# Particle Size Analysis of Soils – With / Without Hydrometer

**References:** ASTM D422-63 (Re-approved 1998), *Standard Test Method for Particle-Size Analysis of Soils*, pp.10-17.

ASTM D2487-00 (Re-approved 2000), *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System),* pp.246-257.

ASTM D2216-90 (Re-approved 1990), *Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures*, pp.278-281.

ASTM D2217-66 (Re-approved 1978), *Standard Method for Wet Preparation of Soil Samples for Particle Size Analysis and Determination of Soil Constants*.

The American Association of State Highway and Transportation Officials, *Standard Specifications for Transportation Materials and Methods of Sampling and Testing*, July 1978, 12th edition, pp.250-276.

Department of the Army, E M 1110-2-1906, *Laboratory Soils Testing*, November 1970, pp. V-1 – V-28.

*GEOSYSTEM* Von Gunten Engineering Software, Inc. Copyright 2005.

## 1. Scope and Application

**Matrices:** Soil and sediment samples, as received from the field.

**Definitions:** Refer to Alpha Analytical Quality Manual.

This analytical method covers the quantitative determination of the distribution of particle size in soils and sediments. The distribution of particle sizes larger than 75µm (retained on the No.200 sieve) is determined by sieving. The distribution of particle sizes smaller than 75µm (not retained on the No.200 sieve) is determined by a sedimentation process, using a hydrometer.

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one or more of the following laboratory personnel before performing the modification: Area Supervisor, Department Supervisor, Laboratory Director, or Quality Assurance Officer.

This method is restricted to use by or under the supervision of analysts experienced in the operation of the equipment and in the interpretation of data. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability and completing the record of training.

A major modification to this procedure requires demonstration of performance. The identification of major method modification requiring performance demonstration is directed by the Quality Assurance Officer and/or Laboratory Director on a case-by-case basis.

## 2. Summary of Method

Particle Size *without* Hydrometer (often referred to as *Wet Sieve* or *Grain Size Analysis*) is determined by drying a homogenized soil sample. The dried homogenate is placed onto a number 200 sieve, washed with tap water, re-dried, and re-homogenized. The dried soil is mechanically sieved with an array of sieve sizes. The distribution of soil sample remaining in each

of the sieves is determined by weight and represents various classes of soil including cobble, gravel, course and fine sand, silt and clay.

Particle Size with Hydrometer is determined by drying a homogenized soil sample and immersing it in a *sodium hexametaphosphate* solution. A hydrometer test is then performed which defines the fraction of sample that is silt and clay. The sample from the hydrometer test is transferred to a number 200 sieve and washed with tap water to remove all particles less than 75 μm. The sample remaining on the number 200 sieve is then re-dried and re-homogenized and is mechanically sieved with an array of sieve sizes, that define the medium and fine sands present in the sample.

When receiving limited amount of sample (e.g. 75-100gm), the test can be performed on a wet sample. % solids must be analyzed and the dry weight used for final calculations. Then proceed as in Section 5.2.

### 2.1 Method Modifications from Reference

A 10,000rpm mixer is only used in the case of clay-like samples.

## 3. Reporting Limits

Not Applicable

## 4. Interferences

Special consideration should be given to soils from a marine environment or other sources where high soluble salt concentrations may be present. The degree to which the salts present in these soils are diluted or concentrated must be given consideration if meaningful results are to be obtained.

## 5. Health and Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material safety data sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

## 6. Sample Collection, Preservation, Shipping and Handling

### 6.1 Sample Collection

A minimum of 500-grams of sample must be collected in a ziploc bag.

### 6.2 Sample Preservation

None.

### 6.3 Sample Shipping

No special shipping requirements.

### 6.4 Sample Handling

The samples must be immediately aliquoted and dried in an oven or air dried in a hood. Remaining sample can be stored at room temperature. Hold times are not applicable to particle-size determination.

## 7. Equipment and Supplies

**7.1 Analytical balance**: Capable of weighing to the nearest 0.01g with auto enter for weights directly to the GEOSYSTEM program.

