Hot rolled steel plates, sheets and coils

Processing of material

Flanging and forming

In this data sheet, we have compiled information on flanging and bending our hot-rolled steel products:
- flangeability
- energy required for bending
- comparison of steel grades in terms of flangeability

Ruukki is a metal expert you can rely on all the way, whenever you need metal based materials, components, systems or total solutions. We constantly develop our product range and operating models to match your needs.

- **Flangeability**
  Flangeability refers to the bending characteristics of a flat steel product. In a press brake, the plate is bent by pressing it between a plunger and a die to the required angle or bending radius.

  Regardless of the strength or hardness of the steel, a basic requirement for successful flanging or bending is that, prior to commencing work, the steel plate that has been stored in a cold atmosphere is allowed to warm up thoroughly to room temperature (+20°C). Figure 1 shows the time required for warming up. The measurements were carried out on 200 mm x 300 mm plates. Plates stacked on top of each other warm up significantly slower.

  Figure 2 shows the principles of two flanging methods: free bending and bottoming. In free bending, the plate rests on the upper edges of the die gap for the entire duration of the pass. The required bending radius is obtained by adjusting the stroke length. In bottoming, the stroke length is sufficient for the plunger to press the plate entirely against the die. An edge matching that of the plunger and die is formed in the plate.

- **Energy required for bending**
  The energy required for bending and flanging depends on factors such as those shown in Figure 3. There are several formulae for calculating the energy required, which give deviating results. Both theoretical knowledge and practical experience is required for optimal results. The condition of tools also affects the results.

  Various steel grades can be compared by means of the tensile strength: the greater the tensile strength, the more energy is required for bending. However, the formable Laser 355 MC steel requires nearly 15% less energy than the S355 grade as per EN 10025-2, for example, and the Optim 650 MC steel requires approximately 1.5 times greater energy compared with S355 even though Optim 650 MC has almost twice as much yield strength as S355.

- **Comparison of steel grades in terms of flangeability**
  A comparison of steel grades in terms of flangeability is shown in Table 1.

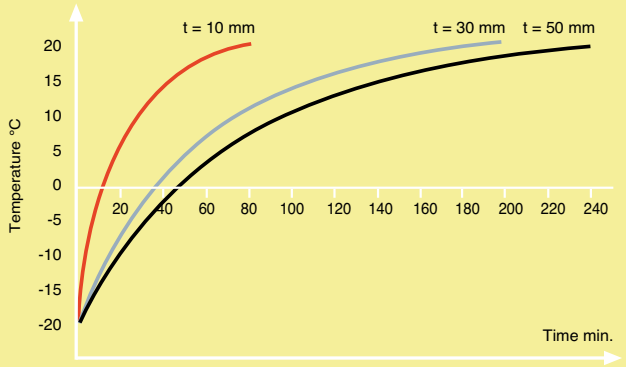
  Flanging and free bending of the Raex abrasion resistant steels
  Despite of their high strength, the Raex 400 and Raex 450 steel grades can be formed by free bending and flanging. However, the bending force, springback effect and the bending radius are greater than those for softer structural steels. When bending or flanging, attention must be paid to workshop practices and the condition of the tools, and work should be planned carefully.

  General recommendations for the bending of abrasion resistant steels:
  - Use the widest possible bending radii. The values are presented in Table 2.
  - Grind away any scratches and other surface defects on the tension side face of the plate – otherwise they may develop into cracks.
  - Grind away any rough edges on a thermally or me chanically cut plate, at least on the tension side of the plate.
  - Carry out the bending in a single pass to the ultimate curvature; springback must not occur during the work.
  - The die and plunger surfaces of the press brake must be smooth.
  - Lubrication of the bending surfaces reduces friction.
  - Preheating to 100 – 200°C reduces the required bending force and risk of cracking.
  - A die of the type shown in Figure 4 improves the quality of work.

  Warning
  Workshop processing, such as bending or flanging, of hardened Raex steels requires special care. The instructions issued by the steel supplier and high-quality workshop practices are an essential aspect of safety at work.

