

**FIELD SAMPLING AND TESTING MANUAL**  
**ROUNDING PROCEDURES**  
**FOR DETERMINING SIGNIFICANT DIGITS**

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## ROUNDING NUMBERS FOR DETERMINING SIGNIFICANT DIGITS

It is necessary to perform all mathematical calculations in the proper format. The industry references The American Society for Testing Materials (ASTM) Standard E-29, "Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications."

### ROUNDING OFF RULES

- A. When the figure next beyond the last place to be retained is less than 5, retain unchanged the figure in the last place retained.

Example: Round to the nearest tenth (0.1)

45.71	=	45.7
45.72	=	45.7
45.73	=	45.7
45.74	=	45.7

- B. When the figure next beyond the last place to be retained is greater than 5, increase by 1 the figure in the last place retained.

Example: Round to the nearest tenth (0.1)

45.76	=	45.8
45.77	=	45.8
45.78	=	45.8
45.79	=	45.8

- C. When the next figure beyond the last place to be retained is 5 and there are no figures beyond this 5, or only zeros, increase the figure to be retained by 1 if it is odd.

Example: Round to the nearest tenth (0.1) 45.7500 = 45.8

**Leave the figure unchanged if it is even.**

Example: Round to the nearest tenth (0.1) 45.4500 = 45.4

**Increase the figure by 1 in the last place retained, if there are figures beyond this 5.**

Example: Round to the nearest tenth (0.1)

45.45001	=	45.5
45.45105	=	45.5
45.45099	=	45.5

### COMPUTER AND CALCULATOR ROUNDING (unofficial rounding)

Today's computers and calculators provide automatic rounding. However, in the case of part "C" above, they simply round up.

When using hand held calculators, many people carry all of the decimals, beyond significant figures, when making several related computations. This is not the correct method to perform computations; however, it does save time. You may choose to carry the decimals through long computations however, if the computation results in a value that is near a specification limit, the computation must be recalculated using the methods described below. The methods described below are the official round-off procedures of the NDDOT.

## GENERAL PROCEDURES FOR ROUNDING

Primary calculations are carried out and rounded to one decimal place more than is needed in the final answers.

### When adding:

Primary calculations are carried out - rounded to hundredths (0.01)

510.37 cu. yds.  
 270.12 cu. yds.  
+121.89 cu. yds.  
 902.38 cu. yds. = Total cubic yards of riprap placed.  
 902.4 cu. yds. = Final answers are rounded to tenths (0.1).

When using a calculation where rounding cannot be set, expect some differences in the answers. Do not carry calculations to decimal places beyond those needed.

### Calculating to tenths (0.1):

When tenths are required, primary calculations are carried out and rounded to hundredths (0.01). Final answers are rounded to tenths (0.1).

### When multiplying:

<u>Primary – Calculation A</u>	<u>Primary – Calculation B</u>
25.52 x 13.14 = 335.3328	9.45 x 3.2 = 30.240
Rounded to: 335.33	Rounded to: 30.24

### Final Calculation

335.33 X 30.24 = 10,140.3792  
 Rounded to: 10,140.4

### Calculating to hundredths (0.01):

When hundredths are required, primary calculations are carried out and rounded to thousandths (0.001). Final answers are rounded to hundredths (0.01).

**When dividing:**

Primary – Calculation A

$$542.15 \div 28.47 = 19.0428$$

Rounded to: 19.043

Primary – Calculation B

$$138.46 \div 12.12 = 11.4241$$

Rounded to: 11.424

Final Calculation

$$19.043 \div 11.424 = 1.667$$

Rounded to: 1.67

**Calculating to thousandths (0.001):**

When thousandths are required, primary calculations are carried out and rounded to ten thousandths (0.0001). Final answers are rounded to thousandths (0.001).

**When adding:**

Primary – Calculation A

$$\begin{array}{r} 4.46891 \\ 2.15672 \\ 1.12013 \\ + 0.01882 \\ \hline 7.76458 \end{array}$$

Rounded to: 7.7646

Primary – Calculation B

$$\begin{array}{r} 3.97163 \\ 1.05872 \\ 2.18291 \\ + 1.50562 \\ \hline 8.71888 \end{array}$$

Rounded to: 8.7189

Final Calculation

$$\begin{array}{r} 7.7646 \\ + 8.7189 \\ \hline 16.4835 \end{array}$$

Rounded to: 16.484

**Rounding final answers to whole units:**

Always round the numbers you have to work with to one more decimal place than needed in the final answer. If the final answer is to be in tenths (0.1), round the numbers to hundredths (0.01). If the final answer is to be in hundredths (0.01), round the number to thousandths (0.001). If the final answer is to be to the nearest whole number, round the numbers to tenths (0.1).

The following values will be added to find an answer to the nearest whole number:

460.57 cu. yds.	460.6 cu. yds.
571.59 cu. yds.	571.6 cu. yds.
<u>+342.65 cu. yds.</u>	<u>+342.7 cu. yds.</u>
1374.9 cu. yds.	1375 cu. yds.

Note how the numbers are rounded to tenths before they are added and how the final answer is rounded to a whole number.

**One more rule:** In calculations using Pi (3.1416), the first calculation is made without rounding. In other words, the number 3.1416 is not rounded, but the first calculation using 3.1416 is rounded.

### TECHNICAL DESCRIPTION OF ROUND-OFF RULE

Discard the  $(k + 1)$ th and all subsequent decimals.

- (a) If the number thus discarded is less than half a unit in the  $k$ th place, leave the  $k$ th decimal unchanged ("*rounding down*").
- (b) If it is greater than half a unit in the  $k$ th place, add one to the  $k$ th decimal ("*rounding up*").
- (c) If it is exactly half a unit, round off to the nearest even decimal (example: rounding off 3.45 and 3.55 to one decimal gives 3.4 and 3.6, respectively).

The last part of the rule is supposed to ensure that in discarding exactly half a decimal, rounding up and rounding down happens about equally often, on the average.

If we round off 1.2535 to 3, 2, 1 decimals, we get 1.254, 1.25, 1.3, but if 1.25 is rounded off to one decimal, without further information we get 1.2.

For further or additional determinations, refer to ASTM E-29, "Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications."