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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Practice for Using Significant Digits in Calculating and Reporting Geotechnical Test Data[1]

This standard is issued under the fixed designation D 6026; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ϵ^1 NOTE—Paragraph 1.3 was added editorially October 1998.

1. Scope

1.1 This practice is intended to assist in the use of uniform methods of indicating the number of digits that are to be considered significant and rounding for intermediate calculations when reporting geotechnical test results.

1.2 This practice uses a variation of the traditional rounding method (see Practice E 29) that recognizes the algorithm common to most hand-held calculators.

1.3 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Nat all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[2]

IEEE/ASTM SI 10 Standard for Use of the International System of Units (SI): *The Modern Metric System*

3. Terminology

3.1 *Definitions:*

3.1.1 *accuracy*, *n*—the degree of agreement of individual or average measurements with an accepted reference value.

3.1.2 *number*, *n*—a measured, observed, or approximated number, except when used in the context of ″number of significant digits" or ″number of decimal places."

3.1.3 *precision*, *n*—the degree of mutual agreement among individual measurements.

3.1.4 *rounding*, *n*—the process of reducing the number of digits in a number according to rules relating to the required accuracy of the value.

3.1.5 *significant digit*—any of the integers one through nine and zeros except leading zeros and some trailing zeros.

3.1.5.1 Zero is a significant digit if it comes between two non-zero integers.

3.1.5.2 Zeros leading the first nonzero digit of a number indicate the order of magnitude only and are not significant digits. For example, the number 0.0034 has two significant digits.

3.1.5.3 Zeros trailing the last nonzero digit for numbers represented with a decimal point are significant digits. For example, 4.00 and 4.01 have three significant digits.

3.1.5.4 The significance of trailing zeros for numbers represented without use of a decimal point can only be identified from knowledge of the source of the value.

4. Significance and Use

4.1 The guidelines presented in this practice for retaining significant digits and rounding numbers may be adopted by the using agency or user. Generally, their adoption should be used for calculating and reporting test data when specified requirements are not included in a standard.

4.2 The guidelines presented herein should not be interpreted as absolute rules but as guides to calculate and report observed or test data without exaggerating or degrading the accuracy of the values.

5. Guidelines for Rounding Numbers in Calculation and Reporting of Test Results

5.1 *General Discussion*—Rounding test results avoids the misleading impression of precision while preventing the loss of information due to coarse resolution. Any approach to retention of significant digits of necessity involves some loss of information; therefore, the level of rounding should be selected carefully considering both planned and potential uses for the data.

5.2 *Rounding Numbers*—When a numerical value is to be rounded to fewer digits than the total number available, the following procedure is to be followed:

When the first digit dropped is:	The last digit retained is:	Examples
<5	unchanged	2.44 to 2.4

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[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.91 on Standards Development and Review.

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[2] *Annual Book of ASTM Standards*, Vol 14.02.

>5	increased by 1	2.46 to 2.5
Exactly 5	always increase by 1	2.55 to 2.6 or 2.45 to 2.5
5 followed only by zeros	increased by 1	2.5500 to 2.6

5.2.1 The rounded value should be obtained in one step by direct rounding of the most precise value available and not in two or more successive roundings. For example, 89 490 rounded to the nearest 1000 is at once 89 000. It would be incorrect to round first to the nearest 100, giving 89 500 and then to the nearest 1000, giving 90 000.

5.2.2 The same rule applies when rounding a number with many digits to a number with a few digits as occurs when using a computer or calculator that displays the answer to a computation as ten or more digits and the answer is to be recorded to a few digits. For example, the number 2.34567 rounded to two significant digits would be 2.3.

5.2.3 The procedure and examples presented in 5.2 differ from that indicated in Practices E 29 and IEEE/ASTM SI 10, which state the historical method of rounding, that is, only rounding up odd digits followed by a five, while even digits stay the same (2.55 to 2.6 or 2.45 to 2.4). Unfortunately, calculators and computers do not, in general, follow this rule but rather always round up. Recognizing the wide-spread use of calculators and computers, the policy as stated in 5.2, 5.2.1 and 5.2.2 should be followed. The use of calculators, computers, and so forth, which follow Practices E 29 and IEEE/ASTM SI 10 rules of rounding, however, shall not be regarded as nonconformance with this practice.