**7.2 Aluminum pie tins, plastic 250-mL beakers, *Parafilm***

**7.3 Fume hood, sink with tap water**

**7.4 Mechanical stirring apparatus, malt mixer (at least 10,000 rpm)**

**7.5 Stainless steel spatulas, spoons, and mixing bowls**

**7.6 Drying ovens:** Maintained at 110±5°C , 40°C±5°C

**7.7 Hydrometer:** 151H, per ASTM specifications E 100

**7.8 Sedimentation cylinder:** 1000mL glass with large rubber stoppers to fit

**7.9 Thermometer:** Accurate to 0.5°C (able to read 20°C)

**7.10 Timing device:** With a second hand

**7.11 Constant room-temperature, 20°C**

**7.12 Mechanical sieve shakers:** Models RX-29, Type:110V, 60HZ and CI-305A-1, Type: 120V, 60HZ

**7.13 Sieves:** Square-mesh, woven-wire cloth per ASTM specifications E11: 3in., 2in., 1.5in., 1.0in., 0.75in., 0.375in., #4, #10, #20, #40, #60, #100, #140, #200,#230,#270 Pan

**7.14 Paint brushes:** For sieve cleaning

**7.15 Mortar and Rubber-Covered Pestle**

## 8. Reagents and Standards

**8.1 Deionized (DI) water:** ASTM Type II laboratory reagent grade water.

**8.2 Sodium Hexametaphosphate Solution:** Dissolve 40g into 500-mL DI water, dilute to 1-L with DI water. (Solution expires monthly, and must be kept at a pH of 8-9, using sodium carbonate.) Store at room temperature.

**8.3 Sodium Carbonate, 0.5M:** Thoroughly dissolve 26.49g of $Na_2CO_3$ in 400-mL DI water, dilute to 500-mL. Store at room temperature.

**8.4 Wide-Range pH paper.**

# 9. Quality Control

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

## 9.1 Blank(s)

Not applicable.

## 9.2 Laboratory Control Sample (LCS)

Not applicable.

## 9.3 Initial Calibration Verification (ICV)

Not applicable.

## 9.4 Continuing Calibration Verification (CCV)

Not applicable.

## 9.5 Matrix Spike

Not applicable.

## 9.6 Laboratory Duplicate

Not applicable.

## 9.7 Method-specific Quality Control Samples

Not applicable.

## 9.8 Method Sequence

Refer to Section 10

# 10. Procedure

## 10.1 Equipment Set-up

Not applicable.

## 10.2 Initial Calibration

Not applicable.

## 10.3 Equipment Operation and Sample Processing

### 10.3.1 Sample Preparation – Particle Size with/without Hydrometer

Samples are prepared immediately upon arrival.

**10.3.1.1** Homogenize the sample using a stainless steel mixing bowl, spatula, and/or spoon Transfer a sample aliquot into a properly labeled aluminum pie tin and dry in an oven or set to air-dry in a hood. (It is recommended that entire sample is set to dry, since dry weight is unknown.) A matrix duplicate, if not already specified by the client, is chosen and set to dry in its own tin. *Note: Samples can be dried overnight in an oven set at 110 °C, with the exception of claylike samples. Claylike samples are partially dried in an oven or in the hood and broken up as they are drying to help prevent solidifying of samples. Note in the case of limited sample, a smaller aliquot may be taken upon approval of the Project Manager.*

**10.3.1.2** Carefully grind dried sample using a mortar and pestle. Do not grind any shells, wood, rocks, or large particles. Remove any matter that does not properly represent the sample.

**10.3.1.3** If only a limited amount of sample is available, see Section 5.2.1 regarding Hydrometer analysis.

**10.3.2 Particle Size (without Hydrometer) Analysis**

**10.3.2.1** Weigh approximately 100g to 500g of the sample, as prepared in Sec.14.1, and record this weight as the *original sample weight*. A sample consisting of heavy materials, such as large rocks, requires a greater *original sample weight* for proper sample representation.

**10.3.2.2** Transfer entire sample to a No. 200 sieve and wash with tap water until the wash water is clear. (Be very careful not to damage the sieve or to lose any soil by splashing the material out of the sieve. Do not force material through sieve with fingers.) Transfer washed material on the No. 200 sieve to aluminum tin. Dry the residue in an oven at 105°C, overnight, or until completely dry.

**10.3.2.3** Remove dried sample residue from oven. Gently grind and weigh the residue. Record this weight as the *post-wash weight*.

