ISO 2566-1:2021(E)

ISO TC 17/SC 20

Date: 2021-12-15

Secretariat: SIS

Steel — Conversion of elongation values — Part 1: Carbon and low-alloy steels

Acier — Conversion des valeurs d'allongement — Partie 1: Aciers au carbone et aciers faiblement alliés

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Published in Switzerland

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 20, *General technical delivery conditions, sampling and mechanical testing methods,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 459/SC 1, *Test methods for steel (other than chemical analysis),* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 2566-1:1984), of which it constitutes a minor revision. The changes are as follows:

— complete editorial revision;

— Tables 2 to 5 have been renamed due to reordering in order to follow the logical flow of information of this document;

— Clause 9 has been restructured into four sub-clauses in order to follow the logical flow of information of this document.

A list of all parts in the ISO 2566 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

This corrected version of ISO 2566-1:2021 incorporates the following corrections:

— two of the values given in Tables 1 and 3 were incorrect: the value "1,960" was replaced with "0,960" in Table 1 and the value "0,754" was replaced with "0,574" in Table 3.

Introduction

Several different gauge lengths are commonly in use for the determination of percentage elongation of steels in tensile testing. Fixed gauge lengths of 50 mm, 80 mm, 100 mm and 200 mm are used; proportional gauge lengths of $k\sqrt{S_0}$ are also used for flat and round test pieces, where k may be one of a number of values, i.e. 4; 5,65; 8,16 or 11,3.

The value $5{,}65\sqrt{S_0}$ is adopted as the internationally preferred proportional gauge length.

Arising from this choice and the existence of specifications stipulating minimum percentage elongations on different gauge lengths, a growing need has been evident for an International Standard that could be used to convert test results into values based on the different gauge lengths. Accordingly, this document includes tables of conversion factors, tables of actual conversions for some of the most commonly used gauge lengths and elongation values, and figures which may also be used for such conversions. When using these conversions, however, note should be taken of the limitations on their applicability, as stated in Clause 1.

Steel — Conversion of elongation values — Part 1: Carbon and low alloy steels

1 Scope

This document specifies a method of converting room temperature percentage elongations after fracture obtained on various proportional and non-proportional gauge lengths to other gauge lengths.

Formula (1), on which conversions are based, is considered to be reliable when applied to carbon, carbon manganese, molybdenum and chromium molybdenum steels within the tensile strength range 300 N/mm² to 700 N/mm² and in the hot-rolled, hot-rolled and normalized or annealed conditions, with or without tempering.

These conversions are not applicable to:

a) cold reduced steels;

b) quenched and tempered steels;

c) austenitic steels.

These conversions are not applicable when the gauge length exceeds $25\sqrt{S_0}$ or where the width to thickness ratio of the test piece exceeds 20.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1.1
gauge length
length of the parallel portion of the test piece used for measurement of strain

Note 1 to entry: The term is hereafter used in this document to denote the original gauge length, L_0, marked on the test piece for the determination of percentage elongation after fracture, A.

3.1.2
proportional gauge length

gauge length (3.1.1) having a specified relation to the square root of the cross-sectional area, for example $5,65\sqrt{S_0}$

3.1.3
non-proportional gauge length
gauge length (3.1.1) not specifically related to the cross-sectional area of the test piece, usually expressed in a given dimension, for example 50 mm

3.2 Symbols

A	Percentage elongation after fracture on a gauge length, obtained on test
A_r	Percentage elongation on a different gauge length, required by conversion
d	Diameter of test piece
L_0	Original gauge length
S_0	Original cross-sectional area of test piece

4 Basic formula

The data contained in this document are based on the Oliver formula[1], which is now widely used for such elongation conversions. The Oliver formula can, in a simplified form, be expressed as Formula (1):

$$A_{\mathrm{r}} = 1,74A\left(\frac{\sqrt{S}_0}{L_0}\right)^{0,4} \quad (1)$$

where

A_{r} is the required elongation on gauge length L_0;

A is the elongation on gauge length of $4\sqrt{S_0}$;

L_0 is the original gauge length;

S_0 is the original cross-sectional area of test piece.

Formula (1) gives a direct conversion of elongation on $4\sqrt{S_0}$ to the equivalent for a test piece of cross-sectional area S_0, and a gauge length L_0. Expressed in terms of $5,65\sqrt{S_0}$, which is now regarded as the internationally accepted standard gauge length, it becomes Formula (2):

$$A_{\mathrm{r}} = 2A\left(\frac{\sqrt{S}_0}{L_0}\right)^{0,4} \quad (2)$$

where A is the elongation on gauge length of $5,65\sqrt{S_0}$.

