COMPLETE TECHNICAL GUIDE / ENGLISH

CNC bending

Clear bend radii, hole positions and flat patterns



Illustrative process image.

Information for design and quotation
Technical explanations, tables, diagrams and practical examples. Preliminary recommendations are checked for the project material, tooling and geometry. Tolerances and the final manufacturing route are confirmed in the quote.

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How to use this guide
Consult the geometry chapters before finalising the drawing. Check tables and examples, then use the quotation checklist. Example numbers illustrate calculations; they do not implicitly represent guaranteed capacities or tolerances.

The model and drawing

Recommended package

Send the STEP model of the finished part and a dimensioned PDF. Include material, thickness, internal radius, angles and quantity. A DXF flat pattern is useful, but must be checked against production tooling.

Unambiguous dimensions

State whether lengths are internal or external. For angles, show the final angle between faces. Identify the visible face and any surfaces where tooling marks are unacceptable.

Capacity

Permissible length, thickness and geometry depend on material, required force and tooling. Laser cutting limits are not bending limits. Capacity is confirmed for each part.

Radii and unfolding

Internal radius

A radius of the order of sheet thickness can be a starting point for some ductile sheets, but does not apply universally. Alloy, delivery condition and rolling direction can require larger radii.

Do not set a universal K-factor

The flat pattern depends on achieved radius, die, punch and process. A K-factor taken from CAD must be verified; parts with critical dimensions may need trials and corrections.

Standardise radii

Where function permits, use the same radius and common angles. Reduce tooling changes and avoid very short or closely spaced bends without checking access.

Holes, reliefs and access

Holes near a bend

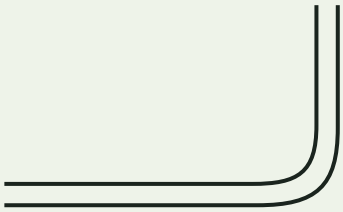
As a conservative preliminary check, keep the hole-edge-to-bend-tangent distance at least 2t. Radius and tooling may require more. Functional holes in the deformation zone may need machining after bending.

Reliefs at bend ends

Provide reliefs extending beyond the deformation zone and avoid corners that can initiate cracks. Agree shape and dimensions with the workshop according to material and tooling.

Tooling access

U-shaped parts, enclosed boxes and return flanges may collide with the punch or machine. Check bend sequence; a part may require special tooling or division into subassemblies.



R: internal radius

t: sheet thickness

Angle: defined in final condition

Illustrative diagram; not to scale. This is not a manufacturing drawing.

Air bending and tooling selection

Punch, die and part

In air bending, the sheet is supported by the die and pressed by the punch. The achieved radius and final angle depend on die opening, material, thickness and stroke. A radius modelled in CAD is not automatically achieved simply by selecting a punch with the same radius.

Why each geometry is checked

Required force increases with material strength, thickness and bend length. A short, thick part cannot be compared directly with a long, thin one. Usable machine length does not guarantee every bend along that length. Tooling and access form part of technical confirmation.

Marks and protection

Tooling contact can leave marks, especially on cosmetic surfaces. Identify the visible face and film or protection requirements. Do not specify an unknown film without checking it; it can affect both process and appearance.



R: internal radius

t: sheet thickness

Angle: defined in final condition

Illustrative diagram; not to scale. This is not a manufacturing drawing.

Radius, rolling direction and springback

Material behaviour varies

Alloy, delivery condition, thickness and rolling direction affect bendability. Forming steel, stainless steel and aluminium do not automatically share the same minimum radius. On a low-ductility material, too small a radius can cause cracks even when the CAD geometry is valid.

Springback

After the force is removed, the part can recover partially through elastic springback and the angle changes. The workshop compensates the process for the required final angle. Do not send an “overbent” model to compensate springback without declaring the change, since programming may apply further compensation.

Final drawing and trial

Define the accepted final geometry in the model and drawing. For sensitive materials or geometries, a trial using the actual batch helps determine settings. Acceptance criteria should include angle, final dimensions and appearance, rather than only matching the flat pattern.

