# ATTI
# SOILS & AGGREGATE
# TECHNICIAN REVIEW CLASS

**THURSDAY & FRIDAY**: **7:30 am - 3:30 pm**

## Introduction:

- Review ATTI Soils & Aggregate Workbook
- Demonstrate Test Methods
- Practice Calculations
- Practice Performance (Hands-On)

| | | |
|---|---|---|
| ARIZ 105 | Sampling Soils and Aggregates | ***Station #1*** |
| AASHTO R 76 | Reducing Field Samples of Aggregate to Testing Size | ***Station #1*** |
| ARIZ 201 | Sieving of Coarse and Fine Graded Soils & Aggregates | ***Station #2*** |
| AASHTO T 11 | Matl's Finer than No. 200 Sieve in Mineral Agg's by Washing | ***Station #2*** |
| ARIZ 210 | Specific Gravity and Absorption of Coarse Aggregate | ***Station #3*** |
| AASHTO T 19 | Unit Weight and Voids in Aggregate | ***Station #3*** |
| ARIZ 211 | Specific Gravity and Absorption of Fine Aggregate | ***Station #4*** |
| AASHTO T 255 | Total Evaporable Moisture Content of Aggregate by Drying | ***Station #4*** |
| ARIZ 212 | Percentage of Fractured Coarse Aggregate Particles | ***Station #5*** |
| ARIZ 233 | Flakiness Index of Coarse Aggregate | ***Station #5*** |
| ARIZ 236 | Determining pH & Resistivity of Soils and Aggregates | ***Station #5*** |
| ARIZ 225 | Proctor Method A | ***Station #6*** |
| ARIZ 245 | Proctor Method D | ***Station #6*** |
| AASHTO T 89 | Determining the Liquid Limit of Soils | ***Station #7*** |
| AASHTO T 90 | Determining the Plastic Limit & Plasticity Index of Soils | ***Station #7*** |
| AASHTO T 265 | Laboratory Determination of Moisture Content of Soils | ***Station #7*** |
| AASHTO T 176 | Sand Equivalent Test | ***Station #8*** |
| AASHTO T 21 | Organic Impurities in Fine Aggregates for Concrete | ***Station #8*** |
| | **Lunch 11:30 am – 12:00 pm** | |
| Practice Calculations | 12:00 pm – 1:30 pm | ***Classroom - Station #9*** |
| Practice Performance | 1:30 pm – 3:30 pm | |

# SOILS & AGG TECHNICIAN REVIEW TRAINING

# Practice Calculations

# PERCENT PASSING CALCULATION (ARIZ 201)

To calculate percent passing you will need a scientific calculator with at least one memory.

Always add up all the weights, **never change the amount in the total box**. If the calculated total is 1.0% or less from the total in the total box, adjust the number of the sieve weight with the largest amount retained, except for the passing #4.

## COARSE SIEVE

a. To get the Coarse sieve factor, divide 100 by the total weight of sample (the number in the total box).
b. Place the factor in the memory of the calculator (MR+).
c. Enter 100 in the calculator, subtract the first weight retained, times (x) the factor (memory recall) (MR),then the = key this will give you the % passing that sieve.
d: Keeping that number in the calculator subtract the next weight retained, multiply it by the factor (MR) until all % passing is calculated and recorded.
e. Continue this down to the #4 weight retained.
f. Then do a check on the pass #4 by, multiplying the weight passing the #4 times the factor (MR).

## FINE SIEVE

Always add up all the weights, **never change the amount in the total box**. If the calculated total is 1.0% or less from the total in the total box, adjust the number of the sieve weight with the largest amount retained except, for the passing #200.

a. Subtract the “Total Dry Weight” from the “Dry Wt. of -#4 Split” weight to get the elutriation weight and record it in the box provided.
b. To get the fine sieve factor, take the % passing the #4 (whole number) and divide it by the adjusted split weight.
c. Place the factor in the memory of the calculator.
d. Enter the % pass the #4 (whole number) in the calculator, subtract the weight retained on the #8 sieve, multiply, (x) it by the factor (MR) = to get the % passing the #8.
e. Keeping that number in the calculator subtract the next weight retained (#10), multiply (x) it by the factor (MR) until all % passing is calculated and recorded.
f. Continue this procedure down to the #200.
g. Do a check on the pass #200 by multiplying the (weight passing the 200 sieve plus + the elutriation weight) by the factor (MR).

When all the percent pass results are recorded, you may now record the percent retained for each sieve. Start with the largest % pass and subtract the next smaller % pass from it. Continue this down to the #200 sieve(Rounded).

# ARIZONA DEPARTMENT OF TRANSPORTATION
## SOIL AND AGGREGATE TABULATION

USE CAPITAL LETTERS

LAB NUMBER | ORG NUMBER | MATL | TYPE | PURPOSE | TEST LAB | SIZE | SIZE %

TEST NO. | LOT OR SUFFIX | SAMPLED BY | MO | DAY | YEAR | TIME (MILITARY TIME)

SAMPLED FROM | LIFT NO. | RDWY | STATION (IF MILEPOST, INPUT DECIMAL)

ORIGINAL SOURCE | PROJECT ENGINEER / SUPERVISOR | PROJECT NUMBER | TRACS NUMBER

REMARKS

Practice Calculations

CONTACT PHONE NO. - ( ) -

**ARIZ 201**
- ☐ Dried to Constant Wt.
- ☐ Not Dried to Constant Wt.

**ARIZ 248**
- ☐ Alt. 1 ☐ Alt. 2 ☐ Alt. 3
- ☐ Alt. 4 ☐ Alt. 5

% OVERSIZE: + 3 " | + 6 "

COARSE FACTOR = 100 / COARSE SIEVE TOTAL

WET SAMPLE PREWEIGHT = _____

WET WT. OF - # 4 = _____

- # 4 SPLIT WET WT. = _____

| | WEIGHTS RETAINED | % RET. | % PASS | SPECS. | CUMULATIVE % RET. FINENESS MODULUS |
|---|---|---|---|---|---|
| 3" | | | | | |
| 2 1/2" | | | | | |
| 2" | | | | | |
| 1 1/2" | 966 | | | | |
| 1" | 1850 | | | | |
| 3/4" | 2133 | | | | |
| 1/2" | 2237 | | | | |
| 3/8" | 1085 | | | | |
| 1/4" | 721 | | | | |
| # 4 | 885 | | | | |
| - # 4 | 11785 | | | | |
| Total | 21627 | | | | |

