UDC 621.981.01 : 669.14-4 October 1975

Cold Bending of Flat Rolled Steel Products

DIN 6935

Kaltbiegen von Flacherzeugnissen aus Stahl

Dimensions in mm

1 General

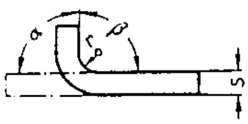
This Standard applies to bent components made from flat steel products for application in steel construction and general mechanical engineering.

For standards covering flat steel products, see page 4.

When bending flat rolled steel, such as sheets and plates, strips, wide flats etc., the rolling direction should be considered, since bending should if possible be carried out transverse to the rolling direction owing to the greater suitability to bending offered.

The bending suitability of the rolled steel shall be agreed with the manufacturer's works when ordering. To guarantee the bending suitability the rolled surface must be in satisfactory condition and the sheared edges must be straight. Furthermore, in the case of flat rolled steel, sheared edges on the outside of a bend must be deburred at the bending location in order to prevent cracks from spreading from the cut edges.

2 Bending radii



r Bending radius
α Bending angle
β Opening angle

The bending angle α may have any value between 0° and 180°. The thickness s is reduced by up to approx. 20 % in the rounded portion

To promote uniformity of radiusing on bending dies it is recommended that only bending radii from the series below should be chosen for bending purposes. The values printed in bold type are preferred.

r	1	1,2	1,6	2	2,5	3	4	5	6	8	10	12	16	20	25	28	32	36	40	45	50	63	80	100

These bending radii agree with the radiusing according to DIN 250.

Table 1 gives the minimum permissible bending radii which may be chosen for given sheet and plate thicknesses and materials for the bending machines applicable. The indicated values apply to bending angles $\alpha \leq 120°$. For bending angles $\alpha > 120°$ the next higher value in the Table should be used, e.g., if Q St 42-2 plates with a thickness s = 6 mm are to be bent transverse to the rolling direction, the minimum permissible bending radius would be $r = 10$ mm for $\alpha \leq 120°$ and $r = 12$ mm for $\alpha > 120°$.

Table 1. Minimum permissible bending radius r

Steel grades with a guaranteed minimum tensile strength N/mm²	for bending transverse and parallel to the rolling direction	Minimum permissible bending radius r for thicknesses s														
		1	above 1 to 1,5	above 1,5 to 2,5	above 2,5 to 3	above 3 to 4	above 4 to 5	above 5 to 6	above 6 to 7	above 7 to 8	above 8 to 10	above 10 to 12	above 12 to 14	above 14 to 16	above 16 to 18	above 18 to 20
up to 390	transverse	1	1,6	2,5	3	5	6	8	10	12	16	20	25	28	36	40
	parallel	1	1,6	2,5	3	6	8	10	12	16	20	25	28	32	40	45
above 390 to 490	transverse	1,2	2	3	4	5	8	10	12	16	20	25	28	32	40	45
	parallel	1,2	2	3	4	6	10	12	16	20	25	32	36	40	45	50
above 490 to 640	transverse	1,6	2,5	4	5	6	8	10	12	16	20	25	32	36	45	50
	parallel	1,6	2,5	4	5	8	10	12	16	20	25	32	36	40	50	63

Table 2 gives the permissible variations for the minimum bending radii, which must be reckoned with regarding the various sheet and plate thicknesses and materials.

Table 2. Permissible variations for minimum bending radii r

Steel grades with a guaranteed minimum tensile strength N/mm²	Permissible variations for minimum bending radii r at thicknesses s		
	up to 3	above 3 to 8	above 8 to 20
up to 390	$^{+0,5}_{0}$	$^{+1}_{0}$	$^{+1,5}_{0}$
above 390 to 490	$^{+0,8}_{0}$	$^{+1,5}_{0}$	$^{+2}_{0}$
above 490 to 640	$^{+1}_{0}$	$^{+2}_{0}$	$^{+3}_{0}$

Continued on pages 2 to 4

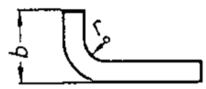
3 Material check list

Table 3 gives a guide to the grades for which suitability for cold bending, cold flanging and cold curling is guaranteed, subject to observance of the minimum permissible bending radii laid down in Table 1 (see also DIN 17100, September 1966 issue, Section 7.4.1).