5.3 *Recording Test Data*—When recording direct measurements, as in reading marks on a buret, ruler, or dial, record all digits known exactly, plus one digit, which may be uncertain due to estimation.

5.3.1 When the measuring device has a vernier scale, record the last digit from the vernier.

5.3.2 The number of significant digits given by a digital display or printout from an instrument should be greater than or equal to the sensor to which it is connected. Care should be taken not to record digits beyond the precision of the sensor, however. For example, using a pressure transducer with the precision of 1 kPa should not be read to the nearest 0.1 kPa because the readability of the output instrument displays more digits.

5.4 *Calculation of Test Result from Test Data*—When calculating a test result from test data, avoid rounding of intermediate quantities. As far as is practicable with the calculating device or form used, carry out calculations with the test data exactly and round only the final result.

5.5 *Reporting Data*—This data should conform with instructions in the respective standard. For example, when the computed value for liquid limit of a soil is recorded on the data form sheet to the nearest 0.1 % but is to be reported to the nearest 1 %.

5.5.1 If the number of significant digits in the reported values are not specified, the data used in calculations and reported should be in accordance with the rules of significant digits as described in Section 6.

6. Guidelines for Retaining Significant Digits in Calculation and Reporting of Test Results

6.1 Upon completion of mathematical calculations, use the following rules as guidelines to determine the proper number of significant digits or decimal places of rounded numbers.

6.1.1 The rule when adding or subtracting test data is that the number of decimal places in the result is the same as in the number containing the fewest digits following the decimal. Examples include:

6.1.1.1 11.24 + 9.3 + 6.32 = 26.9, since the last significant digit of 9.3 is the first following the decimal place, and 26.9 results by rounding the exact sum, 26.86.

6.1.1.2 926 − 923.4 = 3.

6.1.2 The rule when multiplying or dividing is that the result shall contain no more significant digits than the value with the smaller number of significant digits. Examples include:

6.1.2.1 11.38 × 4.3 = 49, since the factor 4.3 has two significant digits.

6.1.2.2 Determine the volume, V, of an object having a base area, A, of 28.48 in.^{2} and a height, h, of 6.12 in., $V = Ah = (28.48 \text{ in.}^2)(6.12 \text{ in.}) = 174$, the answer to three significant figures in agreement with the height measurement.

6.1.3 The rules for logarithms and exponentials are: digits of $\ln(x)$ or $\log_{10}(x)$ are significant through the nth place after the decimal when x has n significant digits. The number of significant digits of e^x or 10^x is equal to the place of the last significant digit in x after the decimal. Examples include:

6.1.3.1 ln(3.46) = 1.241 to three places after the decimal, since 3.46 has three significant digits.

6.1.3.2 $10^{3.46} = 2900$ has two significant digits, since 3.46 is given to two places after the decimal.

6.1.4 When an exact count is used in a calculation with a number, the number of significant digits in the result is the same as the number of significant digits in the number. For example, the sum of two measurements was found to be 8.24 in. To find the average value, this sum must be divided by two. In this case, however, two is not a measurement but an exact count. Therefore, 8.24 in./2 = 4.12 in. Since 8.24 has three significant digits, the results also contain three significant digits.

6.1.5 To preserve accuracy in calculations using constants, tabulated numbers, or conversion factors with measured values, the tabular values should retain at least one more significant digit than the measured number. For example, compute the inside circumference, C, of a mold having an inside diameter, d, of 6.025 in. The equation for circumference is:

$$C = \pi d = \pi \times = (3.1416) \times (6.025) = 18.93 \text{ in.} \quad (1)$$

7. Guidelines for Applicability to Committee D-18 Standards

7.1 If the rounding method of Section 5 is to apply to all data, calculations and results in the standard, and if all numbers expressed in the standard are to conform to the guidelines for significant digits as described in Section 6, then a statement similar to the following should be included in the scope of the standard:

> All observed and calculated values shall conform to the guidelines for significant digits and shall be