IF TOTAL SAMPLE IS WASHED:
UNWASHED WT. = _____
WASHED WT. = _____
ELUTRIATION = _____

DRY WT. OF - # 4 SPLIT: 511

FINE FACTOR = % PASS # 4 / DRY WT. OF - # 4 SPLIT

| | WEIGHTS RETAINED | % RET. | % PASS | SPECS. | |
|---|---|---|---|---|---|
| #8 | 125 | | | | |
| #10 | 66 | | | | |
| #16 | 32 | | | | |
| #30 | 34 | | | | |
| #40 | 29 | | | | |
| #50 | 22 | | | | |
| #100 | 27 | | | | |
| #200 | 51 | | | | |
| -#200 | 1 | | | | |
| Total | 390 | | | | |
| Elutriation | | | | | |

Dry Weight = -#4 Split - Total Dry Weight

FINENESS MODULUS = TOTAL CUMULATIVE % RET. / 100

T = AASHTO Tests

| | | | SPECS. |
|---|---|---|---|
| Liquid Limit (LL) | T - 89 | | |
| Plastic Limit (PL) | T - 90 | | |
| Plasticity Index (PI) = LL - PL | T - 90 | | |
| Abrasion Method (A,B,C,D) | T - 96 | | |
| @ 100 Revolutions | | % | % |
| @ 500 Revolutions | | % | % |
| Absorption, $H_2O$ | ARIZ 210 ARIZ 211 | % | |
| Specific Gravity, SSD | ARIZ 210 ARIZ 211 | | |
| Specific Gravity, OD | ARIZ 210 ARIZ 211 | | |
| Specific Gravity, Apparent | ARIZ 210 ARIZ 211 | | |
| Proctor Method | | | A - ARIZ 225, C - ARIZ 226, D - ARIZ 226, AD - ARIZ 245, A1 - ARIZ 232, AD1 - ARIZ 246 |
| Optimum Moisture | | % | |
| Max. Dry Density | | PCF | |
| Sand Equivalent | T - 176 ARIZ 242 (MAFC) | | |
| At Least One Fractured Face | ARIZ 212 | % | % |
| At Least Two Fractured Faces | ARIZ 212 | % | % |
| Uncompacted Void Content | ARIZ 247 | % | % |
| Moisture Content | T - 255 T - 265 | % | |
| Flakiness Index | ARIZ 233 | % | % |
| Carbonates | ARIZ 238 | % | % |
| pH | ARIZ 236 OR 237 | | |
| Resistivity (ohm-cm) | ARIZ 236 | | |
| Soluable Salts (PPM) | ARIZ 237 | | |
| Unit Weight | T - 19 | PCF | |
| Voids | T - 19 | % | |
| Organic Imputities | T - 21 | | |
| Chloride Content (PPM) | ARIZ 736 | | |
| Sulfate Content (PPM) | ARIZ 733 | | |
| Exchangeable Sodium (%) | ARIZ 729 | | |
| Exchangeable Sodium (PPM) | ARIZ 729 | | |

WHITE ☐
YELLOW ☐
BLUE ☐

RECEIVED DATE | TEST OPERATOR & DATE | SUPERVISOR & DATE

ADOT 44-9353 R11/14

SEE BACK ALSO

## Specific Gravity and Absorption of Fine Aggregate (ARIZ 211)

**Bulk Sp. Gr. (O.D. basis)** $= \dfrac{A}{B + S - C}$ $\dfrac{(\quad)}{(\quad) + (\quad) - (\quad)} =$ _____

Where: A = mass of oven-dry sample in air, g. **492.9**
B = mass of pycnometer filled with water, g. **672.5**
C = mass of pycnometer with sample and water to calibration mark, g. **980.9**
S = mass of saturated-surface-dry sample, g. **500.2**

**Bulk Sp. Gr. (SSD basis) =** $= \dfrac{S}{B + S - C}$ $\dfrac{(\quad)}{(\quad) + (\quad) - (\quad)} =$ _____

**Apparent Sp. Gr.** $= \dfrac{A}{B + A - C}$ $\dfrac{(\quad)}{(\quad) + (\quad) - (\quad)} =$ _____

**Absorption, percent** $= \dfrac{S - A}{A} \times 100$ $\dfrac{(\quad) - (\quad)}{(\quad)} \times 100 =$ _____ %

## Specific Gravity and Absorption of Coarse Aggregate (ARIZ 210)

**Bulk Sp. Gr. (O.D. basis)** $= \dfrac{A}{B - C}$ $\dfrac{(\quad)}{(\quad) - (\quad)} =$ _____

Where: A = mass of oven-dry sample in air, g. **3950**
B = mass of saturated-surface-dry sample in air, g. **4036**
C = mass of saturated sample in water, g. **2486**

**Bulk Sp. Gr. (SSD basis) =** $= \dfrac{B}{B - C}$ $\dfrac{(\quad)}{(\quad) - (\quad)} =$ _____

**Apparent Sp. Gr.** $= \dfrac{A}{A - C}$ $\dfrac{(\quad)}{(\quad) - (\quad)} =$ _____

**Absorption, percent** $= \dfrac{B - A}{A} \times 100$ $\dfrac{(\quad) - (\quad)}{(\quad)} \times 100 =$ _____ %

*Practice Calculations # 4*

| Flakiness Index (ARIZ 233) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Sieve Size** | **1-1/2"** | **1"** | **3/4"** | **1/2"** | **3/8"** | **1/4"** | **# 4** | **# 8** |
| % Pass from Sieve Analysis | | | | | | | | |
| % Ret. From Sieve Analysis (F) | | | | | | | | |
| Weight of Test Sample | | | 1515 | 1015 | | | | 55 |
| Weigh Passing Slot | | | 285 | 175 | | | | 9 |
| * Percent Passing Slot (P) | | | | | | | | |
| NOTE: Only the size fractions which have 10 or more percent retained are tesed for passing the appropriate slot, and used to determine the Flakiness Index by the eequation below. | * Percent Passing Slot (P) = $\frac{\text{Weight Passing Slot}}{\text{Weight of Test Sample}} \times 100$ | | | | | | | |

FLAKINESS INDEX = $\frac{\{F\ (11/2")\ X\ P\ (11/2")\} + \ldots\ldots + \ldots\ldots + \{F\ (No.\ 8\ X\ P\ (No.\ 8)\}}{\{F\ (1\text{-}1/2")\ + \ldots\ldots + \ldots\ldots + \{F\ (No.\ 8)\}}$

**Fractured Particles (ARIZ 212)**

At least one Fractured Face:

Wt. of test sample (Wa) = **496**

Wt. of fract. Particles(Wf) = **444**

Fract. Particles (FF) = $\frac{Wf}{Wa} \times 100$ = _____ %

At least two Fractured Face:

Wt. of test sample (Wa) = NA

Wt. of fract. Particles(W2) = NA

Fract. Particles (FF2) = $\frac{W\ 2}{Wa} \times 100$ = NA %

FLAKINESS INDEX = $\frac{(\quad \times \quad) + (\quad \times \quad) + (\quad \times \quad) =}{(\quad) + (\quad) + (\quad) =}$ = _____ %

Moisture Content (T255, T265) = $\frac{\text{Wet Weight - Dry Weight}}{\text{Dry Weight}} \times 100$ $\left(\frac{1058.9 - 1035.2}{1035.2}\right) \times 100$ = _____ %

*Practice Calculations # 4*

## Sand Equivalent AASHTO T176)

(ARIZ 242 FOR M.A.F.C)

Sand Reading 3.8

Clay Reading 6.1

Sand Equiv. _____

Sand Reading 4.3

Clay Reading 6.6

Sand Equiv. _____

Sand Reading 4.1

Clay Reading 6.7

Sand Equiv. _____

$$\frac{\text{Sand Reading}}{\text{Clay Reading}} \times 100$$

Average Sand Equiv. = _____

## Abrasion AASHTO T96)

% Abrasion =

Where: A = Original Mass (5000 ± 10 grams)

B = Plus # 12 Material after Abrasion

100 Rev.: _____ x 100 = _____ %

500 Rev.: _____ x 100 = _____ %

Type of Abrasion _____

Soils Practice Calculations # 4

## Plasticity Index (AASHTO T89 & 90)

**Liquid Limit (LL) :**

**Bottle # 7** **Tare Wt. of Bottle: 60.08** **# Blows 25**

% Moisture =

$$\frac{\text{(Wet Wt. With Bottle) - (Dry Wt. With Bottle)}}{\text{(Dry Wt. With Bottle - Tare Wt. of Bottle)}} \times 100 =$$

$$= \frac{(\ 75.85 - 72.85\ )}{(\ -\ )} \times 100 = \_\_\_\_ \%$$

**Liquid Limit =** _____ (For 25 Blows)

**Plastic Limit (PL) :**

Bottle # **21** **Tare Wt. of Bottle: 55.69**

$$\frac{\text{(Wet Wt. With Bottle) - (Dry Wt. With Bottle)}}{\text{(Dry Wt. With Bottle - Tare Wt. of Bottle)}} \times 100 =$$

$$= \frac{(\ 63.21 - 62.25\ )}{(\ -\ )} \times 100 = \_\_\_\_ \%$$

**Plastic Limit =** _____

**Plasticity Index (PI) :**

**PI =** (LL - PL) = (  ) - (  ) = _____

ARIZONA DEPARTMENT OF TRANSPORTATION

# CALIBRATION OF PROCTOR MOLD
## ARIZ 225 Appendix A

✓ Four Inch Mold _____ Six Inch Mold Mold I. D. #: 2A

Calibration Date: _____ Calibration Expiration Date: _____

Temperature of water used for Calibration: 78 ° F

Unit Weight of Water: _____ lb. /cu. ft.

Test Operator: _____ Supervisor and Date: _____

| Weight of Baseplate, Empty Mold, and Glass Plate (grams) | Weight of Baseplate, Mold Filled with Water, and Glass Plate (grams) | Weight of Water to Fill Mold (grams) |
|---|---|---|
| 4525.6 | 5465.2 | |

$$V = \left[\begin{array}{c}\text{Volume of Mold} \\ \text{(cu. ft.)}\end{array}\right] = \frac{\text{Weight of Water to Fill Mold (grams)}}{\left[\begin{array}{c}\text{Unit Weight of Water} \\ \text{(lb. / cu. ft.}\end{array}\right] \text{X } [453.6 \text{ (grams / lb.)}]}$$

$$V = \frac{(\quad)}{(\quad) \text{ X } (\quad 453.6 \quad)} = \_\_\_\_\_ \text{ cu. ft.}$$

REMARKS: Practice Calulation # 4

## Unit Weight of Water Table

| Temp °F | lbs/cu. Ft. | Temp °F | lbs/cu. Ft. |
|---|---|---|---|
| 68 | 62.315 | 77 | 62.243 |
| 69 | 62.308 | 78 | 62.234 |
| 70 | 62.301 | 79 | 62.225 |
| 71 | 62.293 | 80 | 62.216 |
| 72 | 62.285 | 81 | 62.206 |
| 73 | 62.277 | 82 | 62.196 |
| 74 | 62.269 | 83 | 62.186 |
| 75 | 62.261 | 84 | 62.176 |
| 76 | 62.252 | 85 | 62.166 |
| | | 86 | 62.155 |

Arizona Department of Transportation

**METHOD A** or **ALTERNATE METHOD D** PROCTOR DENSITY

(Arizona Test Method 225 or 245)

Project No: _____ Lab No : _____ Rec'd Date: 05/04/2011

Source and Type of Material : _____

Proctor Method Used : **Method A** _____ or **Alternate Method D** _____

Test Operator and Date : _____ Supervisor and Date: _____

| Weight of Mold = **M2** = **2015** grams | Volume of Mold = **VM** = _____ cu. ft. | a = VM x 453.6 = _____ |
|---|---|---|

| b | M1 | c | WD | ED | Moisture Determination | | | | DD |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | WW | DW | d | e | |
| Approx % of water Added | Wt. of Sample and Mold | Wet Wt. of Sample **M1 - M2** | Wet Density lb/ cu ft **c / a** | Est. Dry Density **WD x 100 / b + 100** | Wet Wt. of Moisture Sample | Dry Wt. of Moisture Sample | Wt. of Water **WW - DW** | Percent Moisture **d x 100 / DW** | Dry Density lb/cu ft **WD x 100 / e + 100** |
| 6 | 4019 | | | | 334.0 | 309.5 | | | |
| 8 | 4129 | | | | 473.6 | 427.7 | | | |
| 10 | 4110 | | | | 399.9 | 356.6 | | | |
| 12 | 4058 | | | | 387.7 | 339.9 | | | |
| | | | | | | | | | |

