, July 1988.

4.3 U.S. Department of Transportation, 1983. *Hazardous Materials Regulations*, 49 CFR 171-177.

4.4 United States Environmental Protection Agency, 1984. *User's Guide to the Contract Laboratory Program, Office of Emergency and Remedial Response*, Washington, DC.

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4.5 USAEC, May 1993. *U.S. Army Environmental Center Guidelines for Implementation of ER 1110-1-263 for USAEC Projects.*

4.6 USATHAMA, January 1990. *U.S. Army Toxic and Hazardous Materials Agency Quality Assurance Program, USATHAMA PAM 11-41.*

## 5.0 DEFINITIONS

**Carrier** - A person or firm engaged in the transportation of passengers or property.

**Chain-of-Custody Record Form** - A Chain-of-Custody Record Form is a printed form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to the subsequent custodian. Attachment 9.7 shows a typical Chain-of-Custody Record. Chain-of-Custody Record Form is a controlled document. One copy of the form must be retained in the project file.

**Custodian** - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under your custody if:

- You possess the sample.
- It is in your view, after being in your physical possession.
- It was in your physical possession and then you locked it up to prevent tampering.
- You have designated and identified a secure area to store the sample.

**Environmental Sample** - A low concentration sample typically collected offsite and not requiring DOT hazardous waste labelling as a high hazard sample.

**Hazardous Waste Sample** - A medium to high concentration sample (e.g., source material, sludge, leachate) requiring DOT labelling and Contract Lab handling as a high hazard sample.

**Hazardous Material** - A substance or material in a quantity and form which may pose an unreasonable risk to health and safety or property when transported in commerce ("commerce" here to include any traffic or transportation). Defined and regulated by DOT (49 CFR 173.2) and listed in Attachment 9.1.

**Hazardous Waste** - Any substance listed in 40 CFR Subpart D (261.30 et seq) or 40 CFR otherwise characterized as ignitable, corrosive, reactive, or EP toxic as specified under Subpart C

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(261.20 et seq) that would be subject to manifest requirements specified in 40 CFR 262. Defined and regulated by EPA.

**Marking** - Applying the descriptive name, instructions, cautions, weight, or specification marks or combination thereof required to be placed outside containers of hazardous materials.

**n.o.i.** - Not otherwise indicated.

**n.o.s.** - Not otherwise specified.

**ORM** - Other regulated material.

**Packaging** - The assembly of one or more containers and any other components necessary to assure compliance with the minimum packaging requirements of 49 CFR 172, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, and multi-unit tank car tanks.

**Placard** - Color-coded, pictorial sign depicting the hazard class symbol and name to be placed on all four sides of a vehicle transporting certain hazardous materials.

**Reportable Quantity (RQ)** - A parenthetical note of the form "(RQ-100/454)" following an entry in the DOT Hazardous Materials table (49 CFR 172.101) indicates the reportable quantity of the substance in pounds and kilograms. If a spill of that amount or more of the substance occurs during transit or storage, a report must be filed with DOT according to 171.15-17 concerning hazardous materials incident reports. If the material spilled is a hazardous waste, a report must always be filed, regardless of the amount, and must include a copy of the manifest. If the RQ notation appears, it must be shown either immediately before or after the proper shipping name on the shipping paper (or manifest). Most shipping papers and manifests will have a column designated "HM" which may be used for this purpose.

**Sample** - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

## 6.0 RESPONSIBILITIES

**6.1 Field Operations Leader** - Responsible for determining that samples are properly packaged and shipped, and for determining that the chain-of-custody procedures are implemented from the time the samples are collected to their release to the shippers.

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**6.2 Field Samplers** - Responsible for implementing the packaging and shipping requirements and for initiating the chain-of-custody records until they are relinquished to another custodian, to the shipper, or to the carrier.

## **7.0 EQUIPMENT**

1. Coders
2. Teflon® and Nylon Strapping Tape
4. Vermiculite or Styrofoam Packaging Materials
5. Bubble Pack
6. Sampling Gloves
7. Poly-net
8. Reclosable Plastic Bags
9. Permanent Felt Tip Marker
10. Pen, Black Permanent Ink
11. Shipping Coolers
12. Ice or Blue Ice.

## **8.0 PROCEDURE**

### **8.1 Sample Packaging and Shipping**

Samples collected for shipment from a site should be classified as either environmental or hazardous material (or waste) samples. In general, environmental samples are collected off-site (e.g., from streams, ponds, or wells) and are not expected to be grossly contaminated with high levels of hazardous materials. On-site samples (e.g., soil, water, and materials from drums or bulk storage tanks, obviously contaminated ponds, lagoons, pools, and leachates from hazardous waste sites) are considered hazardous. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples. If there is any doubt, a sample should be considered hazardous and shipped accordingly.
- Protect the health and safety of laboratory personnel receiving the samples. Special precautions are used at laboratories when samples other than environmental samples are received.

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## 8.2 Environmental Samples

### 8.2.1 Packaging

Environmental samples may be packaged following the procedures outlined in Section 8.4 for samples classified as "flammable liquids" or "flammable solids". Requirements for marking, labeling, and shipping papers do not apply.

Environmental samples may also be packaged without being placed inside metal cans as required for flammable liquids or solids.

- Place each sample container, properly identified and with a sealed lid, in a polyethylene bag and seal the bag.
- Place sample in a fiberboard container or metal picnic cooler which has been lined with a large polyethylene bag.
- Pack with enough noncombustible, absorbent, cushioning materials to minimize the possibility of the container breaking.
- Seal large bag.
- Seal or close outside container.

### 8.2.2 Marking/Labeling

Sample containers must have a completed sample identification and the outside container must be marked "Environmental Sample". The appropriated side of the container must be marked "This End Up" and arrows placed accordingly. No DOT markings or labeling are required.

### 8.2.3 Shipping Papers

No DOT shipping papers are required. However, the appropriate chain-of-custody forms must be included with the shipment.

### 8.2.4 Transportation

There are no DOT restrictions on mode of transportation.

## 8.3 Determination of Shipping Classification for Hazardous Materials Samples

Samples not determined to be environmental samples, or samples known or expected to contain hazardous materials, must be considered hazardous material samples and transported according to the requirements listed below.

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### 8.3.1 Known Substances

If the substance in the sample is known or can be identified, package, mark label, and ship according to the specific instructions for that material (if it is listed) in the DOT Hazardous Materials Table, 49 CFR 172.101.

Unz and Company have published the following steps to help locate a proper shipping name from the Hazardous Materials Table, 48 CFR 172.101.

1. Look first for the chemical or technical name of the material, for example, ethyl alcohol. Note that many chemicals have more than one technical name; for example, perchloroethylene (not listed in 172.101) is also called tetrachloroethylene (listed in 172.101). It may be useful to consult a chemist for all possible technical names a material can have. If your material is not listed by its technical name, then....
2. Look for the chemical family name. For example, pentyl alcohol is not listed, but the chemical family name is alcohol, n.o.s. (not otherwise specified). If the chemical family name is not listed, then....
3. Look for a generic name based on end use. For example, Paint, n.o.s. or Fireworks, n.o.s. If a generic name based on end use is not listed, then....
4. Look for a generic family name based on end use. For example, Drugs, n.o.s. or Cosmetics, n.o.s. Finally if your material is not listed by a generic family name but you suspect or know the material is hazardous because it meets the definition of one or more hazard classes, then....
5. You will have to go to the general hazard class for a proper shipping name. For example, Flammable Liquid, n.o.s., or Oxidizer, n.o.s.

### 8.3.2 Unknown Substances

For samples of hazardous substances of unknown content, select the appropriate transportation category according to the DOT Hazardous Materials Classification (Attachment 9.1), a priority system of transportation categories.

The correct shipping classification for an unknown sample is selected through a process of elimination, utilizing Attachment 9.1. Unless known or demonstrated otherwise (through the use of radiation survey instruments), the sample is considered radioactive and appropriate shipping regulations for "radioactive material" are followed.

If radioactive material is eliminated, the sample is considered to contain "Poison A" materials (Attachment 9.2), the next classification on the list. DOT defines "Poison A" as extremely dangerous

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poisonous gases or liquids of such a nature that a very small amount of gas, or vapor of the liquid, mixed with air is dangerous to life. Most Poison A materials are gases or compressed gases and would not be found in drum-type containers. Liquid Poison A would be found only in closed containers; however, all samples taken from closed drums do not have to be shipped as Poison A, which provides for a "worst case" situation. Based upon information available, a judgement must be made whether a sample from a closed container is a Poison A.

If Poison A is eliminated as a shipment category, the next two classifications are "flammable" or "nonflammable" gases. Since very few gas samples are collected, "flammable liquid" would be the next applicable category. With the elimination of radioactive material, Poison A, flammable gas, and nonflammable gas, the sample can be classified as flammable liquid (or solid) and shipped accordingly. These procedures would also suffice for shipping any other samples classified below flammable liquids in the DOT classification table (Attachment 9.1). For samples containing unknown material, categories listed below flammable liquids/solids on Attachment 9.1 are generally not used because showing that these materials are not flammable liquids (or solids) requires flashpoint testing, which may be impractical and possibly dangerous at a site. Thus, unless the sample is known to consist of material listed as less hazardous than flammable liquid (or solid) on Attachment 9.1, it is considered a flammable liquid (or solid) and shipped as such.

For any hazardous material shipment, utilize the shipping checklist (Attachment 9.3) as a guideline to ensure that all sample-handling requirements are satisfied.

#### **8.4 Packaging and Shipping of Samples Classified as Flammable Liquid (or Solid)**

##### **8.4.1 Packaging**

Applying the word "flammable" to a sample does not imply that it is in fact flammable. The word prescribes the class of packaging according to DOT regulations.

1. Collect sample in the prescribed container with nonmetallic, Teflon<sup>®</sup>-lined screw cap. To prevent leakage, fill container no more than 90% full. If an air space in the sample container would affect sample integrity, place that container within a second container to meet the 90% requirement.
2. Complete sample label and identification tag and attach securely to sample container.
3. Seal container and place in a 2-mil thick (or thicker) polyethylene bag, one sample per bag. Position identification tag so that it can be read through the bag. Seal bag.

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4. Place sealed bag inside metal can and cushion it with enough noncombustible, absorbent material (for example vermiculite or diatomaceous earth) between the bottom and sides of the can and bag to prevent breakage and absorb leakage. Pack one bag per can. Use clips, tape, or other positive means to hold can lid securely, tightly and permanently. Mark can as indicated in Paragraph 1 of Section 8.4.2, below.
5. Place one or more metals cans (or single 1-gallon bottle) into a strong outside container, such as a metal picnic cooler or a DOT-approved fiberboard box. Surround cans with noncombustible, absorbent cushioning material for stability during transport. Mark containers as indicated in Paragraph 2 of Section 8.4.2.

#### 8.4.2 Marking/Labeling

1. Use abbreviations only where specified. Place the following information, either-hand printed or in label form, on the metal can (or 1-gallon bottle):
  - Laboratory name and address.
  - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325".
  - Not otherwise specified (n.o.s.) is not used if the flammable liquid (or solid) is identified. Then the name of the specific material is listed before the category (for example, Acetone, Flammable Liquid), followed by its appropriate UN number found in the DOT hazardous materials table (49 CFR 172.101).
2. Place all information on outside shipping container as on can (or bottle), specifically:
  - Proper shipping name.
  - UN or NA number.
  - Proper label(s).
  - Addressee and sender.

Place the following labels on the outside container: "Cargo Aircraft Only" and "Flammable Liquid" (or "Flammable Solid"). "Dangerous When Wet" label should be used if the solid has not been exposed to a wet environment. "Laboratory Samples" and "THIS SIDE UP" or "THIS END UP" should also be marked on the top of the outside container, and upward-pointing arrows should be placed on all sides of the container.

#### 8.4.3 Shipping Papers

1. Use abbreviations only where specified. Complete the carrier-provided bill of lading and sign certification statement (if carrier does not provide, use standard industry form, see

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Attachment 9.4). Provide the following information in the order listed (one form may be used for more than one exterior container).

- "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325)".
  - "Limited Quantity" (or "Ltd. Qty. ").
  - "Cargo Aircraft Only".
  - Net weight (wt) or net volume (vol), just before or just after "Flammable Liquid n.o.s." or "Flammable Solid, n.o.s.", by item, if more than one metal can is inside an exterior container.
  - "Laboratory Samples" (if applicable).
2. Include Chain-of-Custody Record, properly executed in outside container.
  3. "Limited Quantity" of "Flammable Liquid, n.o.s." is limited to one pint per inner container. For "Flammable Solid, n.o.s.", net weight of inner container plus sample should not exceed one pound; total package weight should not exceed 25 pounds.