Table 3. Material check list

Type of steel	Steel grade with a guaranteed minimum tensile strength		
	up to 390 N/mm²	above 390 to 490 N/mm²	above 490 to 640 N/mm²
general structural steels according to DIN 17100	Q St 34-2 Q St 37-2, Q St 37-3	Q St 42-2, Q St 42-3 Q St 46-2	Q St 52-3

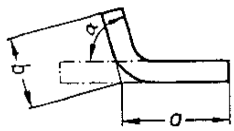
4 Smallest leg length



For bending of sheet and plate sections the leg length b is taken as being approximately 4 · r.

5 Permissible variations for angular positions on bending sections

Table 4. Permissible variations in angular positions



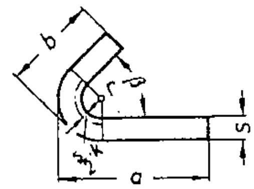
Leg length a and b (The shorter leg length counts as the nominal dimension)	up to 30	above 30 to 50	above 50 to 80	above 80 to 120	above 120
Permissible variations in bending angle α	± 2°	± 1° 45′	± 1° 30′	± 1° 15′	± 1°

The values apply when r : s = 4. For a larger (r : s) ratio a larger variation must be reckoned with owing to spring-back.

6 Calculation of flat lengths

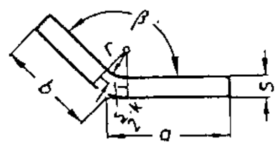
Flat length = a + b + v. Depending on the value of the bending angle, so v varies and represents a compensating value which may be either negative or positive if the opening angle β lies between 0° and 65° (calculated value 65° 24' 30"); if the opening angle is above 65° v can only be negative.

Flat lengths should be rounded up to whole millimetres.



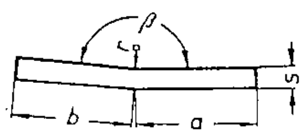
Opening angle β 0° to 90°:

Compensating value $v = \pi \cdot \left(\frac{180^\circ - \beta}{180^\circ}\right) \cdot \left(r + \frac{s}{2} \cdot k\right) - 2\,(r + s)$ (1)



Opening angle β > 90° to 165°:

Compensating value $v = \pi \cdot \left(\frac{180^\circ - \beta}{180^\circ}\right) \cdot \left(r + \frac{s}{2} \cdot k\right) - 2\,(r + s) \cdot \tan \frac{180^\circ - \beta}{2}$ (2)



Opening angle β > 165° to 180°:

Compensating value v = 0

The values for v are negligibly small in this case and accuracy is adequate for practical purposes.

