SRI LANKA STANDARD 102 : 2008
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RULES FOR ROUNDING OFF NUMERICAL VALUES
(First Revision)

SRI LANKA STANDARDS INSTITUTION

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(First Revision)

SLS 102 : 2008
(Attached AMD 460)

Gr. 5

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This standard does not purport to include all the necessary provisions of a contract.

Sri Lanka Standard
RULES FOR ROUNDING OFF NUMERICAL VALUES
(First Revision)

FOREWORD

This standard was authorized for adoption and publication as a Sri Lanka Standard by the Council of Sri Lanka Standards Institution on 2008-08-28.

This is the first revision of this standard which was initially prepared under the authority of the Metric Divisional Committee of the Sri Lanka Standards Institution and published in 1971 numbered CS 102.

This standard was prepared as a guide to all those who deal with scientific work, to have a uniform and consistent procedure of presenting and interpreting numerical values, particularly in regard to the number of figures* to be used or to be retained. It is also intended to serve as a guide to the Committees responsible for preparation of Sri Lanka Standards.

Principles laid down in the following publications have been taken into consideration in preparing this standard:

IS 2 : 1960 Rules for rounding off numerical values (revised)

ASTM Designation : E-29-06 B Standard practice for using significant digits in test data to determine conformance with specifications.

1 SCOPE

This standard lays down the principles to be used in expressing numerical values and the rules for rounding off of numerical values.

2 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply.

2.1 number of decimal places : A value is said to have as many decimal places as there are number of figures in the value starting from the decimal point and ending with the last figure on the right.

**The word “figure” is used in this standard instead of the word “digit”. Zero is regarded as a figure except when expressly excluded.*

2.2 Number of significant figures

A value is said to have as many significant figures as there are number of figures obtained by counting to the right from the first non-zero figure on the left.
Examples :

Value	Number of Decimal places	Number of significant Figures
453.592 37	5	8
0. 001 238	6	4
4 010. 000 675	6	10
6. 720 00	5	6
11. 34 x 10^5 (see Note 2)	2	4
78 000	0	5
7.00	2	3

NOTES

1 *In writing down values it is recommended (9th C G P M 1948) for clarity of expression that;*

a) Figures on either side of the decimal are grouped in threes with clear gaps in between as in the above examples, and

b) When the value is less than unity, a zero precedes the decimal point.

2. *For the purpose of this standard, the expression 11.34 × 10^5 should be taken to consist of two parts, the value proper which is 11.34 and the unit of expression for the value, 10^5.*

2.3 Fineness of rounding

The unit to which a value is rounded off. In addition to rounding off to unity, values may be rounded off to 0.000 002, 0.000 5, 0.025, 1/8, 1/16, 1/32, 1/64, or to any other unit dependant on the fineness desired. In such cases it is desirable that the fineness of rounding off be stated.

3 KINDS OF NUMERICAL VLAUES

For the purpose of this standard, the numerical values will be regarded as being of three different kinds, namely exact terminating values, inexact values for exact quantities and inexact values subject to inherent limitations of accuracy.

3.1 Exact terminating value

These values are expressed to as many figures as are required to give the complete value, without approximation, uncertainty or tolerance. Many definitive values are of this kind.
For example : 100 cm in a metre; 12 units in a dozen, 6 sides of a hexagon.
These values generally constitute a category of conversion factors.

3.2 Inexact decimal value for exactly defined numbers or quantities

These are exactly defined pure numbers which when expressed as a decimal fraction given irrational value. They can be expressed to any desired accuracy by taking sufficient number of figures.

For example : $\frac{1}{3}$ = 0.333 33 ……………….

$\sqrt{2}$ = 1.414 21 ………………..

π = 3.141 593 ………………

e = 2.718 28 ……………….

Many values having a purely mathematical basis fall into this category.

3.3 Inexact values subject to inherent limitations of accuracy

They include most of the values which are obtained experimentally and may represent the result of a measurement, estimation or calculation.

NOTE *: In reporting exact values to a number of significant figures particularly when some of these include decimal places, in order to differentiate them from inexact values of either kind, it is recommended that the word 'exactly" be used at the end of the value.*
For example : The pound avoirdupois shall be 0.453 592 37 kilogramme exactly.

4 ROUNDING OF NUMBERS

Rounding a number (sometimes called rounding off) consists in the rejection of any figure beyond the number of significant figures which is desired to retain and, if necessary, in the light of the rejected figures, the adjustment of the last figure or figures retained. The unrounded value should embody all the useful information that can be extracted from the data or the computations on which it is based. A necessary preliminary to the rounding of a given number is a decision on the appropriate number of figures to retain. This will be discussed in **5**. In most cases the direction of rounding is evident but sometimes the unrounded number falls exactly midway between two successive round values and a rounding rule is required to provide the desired consistency of procedure. The particular rule chosen is widely used in Sri Lanka and other countries and offers certain advantages which will be seen from the examples and notes which follow. In most instances the rounding will be required to the nearest unit in the last place retained.

