

Method of Test for
MECHANICAL ANALYSIS OF SOILS
DOTD Designation: TR 407M/407

Method A

I. Scope

- A. This method describes the procedure to be used to determine the distribution of particle sizes of soils by sieve and hydrometer analysis.
- B. Reference Documents
 - 1. DOTD TR411, Dry Preparation of Disturbed Samples for Test
 - 2. DOTD TR435, Identification of Collapsible Silt
 - 3. ASTM E11, Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves
 - 4. AASHTO T 88, Standard Method of Test for Particle Size Analysis of Soils
 - 5. AASHTO M339M/339, Standard Specifications for Thermometers Used in the Testing of Construction Materials

II. Apparatus

- A. Balance
 - 1. Sensitive to 0.1 gram for all samples.
 - 2. Sensitive to 1 gram for samples containing material retained on the No. 10 sieve (2.00 mm).
- B. Stirring Apparatus and Dispersion Cup - The stirring apparatus shall consist of a mechanically operated stirring device in which a suitably mounted electric motor turns a vertical shaft at a speed of not less than 10,000 rpm, without load. Attached to the shaft shall be a paddle made of metal, plastic, or hard rubber conforming to either design shown in Figure A-1. The dispersion cup shall conform to either design shown in Figure A-1.
- C. Hydrometer - Model 152 H (Figure A-2).
- D. Sedimentation Cylinders and Rubber Stoppers - A 1000 mL transparent cylinder approximately 18 inches in height and 2.5 inches in diameter. The inside diameter shall be such that the 1000 mL mark is 14.0 ± 1.0 inches from the bottom on the inside of the cylinder.
- E. Thermometer- shall meet the requirements of M 339M/M 339 with a temperature range of at least 16 to 34°C (61 to 93°F) and an accuracy of $\pm 0.5^\circ\text{C}$ ($\pm 1.0^\circ\text{F}$).
Note: Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type T, Class Special; IEC 60584 thermocouple thermometer, Type T, Class I; or ASTM E2877 digital metal stem thermometer.
- F. Water Bath or Constant Temperature Room - Maintaining the soil suspension at a constant temperature (as near as possible) within a range of 18-28°C (65-82°F)
- G. Sieves- A series of standard testing sieves conforming to ASTM E11. The sieves normally required are as follows: 1 inch, 3/4-inch, 1/2 inch, No. 4, No. 10, No. 40, and No. 200 (25.0 mm, 19.0 mm, 12.5 mm, 4.75 mm, 2.00 mm, 425 μm , and 75 μm).
- H. Beaker- Clear glass 250 mL capacity.
- I. Timing Device - Readable to the nearest second.
- J. Oven - Capable of maintaining a temperature of $110 \pm 5^\circ\text{C}$ ($230 \pm 9^\circ\text{F}$).

- K. Distilled Water - Water from municipal sources may be used in lieu of distilled water, provided a series of not less than ten soil samples have been tested using both distilled water and tap water and the corrected hydrometer readings between tap and distilled water differ by no more than 0.5g/L.
- L. Dispersing agent- sodium hexametaphosphate, buffered with sodium carbonate (trade name Calgon)
- M. Stirring Rod - Made of inert material.
- N. Tracing Paper - Cross section or equivalent.
- O. Tared Sample Cups.
- P. Chart - Grain Size Distribution Chart, DOTD Form 03-22-2099 (Figure A-4).
- Q. Worksheet Soils/Soil-Aggregate Worksheet, DOTD Form 03-22-0723 (Figure A-5).

III. Health Precautions

Proper equipment and precautions are to be taken whenever hot materials or equipment must be handled. Use container holders or gloves while handling hot containers. Wear eye protection while stirring and weighing materials.

IV. Composite Correction for Hydrometer Readings

Note A-1: Before making a determination of particle size distribution, hydrometer readings obtained during the test must be corrected to compensate for test conditions that deviate from the hydrometer calibration conditions.

A. Chart Method

Note A-2: The Chart Method is based on the development of a chart from which composite hydrometer corrections can be obtained at each temperature encountered during the test. The corrections can be used in any series of tests using the same hydrometer and stock solution as used to develop the chart. This is the preferred method.

1. Prepare 1000 mL of stock solution by placing 40.0 grams of dispersing agent in a sedimentation cylinder and adding distilled water to equal 1000 mL of solution, stirring until the dispersing agent is dissolved.

Note A-3: Stock solution is not to be kept more than 2 weeks.

2. Prepare a reference solution by placing 125 mL of stock solution in a sedimentation cylinder and adding a sufficient amount of distilled water to bring the solution to a volume of 1000 mL.
3. Place the cylinder and its contents into the constant temperature water bath set at the highest temperature expected during any series of tests.
4. Insert the hydrometer into the solution and allow the temperatures of the solution and hydrometer to stabilize.
5. Read the hydrometer to the nearest 0.5 g/L at the top of the meniscus formed on the

- stem. Record the reading.
6. Remove the hydrometer from the solution and insert the thermometer. When the thermometer reading stabilizes, read the thermometer to the nearest 0.5°C and record.
 7. The hydrometer reading obtained in Step 5 is the composite hydrometer correction corresponding with the temperature of the solution obtained in Step 6. Repeat Steps 4-6 at the lowest temperature setting expected during any series of tests.
 8. On the cross section paper, label the horizontal axis as temperature in 0.5°C increments and the vertical axis as hydrometer reading in 0.5 g/L increments. The temperature axis must span the highest and lowest temperatures expected during any test. Plot the hydrometer readings at the high and low temperature readings and connect with a straight line. This creates a chart of composite hydrometer corrections for each 0.5 degree of temperature difference within the range of expected test temperatures.

B. Reference Solution Method

1. Immediately before preparing the test sample, prepare a 1000 mL reference solution in accordance with Steps A.1 and 2.
2. Place the sedimentation cylinder containing the reference solution and the cylinder containing the test sample in suspension next to each other during the test.
3. Determine the composite hydrometer correction by placing the hydrometer into the reference solution and obtaining a hydrometer reading to the nearest 0.5 g/L immediately before getting the hydrometer reading in the test sample

V. Sample

Refer to TR 411 for sample size and preparation.

