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CONVERSION OF TOLERANCED DIMENSIONS
FROM INCHES INTO MILLIMETRES AND VICE VERSA

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BRIEF HISTORY

The ISO Recommendation R 370, *Conversion of Toleranced Dimensions from Inches into Millimetres and Vice versa*, was drawn up by Technical Committee ISO/TC 3, *Limits and Fits*, the Secretariat of which is held by the Association Française de Normalisation (AFNOR).

Work on this question by the Technical Committee began in 1953, taking into account the studies which had been made by the former International Federation of the National Standardizing Associations (ISA), and led, in 1962, to the adoption of a Draft ISO Recommendation.

In May 1962, this Draft ISO Recommendation (No. 510) was circulated to all the ISO Member Bodies for enquiry. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies:

Australia	Germany	Norway
Austria	Greece	Poland
Belgium	Hungary	Portugal
Burma	India	Romania
Canada	Iran	Spain
Chile	Ireland	Sweden
Czechoslovakia	Italy	Switzerland
Egypt	Japan	Turkey
Finland	Netherlands	United Kingdom
France	New Zealand	Yugoslavia

Two Member Bodies opposed the approval of the Draft:

U.S.A., U.S.S.R.

The Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in May 1964, to accept it as an ISO RECOMMENDATION.

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1. PURPOSE

The present ISO Recommendation concerns the *conversion of toleranced dimensions* from inches into millimetres and vice versa.

The object of the ISO Recommendation is to define, for agreements which refer to it, methods of conversion which ensure, under the most suitable conditions, practical regard for interchangeability corresponding to the specified tolerances.

2. GENERALITIES

2.1 The use of the conversion factor 1 in = 25.4 mm exactly * generally produces converted values containing more decimal places than are required for the desired accuracy.

It is therefore necessary to round these values suitably, in accordance with the degree of accuracy of the toleranced dimensions, which depends on the magnitude of the tolerance specified.

2.2 Application of the rules for rounding, as given in Tables 1 and 2 (clauses 3 and 4 of this ISO Recommendation), guarantees that even in the most unfavourable extreme cases neither of the two specified limits will be exceeded by more than 2 to 2.5 per cent of the value of the tolerance.

2.2.1 In *Method A,* which is generally applicable, unless expressly indicated to the contrary, the rounding is effected *to the nearest rounded value* so that, on the average, the converted tolerances remain statistically identical with the original tolerances.

The limits converted by this method are considered acceptable for interchangeability and serve as a basis for inspection.

2.2.2 In *Method B,* rounding is effected systematically *towards the interior* of the tolerance zone so that, on the average, the converted tolerances are smaller than the original tolerances.

Consequently this method should be employed only when, by special agreement, the original limits have to be respected absolutely (in particular, when components are to be inspected by means of original ** gauges).

These two methods form the subject of clauses 3 and 4 of this ISO Recommendation which relate respectively:

clause 3, to the conversion of inches into millimetres
clause 4, to the conversion of millimetres into inches

and are supplemented:

clause 5, by various special methods of application.

Finally, there is an appendix containing conversion tables from inches into millimetres and vice versa, on the basis of the conversion factor 1 in = 25.4 mm.

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* See ISO Recommendation R 31, Part I, *Fundamental Quantities and Units of the MKSA System and Quantities and Units of Space and Time,* No. 1-3.h.

** Gauges in the dimension to be converted.

3. CONVERSION OF INCHES INTO MILLIMETRES

3.1 Method A (General Rule)

(a) For each dimension in inches, consider only its two limits, maximum and minimum;

(b) Convert the corresponding two values exactly into millimetres by means of the conversion factor: 1 in = 25.4 mm (see the conversion tables in the appendix, pages 9 and 10);

(c) Round the results obtained in this way to the nearest rounded value as indicated in Table 1 below, depending on the original tolerance in inches, i.e. on the difference between the two limits in inches.*

The use of this method guarantees that even in the most unfavourable extreme cases neither of the two original limits will be exceeded by more than 2 per cent of the value of the tolerance.

3.2 Method B (by special agreement)

As Method A, except that the rounding is not effected to the nearest rounded value, but *towards the interior of the tolerance* (i.e. to the next lower value for the upper limit and to the next higher value for the lower limit).

This method should be employed only when the original limits have to be respected absolutely (in particular, when components are to be inspected by means of original gauges).