**10.3.2.4** Refer to Section 9.13 for list of sieves. Record the tare weights of each client-specified empty sieve (including pan). Add sample residue to the stack of sieves. Place lid on stack of sieves. Shake sieves containing sample for 30 minutes. *Note: Seven sieves and pan will fit on each mechanical shaker at one time, but up to thirteen sieves may be required. Consult the Section Supervisor for proper guidance.*

**10.3.2.5** Remove the stack of sieves from the shaker and record the final weight of each sieve. *A brush is used to remove excess sample dust/rocks from sieves, after final weights have been recorded*.

**10.3.2.6** When finished with the sieves, you must clean them. Soak in soapy hot water and use the wire (coarse) sieve brush to remove particulate, taking care not to damage the wire mesh. Brush the sieve on both sides, paying attention to fine matter. Once there are no particles left on the sieve mesh, and the sieve rinses clean, it is ready for reuse.

**10.3.3 Particle Size with Hydrometer Analysis**

**10.3.3.1** Weigh approximately 50g of the sample, as prepared in Section 14.1, into a plastic beaker. Record this weight as *original sample weight* or *hydrometer weight.* Add 125-mL of sodium hexametaphosphate solution, cover with Parafilm, and let sit for at least 16 hours at room temperature.

**10.3.3.1.1** If a limited amount of wet sample is available, refer to Section 5.2.1.

**10.3.3.2** Take the wet sample and homogenize using electric mixer only if needed. Pour entire sample into 1000-mL glass sedimentation cylinder. Bring up to 1000-mL mark with DI water. Cap with rubber stopper.

**10.3.3.3** At a constant room temperature of 20°C, mix the contents of the capped cylinder for one minute by inverting until all contents are suspended (residue on bottom of cylinder has loosened completely). At this point, immediately begin timing analysis. *Note: Small variations of temperature do not introduce differences that are of practical significance*.

**10.3.3.4** Immerse the 151H hydrometer into the sample 30 seconds prior to the time a reading should be taken in order to assure that the hydrometer comes to rest before the appointed reading time. Record each reading when bobbing hydrometer stabilizes. Take readings at 2, 5, 15, 30, 60, 250, and 1440 minutes (total elapsed time). Carefully remove the hydrometer from the soil suspension after each reading, rinse hydrometer with DI, and place it beside the cylinder until the following reading.

**10.3.3.5** Follow steps 10.3.4.2 through 10.3.4.5 for each sample.

### 10.4 Continuing Calibration

Not applicable.

### 10.5 Preventive Maintenance

Not applicable.

## 11. Data Evaluation, Calculations and Reporting

**11.1** Particle size with/without hydrometer is calculated by entering raw data, recorded in the laboratory notebook, into the LIMS. Using the particle percent retained, calculated in LIMS, the analyst calculates the particle percent passing for each sample. This is calculated as follows:

Percent Passing (%) = 100 – Percent Retained (%)

The analyst transfers this data, along with sample identification, into*, GEOSYSTEM.* This program performs all necessary calculations. It determines the particle size distribution ratios and illustrates them graphically.

**11.2** To report *Particle Size With/Without Hydrometer*, first go to the LIMS and “batch” all samples in this analytical batch. Then enter the results from the laboratory notebook into *GEOSYSTEM.* Finally, use the results to create a graph in *GEOSYSTEM.*

**11.2.1** Enter “*GEOSYSTEM*”

**11.2.2** To create a New Project

**11.5.2.1** Type name of project in bottom left hand box that reads "Name"

**11.5.2.2** Click "Open." A box will come up that reads "The Project (name of the project just created) can't be found. Would you like to create it?" Click "Create." This will open a new window

**11.5.3** To Set up Project Data

**11.5.3.1** Click "Project Data" in left hand column

**11.5.3.2** Type full client name, project name, and project number (ETR number)

**11.5.4** To Set up Samples

**11.5.4.1** Click first button on left hand side of the screen (green "+") to create a new source. Each new source is a sample - create one for each sample in the ETR.

**11.5.4.2** Type Sample ID on the "Source" line in the right hand screen and Lab ID where it says "Sample No." in the first card.

**11.5.4.3** Repeat for each sample.

**11.5.5** To Enter Data

**11.5.5.1** Click link for USCS in sample card

**11.5.5.2** Click link for Grain Size at the top of the screen

**11.5.5.3** Click tab for Sieve Test

**11.5.5.4** Chose a 'sieve nest' from the drop down list, (*i.e.*, Army Corps Sieve). If your group of sieves does not match any of these, create a new nest.