VI. Test Specimen Preparation

- A. Prepare the sample in accordance with TR 411, using the 1 inch, 3/4 inch, 1/2 inch, No. 4, and No. 10 sieves. Record the value retained on each sieve to the nearest g.
- B. Calculate the percentages retained on these sieves in accordance with Step VIII. A. and record the results on the worksheet.
- C. Thoroughly mix the material that has passed the No. 10 sieve. From silty or clayey soils obtain a 50.0 gram sample (dry) from the portion passing the No. 10 sieve. From sandy soils obtain a 100.0 gram sample. Record the appropriate computer code (1=50.0 or 2=100.0 g) on the worksheet.

Note A-4: If a 100.0 g sample is used and it is not possible to obtain a hydrometer reading, rerun the sample using a 50.0 g sample.

- D. Place the test specimen in a beaker and add 125 mL of stock solution prepared in accordance with Step IV.A.1. Stir thoroughly and allow the test specimen to soak for a minimum of 12 hours.

VII. Procedure

Note A-5: If a composite hydrometer correction chart has not been developed for the hydrometer used in this series of tests, prepare a reference solution in accordance with Step IV.B.

- A. Fill a sedimentation cylinder with distilled water and place the filled container in the area in which the hydrometer test is to be performed. This water will be used to clean the hydrometer and thermometer after each reading.
- B. Inspect the color of the solution containing the sample after the soaking period. If the solution is black and the material is found to contain 65% or more silt at the conclusion of this procedure, the material will require further testing in accordance with TR 435.
- C. Pour the test specimen and solution into the dispersion cup and wash any material remaining in the beaker into the dispersion cup with distilled water, adding water until the dispersion cup is approximately 2/3 full. Stir the contents with the mechanical stirring apparatus for 60 seconds.
- D. Wash the test specimen from the dispersion cup into a sedimentation cylinder and add a sufficient quantity of distilled water to bring the level approximately 1/8 inches below the 1000 mL mark.
- E. Cover the open end of the cylinder with a rubber stopper and agitate the test specimen for a minimum of 45 seconds by oscillating the cylinder to an inverted position and back to its upright position. The frequency of oscillation should be approximately 1 cycle per second.
- F. Immediately after agitating the test specimen, set the sedimentation cylinder on a level surface that will be vibration-free during the test in the water bath or in a constant temperature room. Using distilled water, rinse the remaining soil particles from the rubber stopper into the sedimentation cylinder and from the sides of the sedimentation cylinder bringing the solution level to the 1000 mL mark. Record the times corresponding to the elapsed time of 60 and 120 minutes from agitation on the worksheet.
- G. Obtain and record the composite hydrometer correction by reading the correction that corresponds with the temperature of the solution from the chart prepared in Step IV.A. or by inserting and reading the hydrometer in the reference solution prepared in Step IV.B. When the reference solution method is being used for the composite hydrometer correction and multiple test specimens are being tested, the temperature taken during the initial composite hydrometer correction shall be the same as the test sample. If this temperature varies more than $\pm 0.5^{\circ}\text{C}$, additional composite correction readings will be necessary.
- H. At an elapsed time of 60 minutes from agitation, carefully insert the hydrometer into the sedimentation cylinder, disturbing the suspension as little as possible. Allow the hydrometer to come to rest and read the hydrometer at the top of the meniscus formed by the suspension around the stem. Record the reading on the worksheet to the nearest 0.5 g/L.
- I. Carefully remove the hydrometer from the suspension and insert the thermometer. Allow the temperature reading to stabilize. Read and record the temperature of the suspension on the worksheet to the nearest 0.5°C .
- J. Remove the thermometer and wash any clinging soil particles from the hydrometer and thermometer by dipping each into the clean water prepared in accordance with Step VI.A.
- K. Repeat Steps G-J at an elapsed time of 120 minutes from agitation.

Note A-6: *The 60 and 120-minute readings allow the determination of the combined percent clay and colloids. Although not required for routine testing, the percent colloids can be determined by taking hydrometer and temperature readings on the same test specimen at elapsed times of 250 and 1440 minutes.*

- L. After the final hydrometer and temperature readings have been taken, wet the 425 μm and 75 μm sieves, then slowly pour the suspension over them and wash until the wash water is clear. Catch all the material, keeping each size separated.

Note A-7: *Disregard and discard floating matter.*

- M. Place each sample cup with the retained material in an oven and dry to a constant mass at 110°C (230±9°F).
N. Weigh and record these values to the nearest 0.1 gram on the worksheet.

VIII. Calculations

Note A-8: *The following calculations can be made on the Soil Templates Spreadsheet.*

- A. Use the following equation for the 25.0 mm, 19.0 mm, 12.5 mm, 4.75 mm, and 2.00 mm sieves to calculate the percent retained (R_x) on each sieve and record on the worksheet to the nearest percent.

$$R_x = \frac{W_x}{W_s} \times 100$$

Where:

R_x = percent retained on each sieve

W_x = mass retained on each sieve, g

W_s = total mass of each sample obtained in step V.

Example:

$$W_x(25.0\text{mm}) = 0 \text{ g}$$

$$W_x(19.0\text{mm}) = 232 \text{ g}$$

$$W_x(12.5\text{mm}) = 95 \text{ g}$$

$$W_x(4.75\text{mm}) = 100 \text{ g}$$

$$W_x(2.00\text{mm}) = 513 \text{ g}$$

$$W_s = 3882 \text{ g}$$

$$R_x = \frac{W_x}{W_s} \times 100$$

$$R_{19.0} = \frac{232}{3882} \times 100$$

$$R_{19.0} = 0.05976 \times 100$$
$$R_{19.0} = 5.97 = 6\%$$

$$R_{12.5} = \frac{95}{3882} \times 100$$

$$R_{12.5} = 0.0244 \times 100$$
$$R_{12.5} = 2.44 = 2\%$$

$$R_{4.15} = \frac{100}{3882} \times 100$$

$$R_{4.15} = 0.0257 \times 100$$
$$R_{4.15} = 2.57 = 3\%$$

$$R_{2.00} = \frac{513}{3882} \times 100$$

$$R_{2.00} = 0.1321 \times 100$$
$$R_{2.00} = 13.21 = 13\%$$

- B. Using the following formula, calculate the corrected hydrometer reading at each time interval by applying the corresponding composite hydrometer correction determined in Step VII.G. Record the corrected hydrometer reading on the worksheet.