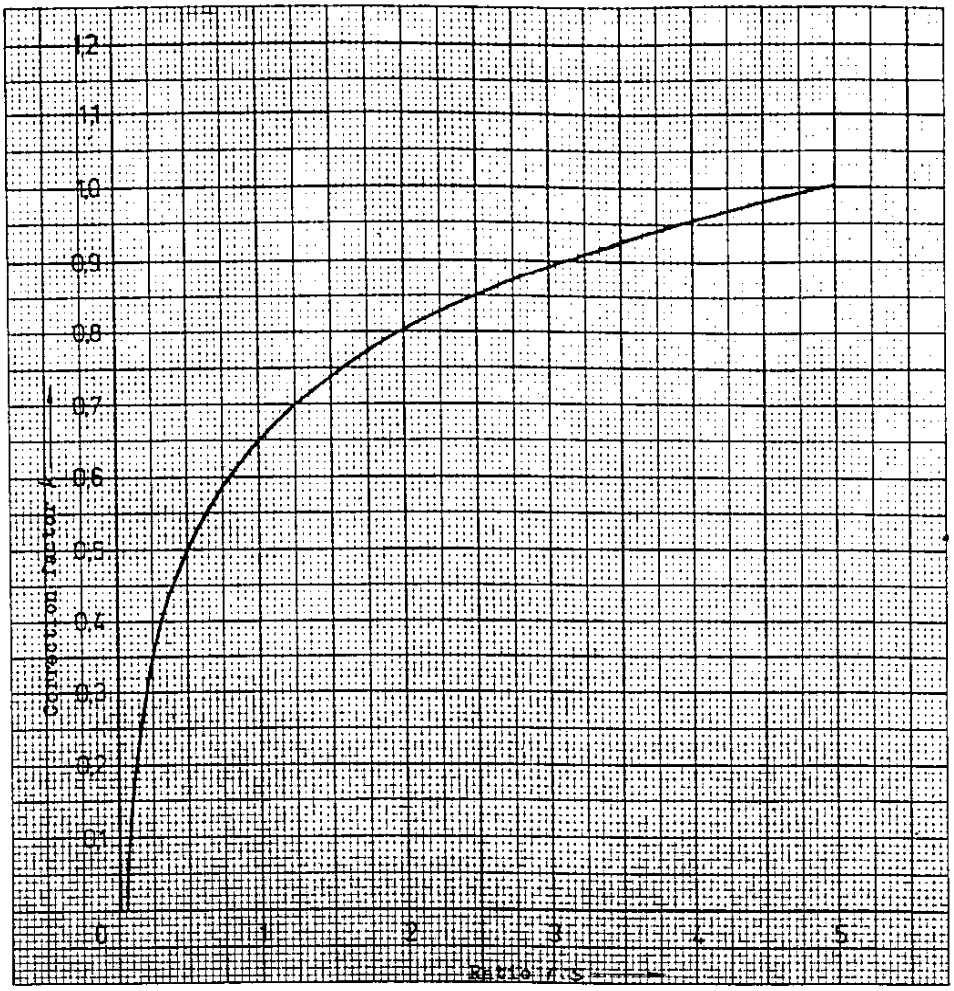
Correction factor k for determination of blanking lengths of bent workpieces

The correction factor k gives the amount by which the position of the neutral line differs from $\frac{s}{2}$ and may be calculated from

$$k = 0.65 + \frac{1}{2} \lg \frac{r}{s} \qquad (3)$$

he can also be taken from the following graphical representation, which corresponds with the equation.

For r : s > 5 equation 3 is no longer valid, so that k = 1 is to be used.



In the case that there are only small requirements for the determination of blanking lengths, the rounded values collected to groups according to Table 5 may be applied for the correction factor k.

Table 5. Correction factor k, rounded values

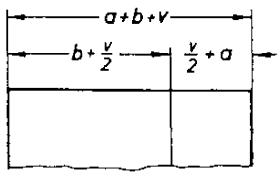
Inside bending radius r as a function of sheet or plate thickness s	Ratio r : s	above 0,65 to 1	above 1 to 1,5	above 1,5 to 2,4	above 2,4 to 3,8	above 3,8
Correction factor k (rounded value)		0,6	0,7	0,8	0,9	1

For any values of β, r and s the compensating values v can also be found, with the aid of correction factor k, by way of the factors shown graphically in DIN 6935 Supplementary Sheet 1.

For calculated compensating values v for various opening angles or bending angles on the basis of the above-mentioned formula for the correction factor k, see DIN 6935 Supplementary Sheet 2.

7 Representation and position of bend lines for developments

The bend line indicates the middle of the bending radius and should be shown in the developed view by a thin continuous line. The position of the bend line results from the adjacent leg lengths a and b with half the positive or negative compensating value v taken into account.