**METHOD A**

WT = _____ WR4 = _____

PR4 = WR4 / WT x 100 = _____

**ALTERNATE METHOD D**

WT = _____ WR 3/4 = _____

PR 3/4 = WR 3/4 / WT x 100 = _____ %

Coarse Aggregate Bulk Oven Dry Specific Gravity : _____

Coarse Aggregate Absorption : _____

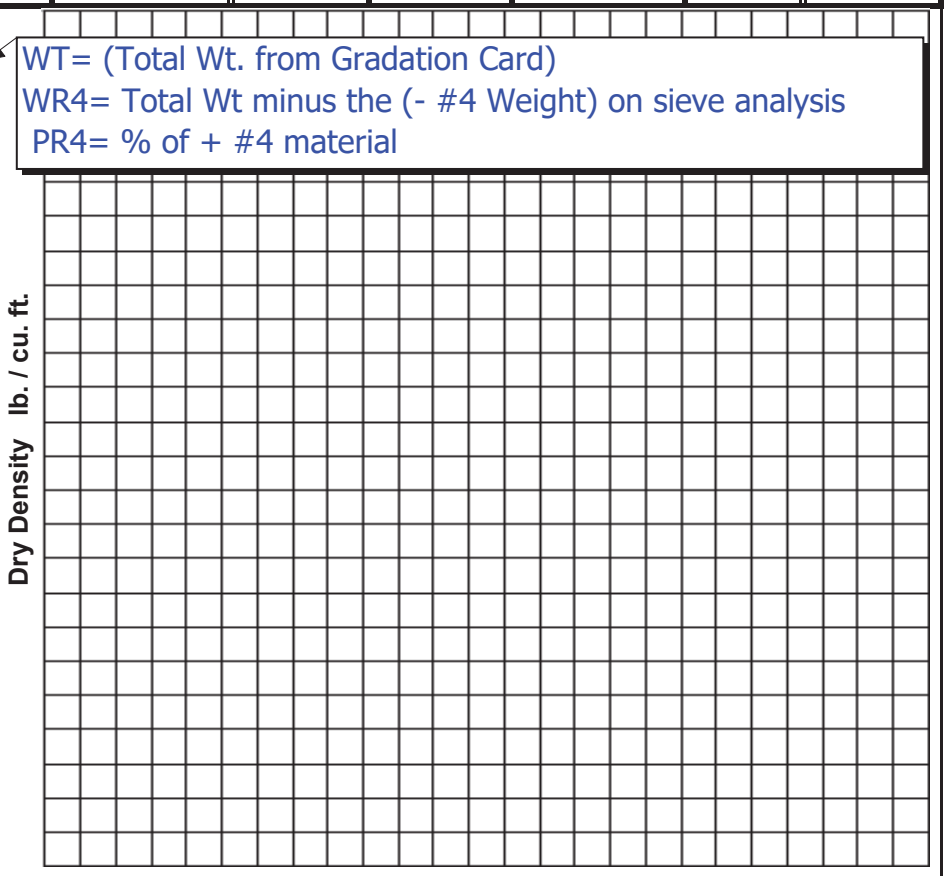
OPTIMUM MOISTURE CONTENT = OM = _____

MAXIMUM DRY DENSITY ( lb. / cu. ft. ) = MD = _____

WT= (Total Wt. from Gradation Card)

WR4= Total Wt minus the (- #4 Weight) on sieve analysis

PR4= % of + #4 material




**Remarks :** *Study Guide Calculations*

# Practice Calculations 4

# ARIZ 236 WORK CARD
# DETERMINING pH AND MINIMUM RESISTIVITY OF SOILS AND AGGREGATES

**Lab Number:** Practice Calulations # 4 **Date:** 10/27/2015

**Project / TRACS #:** _____ **Tested By:** _____

## MINIMUM RESISTIVITY

| Range Setting | | Dial Reading | = | Resistance, Ohms |
|---|---|---|---|---|
| 1,000 | X | 5.8 | = | |
| 1,000 | X | 4.5 | = | |
| 1,000 | X | 4.1 | = | |
| 1,000 | X | 2.7 | = | |
| 1,000 | X | 1.8 | = | |
| 1,000 | X | 1.4 | = | |
| 100 | X | 1.9 | = | |
| 100 | X | 3.9 | = | |
| | X | | = | |
| | X | | = | |
| | X | | = | |

## pH

**Sample Weight:** 50.1 g **Water Weight:** _____ g

**Start Time:** 9:00

Stir _____

Stir _____

Stir _____

Stir _____

Stir _____

Stir _____

Stir _____

Stir _____

Stir _____

**End Time:** _____

**Soil Box Factor =** 6.71 **pH Reading =** 7.86 **pH =** _____

**Buffers used for calibration of pH meter:** _____

---

**(Minimum Resistivity, ohm-cm) = (Resistance, ohms) x (Soil Box Factor, cm)**

( _____ ) X ( _____ ) = _____ ohm-cm

## MINIMUM RESISTIVITY = _____ ohm-cm

ADOT
Intermodal Transportation

# SOILS & AGG TECHNICIAN REVIEW TRAINING

# Practice Calculations

## Answer Key

# Practice Gradation Calculations

COARSE FACTOR: 0.004624

100 / 21627 = 0.004623850

| | Wt. Retained | % RET. | % PASS | Wt. RET. | (Memory Recall) (MR) |
|---|---|---|---|---|---|
| 3" | | | | | |
| 2 1/2" | | | | | |
| 2" | | | 100 | 100 - 966 | x 0.004624 = 95.533361 |
| 1 1/2" | 966 | 4 | 96 | 95.53336108 - 1850 | x (MR) = 86.979239 |
| 1" | 1850 | 9 | 87 | 86.97923891 - 2133 | x (MR) = 77.116567 |
| 3/4" | 2133 | 10 | 77 | 77.11656725 - **2202** | x (MR) = 66.934850 |
| 1/2" | ~~2237~~ | 10 | 67 | 66.93484996 - 1085 | x (MR) = 61.917973 |
| 3/8" | 1085 | 5 | 62 | 61.91797290 - 721 | x (MR) = 58.584177 |
| 1/4" | 721 | 3 | 59 | 58.58417719 - 885 | x (MR) = 54.492070 |
| # 4 | 885 | 5 | | | |
| - # 4 | 11785 | | 54 | -#4 Check = 11785 | x 0.004624 = 54.492070 |
| Total | 21627 | | | | |