$$H = h - C$$

Where:

H = corrected hydrometer reading, g/L

h = hydrometer reading observed during the test, g/L

C = composite hydrometer correction, g/L

Example:

h = 20.5 g/L

C = 3.0 g/L

$$H = h - C$$
$$H = 20.5 - 3.0$$
$$H = 17.5g/L$$

- C. Calculate the percentage of soil remaining in suspension above the center of gravity of the hydrometer bulb to the nearest 0.5 at each time interval using the following equation. Record on the worksheet as percent finer.

$$P = \frac{H}{W} \times 100$$

Where:

P = percent finer

H = corrected hydrometer reading, g/L

W = sample mass obtained in step VI.C., g

Example:

H=17.5 g/L

W=50.0 g

$$P = \frac{H}{W} \times 100$$

$$P = \frac{17.5}{50.0} \times 100$$

$$P = 0.3500 \times 100$$

$$P = 35.00 = 35\%$$

- D. Using the following equations, calculate the effective grain size (D) to the nearest 0.0001 mm corresponding to the percentages determined in Step VIII.C. for each time interval and record on the worksheet.

Note A-9: *Effective grain size is the diameter of the largest particles remaining in suspension above the center of gravity of the hydrometer bulb at the time the hydrometer reading is made.*

Where:

D = Effective Grain Size, mm

$$D = K \sqrt{\frac{L}{T}}$$

Where:

K = constant, dependent on temperature of suspension (Table 1)

L = effective length corresponding to the uncorrected hydrometer reading from Table 2

T = time interval at which readings were taken, minutes

Example:

K = 0.01303 @ 24°C

L = 13.0

T = 60

$$D = K \sqrt{\frac{L}{T}}$$

$$D = 0.01303 \sqrt{\frac{13.0}{60}}$$

$$= 0.01303 \sqrt{0.21666}$$

$$= 0.01303 \times 0.4654767$$

$$D = 0.006065 = 0.0061\text{mm}$$

Note A-10: *The nomograph shown in Figure A-3 is based on the equation for determining effective grain size in Step D. The nomograph provides a quick method for determining effective grain sizes and can be used in lieu of the equation for routine samples. In cases where more accuracy is needed, the equation must be used*

- E. Plot the values calculated in Step VIII.C. and D. for the 60-minute and 120-minute elapsed time intervals and determine the unadjusted percent clay and colloids, as follows.
1. On the semi-log graph paper, locate the percent finer on the vertical axis and project it across the chart until it intersects the vertical line representing the corresponding effective grain size. (Refer to Figure A-4.)
 2. For each, the 60-minute and 120-minute time intervals, plot one point as described in Step 1. Connect the two points with a straight line. Find the point where the straight line intersects the vertical line corresponding to the grain size of 0.005 mm and project it across to the percent finer axis. On the worksheet, record the percent finer value, thus determined, as unadjusted percent clay and colloids, to the nearest percent.

Note A-11: *The unadjusted percent colloids can be determined using the same procedure, except that calculations in Steps VIII.C. and D. are based on 250 and 1440-minute readings and the point where the straight line connecting these two points intersects the vertical line corresponding to an effective grain size of 0.001 mm is recorded as percent colloids. To determine the percent clay, subtract the colloids from the combined clay and colloids.*

- F. For the 425 μm , and 75 μm sieves, use the following equation to calculate the unadjusted percent retained on each sieve and record on the worksheet to the nearest 0.1%. (The sum of these percentages equal the unadjusted percent sand.)

$$r_x = \frac{W_x}{W} \times 100$$

Where:

r_x = unadjusted% retained on each sieve

W_x = mass retained on each sieve obtained in step VII.N.

W = dry mass of sample obtained in step VI.C.

Example:

$$W_x(425\mu m) = 7.2 \text{ g}$$

$$W_x(75\mu m) = 6.6 \text{ g}$$

$$W = 50.0 \text{ g}$$

$$r_x = \frac{W_x}{W} \times 100$$

$$r_{425} = \frac{7.2}{50.0} \times 100$$

$$r_{425} = 0.144 \times 100$$

$$r_{425} = 14.4\%$$

$$r_{75} = \frac{6.6}{50.0} \times 100$$

$$r_{75} = 0.1320 \times 100$$

$$r_{75} = 13.2\%$$

G. Calculate and record the unadjusted percent silt by subtracting the sum of the unadjusted percentages retained on the 425 μm , 75 μm sieve and clay and colloids from 100%.

Example:

$$100 - (14.4 + 13.2 + 32)$$

$$= 100 - 59.6$$

$$= 40.4\% \text{ unadjusted silt}$$

Note A-12: *The percent clay and colloids determined in Step VIII.E.2. and the unadjusted percentages of sand and silt calculated in Steps VIII.F. (sand) and G. (silt) are based on a subsample consisting of material passing the 2.00 mm sieve. If the entire sample prepared in Step VI.A. consists of material passing the 2.00 mm sieve, these values represent the total sample and no adjustment is required. If, however, material coarser than the 2.00 mm sieve was found in Step VI.A., the percentages determined in Steps VIII.E.2.F. and G. must be adjusted to represent the actual sand, silt, and combined clay and colloid content of the total sample.*

H. If an adjustment is required, calculate the adjustment factor using the following formula:

$$Adj = \frac{w_s - (W_{25.0} + W_{19.0} + W_{12.5} + W_{4.75} + W_{2.00})}{W_s}$$

Where:

W_s = total mass of sample, g

$W_{25.0}$ = mass retained on the 25.0 mm sieve, g
 $W_{19.0}$ = mass retained on the 19.0 mm sieve, g
 $W_{12.5}$ = mass retained on the 12.5 mm sieve, g
 $W_{4.75}$ = mass retained on the 4.75 mm sieve, g
 $W_{2.00}$ = mass retained on the 2.00 mm sieve, g