4.1 Rules for rounding

The rule usually followed in rounding off a value to unit fineness of rounding is to keep unchanged the last figure retained when the figure next beyond is less than 5 and to increase by 1 the last figure retained when the figure next beyond is more than 5.

4.1.1 *Rounding off to unit fineness*

The following rules (except in 4.1.4) shall apply in retaining the last place when the fineness of rounding is unity.

Rule I – When the figure next beyond the last figure or place to be retained is less than 5 the figure in the last place retained shall be left unchanged.

Rule II - When the figure next beyond the last figure or place to be retained is more than 5 or 5 followed by any figures other than zeros, the figure in the last place retained shall be increased by 1.

Rule III – When the figure next beyond the last figure or place to be retained is 5 alone or 5 followed by zeros only, the figure in the last place retained shall be,

a) increased by 1 if it is odd, and
b) left unchanged if even (zero would be regarded as an even number for this purpose).

4.1.1.1 The rules for rounding laid down in **4.1.1** may be extended to apply when the fineness of rounding is 0.10, 10, 1 000 etc. For example 6.572 and 43.01 when rounded to fineness of 0.10 becomes 6.60 and 43.00 respectively.

4.1.2 *Rounding off to fineness other than unity*

When the fineness of rounding is not unity, the following rule shall apply:

Rule IV – When rounding to a fineness *n*, other than unity the given value shall be divided by *n*. The quotient shall be rounded off to the nearest whole number in accordance with the rules laid down in 4.1.1 for unit fineness of rounding. The number so obtained that is, the rounded quotient, shall then be multiplied by *n* to get the final rounded value.

NOTE : *The rules for rounding off a value to any fineness of rounding, n, may also be stated in line with those for unit fineness of rounding (see 4.1.1) as follows : Divide the given value by n so that an integral quotient and a remainder are obtained. Round off the value in the following manner*:

a) If the remainder is less than n/2, the value shall be rounded down, such that the rounded value is an integral multiple of n.
b) If the remainder is greater than n/2, the value shall be rounded up, such that the rounded value is an integral multiple of n.
c) If the remainder is exactly equal to n/2, that rounded value shall be chosen which is an integral multiple of 2n.
d) Multiply the rounded quotient by n.

For example : 3.6234 cm when rounded off to a fineness of 1/10 of a centimetre, using the above method, the result will be as follows:

Value	Fineness of rounding	Quotient	Rounded quotient	Final rounded value
3.6234	1/10	36.234	36	36 x 1/10 = 3.6000

TABLE 1 – Examples of rounding off of values

Value	Fineness of rounding	Rounded value	Rule
6.057 46	0.001	6.057	I
18.728 4	1	19	II
9.050 002	0.1	9.1	III
57.455	0.01	57.46	III(*a)*
0.056 5	0.001	0.056	III(*b)*
376.63	0.4	376.8	IV
1 078	50	1 100	IV
1.586	0.02	1.58	IV
30.646	7.5	30.0	IV
0.007 642	0.000 3	0.007 5	IV

4.1.3 *Successive rounding*

The final rounding should be made in one step by applying the rule to the most complete value obtainable and not by successive rounding.

Example 1 : The values 838.51 and 837.49 when rounded off to unity (using 4.1.1) , we get 839 and 837. But if the roundings were made in two stages the results would be as follows:

	1st stage	2nd stage
838.51	838.5	838
837.49	837.5	838

NOTE *: Here it is obvious that the values 837.49 and 838.51 are closer to 837 and 839 respectively and not to 838.*

Example 2 : The values 5.765 4 and 5.754 6 when rounded off to a fineness of 0.01 (using 4.1.1) we get 5.77 and 5.75 respectively. But if the roundings were made in two stages, the results would be as follows:

	1st stage	2nd stage
5.765 4	5.765	5.76
5.754 6	5.755	5.76

4.1.4 The rules given in **4.1.1**, **4.1.2** and **4.1.3** should be used only if no specific criteria for the selection of the rounded number have to be taken into account. In all cases, where safety requirements or prescribed limits have to be respected, rounding off should be done in one direction only.

5 NUMBER OF SIGNIFICANT FIGURES TO BE RETAINED

In retaining the number of significant figures, the accuracy of the original determination or computation should neither be sacrificed nor be exaggerated.