Factor	Possible effect
Alloy and condition	Permissible radius and ductility
Rolling direction	Different sensitivity to cracking
Thickness / batch	Radius and angle variation
Springback	Requires process compensation

Flat-pattern calculation: BA, BD and K-factor

Neutral axis

During bending, the outside stretches and the inside compresses. The K-factor expresses the approximate neutral-axis position within the thickness. In a simplified model, neutral arc length is BA = α × (R + Kt), where α is the bend angle in radians, R the internal radius and t the thickness.

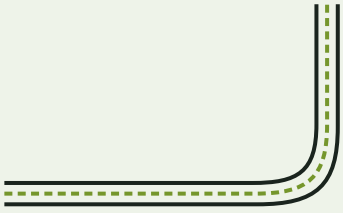
The formula has conditions

BA is bend allowance, the bend-zone length in the flat pattern. Do not add it directly to two external dimensions if those already include the corner zone. For external dimensions, bend deduction is calculated using the dimensioning convention and corresponding geometric setbacks. CAD and workshop must use the same convention.

Do not use a universal K

A software K value is an assumption until correlated with tooling and material. Production uses validated data. If the workshop recalculates the flat pattern, the finished model and dimensions remain the reference; change the DXF only after clarifying the revision.

EXAMPLE / APPLICATION
Mathematical example: t = 2 mm, R = 2 mm, K = 0.40 and a 90° bend give BA ≈ 1.5708 × 2.8 = 4.40 mm. K = 0.40 is selected for this example, not a LaserMet constant.



Neutral axis - diagram

BA = α × (R + Kt)

α in radians

Illustrative diagram; not to scale. This is not a manufacturing drawing.

Minimum flange, returns and access

Flange length

A flange must be supported on the die and positioned. Minimum length depends on tooling opening and shape, rather than thickness alone. A very short flange may fall into the die or need a different manufacturing route. Send its dimension and function before freezing the drawing.

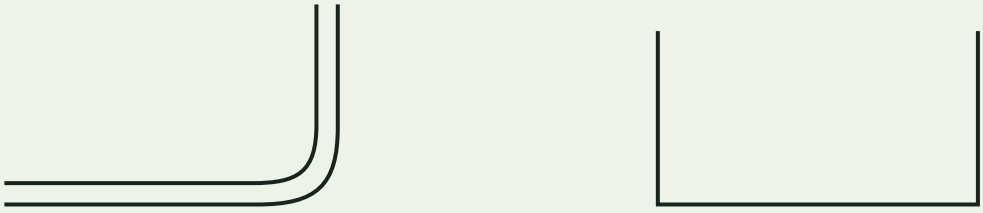
Boxes and U-sections

Check clearance for the punch and part body at every stage. A bend that is feasible individually may become impossible after an earlier flange is formed. Radius, box depth, returns and thickness determine the need for special tooling.

Backgauge access

The part needs a stable locating datum. Cut-outs, angled flanges and asymmetric parts may limit backgauge contact. Designing a reference area or changing bend order can improve repeatability.

Geometry	Required check
Short flange	Support on die
Deep U-section	Punch collision
Return flange	Access and sequence
Asymmetric part	Backgauge datums



U-section: check tool access

Illustrative diagram; not to scale. This is not a manufacturing drawing.

Holes near bends: the correct distance

Measure from the bend tangent

The recommended hole-edge-to-bend-tangent distance is not the distance to an arbitrarily drawn axis in the flat pattern. State the reference explicitly. For a circular hole, centre-to-tangent distance equals clear distance plus d/2.

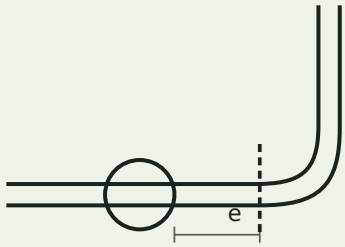
A preliminary criterion, not an absolute rule

The 2t criterion used for preliminary screening must be checked against radius and tooling. A hole can become oval or pull the edge if the deformation zone intersects it. The permissible limit cannot be determined solely from an image of the part.

Design solutions

Move the hole, change radius or flange, add a verified relief or make the hole after bending. Choose according to function: a clearance bolt hole has different requirements from a locating bore. Nearby inserts also require an access check.

EXAMPLE / APPLICATION
At t = 2 mm, d = 6 mm and e = 4 mm from the hole edge to the tangent, the axis is 7 mm from the tangent. This geometry passes only the preliminary 2t screen; it does not confirm tooling or tolerance.



e: hole edge - tangent

c = e + d/2

Illustrative diagram; not to scale. This is not a manufacturing drawing.