Tables 1 to 21 and Figures 1 to 5 are based on Formulae (1) and (2).

Care should be exercised in the case of strip under 4 mm thickness, as the index in Formulae (1) and (2) increases with decreasing thickness; the value to be used shall be the subject of agreement between the customer and the supplier.

5 Requirements on conversions

While, as indicated, the conversions are considered to be reliable within the stated limitations, because of the various factors influencing the determination of percentage elongations, they shall be used for acceptance purposes only by agreement between the customer and supplier.

In cases of dispute, the elongation shall be determined on the gauge length stated in the relevant specification.

6 Conversion from one proportional gauge length to another proportional gauge length

Simple multiplying factors based on the formula are used for such conversions, and the relationships between several of the more widely used proportional gauge lengths are given in Table 1. Detailed conversions of elongations obtained on $4\sqrt{S_0}$ to $5{,}65\sqrt{S_0}$ are given in Table 2.

Table 1 — Conversion factors : Proportional gauge length

Conversion from:	Factor for conversion to:						
	$4\sqrt{S_0}$	$5{,}65\sqrt{S_0}$	$8{,}16\sqrt{S_0}$	$11{,}3\sqrt{S_0}$	$4d$	$5d$	$8d$
$4\sqrt{S_0}$	1,000	0,870	0,759	0,661	0,953	0,870	0,721
$5{,}65\sqrt{S_0}$	1,149	1,000	0,863	0,759	1,093	1,000	0,828
$8{,}16\sqrt{S_0}$	1,330	1,158	1,000	0,879	1,268	1,158	~~1~~0,960
$11{,}3\sqrt{S_0}$	1,514	1,317	1,137	1,000	1,443	1,317	1,091
$4d$	1,050	0,916	0,790	0,694	1,000	0,916	0,758
$5d$	1,149	1,000	0,863	0,759	1,093	1,000	0,828
$8d$	1,389	1,207	1,042	0,918	1,319	1,207	1,000

Table 2 — Elongation values[a] on $5{,}65\sqrt{S_0}$ corresponding to those obtained on $4\sqrt{S_0}$ gauge length

Actual elongation (%) measured on $4\sqrt{S_0}$	Corresponding elongation (%) on $5{,}65\sqrt{S_0}$									
	0	1	2	3	4	5	6	7	8	9
10	9	10	10	11	12	13	14	15	16	17
20	17	18	19	20	21	22	23	23	24	25
30	26	27	28	29	30	30	31	32	33	34
40	35	36	37	37	38	39	40	41	42	43
50	43	44	45	46	47	48	49	50	50	51

[a] Factor 0,87. Values rounded to nearest whole number.

7 Conversion from one non-proportional gauge length to another non-proportional gauge length for test pieces of equal cross-sectional area

The conversion of elongation values of different fixed gauge lengths on test pieces of equal cross-sectional area are also made by simple factors. Conversion factors for gauge lengths of 50 mm, 80 mm, 100 mm and 200 mm are given in Table 3.

Table 3 — Conversion factors[a]: Non-proportional gauge length

Conversion from:	Factor for conversion to:			
	50 mm	80 mm	100 mm	200 mm
50 mm	1,000	0,829	0,758	0,~~754~~574
80 mm	1,207	1,000	0,915	0,693
100 mm	1,320	1,093	1,000	0,758
200 mm	1,741	1,443	1,320	1,000

[a] Provided cross-sectional areas are the same.

8 Conversion from a non-proportional gauge length to another non-proportional gauge length for test pieces of different cross-sectional areas

It is preferable for this calculation to be made in two stages with an initial conversion to $5{,}65\sqrt{S_0}$.

EXAMPLE

Elongation of 24 % on 200 mm for a 40 mm x 15 mm test piece in terms of equivalent on a 30 mm x 10 mm test piece with gauge lengths equal to 200 mm, 100 mm and 50 mm.

24 x 1/0,863 = 27,8 % on $5{,}65\sqrt{S_0}$ (see Table 3)

27,8 x 0,752 = 20,9 % on 30 mm x 10 mm with 200 mm gauge length

27,8 x 0,992 = 27,6 % on 30 mm x 10 mm with 100 mm gauge length

27,8 x 1,309 = 36,4 % on 30 mm x 10 mm with 50 mm gauge length

Elongation on other proportional gauge lengths can be obtained by using the factors given in Table 1.