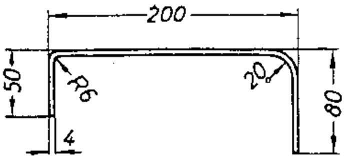


Developments should only be drawn separately if the shape of the sheet or plate blank is not clearly defined beyond all doubt by dimensioning and indication of the bend line.

8 Examples of dimensioning and calculation of flat lengths (numerical values of lengths in mm)

Example 1

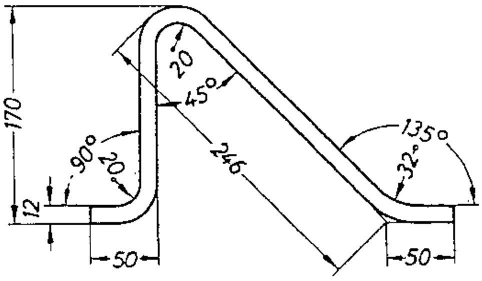
Material: Q St 37-2 (see Table 1, under "steel grades up to 390 N/mm² tensile strength").



Sum of leg lengths . . . . 50 + 200 + 80 = 330
for β = 90°, r = 6, s = 4
it is found that . . . . v = -8.26
for β = 90°, r = 20, s = 4
it is found that . . . . v = -13.44 = -21.7
flat length . . . . = 308.3
≈ 309

Example 2

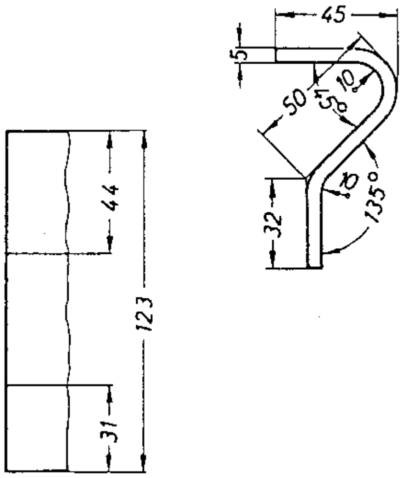
Material: Q St 37-2 (see Table 1, under "steel grades up to 390 N/mm² tensile strength").



Sum of leg lengths . . . . . 50 + 170 + 246 + 50 = 516
for β = 90°, r = 20, s = 12
it is found that . . . . v = -25.41
for β = 45°, r = 20, s = 12
it is found that . . . . v = - 6.12
for β = 135°, r = 32, s = 12
it is found that . . . . v = - 7.25 = -38.78
flat length . . . . = 477.22
≈ 478

9 Example showing development and marking of the bend line position

Material: Q St 52-3 (see Table 1, under "steel grades above 490 to 640 N/mm² tensile strength").



Development:

Sum of leg lengths . . . . 45 + 50 + 32 = 127
for β = 45°, r = 10, s = 5
it is found that . . . . v = -1.72
for β = 135°, r = 10, s = 5
it is found that . . . . v = -3.00 = -4.72
flat length . . . . = 122.28
≈ 123

Position of bend lines:

For leg length = 45, β = 45°, r = 10, s = 5 and v = -1.72

it is found that $45 - \frac{1.72}{2} = 45 - 0.86 = 44.14 \approx 44$

For leg length = 32, β = 135°, r = 10, s = 5 and v = -3

it is found that $32 - \frac{3}{2} = 32 - 1.5 = 30.5 \approx 31$

Other standards

For steel sheet under 3 mm (light sheet), see DIN 1623 Part 1 and Part 2
For general structural steels; quality specifications, see DIN 17100
For cold rolled strip of soft unalloyed steels, see DIN 1624
For cold rolled wide strip and sheet of unalloyed steels, see DIN 1541
For steel plate from 3 to 4.75 mm (medium plate), see DIN 1542
For steel plate over 4.75 mm (heavy plate), see DIN 1543
For cold rolled steel strip, see DIN 1544
For hot rolled strip, hot rolled sheet under 3 mm, see DIN 1016
For rolled flat steel, see DIN 1017 Part 1 and Part 2
For hot rolled wide flats, see DIN 59200