***2202*** 21662 -35

DRY WT. OF- #4 SPLIT: 511

FINE FACTOR: 0.105675

54 / 511 = 0.105675147

| | | | | | |
|---|---|---|---|---|---|
| #8 | ~~125~~ | 14 | 40 | 54 - **128** | x 0.105675 = 40.473581 |
| #10 | 66 | 7 | 33 | 40.47358121 - 66 | x (MR) = 33.499022 |
| #16 | 32 | 3 | 30 | 33.49902153 - 32 | x (MR) = 30.117417 |
| #30 | 34 | 3 | 27 | 30.11741683 - 34 | x (MR) = 26.524462 |
| #40 | 29 | 4 | 23 | 26.52446184 - 29 | x (MR) = 23.459883 |
| #50 | 22 | 2 | 21 | 23.45988258 - 22 | x (MR) = 21.135029 |
| #100 | 27 | 3 | 18 | 21.13502935 - 27 | x (MR) = 18.281800 |
| #200 | 51 | 5 | | | |
| - # 200 | 1 | | 12.9 | 18.28180039 - 51 | x (MR) = 12.892368 |
| Total | 390 | | | | |
| Elutriation | 121 | | -# 200 Check = | 121 + 1 = 122 | x (MR) = 12.892368 |

***128*** 387 3 (Elutriation + - # 200's)

# ARIZONA DEPARTMENT OF TRANSPORTATION
## SOIL AND AGGREGATE TABULATION

USE CAPITAL LETTERS

LAB NUMBER | ORG NUMBER | MATL | TYPE | PURPOSE | TEST LAB | SIZE | SIZE %

TEST NO. | LOT OR SUFFIX | SAMPLED BY | MO | DAY | YEAR | TIME (MILITARY TIME)

SAMPLED FROM | LIFT NO. | RDWY | STATION (IF MILEPOST, INPUT DECIMAL)

ORIGINAL SOURCE | PROJECT ENGINEER / SUPERVISOR | PROJECT NUMBER | TRACS NUMBER

REMARKS

Practice Calculations

CONTACT PHONE NO. - ( ) -

**ARIZ 201**
- ☐ Dried to Constant Wt.
- ☐ Not Dried to Constant Wt.

**ARIZ 248**
- ☐ Alt. 1 ☐ Alt. 2 ☐ Alt. 3
- ☐ Alt. 4 ☐ Alt. 5

% OVERSIZE: + 3 " | + 6 "

COARSE FACTOR: .004624 = 100 / COARSE SIEVE TOTAL (.004623850)

WET SAMPLE PREWEIGHT = _____

WET WT. OF - # 4 = _____

- # 4 SPLIT WET WT. = _____

| | WEIGHTS RETAINED | % RET. | % PASS | SPECS. | CUMULATIVE % RET. FINENESS MODULUS |
|---|---|---|---|---|---|
| 3" | | | | | |
| 2 1/2" | | | | | |
| 2" | | | 100 | | |
| 1 1/2" | 966 | 4 | 96 | | |
| 1" | 1850 | 9 | 87 | | |
| 3/4" | 2133 | 10 | 77 | | |
| 1/2" (2202) | 2237 | 10 | 67 | | |
| 3/8" | 1085 | 5 | 62 | | |
| 1/4" | 721 | 3 | 59 | | |
| # 4 | 885 | 5 | | | |
| - # 4 | 1785 | | 54 | | |
| Total (21662) | 21627 | | | | |

IF TOTAL SAMPLE IS WASHED:
UNWASHED WT. = _____
WASHED WT. = _____
ELUTRIATION = _____

DRY WT. OF - # 4 SPLIT: 511

FINE FACTOR: .105675 = % PASS # 4 / DRY WT. OF - # 4 SPLIT (.105675147)

| | WEIGHTS RETAINED | % RET. | % PASS | SPECS. | |
|---|---|---|---|---|---|
| #8 (128) | 125 | 14 | 40 | | |
| #10 | 66 | 7 | 33 | | |
| #16 | 32 | 3 | 30 | | |
| #30 | 34 | 3 | 27 | | |
| #40 | 29 | 4 | 23 | | |
| #50 | 22 | 2 | 21 | | |
| #100 | 27 | 3 | 18 | | |
| #200 | 51 | 5 | | | |
| -#200 | 1 | | 12.9 | | |
| Total (387) | 390 | | | | Dry Weight |
| Elutriation | 121 | | | | = -#4 Split - Total Dry Weight |

FINENESS MODULUS = TOTAL CUMULATIVE % RET. / 100

T = AASHTO Tests

| | | | SPECS. |
|---|---|---|---|
| Liquid Limit (LL) | T - 89 | | |
| Plastic Limit (PL) | T - 90 | | |
| Plasticity Index (PI) = LL - PL | T - 90 | | |
| Abrasion Method (A,B,C,D) | T - 96 | | |
| @ 100 Revolutions | | % | % |
| @ 500 Revolutions | | % | % |
| Absorption, $H_2O$ | ARIZ 210 ARIZ 211 | % | |
| Specific Gravity, SSD | ARIZ 210 ARIZ 211 | | |
| Specific Gravity, OD | ARIZ 210 ARIZ 211 | | |
| Specific Gravity, Apparent | ARIZ 210 ARIZ 211 | | |
| Proctor Method | | | A - ARIZ 225, C - ARIZ 226, D - ARIZ 226, AD - ARIZ 245, A1 - ARIZ 232, AD1 - ARIZ 246 |
| Optimum Moisture | | % | |
| Max. Dry Density | | PCF | |
| Sand Equivalent | T - 176 ARIZ 242 (MAFC) | | |
| At Least One Fractured Face | ARIZ 212 | % | % |
| At Least Two Fractured Faces | ARIZ 212 | % | % |
| Uncompacted Void Content | ARIZ 247 | % | % |
| Moisture Content | T - 255 T - 265 | % | |
| Flakiness Index | ARIZ 233 | % | % |
| Carbonates | ARIZ 238 | % | % |
| pH | ARIZ 236 OR 237 | | |
| Resistivity (ohm-cm) | ARIZ 236 | | |
| Soluable Salts (PPM) | ARIZ 237 | | |
| Unit Weight | T - 19 | PCF | |
| Voids | T - 19 | % | |
| Organic Imputities | T - 21 | | |
| Chloride Content (PPM) | ARIZ 736 | | |
| Sulfate Content (PPM) | ARIZ 733 | | |
| Exchangeable Sodium (%) | ARIZ 729 | | |
| Exchangeable Sodium (PPM) | ARIZ 729 | | |

WHITE ☐
YELLOW ☐
BLUE ☐

RECEIVED DATE | TEST OPERATOR & DATE | SUPERVISOR & DATE

ADOT 44-9353 R11/14

SEE BACK ALSO

## Specific Gravity and Absorption of Fine Aggregate (ARIZ 211)

**Bulk Sp. Gr. (O.D. basis)** $= \dfrac{A}{B + S - C}$

$\dfrac{(\ 492.9\ )}{(\ 672.5\ ) + (\ 500.2\ ) - (\ 980.9\ )} = 191.8 = \dfrac{2.570}{2.569864}$