#### 8.4.4 Transportation

1. Transport unknown hazardous substance samples classified as flammable liquids by rented or common carried truck, railroad, or express overnight package services. Do not transport by any passenger-carrying air transport system, even if they have cargo-only aircraft. DOT regulations permit passenger airline company cargo only aircraft, but difficulties with most suggest avoiding them. Instead, ship by airline carriers that only carry cargo.
2. For transport by government-owned vehicle, including aircraft, DOT regulations do not apply. However, procedures described above, with the exception of execution of the bill of lading with certification, should still be used.

#### 8.5 Packaging and Shipping of Samples Classified as Poison "A"

This packaging, marking, labeling, and shipping method provides a worst-case procedure for materials classed as Poison A (49 CFR 173.328). In the absence of reliable data that exclude the possibility of the presence of Poison A chemicals or compounds (see Attachment 9.2), these procedures must be followed.

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### 8.5.1 Packaging

Applying the word "poisonous" to a sample does not imply that it is, in fact, poisonous, or how poisonous. It describes the class of packaging according to DOT regulations.

1. Collect samples in a polyethylene or glass container with an outer diameter narrower than the valve hole on a DOT specification #3A1800 or #3AA1800 metal cylinder. To prevent leakage, fill container no more than 90% full. Seal sample container.
2. Complete sample label and identification tag and attach securely to sample container.
3. Attach string or flexible wire to neck of the sample container; lower it into metal cylinder partially filled with noncombustible, absorbent cushioning material (for example, diatomaceous earth or vermiculite). Place only one container in metal cylinder. Pack with enough absorbing material between the bottom and sides of the sample container and the metal cylinder to prevent breakage and absorb leakage. After the cushioning material is in place, drop the end of the string into the cylinder valve hole.
4. Replace valve, torque to 250 ft-lb (for 1-inch opening), and replace valve protector on metal cylinder, using Teflon® tape.
5. Mark and label cylinder as described in Paragraph 1 of Section 5.5.2.
6. Place one or more cylinders in DOT-approved outside container.
7. Mark and label outside container and complete shipping papers as described below.

### 8.5.2 Marking/Labeling

1. Use abbreviations only where specified. Place the following information, either hand-printed or in label form, on the side of the cylinder or on a tag wired to the cylinder valve protector.
  - "Poisonous Liquid, n.o.s." or "Poisonous Gas, n.o.s. NA9035".
  - Laboratory name and address.
  - DOT label "Poisonous Gas" (even if sample is liquid) on cylinder.
2. Put all information on metal cylinder on outside container. Print "Laboratory Sample" and "Inside Packages Comply With Prescribed Specifications" on top and/or front of outside container. Mark "THIS SIDE UP" on top of container and upward-pointing arrows on all four sides.

### 8.5.3 Shipping Papers

1. Use abbreviations only as specified. Complete carrier-provided bill of lading and sign certification statement (if carrier does not provide, use standard industry form, see

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Attachment 9.4). Provide the following information in the order listed. One form may be used for more than one exterior container.

- "Poisonous Liquid, n.o.s. NA9035."
  - "Limited Quantity" or "Ltd. Qty."
  - Net weight (wt) or net volume (vol), just before or after "Poisonous Liquid, n.o.s.", of each cylinder, if more than one is inside the outer container.
2. Include a Chain-of-Custody Record, properly executed, in container or with cylinder.
  3. Accompany shipping container to carrier and, if required, open outside container(s) for inspection.

#### **8.5.4 Transportation**

Transport unknown hazardous substance samples classified as Poison A only by ground transport or Government-owned aircraft. Do not use air cargo, other common-carrier aircraft, or rented aircraft.

#### **8.6 Transport of Investigation and Remediation Wastes**

The packaging, marking, labeling, and other shipping requirements will depend on the particular waste to be transported. Examples of wastes which may be generated during the site investigations are decontamination or cleaning solutions, contaminated disposable items, test pit spoils, drilling cutting or fluids and contaminated monitoring well discharges. Waste materials from remediation include excavation spoils, overpacked drums and discharges from drained lagoons or tanks.

In many cases, wastes generated during site investigations will be disposed of onsite. These relatively small volumes of waste will be dealt with as part of the waste to be cleaned up or isolated during remediation. This avenue should be pursued, if feasible, to avoid the inconvenience of transportation and disposal which are disproportionately expensive for small volumes. If such a solution is approved, materials should be properly bagged, drummed, covered, buried, or otherwise contained at the end of each day.

Those materials which must be transported for treatment, storage, or disposal should be packaged, labeled and marked in accordance with applicable regulations.

Many wastes generated during site investigation and remediation activities will probably be adequately handled under the classification "ORM-E" (i.e., other regulated materials, type E). Types of wastes which would normally fall under this classification are contaminated disposable protective

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clothing and sampling equipment, spent soapy decontamination solutions and rinses, contaminated drilling cuttings or fluids and contaminated soils excavated during site investigations or remediation.

Spent solvents used for decontamination of sampling equipment (e.g., acetone or methanol) should be referenced by the actual product name. Liquids from drums or tanks should be specified as accurately as possible based on results of lab analysis or reliable records. If the liquid is known to be a solvent, organic liquid, or spent distillation bottoms, it should be referenced by its actual or generic name from the Hazardous Materials Table. In cases requiring emergency actions where the identity of a substance is not accurately known, place the substance in one of the general hazard classes in 49 CFR 173.2. The choice of class should be conservative; that is, use the highest priority class based on available information as described in Section 8.3.2.

The following steps for preparing hazardous materials for shipment were extracted from the "Hazardous Materials Transportation Guide for Shippers" published by the U.S. DOT. \*References are to CFR Title 49.

**1. Determine the Proper Shipping Name**

The shipper must determine the proper shipping name of the materials as listed in the Hazardous Materials Table, \*172.101, Column (2).

**2. Determine the Hazard Class or Classes**

- a. Refer to the Table, \*172.101, Column (3) and locate the hazard class of the material or follow the steps described in Section 8.3.2 of this Guideline.
- b. If more than one class is shown for the proper shipping name, determine the proper class by definition.
- c. If the material has more than one hazard, classify the material based on the order of hazards in \*173.2.

**3. Select the Proper Identification Number**

- a. Refer to the Table, \*172.101, Column (3a) and select the Identification Number (ID) that corresponds to the proper shipping name and hazard class.
- b. Enter the ID Number(s) on the shipping papers and display them, as required, on packaging, placards, and/or orange panels.

**4. Determine the Mode(s) of Transport to Ultimate Destination#**

- a. As a shipper, you must assure yourself that the shipment complies with the various modal requirements.

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b. The model requirements may affect the following:

- (1) Packaging
- (2) Quantity per package
- (3) Marking
- (4) Labeling
- (5) Shipping papers
- (6) Certification.

# For example, truck, rail or air.

**5. Select the Proper Label(s) and apply as required**

Required labels are based on the hazard class of the substance to be shipped. No placards are required on vehicles transporting ORM-E substances or limited quantities of any hazardous materials (e.g., hazardous samples as discussed in Section 8.4).

a. Refer to the Table, \*172.101, Column (4) for required label(s).

b. For details in labeling refer to:

- (1) Additional Labels, \*172.402
- (2) Location of Labels, \*172.406
- (3) Packaging (Mixed or Consolidated), \*172.404(a) and (b)
- (4) Packages Containing Samples, \*172.402(h)
- (5) Radioactive Materials, \*172.403
- (6) Authorized Label Modification, \*172.405

**6. Determine and Select the Proper Packaging**

a. Refer to the Table, \*172.101, Column (5a) for exceptions and Column (5b) for authorized Packaging. Consider the following when selecting an authorized container: quantity per package; cushioning material, if required; proper closure and reinforcement; proper pressure; outage; etc, as required.

b. If packaged by a prior shipper, make sure the packaging is correct and in proper condition for transportation.

**7. Mark the Packaging (Including Overpacks)**

a. Apply the required marking (\*172.300); proper shipping name and ID number, when required (\*172.301); Name and address of Consignee and Consignor (\*172.306).

b. For details and other required markings, see \*172.300 through \*172.338.

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### 8. Prepare Shipping Papers

- a. The basic requirements for preparing shipping papers include: proper shipping name; hazard class; ID number; total quantity; shipper's certification.
- b. Make all entries on the shipping papers, using the information required, and in proper sequence (\*172.202).
- c. For additional requirements, see \*172.200 through \*172.205.

### 9. Certification

- a. Each shipper must certify, by printing (manually or mechanically) on the shipping papers, that the materials being offered for shipment are properly classified, described, packaged, marked, and labeled, and are in proper conditions for transportation according to the applicable DOT Regulations (\*172.204).

### 10. Loading, Blocking, and Bracing

When loading hazardous materials into the transport vehicle or freight container, each package must be loaded, blocked, and braced in accordance with the requirements for the mode of transport.

- a. If the shipper loads the freight container or transport vehicle, the shipper is responsible for the proper loading, blocking, and bracing of the materials. The packages must be properly labeled as to the right side up and samples must be packed to avoid damage in case of overturning.
- b. If carrier personnel do the loading, the carrier is responsible.

### 11. Determine the Proper Placard(s)

Each person who offers hazardous materials for transportation must determine that the placarding requirements have been met.

- a. For highway, unless the vehicle is already correctly placarded, the shipper must provide the required placard(s) and required identification number(s) (\*172.506).
- b. For rail, if loaded by the shipper, the shipper must placard the rail car if placards are required. (\*172.508)
- c. For air and water shipments, the shipper has the responsibility to apply the proper placards.

### 12. Hazardous Waste/Hazardous Substance

- a. If the material is classed as a hazardous waste or hazardous substance, most of the above steps will be applicable.
- b. Pertinent Environmental Protection Agency Regulations are found in the Code of Federal Regulations, Title 40, Part 262.

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## 8.7 Chain-of-Custody Guidelines

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is what it is represented to be. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom. These procedures also provide an auditable trail for the evidence as it is moved and/or passes from the custody of one individual to another. In addition, procedures for consistent and detailed records facilitate the admission of evidence under Rule 803(b) of the Federal Rules of Evidence (P.L. 93-575).

Chain-of-custody procedures, record keeping and documentation are an important part of the management control of samples in the AEC program. Regulatory agencies must be able to provide the chain of possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

### 8.7.1 Sample Identification

The following information shall be written in the Field Logbook when in-situ measurements or samples for laboratory analysis are collected:

- project code
- unique sample or log number
- source of sample (including name, location, and sample type)
- date and time of measurement
- samples collected (if any)
- preservative used
- analysis required
- name of collector
- field observations (include pH, temp, depth to water)
- level of personnel protection (if required)
- equipment used to make physical measurements and collect samples
- calibration data for equipment used.

Measurements and observations shall be recorded using black, waterproof ink.

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### 8.7.2 Sample Label

Samples, other than in-situ measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into two portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling Plan. Each sample container is identified by a sample label (see Attachment 9.5).

The sampler fills out the following information on the sample label:

<b>Installation</b>	Installation of sampling activities
<b>Project No.</b>	AEC Work Assignment Number
<b>Location</b>	SWMU number or AOC
<b>Date</b>	A six-digit number indicating the month, day, and year of sample collection; e.g., 12/21/85
<b>Time</b>	A four digit number indication the 24-hour time of collection (for example: 0954 of 9:54 a.m., and 1625 is 4:29 p.m.)
<b>Media Type</b>	Water, Soil, Sediment, Sludge, Leachate, etc.
<b>Method Matrix</b>	Grab or Composite
<b>Site ID</b>	Unique site identification identifying this site
<b>Site Type</b>	Boring, Pond, Ditch, etc.
<b>Field Sample No.</b>	The unique sample number identifying this sample
<b>Depth</b>	Depth sample was collected (i.e., 0-2 ft., surface)
<b>Sampling Technique</b>	Bailer, Pump, Spilt-Spoon, Shelby Tube
<b>Purge Volume</b>	Amount of water purged from well in gallons before sampling
<b>Analysis</b>	Method of analysis for the laboratory
<b>Preservation</b>	Type, quantity, and concentration of preservative added
<b>Collector's Initials</b>	Initials of the sampler
<b>Comments</b>	If the Contract Lab analysis, include the Contract Lab case of SAS number, and Contract Lab sample number from the traffic report, SAS Packing List, or Dioxin Shipment Record. Also, pertinent observations of the sampler (e.g., sequence number for sequential samples).

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### 8.7.3 Sample Identification Tag

A Sample Identification Tag (Attachment 9.6) must also be used for samples collected for Control Lab analysis, if applicable. The Sample Identification Tag is a white, waterproof paper label, approximately 3-by-6 inches, with a reinforced eyelet, and string or wire for attachment to the neck of the sample bottle. The sample tag is a controlled document, and is provided by the regional EPA office. The field sampler completes the sample tag and attaches the sample tag to the field sample container. Following sample analysis, the sample tag is retained by the laboratory as evidence of sample receipt and analysis. The following information is recorded on the tag:

Site Name/Project Code	AEC Work Assignment Number
Field Identification or Station Number	Same as Field Sample Number of Sample Label
Month/Day/Year	Same as Date on Sample Label
Time	Same as Time on Sample Label
Designate: Comp/Grab	Designate the samples as whether grab or composite
Station Location	Site-specific station location designation defined in project-specific work plan
Type of Sample	Type of Sample (matrix), and a brief description of the sampling location
Samplers	Same as Collector's Initials on Sample Label
Signature	The Sampler signs the sample tag
Preservative	Yes or No
Analyses	Check appropriate box(s)
Remarks	Same as Comments on Sample Label (make sure Contract Lab Case No/SAS no. and Contract Lab sample numbers are recorded).
Lab Sample No.	The receiving laboratory assigns the lab number to the sample label (this number is not to used for on-site analyses).

The tag is then tied round the neck of the sample bottle.

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If the sample is to be split, it is equally divided into two similar sample containers. Identical information is completed on the label attached to each split and both of these are marked "Split" on the "Remarks" line.

Blank, duplicate, or field spike samples shall not be identified as such on the label, as this may compromise the quality control function.

#### **8.7.4 Chain-of-Custody Procedures**

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed.

##### **Field Custody Procedures**

1. Samples are collected as described in the project-specific work plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label exactly matches those numbers on the sample log sheet and the Chain-of-Custody Record.
2. The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.
3. When photographs are taken of the sampling as part of the documentation procedures, the name of the photographer, date, time, site location, and site description are entered sequentially in the Site Logbook as photos are taken. Once developed, the photographic prints shall be serially numbered, corresponding to the logbook descriptions.
4. Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions, e.g., a logbook notation would explain that pencil was used to fill out the sample label because a ballpoint pen would not function in freezing weather.

#### **8.7.5 Transfer of Custody and Shipment**

Samples are accompanied by a Chain-of-Custody Record Form (Attachment 9.7). When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as follows:

1. Enter header information (project number and name, Contract Lab case No. or SAS No.). For each station number, enter date, time, composite/grab, station location, number of containers, analytical parameters, Traffic Report/SAS Packing List/Dioxin Shipment Record, and Sample Identification Tag Number

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2. Sign, date, and enter the time under "Relinquished by" entry.
3. Make sure that the person receiving the sample signs for the "Received by" entry, or enter the name of the carrier (e.g., UPS, Federal Express) under "Received by". Receiving laboratory will sign "Received for Laboratory by" on the lower line and enter the date and time.
4. Enter the bill-of-lading or Federal Express airbill number under "Remarks or Reason for Change of Custody", if appropriate.
5. Place the original (top, signed copy) of the Chain-of-Custody Recorded Form in the appropriate sample shipping package. Retain a copy with field records.
6. Shipping containers should be secured to ensure samples have not been disturbed during transport by using nylon strapping tape and EPA custody seals. The custody seals should be placed on the containers so that they cannot be opened without breaking the seal.
7. Complete other carrier-required shipping papers.

The custody record is completed using black waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the sample container (enclosed with the other documentation in a plastic zip-lock bag). As long as custody forms are sealed inside the sample container and the custody seals are intact, commercial carriers are not required to sign off on the custody form.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

#### 8.7.6 Receipt for Sample Form

Whenever samples are split with a private party or government agency, a separate Receipt for Samples Record Form (see Attachment 9.9) is prepared for those samples and marked to indicate with whom the samples are being split. The person relinquishing the samples to the party of agency shall require the signature of a representative of the appropriate party acknowledging receipt of the samples. If a representative is unavailable or refuses to sign, this is noted in the "Received by" space. When

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appropriate, as in the case were the representative is unavailable, the custody record should contain a statement that the samples were delivered to the designated location at the designated time. This form must be completed and a copy given to the owner, operator, or agent-in-charge even if the offer for split samples is declined. The original is retained by the Field Operations Leader.

**9.0 ATTACHMENTS**

- 9.1 DOT Hazardous Materials Classification (49 CFR 173.2)**
- 9.2 DOT List of Class "A" Poison (49 CFR 172.101)**
- 9.3 Hazardous Material Shipping Checklist**
- 9.4 Standard Industry Certification Form**
- 9.5 Sample Label**
- 9.6 Sample Identification Tag**
- 9.7 Chain-of-Custody Record Form**
- 9.8 Chain-of-Custody Seal**
- 9.9 Receipt For Samples Form**

**DOT HAZARDOUS MATERIAL CLASSIFICATION (49 CFR 173.2)**

1. **Radioactive material (except a limited quantity)**
2. **Poison A**
3. **Flammable gas**
4. **Nonflammable gas**
5. **Flammable liquid**
6. **Oxidizer**
7. **Flammable solid**
8. **Corrosive material (liquid)**
9. **Poison B**
10. **Corrosive material (solid)**
11. **Irritating material**
12. **Combustible liquid (in containers have capacities of 110 gallons [415 liters])**
13. **ORM-B**
14. **ORM-A**
15. **Combustible liquid (in containers having capacities of 110 gallon [416 liters] or less)**
16. **ORM-E**

Attachment 9.2

FP 6-7

DOT LIST OF CLASS "A" POISON (49 CFR 172.101)

Material Temperature	Physical State at Standard Temperature
Arsine	Gas
Bromoacetone	Liquid
Chloropicrin and methyl chloride mixture	Gas
Chloropicrin and nonflammable, nonliquified compressed gas mixture	Gas
Cyanogen chloride	Gas (> 13.1°C)
Cyanogen gas	Gas
Gelatin dynamite (H.E. Germaine)	-
Grenade (with Poison "A" gas charge)	-
Hexaethyl tetraphosphate/compressed gas mixture	Gas
Hydrocyanic (prussic) acid solution	Liquid
Hydrocyanic acid, liquefied	Liquid
Insecticide (liquefied) gas containing Poison "A" or Poison "B" material	Gas
Methyldichloroarsine	Liquid
Nitric oxide	Gas
Nitrogen peroxide	Gas
Nitrogen tetroxide	Gas
Nitrogen dioxide, liquid	Gas
Parathion/compressed gas mixture	Gas
Phosgene (diphosgene)	Liquid

## **HAZARDOUS MATERIALS SHIPPING CHECKLIST**

### **Packaging**

1. Check DOT 172.500 table for appropriate type of package for hazardous substance.
2. Check for container integrity, especially the closure.
3. Check for sufficient absorbent material in package.
4. Check for sample tags and log sheets for each sample, and chain-of-custody record.

### **Shipping Papers**

1. Check that entries contain only approved DOT abbreviations.
2. Check that entries are in English.
3. Check that hazardous material entries are specially marked to differentiate them from any nonhazardous materials being set using same shipping paper.
4. Be careful that all hazardous classes are shown for multi-class materials.
5. Check total amounts by weight, quantity, or other measures used.
6. Check that any limited-quantity exemptions are so designated on the shipping paper.
7. Offer driver proper placards for transporting vehicle.
8. Check that certification is signed by shipper.
9. Make certain that driver signs for shipment.

### **RCRA Manifest**

1. Check that approved state/federal manifests are prepared.
2. Check that transporter has the following: valid EPA identification number, valid driver's license, valid vehicle registration, insurance protection, and proper DOT labels for materials being shipped.
3. Check that destination address is correct.
4. Check that driver knows where shipment is going.
5. Check that the driver is aware of emergency procedures for spills and accidents.
6. Make certain driver signs for shipment.
7. Make certain one copy of executed manifest and shipping document is retained by shipper.
8. Check that the authorized Client point-of-contact (2750 ABW/EMC) has signed the manifest.

STANDARD INDUSTRY CERTIFICATION/FORM

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NO PCS	SIZE	GROSS WEIGHT	N L	DOT PROPER SHIPPING NAME	HAZARD CLASS	CODE	I P	CONTAINER NUMBERS	PLC	MARK
1	55 gal	300 lbs	1	Misc. Acid, flammable	Corrosive	55-BK	C	1	✓	
1	55 gal	450 lbs	1	Flammable Liquid, n.o.s.	Flammable Liquid	55-AM	—	2		✓
1	55 gal	250 lbs	1	Flammable Liquid, n.o.s.	Flammable Liquid	55-BK	B	3	✓	
1	18-A	12 lbs.	1	Bromine	Corrosive Material	55-BK	C	4	✓	

<p><b>SHIPPER'S CERTIFICATION</b>          This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.</p> <p style="text-align: center;">_____          Shipper's Signature</p>	<p>           Receipts Rec'd _____            Shipment Date _____ Manifest No _____            Shipper's Work Order _____            Service Order No _____         </p> <p>Copyright ©1979 ATSC (Morris Plains, N.J.)</p> <p style="text-align: right;">Rev. 1-79</p>
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 <b>SAIC</b> <small>An Employee-Owned Company</small>			1710 Goodridge Drive, McLean, Virginia 22102 Telephone # (703) 734-5500 Fax # (703)-506-9689		
<u>Installation:</u>		<u>Project No.:</u>			
<u>Location SWMU No. or AOC:</u>					
<u>Sample Date/Time:</u>		<u>Media Type:</u>		<u>Method Matrix:</u>	
<u>Site ID:</u>			<u>Site Type:</u>		
<u>Field Sample No.:</u>			<u>Depth:</u>		
<u>Sampling Technique:</u>			<u>Purge Volume:</u>		
<u>Analysis:</u>					
<u>Preservative:</u>					
<u>Comments:</u>					
					<u>Collector's Initials:</u> _____

SAMPLE IDENTIFICATION TAG

☆ GPO 505-552

Project Code	Station No.	Month/Day/Year	Time	Designate:		Station Location	Preservative: Yes <input type="checkbox"/> No <input type="checkbox"/>																												
				Comp.	Grab																														
Station Location				Samplers (Signatures)																															
Remarks:							<table border="1"> <tr> <th colspan="2">ANALYSES</th> </tr> <tr> <td>BOD Solids</td> <td>Anions (TSS) (TDS) (SS)</td> </tr> <tr> <td colspan="2">COD, TOC, Nutrients</td> </tr> <tr> <td colspan="2">Phenolics</td> </tr> <tr> <td colspan="2">Mercury</td> </tr> <tr> <td colspan="2">Metals</td> </tr> <tr> <td colspan="2">Cyanide</td> </tr> <tr> <td colspan="2">Oil and Grease</td> </tr> <tr> <td colspan="2">Organics GC/MS</td> </tr> <tr> <td colspan="2">Priority Pollutants</td> </tr> <tr> <td colspan="2">Volatile Organics</td> </tr> <tr> <td colspan="2">Pesticides</td> </tr> <tr> <td colspan="2">Mutagenicity</td> </tr> <tr> <td colspan="2">Bacteriology</td> </tr> </table>	ANALYSES		BOD Solids	Anions (TSS) (TDS) (SS)	COD, TOC, Nutrients		Phenolics		Mercury		Metals		Cyanide		Oil and Grease		Organics GC/MS		Priority Pollutants		Volatile Organics		Pesticides		Mutagenicity		Bacteriology	
ANALYSES																																			
BOD Solids	Anions (TSS) (TDS) (SS)																																		
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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY





CHAIN-OF-CUSTODY SEAL

<b>CUSTODY SEAL</b>	_____
	Date
	_____
	Signature
_____	
<b>CUSTODY SEAL</b>	_____
	Date
	_____
	Signature



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**FIELD PROCEDURE FP 7-1**  
**AQUIFER SLUG TESTING**

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	FP 7-1	1	Page 1 of 6
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	10/04/93	10/04/93	
	Supersedes Procedure Number	Rev.	Date
	630 FP 1	0	
Acceptance - Program QA	Approval - Program Manager		

## 1.0 PURPOSE

The purpose of this procedure is to define the requirements for performing the slug test, which is a single well hydraulic test to determine the transmissivity and hydraulic conductivity of an aquifer.

## 2.0 SCOPE

The slug test method is recommended for confined aquifers with transmissivity less than 7000 ft<sup>2</sup>/day. This method can be used to determine estimates of transmissivity for an aquifer in the immediate vicinity of the tested well. The value of transmissivity determined from slug testing will apply only over the screened interval. The test can be performed using either a rising-head or a falling-head method.

## 3.0 REQUIREMENTS

Prior to testing, the well should be thoroughly developed in accordance with FP 5-4 and water levels allowed to stabilize. Tests performed after extended periods of pumping or water addition may yield inaccurate results. Decontaminate data logger transducer and slugs prior to and immediately after the performance of the slug test according to Field Procedure FP 3-1.

## 4.0 REFERENCES

- 4.1 American Society for Testing and Materials, 1987. *ASTM Method D4630-86 and D4631-86*, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.
- 4.2 Bouwer, H. and R.C. Rice, 1976. *A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers With Completely or Partially Penetrating Wells*, Water Resources Research, Volume 12, No. 3.

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4.3 Cedergren, H.R., 1977. *Seepage, Drainage, and Flow Nets*, 2nd Edition, John Wiley and Sons, Inc., New York.

4.4 Cooper, Hilton H., Jr., John D. Bredehoeft, and Stavros S. Papadopoulos, 1967. *Response of a Finite-Diameter Well to an Instantaneous Charge of Water*, Water Resources Research, Volume 3, No. 1.

4.5 Freeze, R.A. and J.A. Cherry, 1979. *Groundwater*, Prentice Hall, Englewood Cliffs, New Jersey.

4.6 In-Situ, Inc, 1985. *Hermit Environmental Data Logger Model SE1000B Owner's Manual*, Laramie Wyoming.

4.7 Lohman, S.W., 1972. *Groundwater Hydraulics*, U.S. Geological Survey, Professional Paper 708.

4.8 Papadopoulos, Stavros S., John D. Bredehoeft, Hilton H. Cooper, Jr., 1967. *On the Analysis of 'Slug Test' Data*, Water Resources Research, Volume 9, No. 4.

4.9 U.S. Department of Interior, Bureau of Reclamation, 1974. "Designation E-18, Field Permeability Tests in Boreholes" in *Earth Manual*, 2nd Edition, U.S. Government Printing Office, No. 2403-00079.

4.10 U.S. Department of Interior, 1981. *Groundwater Manual*.

## 5.0 DEFINITIONS

**Hydraulic Conductivity (K)** - A quantitative measure of the ability of porous material to transmit water and defined as the volume of water that will flow through a unit cross-sectional area of porous material per unit time under a unit hydraulic gradient. Hydraulic conductivity is dependent upon properties of the medium and fluid. Also referred to as "permeability".

**Transmissivity (T)** - A quantitative measure of the ability of an aquifer to transmit water. It is the product of the hydraulic conductivity and saturated thickness.

**Slug Test** - A rising-head or falling-head test. A slug test consists of adding a slug of water or a solid cylinder of known volume to the well to be tested or removing a known volume of water and

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measuring the rate of recovery of water level inside the well. The slug of known volume acts to raise or lower the water level in the well.

**Rising-Head Test** - A test used in an individual well within the saturated zone to estimate the hydraulic conductivity of the surrounding formation by lowering the water level in the well and measuring the rate of recovery of the water level. The water level may be lowered by pumping, bailing or removing a submerged slug from the well.

**Falling-Head Test** - A test used in an individual well to estimate the hydraulic conductivity of the surrounding formation by raising the water level in the well by insertion of a slug or quantity of water, and then measuring the rate of drop in the water level.

## **6.0 RESPONSIBILITIES**

### **6.1 Field Operations Leader**

The Field Operations leader will be responsible for ensuring that complete documentation is available for boreholes to be tested and for overall implementation of this procedure.

### **6.2 Project Hydrogeologist**

The Project Hydrogeologist will be responsible for planning and overseeing the in-situ hydraulic conductivity (slug) tests. The wells to be tested and the testing methods to be used should be determined by the Project Hydrogeologist. The Project Hydrogeologist should also supervise the testing program to ensure that valid results are obtained.

## **7.0 EQUIPMENT**

1. Metal Slugs
2. One-Quarter Inch Nylon Rope
3. Electric Water Level Indicator
4. Pressure Transducer-Sensor
5. Automatic Data Recording Instrument (i.e., Hermit Environmental Data Logger, In-Situ, Inc., Model SE 1000B)
6. Field Logbook
7. Steel Measuring Tape.

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## 8.0 PROCEDURE

Aquifer transmissivity tests (slug tests) are accomplished by either removal of a quantity of water (rising-head) or introduction of a metal slug or quantity of water (falling-head), and then allowing the water level to stabilize. Water level measurements are taken at closely spaced intervals.

Water introduced into the well as a part of slug testing will be analyzed for the same parameters as water samples taken from the well. The slug testing water sample will be taken from the container used to introduce the water into the well.

A slug composed of inert material is proposed for use in these project-specific activities.

### 8.1 Rising-Head Test

1. All equipment will be decontaminated according to Field Procedure FP 3-1 prior to being used for slug testing.
2. The well should be opened. When wells are located within the 100 year flood plain, and equipped with water tight caps, the well should be unsealed at least 24 hours prior to testing to allow the water level to stabilize. The protective casing will remain locked during this time to prevent vandalism.
3. The Aquifer Test Data form (Attachment 9.1) should be prepared with entries for:
  - Borehole/Well number
  - Project number
  - Project name
  - Aquifer testing team
  - Distance from pumping wells, if appropriate
  - Ground surface elevation
  - Top of well casing elevation
  - Measuring equipment being used
  - Page number
  - Static water level
  - Date
  - Time intervals (0,1,3,5,7,9,10, and 12 minutes and every three minutes thereafter through 60 elapsed minutes, then in 10 minute intervals for the next hour, and in 30 minute intervals for the next 3 hours)
  - For pumping wells, the pumping rate and the period of time pumping last occurred.

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4. Measure the static water level in the well to the nearest 0.01 foot using Field Procedure FP 7-2.
5. The decontaminated automatic data recorder transducer and metal slug are lowered into the well and the displaced water allowed to return to its static level. This can be determined by making periodic water level measurements until the static water level in the well is  $\pm 0.01$  foot of the original static water level.
6. Recording of data with the data logger is initiated and the metal slug quickly withdrawn from the well. Proper operation of the Data Logger will require that the Owners Manual be followed.
7. Data recording will be stopped when the water level stabilizes in the well and the transducer will be removed from the well.
8. The transducer and metal slug will be decontaminated in accordance with Field Procedure FP 3-1.

## **8.2 Falling-Head Test**

1. All equipment will be decontaminated according to Field Procedure FP 3-1.
2. The well should be opened. When wells are located within the 100 year flood plain, and equipped with water tight caps, the well should be unsealed at least 24 hours prior to testing to allow the water level to stabilize. The protective casing will remain locked during this time to prevent vandalism.
3. The Aquifer Test Data form (Attachment 9.1) should be prepared with entries for:
  - Borehole/Well number
  - Project number
  - Project name
  - Aquifer testing team
  - Distance from pumping wells, if appropriate
  - Ground surface elevation
  - Top of well casing elevation
  - Measuring equipment being used
  - Page number
  - Static water level
  - Date

<b>AQUIFER SLUG TESTING</b>	<table> <tr> <td data-bbox="800 172 1045 231">Procedure No.</td> <td data-bbox="1045 172 1208 231">Rev.</td> </tr> <tr> <td data-bbox="800 231 1045 296">FP 7-1</td> <td data-bbox="1045 231 1208 296">1</td> </tr> </table>	Procedure No.	Rev.	FP 7-1	1	Page 6 of 6
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- Time intervals (0,1,3,5,7,9,10, and 12 minutes and every three minutes thereafter through 60 elapsed minutes, then in 10 minute intervals for the next hour, and in 30 minute intervals for the next 3 hours)
  - For pumping wells, the pumping rate and the period of time pumping last occurred.
4. Measure the static water level in the well to the nearest 0.01 foot using Field Procedure FP 7-2.
  5. The decontaminated automatic data recorder transducer is lowered into the well and the displaced water allowed to return to its static level. this can be determined by making periodic water level measurements until the static water in the well is 0.01 foot of the original static water level.
  6. The decontaminated metal slug is lowered into the well to just above the water level in the well.
  7. Recording of data with the data logger is initiated and the metal slug quickly lowered below the water table. Proper operation of the Data Logger will require that the Owners Manual be followed.
  8. Data recording will be stopped when the water level stabilizes in the well. The transducer and metal slug will be removed from the well and decontaminated in accordance with Field Procedure FP 3-1.
  9. Falling-head tests should not be performed where screened intervals straddle the water table.

## 9.0 ATTACHMENTS

### 9.1 Aquifer Test Data Form

**AQUIFER TEST DATA FORM    ATTACHMENT 9.1**  
**FP 7-1**

<b>Project:</b>	<b>Test No.:</b>
<b>Procedure/Rev.:</b>	<b>Well No.:</b>
<b>Type of Test:</b>	<b>Ground Surface Elevation:</b>
<b>Equipment Used:</b>	<b>Top of Casing Elevation:</b>
	<b>Reference Water Level Elevation: _____</b>
	<b>Nearest Pumping Well/ Pumping/Rate/Last Pumped</b>
<b>Test Performed By:</b>	
<b>Start Date and Time:</b>	

Date	Time	Time Change (t/t1)	Water Level	Water Level Change (S/S1)	Discharge Units:	Rate Units:	Remarks

<b>Comments:</b>
Pressure Transducer Tape Attached: (Y/N)
Observation Well (Y/N)
<b>Reviewed By:</b>

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**FIELD PROCEDURE FP 7-2**  
**WATER LEVEL MEASUREMENT**

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Subject  <b>WATER LEVEL MEASUREMENT</b>	Procedure No.	Rev.	
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	Supersedes Procedure Number	Rev.	Date
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Acceptance - Program QA	Approval - Program Manager		

## 1.0 PURPOSE

The purpose of this procedure is to provide general reference information and technical guidance on the measurement of piezometric head levels and the determination of the direction of groundwater flow using contour maps of the water table or potentiometric surface of a confined aquifer.

## 2.0 SCOPE

This procedure gives overall technical guidance for obtaining water level measurements in wells frequently conducted in conjunction with groundwater sampling and preparation of groundwater contour maps. Decontaminate the electric water level indicator prior to and immediately after measuring the water level in the well. This decontamination will be done in accordance with Field Procedure FP 3-1.

## 3.0 REQUIREMENTS

Groundwater level measurements can be made in monitoring wells, private or public water wells, piezometers, open boreholes, or test pits (after stabilization). Groundwater measurements should generally not be made in boreholes with drilling rods or auger flights present. If groundwater sampling activities are to occur, groundwater level measurements shall take place prior to well evacuation or sampling.

## 4.0 REFERENCES

- 4.1 HAZWRAP, July 1990. *Quality Control Requirements for Field Methods*, DOE/HWP-69/R1.
- 4.2 Freeze, R.A. and J.A. Cherry, 1979. *Groundwater*, Prentice-Hall, Englewood Cliffs, New Jersey. pp. 604
- 4.3 United States Environmental Protection Agency, September 1986. *Resource Conservation and Recovery Act (RCRA) Ground Monitoring Technical Enforcement Guidance Document*, OSWER-9950.1.

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## 5.0 DEFINITIONS

**Artesian Conditions** - A common condition in a confined aquifer in which the water level in a well completed within the aquifer rises above the top of the aquifer.

**Confined Aquifer** - An aquifer confined between two low permeability layers (aquitards).

**Equipotential Line** - A contour line on the potentiometric surface or water table showing uniform hydraulic head levels. Equipotential lines on the water table are also called water table contour lines.

**Flow Line** - A line indicating the direction of groundwater movement within the saturated zone. Flow lines are drawn perpendicular to equipotential lines.

**Flow Net** - A diagram of groundwater flow, showing flow lines and equipotential lines.

**Piezometric Head** - The height to which water will rise in a cased well.

**Potentiometric Surface** - A surface which is defined by the levels to which water will rise in cased wells which are screened in a specified zone of an unconfined aquifer or in a confined aquifer.

**Unconfined (water table) Aquifer** - An aquifer in which the water table forms the upper boundary.

**Water Table** - A surface in an aquifer where groundwater pressure is equal to atmospheric pressure and below which all strata are saturated with water.

## 6.0 RESPONSIBILITIES

### 6.1 Field Operations Leader/Project Hydrogeologist

The Field Operation Leader has overall responsibility for obtaining water level measurements and developing groundwater contour maps. The Project Hydrogeologist shall specify the reference point from which water levels are measured, usually a specific point on the upper edge of the inner well casing, the number of data points needed and which wells shall be used for a contour map, and how many complete sets of water levels are required to adequately define groundwater flow directions if there are seasonal variations.

### 6.2 Field Personnel

Field Personnel must have a basic familiarity with the equipment and procedures involved in obtaining water levels, and must be aware of any project-specific requirements.

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## 7.0 EQUIPMENT

The equipment used to make water level measurements consists of the following:

1. Steel Retractable Engineer's Measuring Tape (calibrated to 0.01 foot)
2. Electric Water Level Indicator with the Probe Tape (calibrated to 1.0 foot increments)
3. Portable HNu Photoionization Detector
4. Methanol and Deionized Water for Decontamination of the Water Level Indicator
5. Groundwater Sampling Form and Field Logbook
6. Interface Probe.