9 Conversion from a proportional gauge length to a non-proportional gauge length

9.1 General

The conversion factors are variable according to the cross-sectional area of the non-proportional test piece. Table 4 gives the multiplying factors for conversion from elongation on $5{,}65\sqrt{S_0}$ to the equivalent on fixed gauge lengths of 50 mm, 80 mm, 100 mm and 200 mm for a range of cross-sectional areas. For conversions in the reverse direction, i.e. elongation on a fixed gauge length to the equivalent of $5{,}65\sqrt{S_0}$, the reciprocal of the factors is used.

EXAMPLE

a) Elongation of 20 % on $5{,}65\sqrt{S_0}$ is equivalent to 20 x 1,139 = 22,78 % on a 25 mm wide test piece of 6 mm thickness with a 50 mm gauge length (see Table 4);

b) Elongation of 25 % on a 40 mm x 10 mm test piece of 200 mm gauge length is equivalent to 25 x 1/0,796 = 31,4 % on $5{,}65\sqrt{S_0}$ (see Table 4).

From the examples shown, it will be seen that conversions involving other proportional gauge lengths can be obtained by prior or subsequent use of the factors shown in Table 1.

9.2 Conversion factors from $5{,}65\sqrt{S_0}$ to non-proportional gauge length

Factors shown under "non-proportional gauge lengths" give the value of

$$2\left(\frac{\sqrt{S_0}}{L}\right)^{0,4}$$

To convert from values on a gauge length of $5{,}65\sqrt{S_0}$ to a non-proportional gauge length, multiply by the appropriate factor.

To convert from values on a non-proportional gauge length to $5{,}65\sqrt{S_0}$, divide by the appropriate factor.

See also Figures 1 and 2.

Table 4 — Conversion factors from $5{,}65\sqrt{S_0}$ to non-proportional gauge lengths

Cross sectional area of test piece:	Factor for non-proportional gauge length of:			
mm^2	200 mm	100 mm	80 mm	50 mm
5	0,331	0,437	0,478	0,577
10	0,381	0,502	0,549	0,663
15	0,413	0,545	0,596	0,719
20	0,437	0,577	0,631	0,761
25	0,457	0,603	0,660	0,796
30	0,474	0,626	0,684	0,826
35	0,489	0,645	0,706	0,852
40	0,502	0,663	0,725	0,875
45	0,514	0,679	0,742	0,896
50	0,525	0,693	0,758	0,915
55	0,535	0,706	0,772	0,932
60	0,545	0,719	0,786	0,949
70	0,562	0,741	0,811	0,978
80	0,577	0,761	0,833	1,005
90	0,591	0,780	0,852	1,029
100	0,603	0,796	0,871	1,051
110	0,615	0,812	0,887	1,071
120	0,626	0,826	0,903	1,090
130	0,636	0,839	0,917	1,107
140	0,645	0,852	0,931	1,124
150	0,654	0,863	0,944	1,139
160	0,663	0,875	0,956	1,154
170	0,671	0,885	0,968	1,168
180	0,679	0,896	0,979	1, 182
190	0,686	0,905	0,990	1,195

200	0,693	0,915	1,000	1,207
210	0,700	0,924	1,010	1,219
220	0,706	0,932	1,019	1,230
230	0,713	0,941	1,028	1,241
240	0,719	0,949	1,037	1,252
250	0,725	0,956	1,046	1,262
260	0,730	0,964	1,054	1,272
270	0,736	0,971	1,062	1,281
280	0,741	0,978	1,070	1,291
290	0,747	0,985	1,077	1,300
300	0,752	0,992	1,084	1,309
310	0,757	0,998	1,092	1,317
320	0,761	1,005	1,099	1,326
330	0,766	1,011	1,105	1,334
340	0,771	1,017	1,112	1,342
350	0,775	1,023	1,118	1,350
360	0,780	1,029	1,125	1,357
370	0,784	1,034	1,131	1,365
380	0,788	1,040	1,137	1,372
390	0,792	1,045	1,143	1,379
400	0,796	1,051	1,149	1,386
410	0,800	1,056	1,154	1,393
420	0,804	1,061	1,160	1,400
430	0,808	1,066	1,165	1,406
440	0,812	1,071	1,171	1,413
450	0,815	1,076	1,176	1,419
460	0,819	1,080	1,181	1,426
470	0,822	1,085	1,186	1,432
480	0,826	1,090	1,191	1,438
490	0,829	1,094	1,196	1,444
500	0,833	1,099	1,201	1,450
550	0,849	1,120	1,224	1,477
600	0,863	1,139	1,246	1,503
650	0,877	1,158	1,266	1,528
700	0,891	1,175	1,285	1,550
750	0,903	1,191	1,303	1,572
800	0,915	1,207	1,320	1,592
850	0,926	1,222	1,336	1,612
900	0,936	1,236	1,351	1,630

