

Australian Standard™

**Numerical values—Rounding and
interpretation of limiting values**

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PREFACE

This Standard was prepared by the Standards Australia Committee ME-071, Quantities, Units and Conversions, to supersede AS 2706—1984.

The objective of this Standard is to adopt a consistent procedure in the presentation and interpretation of numerical values, particularly the number of figures to be used and the procedure for rounding. Values are expressed appropriately without using too few or too many figures, and a standard practice is adopted for rounding the last figure.

General principles and working rules relating to the different aspects are set out and illustrated with examples. It is, however, not possible to deal fully with all aspects.

In the preparation of this Standard, reference was made to the following Standards:

- (a) AS ISO 1000 SI units and recommendations for the use of their multiples and of certain other units
- (b) ISO GUM Guide to the Expression of Uncertainty in Measurement
- (c) AS 3807 Vocabulary of basic and general terms in metrology
- (d) AS 3912.1 Quality assurance requirements for measuring equipment, Part 1: Metrological confirmation system for measuring equipment
- (e) ASTM E29 Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which they apply. A ‘normative’ appendix is an integral part of a Standard, whereas an ‘informative’ appendix is only for information and guidance.

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STANDARDS AUSTRALIA

Australian Standard

Numerical values—Rounding and interpretation of limiting values

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard deals with certain aspects of the rounding and interpretation of numerical values. It includes the following:

- (a) Rules for the rounding of numbers, assuming a prior decision on the appropriate number of figures to be retained (see Section 3).
- (b) A discussion of the number of significant figures to be retained in presenting any particular value (see Section 4).
- (c) Conventions concerning the interpretation of specification limits in relation to their mode of expression (see Section 5).

1.2 FORM OF NOTATION

For the purpose of this Standard, all numerical values are expressed in accordance with the decimal system.

1.3 TYPES OF NUMERICAL VALUE

Numerical values may be regarded as being of three different kinds as follows:

- (a) *Exact numerical values* Exact numerical values are expressed to as many figures as are required to give the complete value, without approximation. Many definitive values are of this kind.

Example 1:

1 kilowatt hour (1 kW.h) = 3.6 MJ, exactly

Example 2:

Standard acceleration of free fall, $g_n = 9.806\,65\text{ m/s}^2$, exactly

Example 3:

1 litre (L) = 10^{-3} m^3 , exactly

- (b) *Inexact decimal expressions of exactly defined numbers* Exactly defined numbers can be expressed with any desired accuracy by taking sufficient figures. Many values having a purely mathematical basis fall into this category.

Example 4:

The expressions $1/7$, $1/3$, $\sqrt{2}$, π and e stand for exactly defined numbers. Decimal expressions for these are non-terminating, i.e.—

- (a) 0.142 857 1;
- (b) 0.333 333 3;
- (c) 1.414 213 5;

- (d) 3.141 592 7; and
 - (e) 2.718 281 8, respectively.
- (c) *Inexact values subject to inherent limitations of accuracy* Inexact values that are subject to inherent limitations of accuracy may or may not include figures that are in doubt. Experimentally determined values fall into this category.

Example 5:

The measured electrical resistance of a coil might be reported as $100.021 \pm 0.002 \Omega$ or as 100.02Ω .

Here ± 0.002 represents an estimate of the uncertainty of the determination. Such estimates should follow a recognized convention.

Example 6:

The distance between two stations is stated to be 55.2 km. This value is to some extent inexact. To write this as 55 200 m could imply an accuracy finer than that of the original statement. Such a value should be written in the original form as 55.2 km or in some form such as 55.2×10^3 m.

Broadly, the provisions of this Standard cover the use of all three kinds of values, but particular attention is given to the presentation of values of the kind described in Item (c).

SECTION 2 TERMINOLOGY

2.1 FIGURE

In this Standard, the word ‘figure’ is synonymous with the word ‘digit’. Zero is regarded as a figure unless expressly excluded, e.g., where used to locate a decimal sign as in 0.12.

2.2 NUMBER OF SIGNIFICANT FIGURES AND DECIMAL PLACES

The number of significant figures in a given value is defined as the number of figures obtained by counting to the right from the leftmost non-zero figure inclusive. Normally, the rightmost figure counted is the rightmost figure given. Exceptionally, where the value is given as terminating in one or more zeros, the known or implied accuracy shall be considered before it can be decided how many of the zeros are to be counted.

The number of decimal places in a given value is normally defined as the number of places traversed in moving from the decimal sign to a point immediately to the right of the last figure given.

NOTES:

- 1 The word ‘significant’ in the term ‘significant figures’ has a technical meaning that is not always the same as that in the term ‘physical significance’.
- 2 The use of a specified number of decimal places to ensure a certain degree of accuracy or precision is not always satisfactory. The use of a specified number of significant figures is much preferred. It eliminates confusion, which can arise if a different unit is chosen.

Example 7:

$g_n = 9.81$, to three significant figures but two decimal places.

Example 8:

Density of dry air of normal carbon dioxide content at 15°C and at a pressure of 101.325 kPa:

$= 1.2255 \text{ kg/m}^3$, to five significant figures but four decimal places.

$= 0.001\,225\,5 \text{ t/m}^3$, to five significant figures but seven decimal places.

In the latter form of the value, the first three zeros merely locate and identify the decimal sign (the first zero identifies, the second and third locate) and are not counted as significant.

Example 9:

$= 3.141\,59$, to six significant figures but five decimal places.

$= 3.1416$, to five significant figures but four decimal places.

$= 3.142$, to four significant figures but three decimal places.

Example 10:

The specified minimum yield strength of a material is reported as 241 000 kPa. This is an example of an undesirable expression similar to that given in Example 6.

If, on consideration of the known or implied accuracy, it is decided not to count the last two zeros then there are four significant figures; if the last three zeros are not counted then there are three significant figures. The notation 241.0 MPa or 241 MPa, respectively, is preferred.