## 8.0 PROCEDURE

### 8.1 General

- Initial monitoring of the well headspace and breathing zone concentrations using a PID (HNu) or FID (OVA) and combustible gas meters shall be evaluated by the Health and Safety Officer or his designee to determine required levels of protection.
- All groundwater level measurements shall be made to the nearest 0.01 foot, and recorded in the Field Logbook and the Groundwater Sampling Form (Attachment 9.1). In measuring groundwater levels, there shall be a clearly-established reference point of known altitude, which is normally identified by a mark at one point on the upper edge of the inner well casing. The field notes recorded must clearly describe the reference used. To be useful, the reference point should be tied in with an established USGS benchmark or other properly surveyed altitude datum. Typically, altitude reference data are tied to mean sea level, as determined by the 1929 General Adjustment. An arbitrary datum could be used for an isolated group of wells, if necessary, prior to completion of a differential survey of wells to NGVD of 1929.
- After a monitoring or groundwater observation well has been installed and the groundwater level has stabilized, the initial depth to the water shall be measured and recorded. The date and time of the reading must be recorded. Information related to precipitation should be included in the data. The total depth of the well shall be measured and recorded.
- Cascading water within a borehole can cause false readings. Oil layers may also cause problems in determining the true water level in a well.
- Water level readings shall be taken regularly, as required by the Site Hydrogeologist. All water level measurements at a site used to develop a groundwater contour map must be made in the shortest time practical, and at least during the same day.

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## 8.2 Water Level Measuring Techniques

There are several methods for determining standing or changing water levels in boreholes and monitoring wells. Certain methods have particular advantages and disadvantages depending upon well conditions. A general description of these methods is presented, along with a listing of various advantages and disadvantages of each technique. An effective technique shall be selected for the particular site conditions by the on-site hydrogeologist.

Water levels can be measured by several different techniques, but the same steps shall be followed in each case. The proper sequence is as follows:

1. Check operation of recording equipment above ground. Prior to opening the well, don personal protective equipment as required. Wells that have been completed with a water-tight cap should be unsealed at least 24 hours prior to measurement to allow the water level to stabilize. The protective casing will remain locked during this time to prevent vandalism.
2. All groundwater level measurement devices must be decontaminated in accordance with Field Procedure FP 3-1 at each location to prevent cross-contamination of wells.
3. Record all information specified below on a Groundwater Sampling Form (Attachment 9.1) or in Field Logbook.
4. The presence of light floating and dense sinking immiscible liquids will be determined using an interface probe by first checking the surface of the groundwater and then the base of the well.
5. Record well number, top of casing altitude, and surface altitude, if available. Well diameter and total depth should be recorded. Water levels shall be taken from the surveyed reference mark on the top edge of the inner well casing.
6. Record water level to the nearest 0.01 foot (0.3 cm).
7. Record the time and day of the measurement.
8. Many water level measuring devices have marked metal or plastic bands clamped at intervals along the measuring line used for reference points to obtain depth measurements. The spacing and accuracy of these bands shall be checked frequently as they may loosen and slide up or down the line, resulting in inaccurate reference points.

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### 8.3 Water Level Measuring Devices

#### 8.3.1 Electric Water Level Indicators

These devices consist of a spool of small-diameter cable and a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact.

There are a number of commercial electric sounders available, none of which is entirely reliable under all conditions likely to occur in a contaminated monitoring well. In conditions where there is oil on the water, groundwater with high specific conductance, water cascading into the well, or a turbulent water surface in the well, measuring with an electric sounder may be difficult.

For accurate readings, the probe shall be lowered slowly into the well. The electric tape is marked at the measuring point where contact with the water surface was indicated. The distance from the mark to the nearest tape band is measured using an engineer's folding rule or steel tape and added or subtracted to the nearest band reading to obtain the depth to water. Band spacing shall be checked periodically.

#### 8.3.2 Chalked Steel Tape

Water level is measured by chalking a weighted steel tape and lowering it a known distance (to any convenient whole foot mark) into the well or borehole. Water level is determined by subtracting the wetted chalked mark from the total length lowered into the hole. The tape shall be withdrawn quickly from the well because water has a tendency to rise up the chalk due to capillary action.

Disadvantages to this method include the following: depths are limited by the inconvenience of using heavier weights to properly tension longer tape lengths (typically, 100 foot tapes require a 10 to 12 pound weight to tension adequately); ineffective if borehole/well wall is wet or inflow is occurring above the static water level; chalking the tape is time consuming; difficult to use during periods of precipitation.

## 9.0 ATTACHMENTS

### 9.1 Water Level Measurement Form

## Water Level Measurements

(Field Sheet)

Measurement Team: \_\_\_\_\_

Project Number and Location: \_\_\_\_\_

Measuring Method: \_\_\_\_\_

Measuring Point: \_\_\_\_\_

Well No.	Date	Time	Tape Reading		Depth to Water (ft)	Remarks
			Measure Pt.	Water Level		

**Measuring Point:** Point where measurement was taken. Top of PVC casing (TOC); Top of Protective Steel Casing (TOSC); Land Surface (LS), etc.

**Depth to Water:** Measurements should be recorded to the nearest 0.01 ft. (e.g., 10.06 feet below TOC)

**Remarks:** Any conditions that may influence the water level measurements.

**Disclaimer**

*Data entered on this form were obtained during field activities. All entries are preliminary in nature, do not represent SAIC's final assessment, and may be subject to revision.*

**FIELD PROCEDURE FP 7-3**  
**BOREHOLE LOGGING**

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<b>Subject</b>  <b>BOREHOLE LOGGING</b>	<b>Procedure No.</b>	<b>Rev.</b>	
	FP 7-3	1	Page 1 of 6
	<b>Issue Date</b>	<b>Effective Date</b>	
	10/04/93	10/04/93	
	<b>Supersedes Procedure Number</b>	<b>Rev.</b>	<b>Date</b>
	630 FP 24		0
<b>Acceptance - Program QA</b>	<b>Approval - Program Manager</b>		

## 1.0 PURPOSE

The purpose of this procedure is to define the requirements necessary for borehole and sample logging. Consequently, the major objectives of this plan are to provide a uniform set of guidelines that will aid in developing consistency among sample descriptions and sample techniques. The importance of accurate, complete, clear, and concise logs cannot be overemphasized.

## 2.0 SCOPE

This procedure applies to descriptions of the standard techniques used for logging boreholes and logging soil/rock samples.

## 3.0 REQUIREMENTS

Careful field documentation and sample description is necessary to ensure that logging is done in a consistent manner.

## 4.0 REFERENCES

- 4.1 Compton, R. R., 1962. *Manual of Field Geology*, John Wiley and Sons, Inc., New York.
- 4.2 Folk, R. L., 1968. *Petrology of Sedimentary Rocks*, Hemphills Bookstore, Austin, Texas, p. 170.
- 4.3 HAZWRAP, July 1990. *Quality Control Requirements for Field Methods*, DOE/HWP-69/R1.
- 4.4 Lewis, D. W., 1984. *Practical Sedimentology*, Van Nostrand Reinhold Company, Inc., New York, New York.
- 4.5 Pettijohn, F. J., 1975. *Sedimentary Rocks*, Harper & Row, New York.

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4.6 U. S. Army Corps of Engineers, 1953. *The Unified Soil Classification System*, Technical Memorandum No. 3-357 (Vol. 1), Waterways Experimental Station Usage, Vicksburg, Mississippi.

4.7 USAEC, May 1993. *U.S. Army Environmental Center Guidelines for Implementation of ER 1110-1-263 for USAEC Projects*.

4.8 USATHAMA, January 1990. *U.S. Army Toxic and Hazardous Materials Agency Quality Assurance Program*, USATHAMA PAM 11-41.

## 5.0 DEFINITIONS

This section provides information that is commonly used in borehole sample descriptions (also see Section 9.0 Attachments).

**Bedding** - Existence of beds or layers (strata), laminae, or other tabular and essentially horizontal units.

**Cohesive** - Having the capacity to stick together or adhere together. In effect, the cohesion of soil is that part of its shear strength which does not depend on interparticle friction.

**Color** - Described using a Munsell color chart, and only colors listed in that chart should be used. If the colors in the sample are variable, adjectives such as "mottled" or "banded" may be used as appropriate (available from USGS, see attachment 9.2).

**Conchoidal** - Shell-like surface form produced by fracture of a brittle material.

**Consistency** - Density or strength of the soil, and is a primary factor in engineering investigations (see Attachment 9.3).

**Fabric** - Orientation of the particles composing a soil or rock.

**Friable** - Easily crumbled.

**Grading** - Degree of mixing size classes in a sedimentary material. Well graded implies uniform distribution from coarse to fine; poorly graded implies lack of uniformity in size or lack of continuous distribution (also see sorting).

**Grain Size** - Size of particles within a rock or a soil sample (see Attachment 9.1).

**Moisture** - Degree of wetness of a soil, i.e. dry, damp, moist, and wet.

**Plasticity** - Property of a material which enables it to undergo permanent deformation without appreciable volume change or elastic rebound, and without rupture.

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**Slickensides** - Polished and striated (scratched) surface that results from friction along a fault plane. Apparent slickensides can sometimes be created during the drilling process.

**Soil Classification** - See Attachment 9.7.

**Sphericity and Roundness** - See Attachment 9.6.

**Texture** - Geometric aspects of the component particles of a soil or rock, including size, shape, and arrangement.

## **6.0 RESPONSIBILITIES**

### **6.1 Field Operations Leader**

The Field Operations Leader is responsible for ensuring that field personnel have been trained in the use of this procedure, for verifying that monitoring well installation activities are performed in compliance with this procedure, and to ensure consistency in logging between Field Geologists.

### **6.2 Field Geologist and/or Field Technician**

The Field Geologist is responsible for on-site monitoring of drilling and soil sampling operations, for recording (logging) pertinent information regarding the geologic materials penetrated during the operations, and that the well and sample numbering system follows that described in the project-specific work plan.

## **7.0 EQUIPMENT**

The following is a list of required and optional equipment necessary for borehole logging.

### **7.1 Required Equipment**

1. Clipboard
2. Soil Boring Forms
3. Portable Organic Vapor Detector
4. Field Logbook, Straight Edge, and Black Permanent Ink
5. 100-foot Weighted Engineer's Tape (calibrated to 0.01 foot)
6. Folding Rule or Tape Measure (calibrated to 0.01 foot)
7. Sand Gauge
8. Color Chart

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9. Acid Bottle
10. Water Level Indicator
11. Site Map
12. Copy of Drilling Contract
13. Waterproof Marking Pen
14. Sample Jars or Bags

## **7.2 Optional Equipment**

1. Hand Lens X10
2. Brunton Compass
3. Pocket Penetrometer
4. Equipment Pouch
5. Flagging Tape
6. Cooler and Water Bottles
7. Flashlight
8. Rock Hammer

## **8.0 PROCEDURE**

### **8.1 Recording Data**

Borehole information that is recommended in the Field Logbook is listed in Field Procedure FP 1-2. In addition to the Field Logbook, it is required that soil logging data be recorded on a pre-printed boring log (Attachment 9.8). This activity is usually accomplished in the field office and is done to provide a clear and concise record of borehole lithology. Also, this method allows a rapid means in which data can be discussed and interpreted.

### **8.2 Information to be Gathered During Borehole Logging**

The percent of core recovery is recorded on the log form. This number is the ratio of the actual core recovered over the interval in which the sample was taken. For instance, if a continuous core barrel is driven five feet but only four feet are retained by the core barrel, then there was an 80 percent core recovery.

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The most important information on the form is the description of each sample or geologic unit. Any obvious features related to contamination should also be noted such as odor or staining. The description of lithologic samples should include color, consistency, texture, mineralogy, and moisture of the sample or unit. These characteristics should be described according to guidelines given in the attachments. Soil sampling will be performed in accordance with Field Procedure FP 6-3 and the sampling intervals noted on the log form.

### 8.3 Logging Guidelines

For accuracy and consistency, boring log descriptions should generally be completed in the following order. Refer to the listed attachments and to Field Procedure FP 6-3 for guidance.