Where: A = mass of oven-dry sample in air, g. **492.9**
B = mass of pycnometer filled with water, g. **672.5**
C = mass of pycnometer with sample and water to calibration mark, g. **980.9**
S = mass of saturated-surface-dry sample, g. **500.2**

**Bulk Sp. Gr. (SSD basis) =** $= \dfrac{S}{B + S - C}$

$\dfrac{(\ 500.2\ )}{(\ 672.5\ ) + (\ 500.2\ ) - (\ 980.9\ )} = 191.8 = \dfrac{2.608}{2.607925}$

**Apparent Sp. Gr.** $= \dfrac{A}{B + A - C}$

$\dfrac{(\ 492.9\ )}{(\ 672.5\ ) + (\ 492.9\ ) - (\ 980.9\ )} = 184.5 = \dfrac{2.672}{2.671545}$

**Absorption, percent** $= \dfrac{S - A}{A} \times 100$

$\dfrac{(\ 500.2\ ) - (\ 492.9\ )}{(\ 492.9\ )} = 7.3 \times 100 = \dfrac{1.48}{1.4810306}\ \%$

## Specific Gravity and Absorption of Coarse Aggregate (ARIZ 210)

**Bulk Sp. Gr. (O.D. basis)** $= \dfrac{A}{B - C}$

$\dfrac{(\ 3950\ )}{(\ 4036\ ) - (\ 2486\ )} = 1550 = \dfrac{2.548}{2.548387}$

Where: A = mass of oven-dry sample in air, g. **3950**
B = mass of saturated-surface-dry sample in air, g. **4036**
C = mass of saturated sample in water, g. **2486**

**Bulk Sp. Gr. (SSD basis) =** $= \dfrac{B}{B - C}$

$\dfrac{(\ 4036\ )}{(\ 4036\ ) - (\ 2486\ )} = 1550 = \dfrac{2.604}{2.603871}$

**Apparent Sp. Gr.** $= \dfrac{A}{A - C}$

$\dfrac{(\ 3950\ )}{(\ 3950\ ) - (\ 2486\ )} = 1464 = \dfrac{2.698}{2.698087}$

**Absorption, percent** $= \dfrac{B - A}{A} \times 100$

$\dfrac{(\ 4036\ ) - (\ 3950\ )}{(\ 3950\ )} = 86 \times 100 = \dfrac{2.18}{2.1772152}\ \%$

*Practice Calculations # 4 Key*

| Flakiness Index (ARIZ 233) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Sieve Size** | **1-1/2"** | **1"** | **3/4"** | **1/2"** | **3/8"** | **1/4"** | **# 4** | **# 8** |
| % Pass from Sieve Analysis | | | 77 | 67 | | | | 40 |
| % Ret. From Sieve Analysis (F) | | | 10 | 10 | | | | 14 |
| Weight of Test Sample | | | 1515 | 1015 | | | | 55 |
| Weigh Passing Slot | | | 285 | 175 | | | | 9 |
| * Percent Passing Slot (P) | | | *19* | *17* | | | | *16* |
| NOTE: Only the size fractions which have 10 or more percent retained are tesed for passing the appropriate slot, and used to determine the Flakiness Index by the eequation below. | * Percent Passing Slot (P) = $\frac{\text{Weight Passing Slot}}{\text{Weight of Test Sample}} \times 100$ | | | | | | | |

**Fractured Particles (ARIZ 212)**

At least one Fractured Face:

Wt. of test sample (Wa) = **496**

Wt. of fract. Particles(Wf) = **444**

Fract. Particles (FF) = $\frac{Wf}{Wa} \times 100$ = ***90*** %

*89.516129*

At least two Fractured Face:

Wt. of test sample (Wa) = NA

Wt. of fract. Particles(W2) = NA

Fract. Particles (FF2) = $\frac{W\,2}{Wa} \times 100$ = NA %

FLAKINESS INDEX = $\frac{\{F\,(11/2") \times P\,(11/2")\} + \ldots\ldots + \ldots\ldots + \{F\,(No.\ 8 \times P\,(No.\ 8)\}}{\{F\,(1\text{-}1/2") + \ldots\ldots + \ldots\ldots + \{F\,(No.\ 8)\}}$

FLAKINESS INDEX = $\frac{(\ 10 \times 19\ ) + (\ 10 \times 17\ ) + (\ 14 \times 16\ )}{(\ 10\ ) + (\ 10\ ) + (\ 14\ )} = \frac{(\ 190\ ) + (\ 170\ ) + (\ 224\ )}{(\ 10\ ) + (\ 10\ ) + (\ 14\ )} = \frac{584}{34}$ = ***17*** % (*17.17647*)

Moisture Content (T255, T265) = $\frac{\text{Wet Weight - Dry Weight}}{\text{Dry Weight}} \times 100$

$\frac{(\ 1058.9\ ) - (\ 1035.2\ )}{(\ 1035.2\ )} \times 100$ = ***2.3*** % (*2.289413*)

## Sand Equivalent
**AASHTO T176)**
(ARIZ 242 FOR M.A.F.C)

| | | |
|---|---|---|
| Sand Reading | 3.8 | |
| Clay Reading | 6.1 | |
| Sand Equiv. | ***63*** | |
| | *62.30* | |
| Sand Reading | 4.3 | |
| Clay Reading | 6.6 | |
| Sand Equiv. | ***66*** | |
| | *65.15* | |
| Sand Reading | 4.1 | |
| Clay Reading | 6.7 | |
| Sand Equiv. | ***62*** | |
| | *61.19* | |

$$\frac{\text{Sand Reading}}{\text{Clay Reading}} \times 100$$

Average Sand Equiv. = ***64*** / *63.67*

## Abrasion
**AASHTO T96)**

% Abrasion =

Where: A = Original Mass (5000 ± 10 grams)

B = Plus # 12 Material after Abrasion

100 Rev.: _____ x 100 = _____ %

500 Rev.: _____ x 100 = _____ %

Type of Abrasion _____

*Soils Practice Calculations # 4 Key*

## Plasticity Index
**(AASHTO T89 & 90)**

**Liquid Limit (LL) :**

**Bottle #** 7 **Tare Wt. of Bottle:** 60.08 **# Blows** 25

% Moisture =

$$\frac{\text{(Wet Wt. With Bottle) - (Dry Wt. With Bottle)}}{\text{(Dry Wt. With Bottle - Tare Wt. of Bottle)}} \times 100 =$$

*(3.0 / 12.8) X 100 = 23.49256069*

$$= \frac{(75.85 - 72.85)}{(72.85 - 60.08)} \quad \frac{3.0}{12.77} \times 100 = 23\ \%$$