Bend reliefs and enclosure corners

Why they are needed

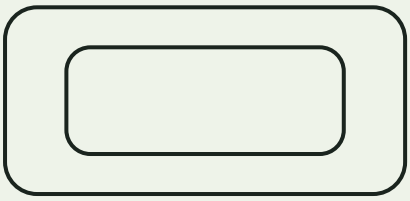
When one sheet area bends while its neighbour remains flat, material at the boundary can stretch, tear or bulge. A relief separates the forming zone. Design its shape and length relative to radius and thickness, avoiding a very fragile edge.

Two flanges at the same corner

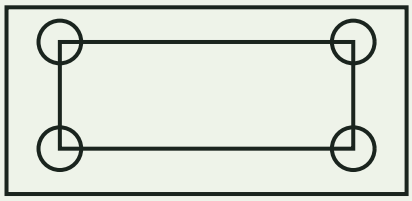
On an enclosure, neighbouring flanges may overlap or leave gaps. Include thickness, radius and assembly clearance in the finished model. Do not construct a box from zero-thickness faces or assume every corner closes without cuts or welding.

Corner function

For a sealed box, incorporate the relief into the closure and welding solution. For a cosmetic enclosure, assess the visible gap and grinding. For a mechanical support, check remaining material; a relief must not weaken a loaded zone without control.



Internal radius



Corner relief: schematic example

Illustrative diagram; not to scale. This is not a manufacturing drawing.

Tolerances after bending and assembly

Individual dimensions and accumulated deviations

Length and angle deviations can accumulate in a part with several bends. A dimension between two holes on the same flat face differs from the distance between holes on separate flanges. Identify the surfaces and datums determining assembly.

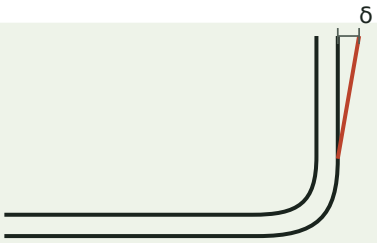
Effect of angular deviation

Angular deviation moves a flange end. Approximate transverse displacement for a flange of length L and a small deviation δ is L × sin δ. A long flange is more sensitive than a short one at the same angle.

Inspection dimensions

Dimension clearly after bending and before/after finishing. If function is assembly fit, an agreed trial or gauge can be more relevant than excessive dimensioning of every face. Avoid contradictory dimensions and define requirement priorities in the drawing.

EXAMPLE / APPLICATION
Geometric example: at L = 100 mm and δ = 1°, displacement is approximately 1.75 mm. This is not a LaserMet tolerance; it shows why angle can affect end position.



Displacement ≈ L × sin δ

Geometric effect, not a tolerance

Illustrative diagram; not to scale. This is not a manufacturing drawing.

Complete example: bracket and enclosure

L-bracket

Provide the final model, material, thickness, internal radius, final angle and flange dimensions. Identify mounting holes and their distance from the tangent. If lengths are external, state this convention; do not also supply a flat pattern based on another radius without explaining it.

Enclosure with several bends

Include covers and interfaces in the assembly. Check screw access, clearances, inserts and corners needing welding. For visible faces, specify orientation, surface direction and areas without marks. Use the same revision for model, drawing and flat pattern.

Prototype and production

The prototype checks actual assembly and tooling access. After acceptance, fix revision, material, finish and inspection criteria. A flat-pattern correction must not be applied only to a DXF while leaving the final drawing outdated.

Package	Contents
Geometry	Final STEP + dimensioned PDF
Process	Bends, inserts, welds, finish
Inspection	Final dimensions and critical angles
Production	Accepted revision and quantity

Checklist and cost

Checklist

Final STEP; dimensioned PDF; material; thickness; radii; angles; internal/external dimensions; visible face; functional tolerances; quantities and revision.

Practical example

On 2 mm sheet, a hole edge 1 mm from the bend tangent requires revision. A 4 mm distance passes only the preliminary 2t check; the workshop still checks tooling and radius.

Reducing cost

Standardise radii and orientations, restrict tight dimensions to actual functions and verify the flat pattern before production release. Dimensions after bending have different conditions from those of a flat profile.