1. Material type - Attachment 9.1, Attachment 9.4
2. Color. Color should be described using a Munsell color chart, and the colors listed in the chart only. If the colors in the sample are variable, adjectives such as "mottled" or "banded" may be used as appropriate (See Attachment 9.2).
3. Consistency. Consistency is the density or strength of the soil, and is a primary factor in engineering investigations. It is also an important part of geologic and hydrogeologic investigations (Attachment 9.3).
4. Texture. Texture describes the size and shape of soil grains and is often the most important characteristic of a soil. The first step in describing texture is to determine whether the soil consists primarily of sand and gravel (particle size greater than 63 micrometers) or fines (particle size less than 63 micrometers). In the written description, the major soil component should be given first and be capitalized and underlined. The portions of sand, gravel, and fines should be described using only the following semi-quantitative adjectives:

<b>Adjective</b>	<b>Estimated Percent of Total Sample</b>
Trace	0-5
Little	5-12
Some	12-30
And	30-50

For example - SAND, some clay. NOT Sand, lots of clay or Clayey sand. Reference Attachment 9.4

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5. Description of mineralogy should be as simple as possible and, above all, accurate. Relatively common mineralogic descriptions may be used as adjectives:

Arkosic  
 Calcareous  
 Feldspathic  
 Glauconitic  
 Micaceous

More complicated descriptions should generally be enclosed in parentheses.

6. Moisture Content. If the drilling method permits, the moisture content of the sample (dry, damp, moist, or wet) should be noted.
7. Geologic Interpretation. If the logger is familiar with the site geology and confident of the interpretation, a brief interpretation of the soil (i.e. "saprolite," "beach sand," "loess," etc.) may be added in parentheses at the end of the description. This is, of course, no substitute for a complete soil description.

## 9.0 ATTACHMENTS

### 9.1 Grain Size

### 9.2 Color

### 9.3 Field Criteria Used in Determining Soil Consistency

### 9.4 Lithology

### 9.5 Sorting

### 9.6 Sphericity and Roundness

### 9.7 Soil Classification Abbreviations

### 9.8 Sample Boring Log Form

## GRAIN SIZE

**Grain Size** - For consistent descriptions of grain size, the grain size classification scheme of Wentworth (1922) should be used. It is also advantageous to carry a pocket grain size card to aid in quick grain size classification in the field.

## Wentworth Grain Classification Scheme

Exact Size Limits (mm)	Approximate inch Equivalents (in.)	Sediment
256	< 10	Boulder gravel
64 - 256	2.5 - 10	Cobble gravel
32 - 64	1.2 - 2.5	Very coarse pebble gravel
16 - 32	0.6 - 1.2	Coarse pebble gravel
8 - 16	0.3 - 0.6	Medium pebble gravel
4 - 8	0.15 - 0.3	Fine pebble gravel
2 - 4	0.08 - 0.15	Granule (or very fine pebble) gravel
1 - 2	0.04 - 0.08	Very coarse sand
0.5 - 1	0.02 - 0.04	Coarse sand
0.25 - 0.5	0.01 - 0.02	Medium sand
0.125 - 0.25	0.005 - 0.01	Fine sand
0.0625 - 0.125	0.002 - 0.005	Very fine sand
0.0039 - 0.0625	0.00015 - 0.002	Silt
Smaller than 0.0039	Smaller than 0.00015	Clay (clay-size materials)

## COLOR

**Color** - The definition of color is self-explanatory; however, the Field Geologist should be aware to note both the fresh and weathered color of a soil or rock sample. Note that soils should be wet before classifying the color. For consistent descriptions of color, the Munsell color charts should be used. These are distributed by:

The Geological Society of America  
Post Office Box 9140  
Boulder, CO 80401

For mixed lithologies within a common interval, provide relative percentages of the two or more lithologies within parentheses following the lithologic name. For example, SAND fine - medium (60%) brownish yellow (10YR 6/6), and GRAVEL coarse (40%) - very pale brown (10YR 7/3), etc. (HAZWRAP, 1989).

**COMMONLY USED FIELD CRITERIA FOR DETERMINING SOIL  
CONSISTENCY**

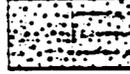
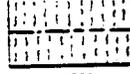
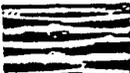
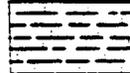
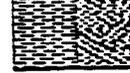
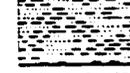
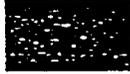
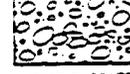
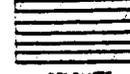
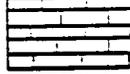
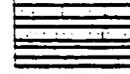
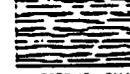
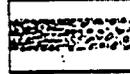
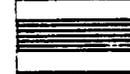
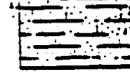
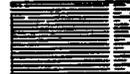
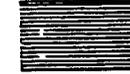
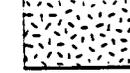
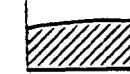
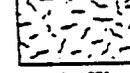
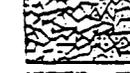
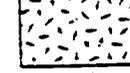
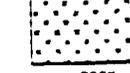
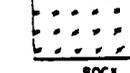
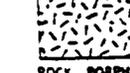
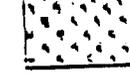
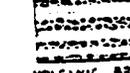
**SOIL CONSISTENCY AS DETERMINED BY POCKET PENETROMETER**

Term	Unconfined Compressive Strength of Fine Grained Soils (After Terzaghi and Peck)		Field Test (After Cooling, Skempton and Glossip)
	Kips/ft <sup>2</sup>	kN/m <sup>2</sup>	
Very soft	0 - 0.5	0 - 25	Squeezes between fingers when fist is closed.
Soft	0 - 5.1	25 - 50	Easily molded by fingers.
Firm	1 - 2	50 - 100	Dented by strong pressure of fingers.
Stiff	2 - 3	100 - 150	Dented only slightly by finger pressure.
Hard	4+	200+	Dented only slightly by pencil point.

**COMMONLY USED FIELD CRITERIA FOR DETERMINING SOIL  
CONSISTENCY (Continued)**

Consistency of Fine Grained Soils - Standard Penetration Test (After Terzaghi and Peck)		Relative Density of Sand Standard Penetration Test (After Terzaghi and Peck)	
Blows 6-inch Penetration	Consistency	Blows 6-inch Penetration	Relative Density
0 - 1	Very Soft	0 - 5	Very Loose
2 - 4	Soft	5 - 10	Loose
5 - 8	Firm	11 - 20	Firm
9 - 15	Stiff	21 - 30	Very Firm
16 - 30	Very Stiff	31 - 50	Dense
31+	Hard	51+	Very Dense

COMMON SYMBOLS USED IN THE LITHOLOGIC DESCRIPTION OF SOIL  
AND ROCK SAMPLES

SURFICIAL						
						
GLACIAL TILL AND MORAINES	GLACIAL TILL AND MORAINES	GRAVEL AND STRATIFIED DRIFT	LOESS	SAND	SOIL, SILT, OR ALLUVIUM	
SEDIMENTARY						
						
BONE	BRECCIA	CHALK	CHERT, BEDDED	CLAY	CLAY, FIRE OR FLINT	CLAY, SAND
						
COAL	COAL, BONY OR IMPURE	COAL, CANNEL	CONGLOMERATE	DOLOMITE	GYPNUM	LIMESTONE, ARGILLACEOUS
						
LIMESTONE, CRYSTALLINE	LIMESTONE, MASSIVELY BEDDED	LIMESTONE, SANDY	LIMESTONE, SHALY	LIMESTONE, THIN-BEDDED	LIMESTONE, CHERTY	PEAT
						
QUARTZITE	ROCK, PHOSPHATE	SALT	SANDSTONE, BEDDED	SANDSTONE, CALCAREOUS	SANDSTONE, CROSS-BEDDED	SANDSTONE, MASSIVE
						
SANDSTONE, SHALY OR THIN-BEDDED	SHALE	SHALE, CANNEL	SHALE, CARBONACEOUS	SHALE, OIL	SHALE, SAND	SLATE
						MARBLE
METAMORPHIC						
						
GNEISS	GNEISS, CONTORTED	GNEISS AND SCHIST	METAMORPHISM <small>(May be combined with metamorphic and igneous patterns)</small>	SCHIST	SCHIST, CONTORTED	SCHISTOSE OR GNEISSOID GRANITE
IGNEOUS AND VEIN MATTER						
						
BASALTIC FLOWS	BEDDED LAVA (ANDESITIC)	BEDDED LAVA AND TUFF	BEDROCK	GRANITE	ORE <small>(Dark or cross areas)</small>	ORE
						
ORE, LEAN	QUARTZ	ROCK, BRECCIATED	ROCK, MASSIVE IGNEOUS	ROCK, MASSIVE IGNEOUS	ROCK, MASSIVE IGNEOUS	ROCK, MASSIVE IGNEOUS
						
ROCK, MASSIVE IGNEOUS	ROCK, MASSIVE IGNEOUS	ROCK, MASSIVE IGNEOUS	ROCK, MASSIVE IGNEOUS	ROCK, MASSIVE IGNEOUS	ROCK, PORPHYRITIC	ROCK, PORPHYRITIC
						
ROCK, PORPHYRITIC	SOAPSTONE, TALC.	VOLCANIC BRECCIA	VOLCANIC BRECCIA			

**SORTING**

The generally accepted standard for describing the degree of sorting in a soil or rock sample based on the Folk Classification Scheme, 1968.

Visual Standard	Phi Standard Deviation	Verbal
	0.35 _____	0.35 - 0.50 well sorted
	0.50 _____	0.50 - 1.0 moderately sorted
	1.00 _____	1.0 - 2.0 poorly sorted
	2.00 _____	> 2.00 very poorly sorted

**SPHERICITY AND ROUNDNESS**

Sphericity is a measure of how nearly equal the axial dimensions of a particle are. True sphericity is the surface area of a grain divided into the surface area of a sphere of the same volume.

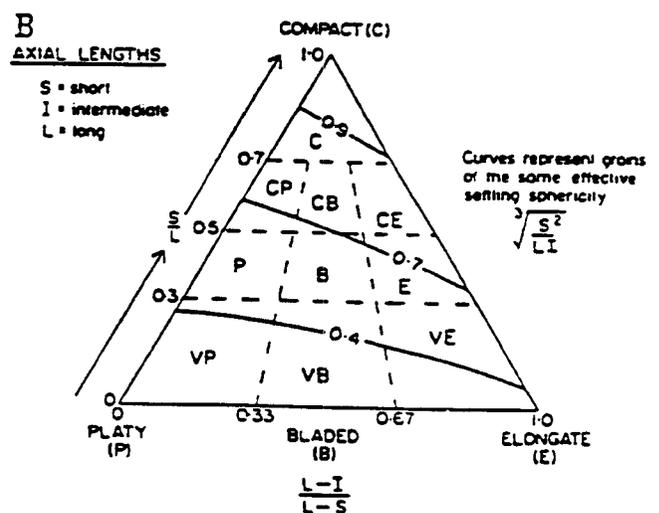
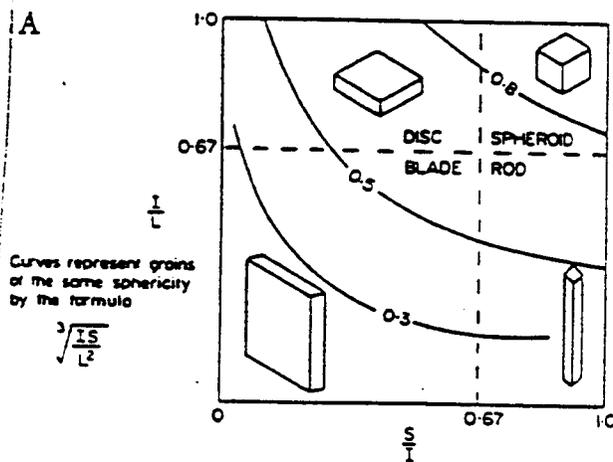
Operational sphericity is:

$$\sqrt[3]{\frac{V_p}{V_{cs}}}$$

where  $V_p$  = volume of particle and  $V_{cs}$  = volume of smallest sphere that would enclose the particle.  $V_{cs}$  is approximated by

$$\sqrt[3]{\frac{L \cdot I \cdot S}{L^3}} = \sqrt[3]{\frac{I \cdot S}{L^2}}$$

where  $I$  = intermediate axis,  $S$  = short axis, and  $L$  = long axis.