**Liquid Limit =** ***23*** (For 25 Blows)

**Plastic Limit (PL) :**

Bottle # 21 **Tare Wt. of Bottle:** 55.69

$$\frac{\text{(Wet Wt. With Bottle) - (Dry Wt. With Bottle)}}{\text{(Dry Wt. With Bottle - Tare Wt. of Bottle)}} \times 100 =$$

*(0.96 / 6.56) X 100 = 14.63414634*

$$= \frac{(63.21 - 62.25)}{(62.25 - 55.69)} \quad \frac{0.96}{6.56} \times 100 = 15\ \%$$

**Plastic Limit =** ***15***

**Plasticity Index (PI) :**

**PI =** (LL - PL) = ( 23 ) - ( 15 ) = ***8***

ARIZONA DEPARTMENT OF TRANSPORTATION

# CALIBRATION OF PROCTOR MOLD
## ARIZ 225 Appendix A

✓ Four Inch Mold _____ Six Inch Mold Mold I. D. #: 2A

Calibration Date: _____ Calibration Expiration Date: _____

Temperature of water used for Calibration: 78 ° F

Unit Weight of Water: 62.234 lb. /cu. ft.

Test Operator: _____ Supervisor and Date: _____

| Weight of Baseplate, Empty Mold, and Glass Plate (grams) | Weight of Baseplate, Mold Filled with Water, and Glass Plate (grams) | Weight of Water to Fill Mold (grams) |
|---|---|---|
| 4525.6 | 5465.2 | 939.6 |

$$V = \left[\text{Volume of Mold (cu. ft.)}\right] = \frac{\text{Weight of Water to Fill Mold (grams)}}{\left[\text{Unit Weight of Water (lb. / cu. ft.}\right] \text{ X } [453.6 \text{ (grams / lb.)}]}$$

$$V = \frac{(\ 939.6\ )}{(\ 62.234\ ) \text{ X } (\ 453.6\ )} = \frac{0.0333}{0.033284516} \text{ cu. ft.}$$

REMARKS: Practice Calulation key

## Unit Weight of Water Table

| Temp °F | lbs/cu. Ft. | Temp °F | lbs/cu. Ft. |
|---|---|---|---|
| 68 | 62.315 | 77 | 62.243 |
| 69 | 62.308 | 78 | 62.234 |
| 70 | 62.301 | 79 | 62.225 |
| 71 | 62.293 | 80 | 62.216 |
| 72 | 62.285 | 81 | 62.206 |
| 73 | 62.277 | 82 | 62.196 |
| 74 | 62.269 | 83 | 62.186 |
| 75 | 62.261 | 84 | 62.176 |
| 76 | 62.252 | 85 | 62.166 |
| | | 86 | 62.155 |

Arizona Department of Transportation

**METHOD A** or **ALTERNATE METHOD D** PROCTOR DENSITY

(Arizona Test Method 225 or 245)

Project No: _____ Lab No : _____ Rec'd Date: 01/00/1900

Source and Type of Material : _____

Proctor Method Used : **Method A** _____ or **Alternate Method D** _____

Test Operator and Date : _____ Supervisor and Date: _____

Weight of Mold = **M2** = **2015** grams | Volume of Mold = **VM** = ***0.0333*** cu. ft. | **a** = VM x 453.6 = ***15.1049***

| b | M1 | c | WD | ED | Moisture Determination | | | | DD |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | WW | DW | d | e | |
| Approx % of water Added | Wt. of Sample and Mold | Wet Wt. of Sample **M1 - M2** | Wet Density lb/ cu ft **c / a** | Est. Dry Density **WD x 100 / b + 100** | Wet Wt. of Moisture Sample | Dry Wt. of Moisture Sample | Wt. of Water **WW - DW** | Percent Moisture **d x 100 / DW** | Dry Density lb/cu ft **WD x 100 / e + 100** |
| 6 | 4019 | *2004* | *132.7* | *125.2* | 334.0 | 309.5 | *24.5* | *7.9* | *123.0* |
| 8 | 4129 | *2114* | *140.0* | *129.6* | 473.6 | 427.7 | *45.9* | *10.7* | *126.5* |
| 10 | 4110 | *2095* | *138.7* | *126.1* | 399.9 | 356.6 | *43.3* | *12.1* | *123.7* |
| 12 | 4058 | *2043* | *135.3* | *120.8* | 387.7 | 339.9 | *47.8* | *14.1* | *118.6* |
| | | | | | | | | | |

**METHOD A**

WT = **21627** WR4 = **9842**

PR4 = WR4 / WT x 100 = ***46%*** ***45.50793%***

**ALTERNATE METHOD D**

WT = _____ WR 3/4 = _____

PR 3/4 = WR 3/4 / WT x 100 = _____ %

Coarse Aggregate Bulk Oven Dry Specific Gravity : _____

Coarse Aggregate Absorption : _____

OPTIMUM MOISTURE CONTENT = OM = ***10.9*** Sm Graph

MAXIMUM DRY DENSITY ( lb. / cu. ft. ) = MD = ***126.8***

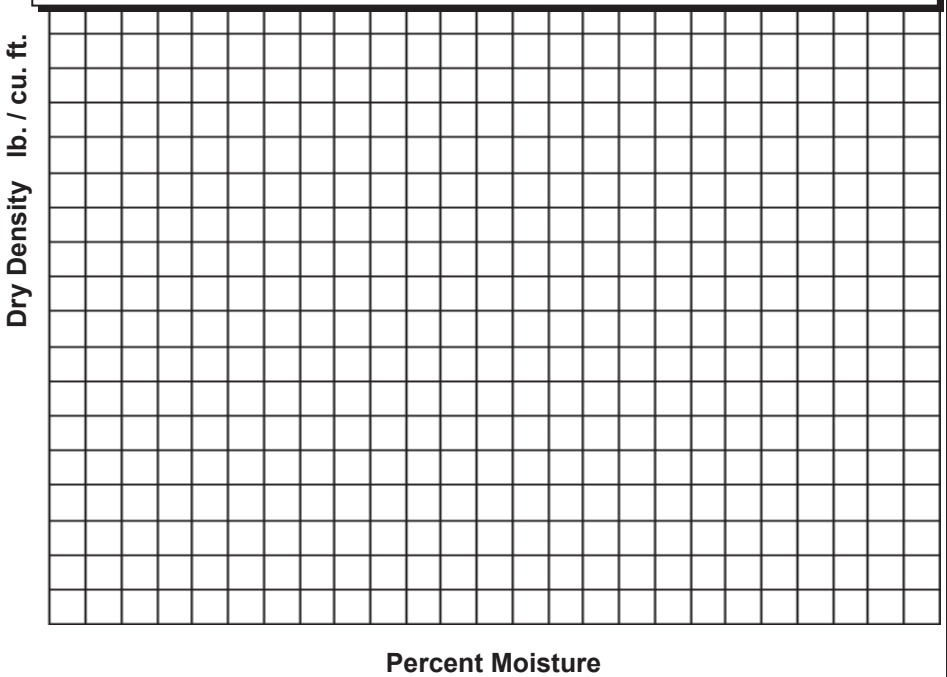
WT= (Total Wt. from Gradation Card)