TABLE 1

Original tolerance in inches		Round off to a whole number of
not less than	and below	
in	in	mm
0.000 01	0.0001	0.000 01
0.0001	0.001	0.0001
0.001	0.01	0.001
0.01	0.1	0.01
0.1	1	0.1

Example

Suppose that a dimension is expressed in inches as follows:

$$1.950 \pm 0.016 \ (=1.966, \ 1.934)$$

Conversion of the two limits into millimetres gives

$$49.1236 \text{ and } 49.9364$$

As the tolerance equals 0.032 in and thus lies between 0.01 and 0.1 in, it is necessary, employing Method A, to round these values to the nearest 0.01 mm. The values in millimetres to be employed for these two limits are thus

$$49.12 \text{ and } 49.94$$

(Rounding towards the interior of the tolerance, according to Method B, would give limits of 49.13 mm and 49.93 mm, i.e. a tolerance reduced to 0.80 mm instead of 0.82 mm, as given by Method A.)

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* This amounts to rounding each of the two values converted into millimetres to a whole number of 1×10^{-n} mm, when the original tolerance in inches lies between 1×10^{-n} and less than 10×10^{-n} in.

4. CONVERSION OF MILLIMETRES INTO INCHES

4.1 Method A (General Rule)

(a) For each dimension in millimetres consider only its two limits, maximum and minimum;

(b) Convert the corresponding two values into inches by means of the table on page 11 (based on the conversion factor: 1 mm = 1/25.4 in)

(c) Round the results obtained in this way to the nearest rounded value as indicated in Table 2 below, depending on the original tolerance in millimetres, i.e. on the difference between the two limits in millimetres.*

The use of this method guarantees that even in the most unfavourable extreme cases neither of the two original limits will be exceeded by more than 2.5 per cent of the value of the tolerance.

4.2 Method B (by special agreement)

As Method A, except that the rounding is not effected to the nearest rounded value, but *towards the interior of the tolerance* (i.e. to the next lower value for the upper limit and to the next higher value for the lower limit).

This method should be employed only when the original limits have to be respected absolutely (in particular, when components are to be inspected by means of original gauges).

TABLE 2

Original tolerance in millimetres		Round off to a whole number of
not less than	and below	
mm	mm	in
0.0003	0.005	0.000 001
0.005	0.05	0.000 01
0.05	0.5	0.0001
0.5	5	0.001
5	50	0.01

Example

Suppose that a dimension is expressed in millimetres as follows:

$$49.5 \pm 0.4 \ (= 49.1, 49.9)$$

Conversion of the two limits into inches gives

$$1.933\,070\,9 \text{ and } 1.964\,566\,9$$

As the tolerance equals 0.8 mm, and thus lies between 0.5 and 5 mm, it is necessary, employing Method A, to round these values to the nearest 0.001 in. The values in inches to be employed for these two limits are thus

$$1.933 \text{ and } 1.965$$

(Rounding towards the interior of the tolerance, according to Method B, would give limits of 1.934 in and 1.964 in, i.e. a tolerance, reduced to 0.030 in instead of 0.032 in as given by Method A).

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* For tolerances equal to at least 0.0005 mm, this is the same as rounding each of the two values converted into inches to a whole number of $1 \times 10^{-(n+2)}$ in, when the original tolerance in millimetres lies between 5×10^{-n} and less than 50×10^{-n} mm.

5. SPECIAL METHODS OF APPLICATION

5.1 Rounding to the nearest rounded value

If the value to be rounded lies exactly half-way between the two nearest rounded values, it is preferable to take the even value.

5.2 Basic size and deviations

In order to avoid any accumulation of rounding errors, it is essential to convert the limits of size themselves, and in cases where they are indicated by a basic size and two deviations it is thus first of all necessary to calculate the limits.

However (except when Method B is specified), the manufacturer is free to make separate conversions, based on the original tolerance, of the basic size *to the nearest rounded value* and of each of the deviations towards the interior of the tolerance. This method, which gives the same guarantee of interchangeability as Method A, may sometimes simplify the conversion procedure, but results in practice in smaller converted tolerances.

5.3 Limitation imposed by accuracy of measurement

If the degree of rounding given for the smallest tolerances in Tables 1 and 2 is too fine for the available accuracy of measurement, the limits which are acceptable in regard to interchangeability should be determined separately in each case for those dimensions to which these tolerances apply.

(Example.—If the accuracy of measurement is limited to 0.001 mm, the study of the particular case shows that the values converted from 1 in ± 0.0005 in can be rounded to 25.413 mm and 25.387 mm instead of 25.4127 mm and 25.3873 mm without any disadvantage, since neither of the two original limits is exceeded by more than 1.2 per cent of the tolerance).

