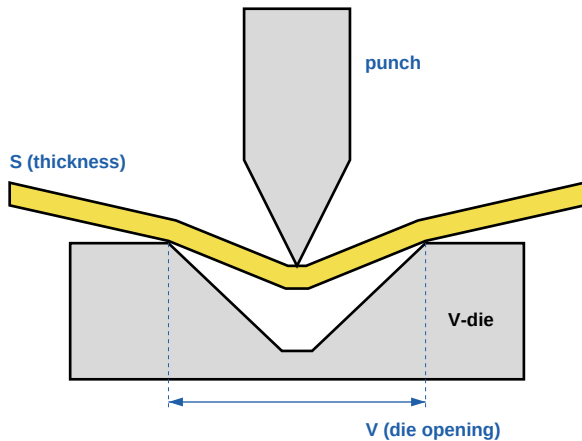


# Sheet Bending Chart



Air bending: the punch pushes the sheet into the V without bottoming. The inside radius comes from the die, not the punch - about  $0.16 \times V$  - and the angle from how far the punch goes down.

Choosing the V: 6 x S for sheet under 3 mm, 8 x S from 3 to 10 mm, 10 - 12 x S over 10 mm. A narrower V needs more force and marks the sheet; a wider V needs less force but gives a bigger radius and needs a longer flange.

Shortest flange: about  $0.7 \times V$ , or the sheet slips into the die.

Force:  $P$  (tonnes per metre) =  $1.42 \times R_m \times S \times S / (V \times 9.81)$ ,  $R_m$  in N/mm<sup>2</sup>. Multiply by the bend length in metres. Keep under the machine's rating, and under the die's tonnes-per-metre rating on short bends.

Bend across the rolling direction where you can - tight bends along the grain can crack.

inside radius  $R_i$  = about  $0.16 \times V$

## Force in tonnes per metre of bend - mild steel (Rm 450 N/mm<sup>2</sup>); blank = V outside 6 - 12 x S

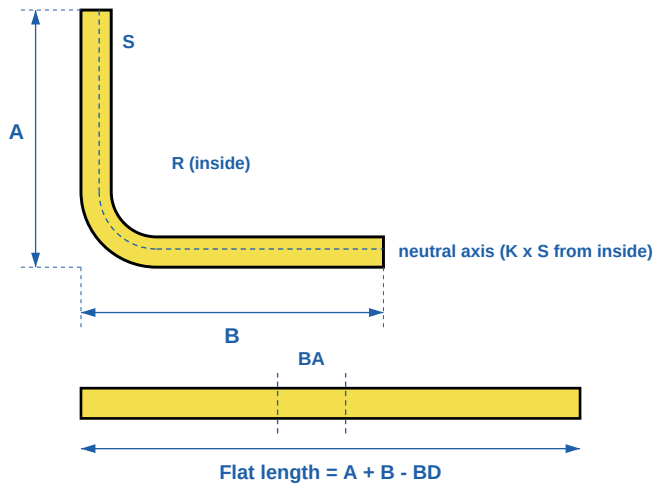
| S mm \ V mm | 4   | 6   | 8   | 10  | 12  | 16  | 20 | 25 | 32 | 40 | 50 | 63  | 80  | 100 | 125 |
|-------------|-----|-----|-----|-----|-----|-----|----|----|----|----|----|-----|-----|-----|-----|
| 0.5         | 4.1 | 2.7 |     |     |     |     |    |    |    |    |    |     |     |     |     |
| 0.8         |     | 6.9 | 5.2 | 4.2 |     |     |    |    |    |    |    |     |     |     |     |
| 1           |     | 11  | 8.1 | 6.5 | 5.4 |     |    |    |    |    |    |     |     |     |     |
| 1.2         |     |     | 12  | 9.4 | 7.8 |     |    |    |    |    |    |     |     |     |     |
| 1.5         |     |     |     | 15  | 12  | 9.2 |    |    |    |    |    |     |     |     |     |
| 2           |     |     |     |     | 22  | 16  | 13 | 10 |    |    |    |     |     |     |     |
| 2.5         |     |     |     |     |     | 25  | 20 | 16 |    |    |    |     |     |     |     |
| 3           |     |     |     |     |     |     | 29 | 23 | 18 |    |    |     |     |     |     |
| 4           |     |     |     |     |     |     |    | 42 | 33 | 26 | 21 |     |     |     |     |
| 5           |     |     |     |     |     |     |    |    | 51 | 41 | 33 |     |     |     |     |
| 6           |     |     |     |     |     |     |    |    |    | 59 | 47 | 37  |     |     |     |
| 8           |     |     |     |     |     |     |    |    |    |    | 83 | 66  | 52  | 42  |     |
| 10          |     |     |     |     |     |     |    |    |    |    |    | 103 | 81  | 65  | 52  |
| 12          |     |     |     |     |     |     |    |    |    |    |    |     | 117 | 94  | 75  |
| 15          |     |     |     |     |     |     |    |    |    |    |    |     |     | 147 | 117 |