Time required for warming up a plate

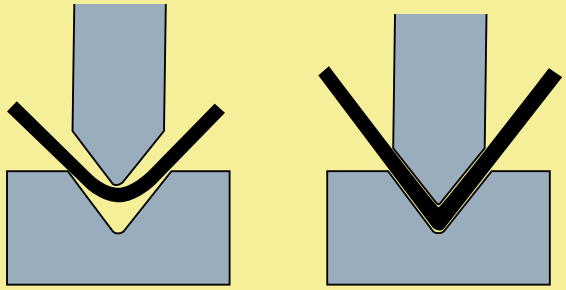
Figure 1



Workshop, concrete floor; warm-up time from -20°C to +20°C.

Free bending and bottoming

Figure 2



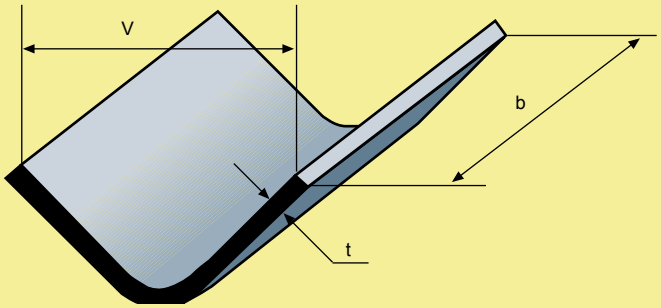
Free bending *Bottoming*

Energy required for bending

Figure 3

$$F = C \cdot \frac{R_m \cdot b \cdot t^2}{V}$$

R_m = tensile strength of the plate, MPa
t = plate thickness, mm
C = constant (1.2 – 1.5)
b = length to be bent, mm
V = width of the V groove, mm