Example:

$$W_s = 3882g$$

$$W_{25.0} = 0g$$

$W_{19.0} = 232g$
 $W_{12.5} = 95g$
 $W_{4.75} = 100g$
 $W_{2.00} = 513g$

$$Adj = \frac{3882 - (0 + 232 + 95 + 100 + 513)}{3882}$$

$$= \frac{3882 - 940}{3882}$$

$$= \frac{2942}{3882}$$

$$Adj = 0.76$$

- I. Using the adjustment factor calculated in Step G., calculate adjusted percentages of materials retained on the 425 μm and 75 μm sieves, and clay and colloids. Calculate the adjusted percent silt in accordance with Step 2.
1. Calculate the adjusted percent sand (material retained on the 425 μm plus the 75 μm sieves) and clay and colloids (material passing the 75 μm sieve [0.005 mm effective grain size]) as follows:

$$R_n = r_n \times Adj$$

Where:

r_n = unadjusted percent retained on sieve
 Adj = adjustment factor

Example:

$r_{425} = 14.4$
 $Adj = 0.76$

$$R_{425} = r_{425} \times Adj$$

$$= 14.4 \times 0.76$$

$$R_{75} = 10.94 = 11\%$$

Example:

$r_{75} = 13.2$
 $Adj = 0.76$

$$\begin{aligned}
 R_{75} &= r_{75} \times Adj \\
 &= 13.2 \times 0.76 \\
 R_{75} &= 10.03 = 10\%
 \end{aligned}$$

Example:

$$\begin{aligned}
 r_{0.005} &= 32 \\
 Adj &= 0.76
 \end{aligned}$$

$$\begin{aligned}
 R_{0.005} &= r_{0.005} \times Adj \\
 &= 32 \times 0.76 \\
 R_{0.005} &= 24.32 = 24\%
 \end{aligned}$$

2. Calculate the adjusted percent silt in the total sample as follows:

$$S = 100 - (R_{25.0} + R_{19.0} + R_{12.5} + R_{4.75} + R_{2.00} + R_{425} + R_{75} + R_{0.005})$$

Where:

- $R_{25.0}$ = adjusted % retained on 25.0 mm sieve
- $R_{19.0}$ = adjusted % retained on 19.0 mm sieve
- $R_{12.5}$ = adjusted % retained on 12.5 mm sieve
- $R_{4.75}$ = adjusted % retained on the 4.75 mm sieve
- $R_{2.00}$ = adjusted % retained on the 2.00 mm sieve
- R_{425} = adjusted % retained on the 425 μ m sieve
- R_{75} = adjusted percent retained on 75 μ m sieve
- $R_{0.005}$ = adjusted percent clay and colloids

Example:

$$\begin{aligned}
 R_{25.0} &= 0\% \\
 R_{19.0} &= 6\% \\
 R_{12.5} &= 2\% \\
 R_{4.75} &= 3\% \\
 R_{2.00} &= 13\% \\
 R_{425} &= 11\% \\
 R_{75} &= 10\% \\
 R_{0.005} &= 24\%
 \end{aligned}$$

$$S = 100 - (R_{25.0} + R_{19.0} + R_{12.5} + R_{4.75} + R_{2.00} + R_{425} + R_{75} + R_{0.005})$$

$$S = 100 - (0 + 6 + 2 + 3 + 13 + 11 + 10 + 24)$$

$$S = 100 - (69)$$

$$S = 31\%$$

IX. Report

- A. Report the percent retained on the following sieves, to the nearest percent.

1. 25.0 mm (1 inch)
2. 19.0 mm (3/4 inch)
3. 12.5 mm (1/2 inch)

4. 4.75 mm (No.4)
5. 2.00 mm (No. 10)
6. 425 μm (No. 40)
7. 75 μm (No. 200)

B. Report the percent clay and colloids, to the nearest percent.

C. Report the percentages passing the following sieves, to the nearest percent.

1. 2.00 mm (No. 10)
2. 425 μm (No. 40)
3. 75 μm (No. 200)

D. Report unadjusted values for silt, sand and clay and colloids to the nearest percent.

X. Normal Test Reporting Time

Normal test reporting time is 3 days.

TABLE 1					
VALUES OF K FOR USE IN EQUATION FOR COMPUTING EFFECTIVE GRAIN SIZE					
TEMP OF SUSPENSION °C	K	TEMP OF SUSPENSION °C	K	TEMP OF SUSPENSION °C	K
18.0	0.01398	21.5	0.01342	25.0	0.01288
18.5	0.01390	22.0	0.01334	25.5	0.01280
19.0	0.01382	22.5	0.01326	26.0	0.01273
19.5	0.01374	23.0	0.01318	26.5	0.01265
20.0	0.01366	23.5	0.01311	27.0	0.01258
20.5	0.01358	24.0	0.01303	27.5	0.01250
21.0	0.01350	24.5	0.01295	28.0	0.01243

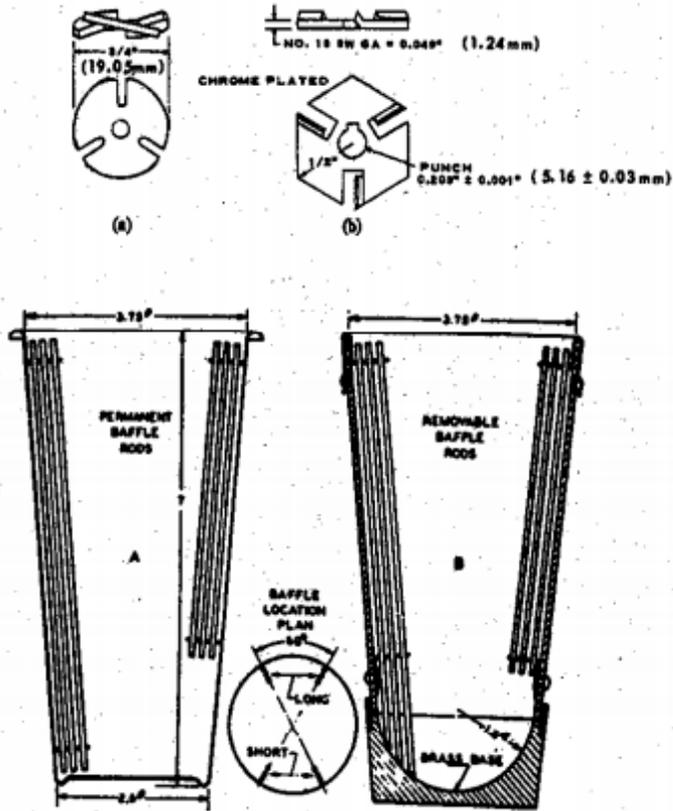
Note: Values for K are based on the equation $K = 0.0172834 e^{-0.0117685 C}$
 Where C = Temperature of Suspension in Degrees Celsius