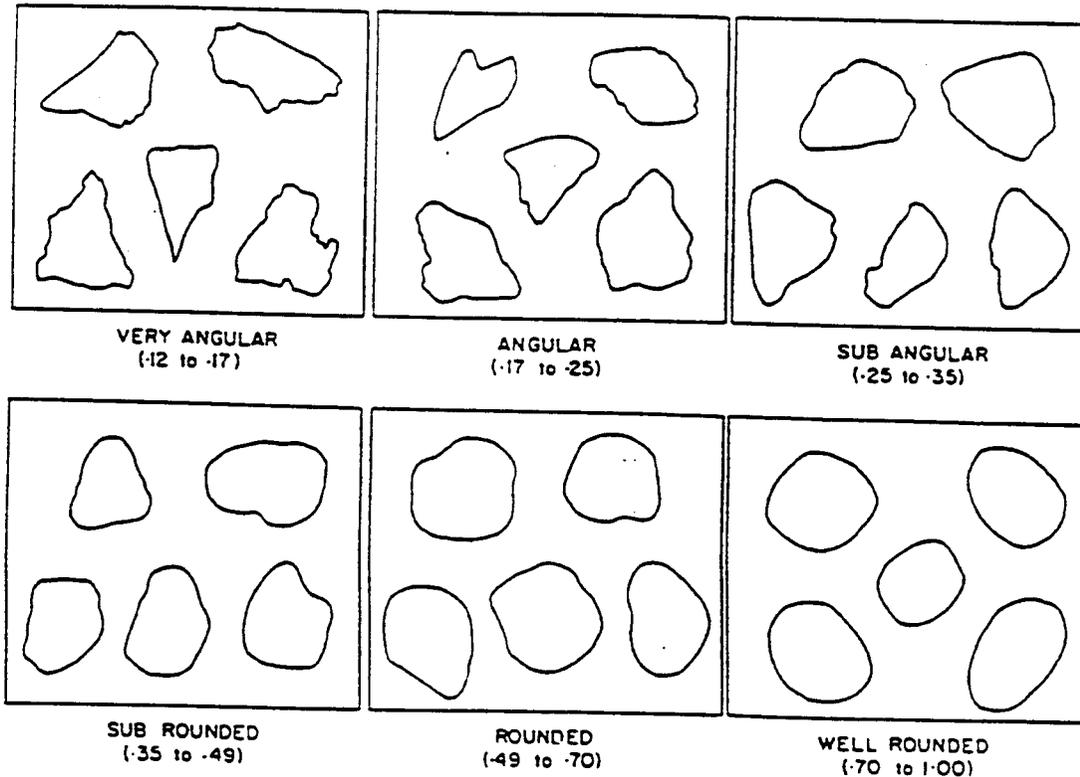
**SPHERICITY AND ROUNDNESS (Continued)**

Roundness indicates the extent of abrasion the grains have undergone. Extent of abrasion reflects overall transport history but does not necessarily reflect the distance the grains have traveled from their source. Rounded grains may have been derived locally from a sedimentary rock, or may have been extensively abraded in an environment near the source, such as a beach adjacent to a cliff.

Quantitatively, true roundness is generally expressed by the formula:

where  $r$  = radius of curvature of grain corners,  $R$  = radius of largest inscribed circle, and  $N$  = number of corners.

Unless highly detailed work is justified by the likely results, practical measures of roundness rely on visual comparison with standard silhouette charts.



Silhouette comparison diagram for sand grain roundness.

MAJOR DIVISIONS			Graphic Symbol	Letter Symbol	Typical Descriptions
More than 50% of Material is Larger than No. 200 Sieve Size	Gravel and Gravelly Soils	Clean Gravels (Little or No Fines)		GW	Well Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
				GP	Poorly-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
		Gravels with Fines (Appreciable Amount of Fines)		GM	Silty Gravels, Gravel-Sand-Silt Mixtures
				GC	Clayey Gravels, Gravel-Sand-Clay Mixtures
	Sand and Sandy Soils	Clean Sand (Little or No Fines)		SW	Well-Graded Sands, Gravelly Sands, Little or No Fines
				SP	Poorly-Graded Sands, Gravelly Sands, Little or No Fines
		Sands with Fines (Appreciable Amount of Fines)		SM	Silty Sands, Sand-Silt Mixture
				SC	Clayey Sands, Sand-Clay Mixtures
More than 50% of Material is Smaller than No. 200 Sieve Size	Silts and Clays	Liquid Limit Less than 50		ML	Inorganic Silts and Very Fine Sands, Rock Flour, Silty or Clayey Fine Sands or Clayey Silts with Slight Plasticity
				CL	Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays
				OL	Organic Silts and Organic Silty Clays of Low Plasticity
	Silts and Clays	Liquid Limit Greater than 50		MH	Inorganic Silts, Micaceous or Diatomaceous Fine Sands or Silty Soils
				CH	Inorganic Clays of High Plasticity, Fat Clays
				OH	Organic Clays of Medium to High Plasticity, Organic Silts
Highly Organic Soils				PT	Peat, Humus, Swamp Soils with High Organic Contents

Unified Soil Classification System



**FIELD PROCEDURE FP 7-4**  
**FIELD MEASUREMENT OF pH AND**  
**OXIDATION-REDUCTION POTENTIAL (Eh)**

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	Issue Date	Effective Date	
	10/04/93	10/04/93	
	Supersedes Procedure Number	Rev.	Date
	630 FP 30		0
Acceptance - Program QA	Approval - Program Manager		

### 1.0 PURPOSE

The purpose of this procedure is to define the necessary steps for conducting pH and Oxidation-Reduction Potential (Eh) measurements of aqueous solutions such as groundwater during field investigations.

### 2.0 SCOPE

2.1 This procedure applies to the general calibration, operation and maintenance of pH and Eh hand-held meter(s) and electrode(s).

2.2 This procedure may also be used in conjunction with the manufacturer's instructions for specific pH and Eh measuring devices.

### 3.0 REQUIREMENTS

The chemical parameters acidity/alkalinity (pH) and the oxidation-reduction potential (Eh) are measured for aqueous solutions to provide basic information on groundwater or surface water chemistry at a site. pH and Eh are important environmental parameters that should be measured during site investigations to provide information concerning the extent of contamination or the potential for migration of certain parameters, such as metals. pH measurements are taken on purge waters from monitoring wells to aid in assessing when sufficient water has been removed from the well to ensure that representative groundwater samples will be collected. Eh measurements are taken to assess the oxidation-reduction potential of an aqueous solution. Equilibrium relationships and redox reactions of the various chemical constituents are defined relative to pH and Eh conditions within the aqueous environment.

FIELD MEASUREMENT OF pH AND OXIDATION-REDUCTION POTENTIAL (Eh)	Procedure No. FP 7-4	Rev. 1	Page 2 of 5
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#### 4.0 REFERENCES

- 4.1 OMEGA Engineering, Inc., 1986. *Model PHH 60/80 Hand Held pH Meter Instruction Manual*.
- 4.2 Denver, J.I., 1982. *The Geochemistry of Natural Waters*, Prentice-Hall, New Jersey, pp. 388.
- 4.3 Felter, C.W., 1988. *Applied Hydrogeology*, Second Edition, Macmillian Publishing Co., New York, pp. 592.
- 4.4 United States Environmental Protection Agency, 1987. *Groundwater Handbook*, EPA/625/6-87/016.

#### 5.0 DEFINITIONS

**pH** - The negative logarithm of the concentrations of H<sup>+</sup> and OH<sup>-</sup> ions in an aqueous or non-aqueous medium. Acidic mediums have a pH of less than 7.0 and alkaline or basic mediums have a pH varying from greater than 7 to 14. A pH of 7.0 is considered neutral. Temperature of a sample is normally measured in conjunction with pH and Eh measurements in the field.

**Eh** - The oxidation potential of an aqueous solution. Measurement of Eh is usually expressed in millivolt (mV) units.

#### 6.0 RESPONSIBILITIES

##### 6.1 Field Operations Leader

The Field Operations Leader is responsible for the overall use of the pH and Eh measurement equipment and that adequate materials or supplies are available for the calibration, use, and maintenance of measuring equipment. The Field Operations Leader is also responsible for ensuring that the calibration and use methodology is consistent and that workers have been instructed in the proper use of equipment.

##### 6.2 Field Team Leader

The Field Team Leader is responsible for the correct calibration and use of the hand-held pH and Eh equipment and that other field personnel are trained in the proper operation of the equipment.

<b>FIELD MEASUREMENT OF pH AND OXIDATION-REDUCTION POTENTIAL (Eh)</b>	Procedure No. FP 7-4	Rev. 1	Page 3 of 5
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## 7.0 EQUIPMENT

General equipment necessary for field measurement of pH and Eh are as follows:

1. OMEGA Model PHH 60/80 Hand-held pH Meter (with mV reading capability), electrodes for pH and temperature, or equivalent. An oxidation-reduction potential (ORP) electrode compatible with the pH instrument is required to measure relative Eh. This electrode is usually a Platinum or Gold band type.
2. pH Calibration Solutions, as required, usually pH 4.01, pH 7.01, and pH 10.01
3. Batteries, as required by the manufacturer's equipment operation manual.

## 8.0 PROCEDURE

The procedure for calibration, operation, and maintenance of the OMEGA Model PHH 60/80 Hand-held pH/Eh Meter is outlined below. If a different instrument is used, the owner's manual should be consulted for instructions.

### 8.1 Calibration

#### 8.1.1 OMEGA Model PHH 60/80 pH Meter Calibration

The OMEGA Model PHH 60/80 pH Meter is laboratory calibrated prior to shipment from the manufacturer. Calibration shall be performed daily utilizing fresh buffer solutions that are standardized against National Institute of Standards and Technology (NIST) certified pH references to within 0.01 pH at 25°Celsius. In addition, calibration should be verified prior to sampling at a well location or every two hours if used in continuous operation at one location. When checked, if the calibration is off more than 0.3 pH units relative to the test buffer solutions, the instrument should be re-calibrated with the standardized buffer solutions. The following procedural steps for calibration should be followed:

1. Rinse the pH electrode with ASTM Type II reagent-grade water.
2. Insert the pH electrode into a container containing fresh pH 7.01 buffer solution (Fisher Scientific, monobasic potassium phosphate and sodium hydroxide, 0.05 Molar).
3. Press the "Calibrate" button.
4. Adjust the CAL pot until the 7.01 pH is visible on the meter readout.
5. Wait until the "Ready" indicator is visible on the meter readout.
6. Adjust the pH reading up or down to the standardized pH buffer solution value.
7. Remove the electrode from the solution, rinse with ASTM Type II reagent-grade water.

<b>FIELD MEASUREMENT OF pH AND OXIDATION-REDUCTION POTENTIAL (Eh)</b>	<b>Procedure No.</b> FP 7-4	<b>Rev.</b> 1	<b>Page 4 of 5</b>
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8. Insert electrode into a container containing either a pH 4 or a pH 10.01 buffer solution. Use the appropriate solution that is in the expected pH range of sampler (Recommended buffer solutions: Fisher Scientific, pH 4 - potassium biphthalate, 0.05 Molar; pH 10: potassium carbonate, potassium borate, and potassium hydroxide, 0.05 Molar).
9. Adjust the SLOPE until the display reads the correct value for the standardized buffer solution. "Enter" this value.
10. Remove the electrode and rinse in ASTM Type II reagent-grade water. The pH meter is now calibrated. Record all adjustments in the Field Equipment Logbook.

### 8.1.2 Eh Calibration

Eh or ORP electrodes are factory calibrated and require no calibration. However, the instrument readings should be checked and adjusted if necessary with solutions of known electrochemical potential. The instruction manual should be consulted when correcting the Eh reading based on a prepared check solution.

### 8.2 Operation

1. Collect an aqueous sample in a clean container of sufficient volume to cover the electrode detectors.
2. Extend electrode in either the 90 degree or 180 degree measurement position.
3. Energize instrument by depressing the ON/OFF switch once.
4. Rinse the electrode thoroughly with distilled water to prevent cross-contamination.
5. Immerse pH (or Eh) and temperature electrodes in sample. Do not immerse electrode caps.
6. Select the desired parameter by depressing pH/PPM switch.
7. Agitate electrode briefly and observe reading. pH will be reported to 0.1 standard units. The reading for Eh will be in millivolts (mV). Record the instrument readings in the Field Equipment Logbook.
8. Rinse electrodes thoroughly with ASTM Type II reagent-grade water and replace the electrode storage caps; fill the pH electrode cap with a small amount of pH 4 buffer or potable water to keep the bulb from drying out.
9. Remove the battery when the instrument will be stored for a long period.

**Note:** Measurement of Eh and pH cannot be done concurrently with the same instrument. Readings for each are taken with the appropriate electrode attached to the instrument or separate instruments are utilized. It is very important that the Eh and pH measurement be taken quickly with a minimum sample exposure to air to avoid the

<b>FIELD MEASUREMENT OF pH AND OXIDATION-REDUCTION POTENTIAL (Eh)</b>	<b>Procedure No.</b> FP 7-4	<b>Rev.</b> 1	<b>Page 5 of 5</b>
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diffusion of oxygen into the sample and the diffusion of carbon dioxide out of the sample.

Measurement of Eh in a groundwater sample presents some problem. First, by the time a sample reaches equilibrium, oxygen has diffused into the sample and changed the redox potential. Although a true Eh reading of the sample is not likely to be obtained, a general value for the sample can be achieved by minimizing air contact with the water. Second, many redox couples do not behave in a reversible fashion at the platinum electrode. Third, some systems give mixed potentials that are influenced by several different couples and never read a true equilibrium.