## V-die opening and other materials

| V opening mm | Inside radius $R_i$ | Min flange b | Best for S mm |
|--------------|---------------------|--------------|---------------|
| 4            | 0.6                 | 2.8          | 0.4 - 0.7     |
| 6            | 1.0                 | 4.2          | 0.6 - 1       |
| 8            | 1.3                 | 5.6          | 0.8 - 1.3     |
| 10           | 1.6                 | 7.0          | 1 - 1.7       |
| 12           | 1.9                 | 8.4          | 1.2 - 2       |
| 16           | 2.6                 | 11.2         | 1.6 - 2.7     |
| 20           | 3.2                 | 14.0         | 2 - 3.3       |
| 25           | 4.0                 | 17.5         | 2.5 - 4.2     |
| 32           | 5.1                 | 22.4         | 3.2 - 5.3     |
| 40           | 6.4                 | 28.0         | 4 - 6.7       |
| 50           | 8.0                 | 35.0         | 5 - 8.3       |
| 63           | 10.1                | 44.1         | 6.3 - 10.5    |
| 80           | 12.8                | 56.0         | 8 - 13.3      |
| 100          | 16.0                | 70.0         | 10 - 16.7     |
| 125          | 20.0                | 87.5         | 12.5 - 20.8   |

| Material                     | Rm N/mm <sup>2</sup> | Tonnage x | Min inside radius                       | Springback        |
|------------------------------|----------------------|-----------|-----------------------------------------|-------------------|
| Mild steel S275, DC01 / CR4  | 400 - 450            | 1.0       | 1 x S (0.5 x S cold rolled)             | 1 - 2°            |
| Galvanised, Zintec           | 350 - 450            | 1.0       | 1 x S                                   | 1 - 2°            |
| Structural S355              | 490 - 630            | 1.3       | 1.5 - 2 x S                             | 2 - 3°            |
| Stainless 304 / 316          | 600 - 700            | 1.5       | 1 - 2 x S                               | 3 - 5°            |
| Aluminium 1050 / 1100 (soft) | 70 - 110             | 0.2       | 0 - 0.5 x S                             | about 1°          |
| Aluminium 3003, 5052-H32     | 150 - 230            | 0.5       | 1 x S                                   | 1 - 3°            |
| Aluminium 6061-T6, 6082-T6   | 290 - 310            | 0.7       | 3 - 4 x S - cracks if tighter           | 3 - 6°            |
| Brass (half hard)            | 350 - 450            | 0.9       | 1 x S                                   | 2 - 3°            |
| Copper (soft)                | 220 - 250            | 0.5       | 0 - 0.5 x S                             | about 1°          |
| Wear plate (Hardox 400 type) | 1250                 | 2.8       | 3 - 4 x S, across the rolling direction | 10° +, test first |

# Sheet Bending Chart



BA - bend allowance: the length of the neutral axis round the bend.

$BA = 3.1416 / 180 \times \text{angle} \times (R + K \times S)$

OSSB - outside setback:  $OSSB = \tan(\text{angle} / 2) \times (R + S)$

BD - bend deduction:  $BD = 2 \times OSSB - BA$

Flat length = sum of the outside dimensions - BD for each bend.

Or: flat length = sum of the straight inside lengths + BA for each bend.

K-factor: where the neutral axis sits, as a fraction of S from the inside - 0.33 for tight bends up to 0.5 for large radii (table below, DIN 6935).

Example: 2 mm mild steel, R 2, 90°, outside A 50 x B 30. K = 0.33:

$BA = 1.571 \times (2 + 0.66) = 4.18$ ;  $OSSB = 4$ ;  $BD = 8 - 4.18 = 3.82$ ; flat =  $80 - 3.82 = 76.2$  mm.

Always bend a test piece - the real inside radius depends on the V and the material.