Comparison of steel grades in terms of flangeability

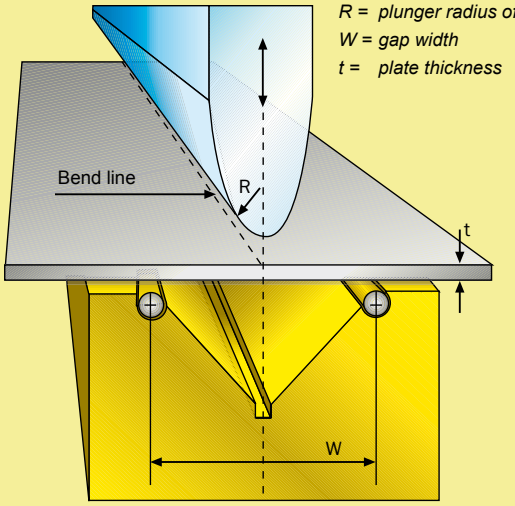
Table 1

	Bend line position vs. rolling direction	Minimum permitted internal bending radius at nominal thicknesses mm														
		>1.5 ≤2.5	>2.5 ≤3	>3 ≤4	>4 ≤5	>5 ≤6	>6 ≤7	>7 ≤8	>8 ≤10	>10 ≤12	>12 ≤14	>14 ≤16	>16 ≤18	>18 ≤20	>20 ≤25	>25 ≤30
Non-alloy steels EN 10025-2:2004 Multisteel																
S235JRC	transversal	2.5	3.0	5.0	6.0	8.0	10.0	12.0	16.0	20.0	25.0	28.0	36.0	40.0	50.0	60.0
	longitudinal	2.5	3.0	6.0	8.0	10.0	12.0	16.0	20.0	25.0	28.0	32.0	40.0	45.0	55.0	70.0
S355J2C	transversal	4.0	5.0	6.0	8.0	10.0	12.0	16.0	20.0	25.0	32.0	36.0	45.0	50.0	65.0	80.0
	longitudinal	4.0	5.0	8.0	10.0	12.0	16.0	20.0	25.0	32.0	36.0	40.0	50.0	63.0	75.0	90.0
Multisteel	in any direction	4.0	5.0	6.0	8.0	10.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	50.0	60.0
Fine grain structural steels EN 10025-3:2004. Multisteel N complies with the requirements for the grade S355N as per this standard.																
Multisteel N	in any direction	–	–	–	8.0	10.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	50.0	60.0
S355N. S355NL	transversal	–	–	–	10.0	12.0	14.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	50.0	60.0
	longitudinal				12.5	15.0	17.5	20.0	25.0	30.0	35.0	40.0	45.0	50.0	62.5	75.0
S420N. S420NL	transversal	–	–	–	20.0	24.0	28.0	32.0	40.0	48.0	56.0	64.0	72.0	80.0	100.0	120.0
	longitudinal				25.0	30.0	35.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	125.0	150.0
Laser. Strip products																
Laser 250 C	in any direction	1.5	1.5	2.0	2.5	3.0	5.0	5.5	7.0	8.5	10.0	11.5	–	–	–	–
Laser 355 MC		0.5	0.7	1.0	1.5	2.0	3.5	4.0	5.0	6.0	7.0	8.0	–	–	–	–
Laser 420 MC		1.2	1.5	2.0	2.5	3.0	5.5	6.5	8.0	9.5	11.0	–	–	–	–	–
Laser. Plate products																
Laser 250 C	in any direction	–	–	–	–	6.0	7.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	25.0	30.0
Laser 355 MC		–	–	–	–	5.0	5.5	6.5	8.0	9.5	11.5	13.0	14.5	16.0	–	–
Laser 420 MC		–	–	–	–	–	–	8.0	10.0	12.0	14.0	16.0	18.0	20.0	–	–
Optim. Strip products																
Optim 500 MC	in any direction	2.0	2.5	3.0	4.0	4.5	7.0	8.0	10.0	12.0	–	–	–	–	–	–
Optim 650 MC		2.5	3.0	4.0	6.0	8.0	10.0	12.0	14.0	–	–	–	–	–	–	–
Optim 700 MC		–	3.5	5.0	6.0	8.0	12.0	14.0	–	–	–	–	–	–	–	–
Optim 900 QC		–	9.0	12.0	15.0	18.0	–	–	–	–	–	–	–	–	–	–
Optim 960 QC		–	10.5	14.0	17.5	21.0	–	–	–	–	–	–	–	–	–	–
Optim. Plate products																
Optim 500 ML	in any direction	–	–	–	–	–	–	9.5	12.0	14.5	17.0	19.0	21.5	24.0	50.0	60.0

The flangeability of the steel grades marked with the symbol C and of the Multisteel, Laser and Optim grades is guaranteed as shown in the table. For the steel grades as per EN 10025-2:2004 without the symbol C, the value given for the next higher thickness class should be used as the minimum bending radius.

Flanging and free bending

Figure 4



R = plunger radius of curvature
W = gap width
t = plate thickness

- *The surface hardness of the upper edges of the die groove must be greater than the hardness of the plate to be bent. In the structure shown in the figure, the upper edges of the die groove are seen with separate, 20-mm-thick steel rods with a hardness of approximately 53 HRC.*
- *The steel rod grooves must be kept clean.*
- *Widening the die groove decreases the required bending force, but it also increases the springback.*
- *Springback:*
  Raex 400: 9° – 13°
  Raex 500: 10° – 15°

Free bending

Table 2

	Thickness mm	Free bending < 90° Plunger radius / plate thickness R/t Bend line position vs. rolling direction		Gap width / plate thickness W/t		Bending to 90° V groove W/t
		Transversal	Longitudinal	Transversal	Longitudinal	
Raex 400	2.5 – 6	3.0	3.0	9	9	≈ 15
Raex 400	(6) – 20	3.0	4.0	9	11	≈ 15
Raex 450	3 – 20	4.0	5.0	11	13	≈ 15
Raex 500	5 – 20	≈ 10.0	≈ 12.0	23	27	–

Recommended limit values for bending.
If you wish to bend plates more than 20 mm thick we recommend consulting our Customer Service.

Our Customer Service is happy to give you further information

Sales, technical support info.metals@ruukki.com

Rautaruukki Corporation, P.O. Box 138, FI-00811 Helsinki, Finland. tel. +358 20 5911 www.ruukki.com