TABLE 2					
VALUES OF L (EFFECTIVE LENGTH) FOR USE IN EQUATION FOR COMPUTING EFFECTIVE GRAIN SIZE					
UNCORRECTIVE HYDROMETER READING, h	EFFECTIVE LENGTH, L	UNCORRECTIVE HYDROMETER READING, h	EFFECTIVE LENGTH, L	UNCORRECTIVE HYDROMETER READING, h	EFFECTIVE LENGTH, L
0	16.3	21	12.9	42	9.4
1	16.1	22	12.7	43	9.3
2	16.0	23	12.5	44	9.1
3	15.8	24	12.4	45	9.0
4	15.6	25	12.2	46	8.8
5	15.5	26	12.1	47	8.6
6	15.3	27	11.9	48	8.5
7	15.2	28	11.7	49	8.3
8	15.0	29	11.6	50	8.1
9	14.8	30	11.4	51	8.0
10	14.7	31	11.2	52	7.8
11	14.5	32	11.1	53	7.7
12	14.3	33	10.9	54	7.5
13	14.2	34	10.8	55	7.3
14	14.0	35	10.6	56	7.2
15	13.8	36	10.4	57	7.0
16	13.7	37	10.3	58	6.8
17	13.5	38	10.1	59	6.7
18	13.4	39	9.9	60	6.5
19	13.2	40	9.8		
20	13.0	41	9.6		

Note: Values for L are based on the equation $L = 16.294 - 0.163h$

TOLERANCES FOR STIRRING PADDLES

- (a) 0.750 ± 0.063 in. (19.05 ± 1.60 mm)
- (b) longest diameter - 0.975 ± 0.063 in. (24.76 ± 1.60 mm)



Upper: Detail of Stirring Paddle
Lower: Dispersion Cups

Figure A - 1

Tolerance for Stirring Paddles

HYDROMETER MODEL 152H

(a) Scale



BOUYOCOS HYDROMETER READINGS - G/L

THE GRAMS PER LITER SCALE (G/L) SHALL BE EXTENDED 5 G/L ABOVE ZERO (1.000 SP.G) AND DOWN TO 60 G/L. THE BULB SHALL BE SYMMETRICAL ABOVE AND BELOW THE MIDDLE DIAMETER, AND SHALL BE BLOWN INTO A MOLD TO ASSURE UNIFORMITY OF PRODUCT.

(b) Hydrometer Dimensions

* THE DIAMETER OF THE STEM MAY BE VARIED TO ADJUST THE LENGTH OF THE SCALE SPECIFIED BUT THE STEM SHALL BE UNIFORM IN DIAMETER FROM TOP TO BOTTOM. THE ACCURACY OF THE SCALE SHALL BE ± 1 SCALE DIVISION DISTRIBUTED UNIFORMLY OVER THE SCALE LENGTH.

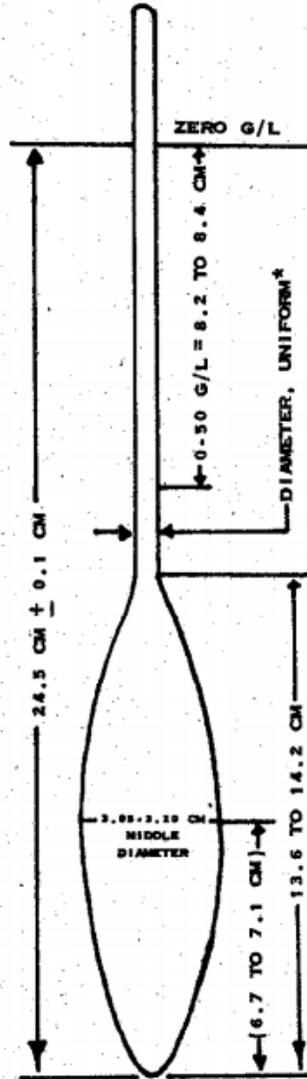
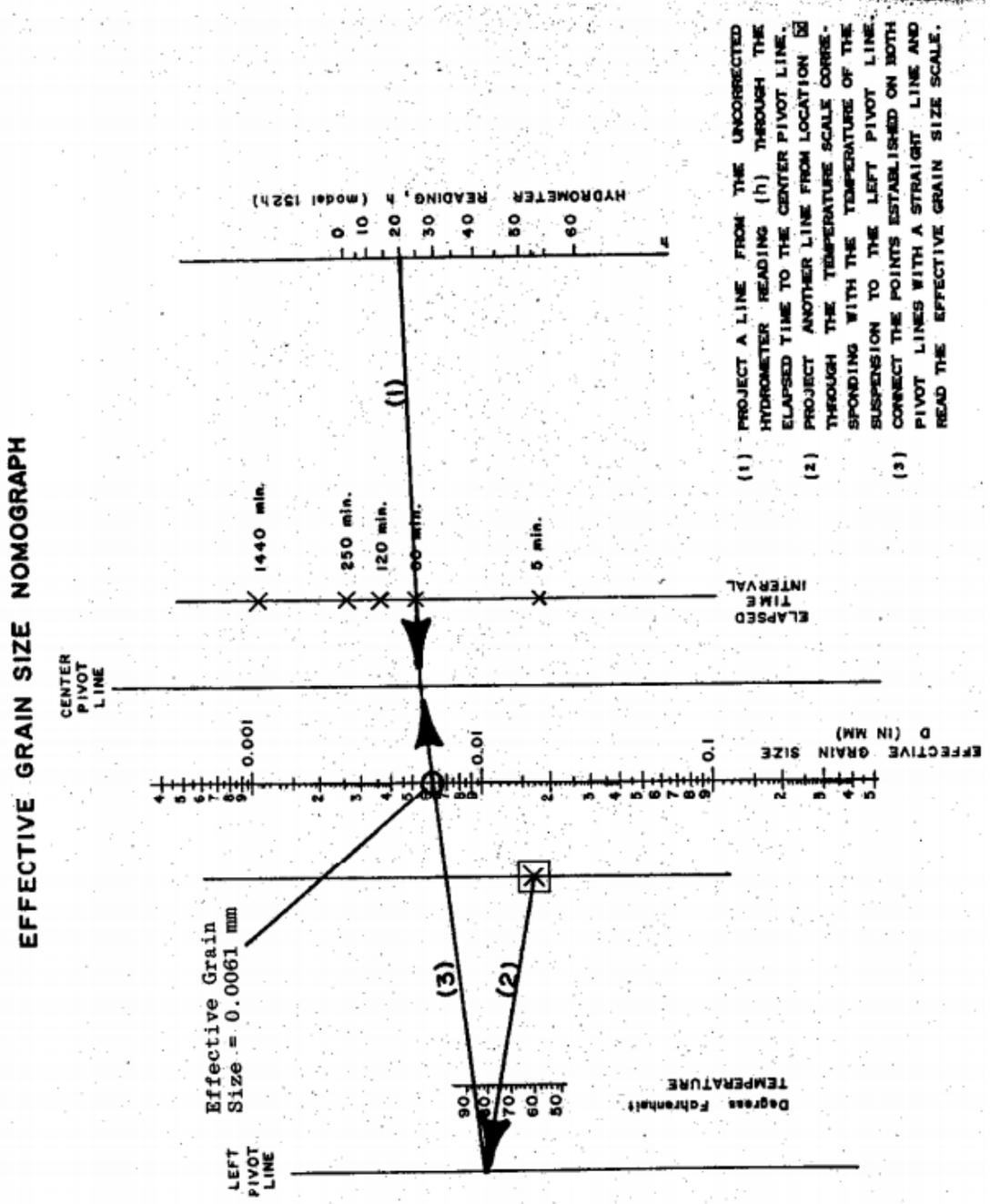