## Bend deduction BD (mm) for 90° bends - blank = radius outside 0.5 - 4 x S

| S mm \ R mm | 0.5  | 1    | 1.5  | 2    | 3     | 4     | 5     | 6     | 8     | 10    | 12    | 16    |
|-------------|------|------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|
| 0.8         | 1.47 | 1.59 | 1.75 | 1.92 | 2.30  |       |       |       |       |       |       |       |
| 1           | 1.82 | 1.92 | 2.06 | 2.23 | 2.59  | 2.97  |       |       |       |       |       |       |
| 1.2         |      | 2.25 | 2.39 | 2.54 | 2.89  | 3.26  |       |       |       |       |       |       |
| 1.5         |      | 2.77 | 2.88 | 3.02 | 3.34  | 3.70  | 4.07  | 4.45  |       |       |       |       |
| 2           |      | 3.64 | 3.72 | 3.84 | 4.13  | 4.46  | 4.81  | 5.18  | 5.94  |       |       |       |
| 2.5         |      |      | 4.59 | 4.68 | 4.93  | 5.24  | 5.57  | 5.93  | 6.66  | 7.42  |       |       |
| 3           |      |      | 5.47 | 5.53 | 5.76  | 6.04  | 6.35  | 6.69  | 7.40  | 8.14  | 8.91  |       |
| 4           |      |      |      | 7.29 | 7.44  | 7.67  | 7.95  | 8.26  | 8.92  | 9.62  | 10.36 | 11.88 |
| 5           |      |      |      |      | 9.17  | 9.35  | 9.59  | 9.87  | 10.48 | 11.15 | 11.85 | 13.32 |
| 6           |      |      |      |      | 10.93 | 11.07 | 11.27 | 11.51 | 12.08 | 12.71 | 13.38 | 14.80 |
| 8           |      |      |      |      |       | 14.58 | 14.70 | 14.88 | 15.35 | 15.90 | 16.51 | 17.84 |
| 10          |      |      |      |      |       |       | 18.22 | 18.34 | 18.71 | 19.19 | 19.73 | 20.96 |

## K-factor (DIN 6935) and sheet gauges

| R / S | K-factor |
|-------|----------|
| 0.5   | 0.25     |
| 0.75  | 0.29     |
| 1     | 0.33     |
| 1.5   | 0.37     |
| 2     | 0.40     |
| 3     | 0.44     |
| 4     | 0.48     |
| 5     | 0.50     |

| Gauge | SWG mm (British) | SWG inch | US steel gauge mm |
|-------|------------------|----------|-------------------|
| 8     | 4.06             | 0.160    | -                 |
| 10    | 3.25             | 0.128    | 3.42              |
| 11    | 2.95             | 0.116    | 3.04              |
| 12    | 2.64             | 0.104    | 2.66              |
| 13    | 2.34             | 0.092    | -                 |
| 14    | 2.03             | 0.080    | 1.90              |
| 16    | 1.63             | 0.064    | 1.52              |
| 18    | 1.22             | 0.048    | 1.21              |
| 20    | 0.91             | 0.036    | 0.91              |
| 22    | 0.71             | 0.028    | 0.76              |
| 24    | 0.56             | 0.022    | 0.61              |
| 26    | 0.46             | 0.018    | 0.45              |
| 28    | 0.38             | 0.015    | 0.38              |
| 30    | 0.31             | 0.012    | -                 |

# Sheet Bending Chart

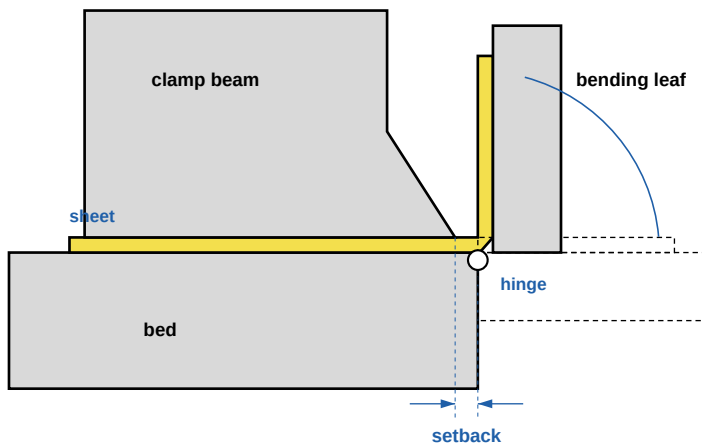
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A manual folder clamps the sheet between the bed and the clamp beam, then the bending leaf swings up about a hinge on the bending edge and folds the sheet round the beam nose.

Capacity is quoted in mild steel over the full length. Stronger material needs a thinner rating, and short work can go a little thicker - but never beyond what the clamp can hold.

Setback: set the clamp beam nose back from the edge by about one sheet thickness. Closer pinches and cracks the sheet; further back gives a bigger radius.

Box and pan folders have a clamp made of removable fingers so the sides of a box can fold up between them.

Flat lengths: use the bend allowance and bend deduction on page 2 - a manual folder gives an inside radius of about  $1 \times S$ , K-factor about 0.4.