5.4 Positional tolerance

If the dimensioning consists solely of a positional tolerance round a point defined by a non-toleranced reference dimension, the reference dimension should be separately converted *to the nearest* rounded value and each of the two deviations of the tolerance should be separately converted *towards the interior of the latter*, all these conversions depending on the original tolerance.

5.5 Toleranced dimension associated with a non-toleranced reference dimension

If the toleranced dimension is situated in a plane the position of which is given by a non-toleranced reference dimension (dimensioning of certain conical surfaces, for example):

(a) Round the reference dimension arbitrarily, to the nearest rounded value.

(b) Calculate exactly, in the new unit of measurement, the maximum and minimum limits of the specified tolerance *zone*, in the plane defined by the new reference dimension obtained in this way.

(c) Round these limits in conformity with the present ISO Recommendation.

(Example.—Suppose that a cone of taper 0.05 has a diameter 1 in ± 0.002 in in a reference plane defined by the non-toleranced positional dimension 0.93 in. By virtue of the taper of the cone, the limits of the tolerance *zone* depend on the position of the reference plane. Consequently, if we round the dimension 0.93 in = 23.622 mm to 23.6 mm, i.e. a reduction of 0.022 mm, each of the two original limits, when converted exactly into millimetres, should be corrected by 0.022 mm × 0.05 = 0.0011 mm in the appropriate sense before being rounded).

APPENDIX

1. TABLES FOR CONVERSION FROM INCHES INTO MILLIMETRES *

1.1 Inches in fractions

in		mm	in		mm
$1/64$	0.015 625	0.396 875	$33/64$	0.515 625	13.096 875
$1/32$	0.031 250	0.793 750	$17/32$	0.531 250	13.493 750
$3/64$	0.046 875	1.190 625	$35/64$	0.546 875	13.890 625
$1/16$	0.062 500	1.587 500	$9/16$	0.562 500	14.287 500
$5/64$	0.078 125	1.984 375	$37/64$	0.578 125	14.684 375
$3/32$	0.093 750	2.381 250	$19/32$	0.593 750	15.081 250
$7/64$	0.109 375	2.778 125	$39/64$	0.609 375	15.478 125
$1/8$	0.125 000	3.175 000	$5/8$	0.625 000	15.875 000
$9/64$	0.140 625	3.571 875	$41/64$	0.640 625	16.271 875
$5/32$	0.156 250	3.968 750	$21/32$	0.656 250	16.668 750
$11/64$	0.171 875	4.365 625	$43/64$	0.671 875	17.065 625
$3/16$	0.187 500	4.762 500	$11/16$	0.687 500	17.462 500
$13/64$	0.203 125	5.159 375	$45/64$	0.703 125	17.859 375
$7/32$	0.218 750	5.556 250	$23/32$	0.718 750	18.256 250
$15/64$	0.234 375	5.953 125	$47/64$	0.734 375	18.653 125
$1/4$	0.250 000	6.350 000	$3/4$	0.750 000	19.050 000
$17/64$	0.265 625	6.746 875	$49/64$	0.765 625	19.446 875
$9/32$	0.281 250	7.143 750	$25/32$	0.781 250	19.843 750
$19/64$	0.296 875	7.540 625	$51/64$	0.796 875	20.240 625
$5/16$	0.312 500	7.937 500	$13/16$	0.812 500	20.637 500
$21/64$	0.328 125	8.334 375	$53/64$	0.828 125	21.034 375
$11/32$	0.343 750	8.731 250	$27/32$	0.843 750	21.431 250
$23/64$	0.359 375	9.128 125	$55/64$	0.859 375	21.828 125
$3/8$	0.375 000	9.525 000	$7/8$	0.875 000	22.225 000
$25/64$	0.390 625	9.921 875	$57/64$	0.890 625	22.621 875
$13/32$	0.406 250	10.318 750	$29/32$	0.906 250	23.018 750
$27/64$	0.421 875	10.715 625	$59/64$	0.921 875	23.415 625
$7/16$	0.437 500	11.112 500	$15/16$	0.937 500	23.812 500
$29/64$	0.453 125	11.509 375	$61/64$	0.953 125	24.209 375
$15/32$	0.468 750	11.906 250	$31/32$	0.968 750	24.606 250
$31/64$	0.484 375	12.303 125	$63/64$	0.984 375	25.003 125
$1/2$	0.500 000	12.700 000	1	1.000 000	25.400 000

* On the basis of the conversion factor 1 in = 25.4 mm.
(All the values in these tables are exact).