FIGURE 2

Figure A - 2
 Hydrometer



- (1) PROJECT A LINE FROM THE UNCORRECTED HYDROMETER READING (h) THROUGH THE ELAPSED TIME TO THE CENTER PIVOT LINE.
- (2) PROJECT ANOTHER LINE FROM LOCATION (2) THROUGH THE TEMPERATURE SCALE CORRESPONDING WITH THE TEMPERATURE OF THE SUSPENSION TO THE LEFT PIVOT LINE.
- (3) CONNECT THE POINTS ESTABLISHED ON BOTH PIVOT LINES WITH A STRAIGHT LINE AND READ THE EFFECTIVE GRAIN SIZE SCALE.

Figure A - 3

Effective Grain Size Nomograph

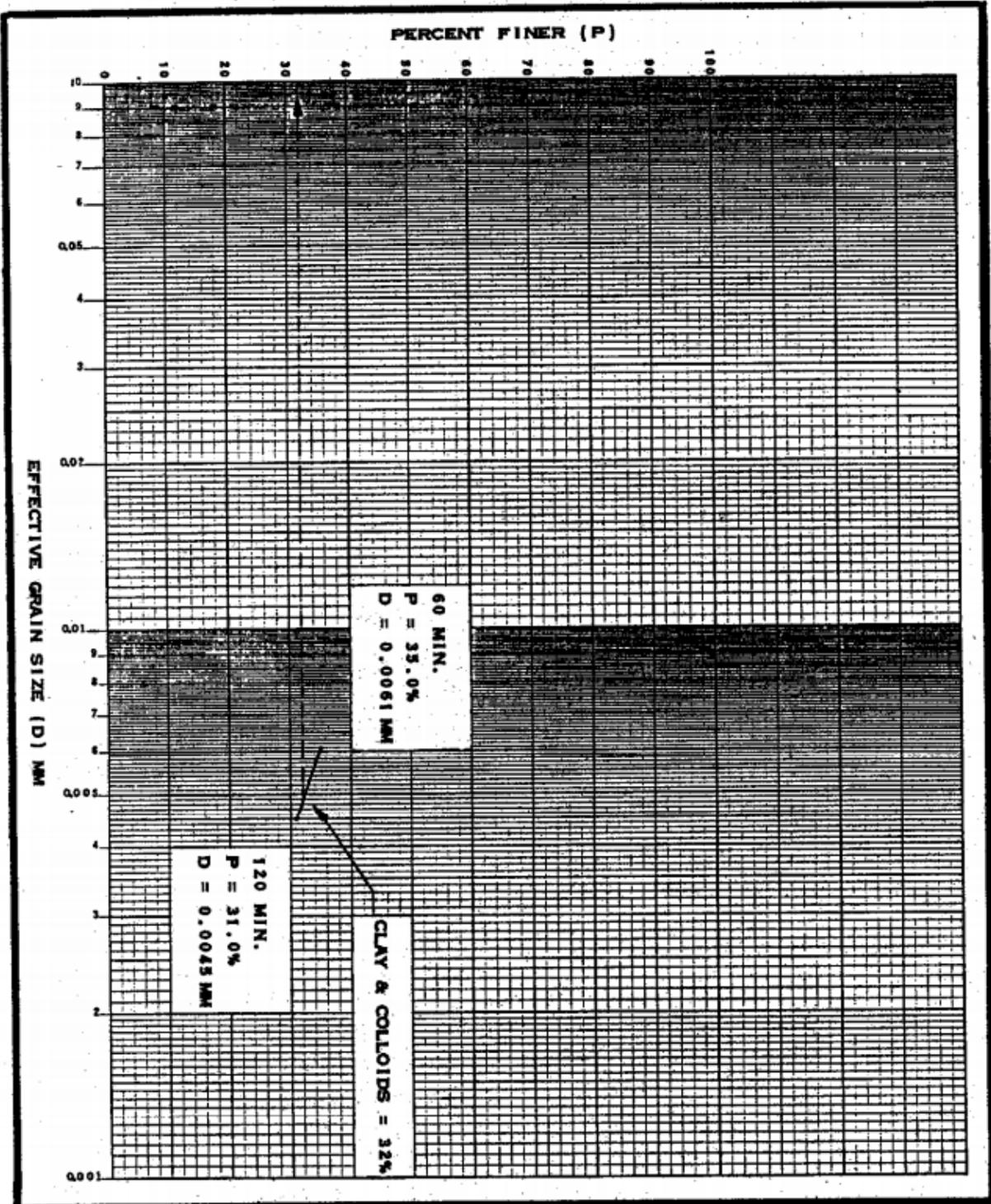


Figure A - 4

Grain Size Distribution

MATT MENU SELECTION - 14		Louisiana Department of Transportation and Development		DOTD 03-22-0723	
SOILS/SOIL-AGGREGATE					
Metric / English	<u>E (M or E - Located on MATT Menu)</u>				
Project No.	<u>999-99-9999</u>	Material Code	<u>521</u>	Lab. No.	<u>22-999169</u>
Date Sampled	<u>04-01-99</u>	Submitted By	<u>0071</u>	Quantity	_____
Purp. Code	<u>3</u>	Pit No.	_____	Spec Code	<u>L</u>
Date Tested	<u>04-06-99</u>	Ident.	<u>S-69</u>	Parish No.	<u>17</u>
From Station	<u>10 + 50</u>	To Station	<u>11 + 50</u>	Location	<u>RT. SHOULDER</u>
Hole No.	_____	Depth, m (ft)	<u>0 + 50</u>	Log Distance, km (mi)	_____
Item No.	_____	Sampled by: <u>John Hintz</u>			
Remarks 1	<u>RET 25 mm = 0%; 12.5 mm = 2.3%</u>				

Hydrometer Analysis (DOTD TR 407)		Graduate No. <u>12</u>	Dry Mass of Sample (W), g (1 = 50.0, 2 = 100.0) _____				
Time	(T) Elapsed Time	Temp °C (0.5° increments)	(h) Hydro Reading (0.5 increments)	(C) Correction (0.5 increments)	Corrected Reading H = h - C	% Finer $P = \frac{H}{W} \times 100$	Effect. Grain Size $D = K \sqrt{P}$
<u>8:10</u>	60 Minutes	<u>24.0</u>	<u>20.5</u>	<u>3.0</u>	<u>17.5</u>	<u>35</u>	<u>0.0061</u>
<u>9:10</u>	120 Minutes	<u>21.0</u>	<u>19.0</u>	<u>3.5</u>	<u>15.5</u>	<u>31</u>	<u>0.0045</u>