## What your folder will take - by its mild steel rating (mm)

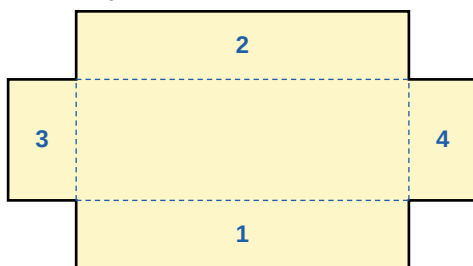
| Machine rated (mild steel mm) | Stainless 304 | Galvanised | Aluminium 1050 soft | Aluminium 5052-H32 | Copper soft | Brass half hard |
|-------------------------------|---------------|------------|---------------------|--------------------|-------------|-----------------|
| 0.6                           | 0.4           | 0.5        | 1.2                 | 0.8                | 0.8         | 0.6             |
| 0.8                           | 0.5           | 0.7        | 1.6                 | 1.1                | 1.0         | 0.8             |
| 1                             | 0.7           | 0.9        | 2.0                 | 1.4                | 1.3         | 1.0             |
| 1.2                           | 0.8           | 1.1        | 2.4                 | 1.7                | 1.6         | 1.2             |
| 1.5                           | 1.0           | 1.4        | 3.0                 | 2.1                | 2.0         | 1.5             |
| 2                             | 1.3           | 1.8        | 4.0                 | 2.8                | 2.6         | 2.0             |
| 2.5                           | 1.6           | 2.2        | 5.0                 | 3.5                | 3.2         | 2.5             |
| 3                             | 2.0           | 2.7        | 6.0                 | 4.2                | 3.9         | 3.0             |

## Setting the clamp beam, and short work

| Setting     | Clamp beam nose set back from the bending edge | Result                                                        |
|-------------|------------------------------------------------|---------------------------------------------------------------|
| Sharp bend  | $1 \times S$                                   | Inside radius about $S$ - normal setting                      |
| Radius bend | $1.5 - 3 \times S$ , or a radius nose bar      | Larger radius - use on aluminium 6xxx, stainless, thick sheet |
| Too close   | Under $1 \times S$                             | Leaf pinches the sheet - marks, cracks, strains the hinges    |
| Leaf offset | Lower the bending leaf by $1 \times S$         | Keeps the leaf face under the sheet so it bends, not wipes    |

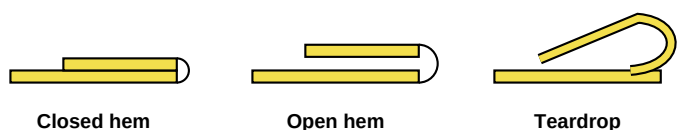
| Work length (% of machine) | Thickness x rating      |
|----------------------------|-------------------------|
| 100%                       | 1.0                     |
| 75%                        | 1.15                    |
| 50%                        | 1.4                     |
| 25%                        | 2.0 - clamp limit first |

### Box or tray blank



Notch the corners (the side height). Fold 1 and 2 on a straight clamp, then 3 and 4 with fingers set to the inside width less 1 - 2 mm.

### Hems



## Hems and folding problems

| Hem                | Flange length                       | Notes                                                                                                                     |
|--------------------|-------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| Closed (flattened) | $4 \times S$ , at least 6 mm        | Fold to about $135^\circ$ , then flatten under the clamp beam. Soft steel and aluminium only - cracks stainless over 1 mm |
| Open               | $4 \times S$ , at least 6 mm        | Leave a gap of at least $1 \times S$ - takes a wire or another sheet                                                      |
| Teardrop           | $4 - 6 \times S$                    | Rounded fold, inside diameter at least $1 \times S$ - for harder material                                                 |
| Safe edge on a box | $2 \times \text{hem} + \text{fold}$ | Hem the edges before folding the sides up                                                                                 |

| Problem                                  | Likely cause                                            | Fix                                                                                    |
|------------------------------------------|---------------------------------------------------------|----------------------------------------------------------------------------------------|
| Angle opens in the middle of a long bend | Beam and leaf deflect - work near the capacity          | Use lighter material, centre the work, adjust the leaf crowning if fitted              |
| Bend line wanders, sheet creeps          | Clamp not tight or setback uneven end to end            | Re-set the nose parallel to the bed; clamp harder                                      |
| Cracks on the outside of the bend        | Setback too small, hard temper, bending along the grain | More setback or a radius bar; bend across the rolling direction                        |
| Angle short after release                | Springback                                              | Overbend: mild steel $1 - 2^\circ$ , aluminium $2 - 3^\circ$ , stainless $3 - 5^\circ$ |
| Last side of a box will not fold         | Fingers too wide, or folding order wrong                | Fingers = inside width less 1 - 2 mm; fold the long sides first                        |
| Scratched or marked finish               | Grit on the beam, sharp nose                            | Clean the beams; protective film or tape on the sheet                                  |