950	0,947	1,249	1,366	1,648
1 000	0,956	1,262	1,380	1,665
1 050	0,966	1,274	1,393	1,681
1 100	0,975	1,286	1,406	1,697
1 150	0,983	1,298	1,419	1,712
1 200	0,992	1,309	1,431	1,727
1 250	1,000	1,320	1,443	1,741
1 300	1,008	1,330	1,454	1,755
1 350	1,016	1,340	1,465	1,768
1 400	1,023	1,350	1,476	1,781
1 450	1,030	1,359	1,486	1,794
1 500	1,037	1,369	1,496	1,806
1 550	1,044	1,378	1,506	1,818
1 600	1,051	1,386	1,516	1,829
1 650	1,057	1,395	1,525	1,841
1 700	1,063	1,403	1,534	1,852
1 750	1,070	1,411	1,543	1,862
1 800	1,076	1,419	1,552	1,873
1 850	1,082	1,427	1,560	1,883
1 900	1,087	1,435	1,569	1,893
1 950	1,093	1,442	1,577	1,903
2 000	1,099	1,450	1,585	1,913
2 050	1,104	1,457	1,593	1,922
2 100	1,109	1,464	1,600	1,931
2 150	1,115	1,471	1,608	1,941
2 200	1,120	1,477	1,615	1,950
2 250	1,125	1,484	1,623	1,958
2 300	1,130	1,491	1,630	1,967
2 350	1,135	1,497	1,637	1,975
2 400	1,139	1,503	1,644	1,984
2 450	1,144	1,510	1,651	1,992
2 500	1,149	1,516	1,657	2,000
2 550	1,153	1,522	1,664	2,008
2 600	1,158	1,528	1,670	2,016
2 650	1,162	1,533	1,677	2,023
2 700	1,167	1,539	1,683	2,031
2 750	1,171	1,545	1,689	2,038
2 800	1,175	1,550	1,695	2,046
2 850	1,179	1,556	1,701	2,053

2 900	1,183	1,561	1,707	2,060
2 950	1,187	1,567	1,713	2,067
3 000	1,191	1,572	1,719	2,074

9.3 Conversion factors from $4\sqrt{S_0}$ to non-proportional gauge length

Factors shown under "non-proportional gauge length" give the value of

$$1{,}74\left(\frac{\sqrt{S_0}}{L}\right)^{0,4}$$

To convert from values on a gauge length of $4\sqrt{S_0}$ to a non-proportional gauge length, multiply by the appropriate factor.

To convert from values on a non-proportional gauge length to $4\sqrt{S_0}$, divide by the appropriate factor.

See also Figures 3 and 4.

Table 5 — Conversion factors from $4\sqrt{S_0}$ to non-proportional gauge length

Cross sectional area of test piece:	Factor for non-proportional gauge length of:			
mm²	200 mm	100 mm	80 mm	50 mm
5	0,288	0,380	0,416	0,502
10	0,331	0,437	0,478	0,577
15	0,359	0,474	0,518	0,625
20	0,380	0,502	0,549	0,662
25	0,398	0,525	0,574	0,693
30	0,413	0,544	0,595	0,718
35	0,426	0,562	0,614	0,741
40	0,437	0,577	0,631	0,761
45	0,447	0,590	0,646	0,779
50	0,457	0,603	0,659	0,796
55	0,466	0,615	0,672	0,811
60	0,474	0;625	0,684	0,825
70	0,489	0,645	0,705	0,851
80	0,502	0,662	0,724	0,874
90	0,514	0,678	0,742	0,895
100	0,525	0,693	0,757	0,914
110	0,535	0,706	0,772	0,932
120	0,544	0,718	0,786	0,948
130	0,553	0,730	0,798	0,963
140	0,562	0,741	0,810	0,978
150	0,560	0,751	0,821	0,991