WR4= Total Wt minus the (- #4 Weight) on sieve analysis

PR4= % of + #4 material

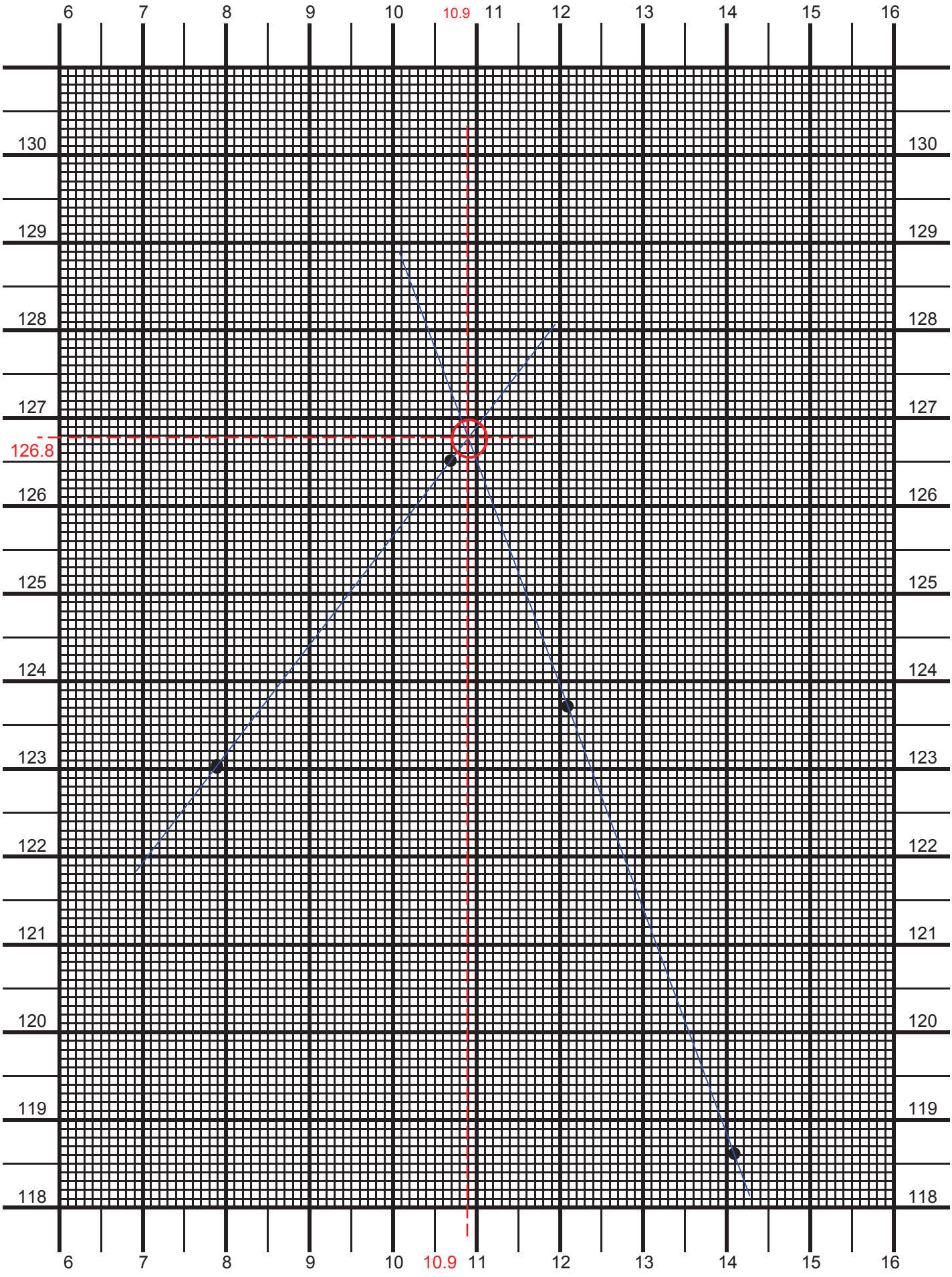
**21627 - 11785 = 9842**

**(9842 / 21627) x 100 = 45.5079299 %**




**Remarks :** *Study Guide Calculations Key*

# Practice Calculations # 4



ADOT Intermodal Transportation

# ARIZ 236 WORK CARD
# DETERMINING pH AND MINIMUM RESISTIVITY OF SOILS AND AGGREGATES

**Lab Number:** Practice Calulations Key **Date:** 10/27/2015

**Project / TRACS #:** **Tested By:**

## MINIMUM RESISTIVITY

| Range Setting | | Dial Reading | | Resistance, Ohms |
|---|---|---|---|---|
| 1,000 | X | 5.8 | = | 5,800 |
| 1,000 | X | 4.5 | = | 4,500 |
| 1,000 | X | 4.1 | = | 4,100 |
| 1,000 | X | 2.7 | = | 2,700 |
| 1,000 | X | 1.8 | = | 1,800 |
| 1,000 | X | 1.4 | = | 1,400 |
| 100 | X | 1.9 | = | 190 |
| 100 | X | 3.9 | = | 390 |
| | X | | = | |
| | X | | = | |
| | X | | = | |

## pH

**Sample Weight:** 50.1 g **Water Weight:** 50.1 g

| | |
|---|---|
| Start Time: | 9:00 |
| Stir | 9:10 |
| Stir | 9:20 |
| Stir | 9:30 |
| Stir | 9:40 |
| Stir | 9:50 |
| Stir | 10:00 |
| Stir | |
| Stir | |
| End Time: | 10:00 |

**Soil Box Factor =** 6.71 **pH Reading =** 7.86 **pH =** 7.9

**Buffers used for calibration of pH meter:** 7 & 10

---

**(Minimum Resistivity, ohm-cm) = (Resistance, ohm) x (Soil Box Factor, cm)**

( 190 ) X ( 6.71 ) = 1274.9 ohm-cm

## MINIMUM RESISTIVITY = 1275 ohm-cm