RETAINED ON 2.00 mm (10) <i>(TR 418 - Method H)</i> Mass Cup + Soil, g _____ Cup No. _____ Mass Cup, g _____ Mass Soil, g _____ RETAINED ON 425 µm (40) <i>(TR 407 & 418 - Method H)</i> Mass Cup + Soil, g <u>15.4</u> Cup No. <u>86</u> Mass Cup, g <u>11.2</u> Mass Soil, g <u>7.2</u> RETAINED ON 75 µm (200) <i>(TR 407 & 418 - Method H)</i> Mass Cup + Soil, g <u>18.7</u> Cup No. <u>87</u> Mass Cup, g <u>12.1</u> Mass Soil, g <u>6.6</u>	<table border="1" style="width:100%; border-collapse: collapse;"> <tr> <th>Size</th> <th>Mass Retained (W)</th> <th>%</th> </tr> <tr> <td>Total Mass, g</td> <td><u>30.2</u></td> <td></td> </tr> <tr> <td>25.0 mm (1)</td> <td><u>0</u></td> <td></td> </tr> <tr> <td>19.0 mm (3/4)</td> <td><u>2.2</u></td> <td></td> </tr> <tr> <td>12.5 mm (1/2)</td> <td><u>0.8</u></td> <td></td> </tr> <tr> <td>4.75 mm (4)</td> <td><u>1.2</u></td> <td></td> </tr> <tr> <td>2.00 mm (10)</td> <td><u>6.5</u></td> <td></td> </tr> <tr> <td>425 µm (40)</td> <td><u>7.2</u></td> <td><u>14.40</u></td> </tr> <tr> <td>75 µm (200)</td> <td><u>6.6</u></td> <td><u>15.25</u></td> </tr> <tr> <td>% Silt</td> <td></td> <td><u>40.40</u></td> </tr> <tr> <td>% Clay & Colloids</td> <td></td> <td><u>32</u></td> </tr> <tr> <td>Pass 4.75 mm (#4)</td> <td></td> <td><u>87</u></td> </tr> <tr> <td>Pass 2.00 mm (#10)</td> <td></td> <td><u>76</u></td> </tr> </table>	Size	Mass Retained (W)	%	Total Mass, g	<u>30.2</u>		25.0 mm (1)	<u>0</u>		19.0 mm (3/4)	<u>2.2</u>		12.5 mm (1/2)	<u>0.8</u>		4.75 mm (4)	<u>1.2</u>		2.00 mm (10)	<u>6.5</u>		425 µm (40)	<u>7.2</u>	<u>14.40</u>	75 µm (200)	<u>6.6</u>	<u>15.25</u>	% Silt		<u>40.40</u>	% Clay & Colloids		<u>32</u>	Pass 4.75 mm (#4)		<u>87</u>	Pass 2.00 mm (#10)		<u>76</u>	<table border="1" style="width:100%; border-collapse: collapse;"> <tr> <th colspan="2">(DOTD TR 407)</th> </tr> <tr> <td>% Ret. 25.0 mm (1)</td> <td><u>0</u></td> </tr> <tr> <td>% Ret. 19.0 mm (3/4)</td> <td><u>0</u></td> </tr> <tr> <td>% Ret. 12.5 mm (1/2)</td> <td><u>2</u></td> </tr> <tr> <td>% Ret. 4.75 mm (4)</td> <td><u>3</u></td> </tr> <tr> <td>% Ret. 2.00 mm (10)</td> <td><u>76</u></td> </tr> <tr> <td>% Ret. 425 µm (40)</td> <td><u>11</u></td> </tr> <tr> <td>% Ret. 75 µm (200)</td> <td><u>10</u></td> </tr> <tr> <td>% Silt</td> <td><u>31</u></td> </tr> <tr> <td>% Clay & Colloids</td> <td><u>30</u></td> </tr> <tr> <td>% Pass 2.00 mm (#10)</td> <td><u>76</u></td> </tr> <tr> <td>% Pass 425 µm (40)</td> <td><u>88</u></td> </tr> <tr> <td>% Pass 75 µm (200)</td> <td><u>88</u></td> </tr> <tr> <td>% Sand (Tot. Material)</td> <td><u>70</u></td> </tr> <tr> <td>% Unadjusted Silt</td> <td><u>30</u></td> </tr> <tr> <td>% Unadjusted Sand</td> <td><u>70</u></td> </tr> <tr> <td>% Unadjusted Clay</td> <td><u>32</u></td> </tr> </table>	(DOTD TR 407)		% Ret. 25.0 mm (1)	<u>0</u>	% Ret. 19.0 mm (3/4)	<u>0</u>	% Ret. 12.5 mm (1/2)	<u>2</u>	% Ret. 4.75 mm (4)	<u>3</u>	% Ret. 2.00 mm (10)	<u>76</u>	% Ret. 425 µm (40)	<u>11</u>	% Ret. 75 µm (200)	<u>10</u>	% Silt	<u>31</u>	% Clay & Colloids	<u>30</u>	% Pass 2.00 mm (#10)	<u>76</u>	% Pass 425 µm (40)	<u>88</u>	% Pass 75 µm (200)	<u>88</u>	% Sand (Tot. Material)	<u>70</u>	% Unadjusted Silt	<u>30</u>	% Unadjusted Sand	<u>70</u>	% Unadjusted Clay	<u>32</u>