### 8.3 Quality Control

Duplicate pH and Eh measurements shall be taken at each sampling location by rinsing the electrode with ASTM Type II reagent-grade water and retesting the sample. Both results shall be recorded. If the results differ  $\pm 0.2$  pH units, the meter shall be recalibrated and the sample shall be retested.

### 8.4 Preventive Maintenance

The pH/Eh meter should be cleaned and inspected daily before and after use. Batteries shall be replaced, as necessary, and the electrodes shall be replaced when required based on the manufacturer's instruction and response of the electrode.

The electrodes can be maintained by cleaning after use with ASTM Type II reagent-grade water and filling the pH electrode's protective cap with a small amount of pH 4 buffer or potable water to keep the bulb from drying out. Electrodes that remain dry or have been etched by high concentrations of acid or base solutions, below pH 3 and above pH 12, may have slow response times. Damaged electrodes should be replaced as necessary.

### 9.0 ATTACHMENTS

None.

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**FIELD PROCEDURE FP 7-5**  
**SPECIFIC CONDUCTIVITY MEASUREMENTS**

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<b>SPECIFIC CONDUCTIVITY MEASUREMENTS</b>	Subject	Procedure No.	Rev.	
		FP 7-5	1	Page 1 of 6
	Issue Date	Effective Date		
	10/04/93	10/04/93		
	Supersedes Procedure Number	Rev.	Date	
	630 FP 31	0		
Acceptance - Program QA	Approval - Program Manager			

## 1.0 PURPOSE

The purpose of this procedure is to define the steps necessary for calibration, operation, and maintenance of the Hach Model 44600 conductivity/TDS meter.

## 2.0 SCOPE

2.1 This procedure applies to the calibration, operation, and maintenance of the Hach Model 44600 conductivity/TDS meter.

2.2 This procedure may also be used in conjunction with the manufacturer's instructions for other specific conductivity meters.

## 3.0 REQUIREMENTS

Electrical conductance of a substance is its ability to conduct an electrical current. Chemically pure water has a low electrical conductance; while water that contains dissolved inorganic solids (chloride, phosphate, etc.) has a higher electrical conductance. Consequently, the greater the amount of dissolved solids in groundwater the greater the water's electrical conductivity.

## 4.0 REFERENCES

4.1 Driscoll, F. G., 1986. *Groundwater and Wells*, Johnson Division, St. Paul, Minnesota, pp. 92-94.

4.2 *Hach Model 44600 Conductivity/TDS Meter Instruction Manuals.*

## 5.0 DEFINITIONS

None.

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## 6.0 RESPONSIBILITIES

The Field Operations Leader is responsible to ensure that the necessary equipment is available for the calibration, use, and maintenance of sampling equipment. The Field Operations Leader is also responsible to ensure that the calibration and the method of operation is consistent and that workers have been instructed in the proper use of equipment.

## 7.0 EQUIPMENT

The following is a list of replacement parts, calibration standards and accessories associated with the operation of the Hach Model 44600 Conductivity/TDS Meter.

### REPLACEMENT PARTS AND ACCESSORIES

Cat. No.	Description	Unit
19380-04	Battery, AA, alkaline . . . . .	4/pkg
1080-42	Beaker, poly, 100 mL . . . . .	each
620-14	Bottle, wash, 120 mL . . . . .	each
14423-26	Gallic Acid Solution, 59-ml dropping bottle . . . . .	each
44600-88	Instruction Manual . . . . .	each
162-36	Phenolphthalein Indicator Solution . . . . .	15 mL
44606-00	Probe, conductivity . . . . .	each
44606-10*	Probe, conductivity, 10-ft cable (optional) . . . . .	each
2105-14	Sodium Chloride Standard Solution, 100 mg/L ( $1990 \pm 20 \mu\text{S/cm}$ , $995 \pm 10 \text{ TDS}$ ) . . . . .	118 mL
23075-14	Sodium Chloride Standard Solution, 85.47 mg/L ( $180 \pm 00 \mu\text{S/cm}$ , $90 \pm 10 \text{ TDS}$ ) . . . . .	118 mL
14400-14	Sodium Chloride Standard Solution, 491 mg/L ( $1000 \pm 10 \mu\text{S/cm}$ , $500 \pm 5 \text{ TDS}$ ) . . . . .	118 mL
23074-14	Sodium Chloride Standard Solution, 10246 mg/L ( $18000 \pm 50 \mu\text{S/cm}$ , $9000 \pm 25 \text{ TDS}$ ) . . . . .	118 mL

\* Refer to specifications for differences in accuracy and zero error.

SPECIFIC CONDUCTIVITY MEASUREMENTS	Procedure No. FP 7-5	Rev. 1 Page 3 of 6
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## 8.0 PROCEDURE

The procedure for calibration, operation, and maintenance of the Hach Model 44600 Conductivity/TDS Meter is outlined below. If a different instrument is used, the owner's manual should be consulted for instructions.

### 8.1 Calibration

Calibration shall be performed daily at or before the first sampling location of the day and when excess variability (see Section 8.3) is noted.

NOTE: Calibration on the 2 mS/cm range with the 100 mg/L NaCl (1.99 mS/cm) standard calibrates all three ranges accurately enough for most applications. However, slightly better accuracy will be gained by calibrating on the particular range to be used using the appropriate standard solution. Refer to *Replacement Parts and Accessories* for a list of available standards offered by Hach Company.

Calibrate as follows:

Sodium Chloride standards are contaminated easily. Always clean the probe before calibration and use a clean, dry container for the standard solution.

1. Be sure the probe is clean.
2. Soak the probe in demineralized water for at least 30 minutes.
3. Remove the probe from the water and fling out drops clinging inside.
4. Immerse the probe to or beyond the vent holes in a beaker containing Sodium Chloride Standard Solution, 1000 mg/L. Agitate vertically to remove entrapped air.
5. Repeat steps 3 and 4 at least once more.
6. Press the POWER I key and CND key. Verify that the LO BAT indication does not appear.
7. Press the 2 mS/cm range key.
8. Check the reading on the display. It should be 1.990 mS/cm. If adjustment is needed, use a small screwdriver to adjust the CAL control next to the display. Counterclockwise adjustment increases the reading. Record calibration and any adjustments made in the Field Equipment Logbook.

SPECIFIC CONDUCTIVITY MEASUREMENTS	Procedure No. FP 7-5	Rev. 1 Page 4 of 6
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## 8.2 Operation

### 8.2.1 Conductivity Measurement

If the probe has been in storage, soaking may be necessary prior to use to ensure the probe is thoroughly wetted.

1. Press the POWER I key and CND key. Verify that the LO BAT indication does not appear.
2. Select the appropriate range. If the range is unknown, begin with the highest range.
3. Insert the probe into the sample solution. Immerse the tip to or beyond the vent holes and agitate the probe vertically to be sure air bubbles are not entrapped. Allow time for the reading to stabilize. If the reading falls within the lowest 10% of the range, select the next lower range and again allow the reading to stabilize before recording the measurement in the Field Logbook. An overrange condition causes a 1 display followed by blank digits.
4. Specific Conductance will be reported to two significant figures below 100 micromhos per centimeter and three significant figures at 100 micromhos per centimeter or above.
5. Rinse the probe thoroughly with demineralized water after each measurement.

### 8.2.2 Total Dissolved Solids Measurement

1. Press the POWER I key and CND key. Verify that the LO BAT indication does not appear.
2. Select the appropriate range. If the range is unknown, begin with the highest range.
3. Insert the probe into the sample solution. Immerse the tip to or beyond the vent holes and agitate the probe vertically to be sure air bubbles are not entrapped. Allow time for the reading to stabilize. If the reading falls within the lowest 10% of the range, select the next lower range and again allow the reading to stabilize before recording the measurement in the Field Logbook.
4. Rinse the probe thoroughly with demineralized water after each measurement.

### 8.2.3 Temperature Measurement

1. Press the POWER I key and °C key. Verify that the LO BAT indication does not appear.
2. Insert the probe into the sample solution. Immerse the tip to or beyond the vent holes and agitate the probe vertically if the sample is not flowing or being stirred to be sure air bubbles are not entrapped near the temperature sensor. Allow the reading to stabilize before recording the measurement in the Field Logbook.
3. Rinse the probe thoroughly with demineralized water after each measurement.

<b>SPECIFIC CONDUCTIVITY MEASUREMENTS</b>	Procedure No. FP 7-5	Rev. 1	Page 5 of 6
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### 8.3 Quality Control

Duplicate conductivity measurements shall be taken at each sampling location by retesting the sample. Both results shall be recorded in the Field Logbook. If the results differ  $\pm 0.2$  percent of the previous reading, the meter shall be recalibrated and the sample retested.

### 8.4 Preventive Maintenance

#### 8.4.1 Cleaning the Probe

The probe should be rinsed thoroughly with deionized water between measurements during normal use. When this is done there will be little chance of interfering substances building up on the probe elements. Should the sample contain oils, greases or fats, however, the electrodes could become coated and affect accuracy of the readings. In this case, the probe should be cleaned with a strong detergent solution or dipped in a 1:1 hydrochloric acid solution and then rinsed thoroughly with deionized water.

#### 8.4.2 Battery replacement

A low battery indication will appear in the upper left corner of the display when battery replacement is needed. Replace the complete set as described in the Battery Installation procedure in the Preparation for Use section of the user's manual.

#### 8.4.3 Probe Replacement

The replacement probe assembly listed in the replacement parts list comes with the cable and the 4-circuit connector installed and with the cable tie properly positioned four inches from the connector. Replace the probe assembly as follows:

1. Remove the batteries from the battery holder.
2. Remove the six screws securing the instrument case.
3. Carefully lift the instrument from the case.
4. Disconnect the probe cable connector from the circuit board jack.
5. Connect the replacement probe cable connector to the circuit board jack and install the instrument in its case. Be sure the cable tie installed on the probe cable is placed inside the compartment housing the circuit boards to provide a strain relief for the probe cable.
6. Secure the instrument in the case with the six screws removed in Step 2. Thread the screws until the heads contact the panel surface. Screws will not become tight with further rotation, but threads will not strip.

<b>SPECIFIC CONDUCTIVITY MEASUREMENTS</b>	Procedure No. FP 7-5	Rev. 1 Page 6 of 6
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7. Replace the batteries.

8. Perform calibration with the new probe. Refer to Section 8.1.

## **9.0 ATTACHMENTS**

### **9.1 Description and Location of Controls and Indicators**

## DESCRIPTION AND LOCATION OF CONTROLS AND INDICATORS

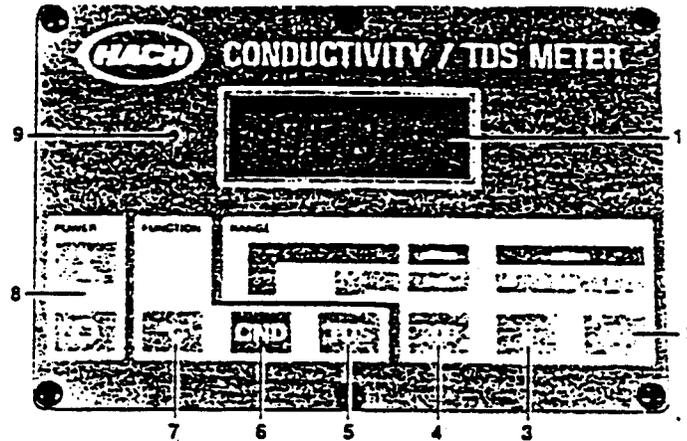


Table 1 Instrument Controls

Item	Name	Description
1	Liquid Crystal Display	A 3 1/2-digit display indicates value of measurement. Readout will be in millisiemens per centimeter, microsiemens per centimeter, grams per liter total dissolved solids, milligrams per liter total dissolved solids or degrees celsius, depending on the function and range switches selected. A low battery indication is incorporated, indicating LO BAT when battery replacement is required.
2	20 Range Key	Selects range 20 for mS/cm conductivity or g/L total dissolved solids.
3	20 Range Key 200 Range Key	Selects range 2 for mS/cm conductivity or g/L total dissolved solids. Selects range 200 for $\mu$ S/cm conductivity or mg/L total dissolved solids.
4		
5	TDS Key	Selects total dissolved solids measurement mode.
6	COND Key	Selects conductivity measurement mode.
7	$^{\circ}$ C Key	Selects temperature measurement mode.
8	Power Keys	Turns operating power on and off. Press I for on, O for off.
9	CAL Control	Used to calibrate the cell constant setting to compensate for variations in probe electrical characteristics.

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