**11.5.5.4.1** Type sieve sizes in Sieve opening size column, using enter to move between columns, and click "save current sieve nest" at the top of the screen - it will ask you to name the nest.

**11.5.5.5** For samples with hydrometer, enter sample weight post wash into box for "Dry sample and tare weight." Type 0 in box for "Tare weight." (For samples with sieve only, skip to 15.5.1.5.6)

**11.5.5.6** Type sample weight into "Dry Sample and Tare" column in line 1 and 0 in "Tare" column.

**11.5.5.7** Enter "Weight retained" (our Sieve - sample Weight) and "Sieve weight" for each sieve. Use enter to move from column to column. Do not enter pan. Click disk icon to save.

**11.5.5.8** Click hydrometer test tab. (For samples with sieve only, skip to 15.5.1.5.14)

**11.5.5.9** Hydrometer sample box: Enter sample weight as post-wash weight. Specific gravity = 2.65

**11.5.5.10** Corrections box: Hydrometer correction @ 20°C = -.04, Meniscus correction = -3

**11.5.5.11** Hydrometer box: Select 151H

**11.5.5.12** Enter hydrometer data starting with 2 minutes; enter reading as whole numbers (i.e. 14 rather than 1.014). Use enter to move through columns; do not need to reenter temperature with every hydrometer reading.

**11.5.5.13** Click disk icon to save.

**11.5.5.14** Click on reports tab.

**11.5.5.15** Click box with check marks at the top of the page - two before "support" this will open a new box, which reads "settings" at the top.

**11.5.5.15.1** Click general settings.

**11.5.5.15.2** Check off "include a disclaimer" and check on "Drop 'tested by' from report if a name is not entered" and "Drop 'checked by' from reports if a name is not entered"

**11.5.5.15.3** Click "ok"

**11.5.5.16** Select "Similar to the Corps of Engineers report form (GSGEOSYS)" from the drop down box.

**11.5.5.17** Click printer icon.

**11.5.5.18** Click "Test 1" tab from right side of the screen.

**11.5.5.19** Click disk for save.

**11.6** Forward all hand recorded raw data from the laboratory notebook, Excel spreadsheets, LIMS batch printouts, and *GEOSYSTEM* graphs for secondary review.

# 12. Contingencies for Handling Out-of-Control Data or Unacceptable Data

All results are reportable without qualification if the QC criteria defined in Section 12.0 are met. If any QC parameters are not met, all associated samples must be evaluated for re-extraction and/or re-analysis. See Sections 12.0 for discussion, including corrective action, for any QC outlier.

Corrective action for non-compliant data is discussed in Section 12.0. If a situation arises (such as loss of sample, or the inability for re-extraction or re-analysis) that requires additional action, the Project Manager and QA Officer will be immediately notified and will contact the client for discussion and/or instruction for any further action. The situation and the agreed upon actions will be discussed in the project narrative that accompanies the data package.

# 13. Method Performance

## 13.1 Detection Limit Study (MDL) / Limit of Detection Study (LOD) / Limit of Quantitation (LOQ)

The laboratory follows the procedure to determine the DL, LOD, and/or LOQ as outlined in Alpha SOP/08-05. These studies performed by the laboratory are maintained on file for review.

These studies are not applicable to this method.

## 13.2 Demonstration of Capability Studies

Refer to Alpha SOP/08-12 for further information regarding IDC/DOC Generation.

These studies are not applicable to this method.

### 13.2.1 Initial (IDC)

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method, prior to the processing of any samples.

### 13.2.2 Continuing (DOC)

The analyst must make a continuing, annual, demonstration of the ability to generate acceptable accuracy and precision with this method.

## 14. Pollution Prevention and Waste Management

Refer to Alpha's Chemical Hygiene Plan and Waste Management and Disposal SOP for further pollution prevention and waste management information.

## 15. Referenced Documents

Chemical Hygiene Plan

SOP/08-05 DL/LOD/LOQ Generation

SOP/08-12 IDC/DOC Generation

SOP/G-008 Hazardous Waste and Sample Disposal

## 16. Attachments

None.