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LIQUID LIMIT No. Blows _____ Mass Cup + Wet Soil, g _____ Mass Cup + Dry Soil, g _____ Mass Water, g _____ Factor _____ Cup No. _____ Mass Cup, g _____ Mass Dry Soil, g _____ % Moisture _____ PLASTIC LIMIT Mass Cup + Wet Soil, g _____ Mass Cup + Dry Soil, g _____ Mass Water, g _____ Cup No. _____ Mass Cup, g _____ Mass Dry Soil, g _____ % Moisture _____	<table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td colspan="2">% Organic Matter (TR 413) _____</td> </tr> <tr> <td>Liquid Limit (TR 428) _____</td> <td>Plasticity Index (TR 428) _____</td> </tr> <tr> <td>Natural Moisture Content, % (TR 403) _____</td> <td>Optimum Moisture Content, % (TR 418) _____</td> </tr> <tr> <td>Maximum Density, kg/m³ (lb/ft³) (TR 418) _____</td> <td>Laboratory Compaction Method (TR 418) _____</td> </tr> <tr> <td>% Cement (TR 432 or Plans) _____</td> <td>% Lime (TR 416) _____</td> </tr> <tr> <td>% Fly Ash _____</td> <td>% Other (Additive) Material Code _____ Percent _____</td> </tr> <tr> <td>Soil Group (TR 423) _____</td> <td>Classification (TR 423) _____</td> </tr> <tr> <td>pH (TR 430) _____</td> <td>Resistivity, ohm-cm (TR 429) _____</td> </tr> <tr> <td>Classification Prefix (TR 423) (G=Siliceous Aggr. N=Non-Siliceous S=Shell) _____</td> <td>(Required only if + 2.00 mm [No. 10] material equals or exceeds 5%)</td> </tr> </table>	% Organic Matter (TR 413) _____		Liquid Limit (TR 428) _____	Plasticity Index (TR 428) _____	Natural Moisture Content, % (TR 403) _____	Optimum Moisture Content, % (TR 418) _____	Maximum Density, kg/m ³ (lb/ft ³) (TR 418) _____	Laboratory Compaction Method (TR 418) _____	% Cement (TR 432 or Plans) _____	% Lime (TR 416) _____	% Fly Ash _____	% Other (Additive) Material Code _____ Percent _____	Soil Group (TR 423) _____	Classification (TR 423) _____	pH (TR 430) _____	Resistivity, ohm-cm (TR 429) _____	Classification Prefix (TR 423) (G=Siliceous Aggr. N=Non-Siliceous S=Shell) _____	(Required only if + 2.00 mm [No. 10] material equals or exceeds 5%)
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Remarks 2 _____

Tested By: _____ Checked By: _____ APPROVED BY: _____
 Date: _____ Date: _____ DATE: _____

Figure A - 5
 Soils/Soil-Aggregate Worksheet (03-22-0723)

DOTD Designation: TR 407M/407

Method B

- I. Scope**
 - A. This method describes an alternate procedure for determining the distribution of particle sizes of silty or sandy soils. This method may be used for soils which are suitable for soil cement stabilization.
 - B. Reference Documents: Refer to Method A

- II. Apparatus**

Refer to Method A.

- III. Composite Correction for Hydrometer Readings**

Refer to Method A.

- IV. Sample Preparation**

Refer to Method A, with the following exceptions.

 - A. From the portion passing the No. 10 sieve, obtain a 100.0 g sample (dry) in accordance with TR 411 and record the value.
 - B. Place the 100.0 g sample in a beaker and add 125 mL of stock solution prepared in accordance with Method A. Mix thoroughly with the stirring rod. There is no 12-hour soak time. Continue to step V. following stirring.

- V. Procedure**

Refer to Method A with the following exception. In Step VII.C., stir for 5 minutes instead of 60 seconds with the mechanical stirring apparatus.

- VI. Calculations**

Refer to Method A.

- VII. Report**

Refer to Method A.

- VIII. Normal Test Reporting Time**

Normal test reporting time is 24 hours.