5.1 Expression of values

The number of significant figures should not be greater than the minimum necessary adequately to express a particular quantity, property or performance, with due regard both to the accuracy available in the determinations and the accuracy desired for use. In quoting a value there may be good reason for adopting any one of the three courses, namely:

a) The value may be given to more figures than those which are considered correct.
a) The value may be given just to the last figure which is considered correct.
b) The value may be given to fewer figures than those which are considered correct.

5.2 Computations

In computing values of different accuracies the number of significant figures retained will affect the final result. Therefore to obtain accurate results the following rules may be recommended for single arithmetical operations.

a) *Addition* : In the addition of several reported values those values which are reported with decimal places should be rounded off so as to retain one more place than the last significant place in the value reported with the least number of decimal places. The resulting sum shall then be rounded off to the last significant place in the value reported with the least number of decimal places.

b) *Subtraction* : When subtracting two values the value reported with more decimal places shall be rounded off before subtraction to the same number of places as the significant place in the value reported with the lower number of decimal places. The result should be reported with the latter number of decimal places.

c) *Multiplication and division* : The number of significant figures retained in the values reported with more significant figures shall be kept one more than the number of significant figures in the values reported with the least number. The result shall be rounded off with the same number of significant figures as in the one with the least number of significant figures.

d) When long computation is carried out in several steps the intermediate results shall be properly rounded at the end of each step so as to avoid the accumulation of rounding errors in such cases. It is recommended that at the end of each step one more significant figure may be retained than is required under (a), (b) and (c).

Example 1 : To find the sum of the rounded off values 763.350, 67.9, 4 700, 878.37, since the least accurate value is 4 700 the other values shall be rounded off to a fineness of 0.1 and then added as shown below:

```
   763.4
    67.9
 4  700
   878.4
 -------
 6 409.7
=========
```

The resulting sum shall then be reported as 6 410.

Example 2 : To find the difference of 1 073.42 and 696.765, since one of the values is significant to the second decimal place, the other value shall also be rounded off to the fineness of 0.01 and then the difference shall be found as follows:

```
 1 073.42
   696.76
 --------
   376.66
=========
```

The difference 376.66 shall be reported as such.

Example 3 : To find the difference of $\sqrt{278}$ and $\sqrt{275}$ to four significant figures:

$$\sqrt{278} = 16.763\ 33$$

$$\sqrt{275} = 16.583\ 12$$

The difference shall be reported as 0.090 21

NOTE : *The loss of significant figures in the subtraction of nearly equal values could be the greatest source of inaccuracy in computation if the appropriate number of decimal places is not retained when rounding off. For example, if the value of the diameter of a bore and the cylinder which fits it are given as 0.169 52 and 0.168 71 then in determining the clearance, the decimal places should be retained, although the value for the clearance itself will have only two significant figures that is, 0.000 81, whilst the values for the diameters are given to five significant figures. Rounding off to two significant figures of the original values will make the result meaningless.*

If however, the difference of two values is desired to be correct to k significant figures and it is known beforehand that the first m significant figures at the left will disappear by subtraction, then the number of significant figures to be retained in each of the values shall be $m + k$ (see example 3).

To ensure a greater degree of accuracy in the computations, it is also desirable to avoid or defer as long as possible certain approximation operations like that of the division or square root. For example, in the determination of sucrose by volumetric method,

the expression $\left(\frac{f_2}{v_2} - \frac{f_1}{v_1}\right) \frac{20\,W_1}{W_2}$ may be better evaluated by

taking its calculation form as 20 W_1 $(f_2\,v_1\ - f_1\,v_2)\,/\,W_2\,v_2\,v_1$ which would defer the division until the last operation of the calculation.

Example 4 : To evaluate $\frac{8.734 \times \sqrt{5}}{\pi}$

Since the numerator is correct to four significant figures, $\sqrt{5}$ also should be expressed as 2.237. And the denominator should be taken as 3.141 6.

Thus $$\frac{8.374 \times 2.217}{3.1416} = 6.216\ 6$$

and the result shall be reported as 6.217.

Example 5 : To evaluate $\frac{\sqrt{67}}{3.13}$ since the denominator is correct to three significant figures, the numerator should be corrected to four significant figures

Thus $$\frac{8.185}{3.13} = 2.615$$

and the result shall be reported as 2.62.

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AMD 460

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TO SLS 102:2008

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Page 9

Example 3: Second line

Delete 16.763 33 and substitute with 16.673 33

Page 10

Example 4: Second line

Delete 2.237 and substitute with 2.236

Example 4: Fourth line

Delete $\frac{8.374 \times 2.217}{3.1416} =$ 6.216 6 and substitute with $\frac{8.734 \times 2.236}{3.1416} =$ 6.216 3

Example 4: Fifth line

Delete 6.217 and substitute with 6.216

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SRI LANKA STANDARDS INSTITUTION

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