

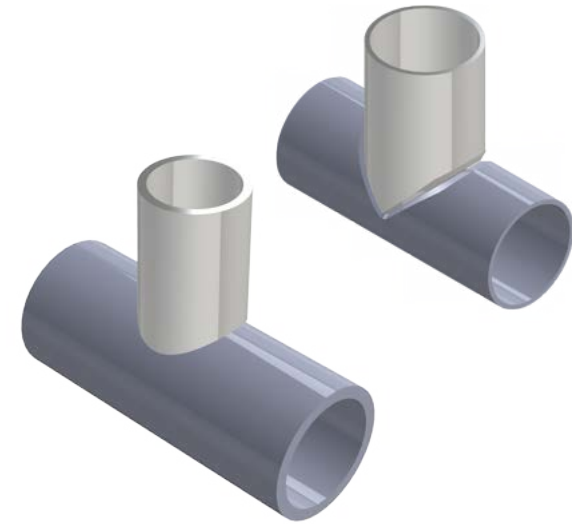
Welcome to the world of Profiling Shapes

Profiling shapes are created by software based tools to calculate cutting paths to profile a saddle connection for example. By entering parameters the predefined profiling shape will create a virtual cutting path which can be cut by HGG's cutting equipment. This document will explain which features the profiling shapes have and something about their application.

All profiling shapes have their own specific features depending on intersection, loads, weld requirements, cutting machine and application specific characteristics. HGG's profiling shapes are based on AWS, API and ASME standards.

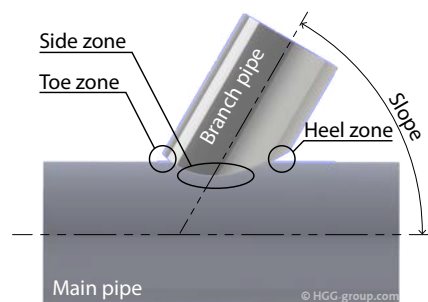
Please contact HGG for more information about shapes and our in-house custom shape development for many different applications.

info@hgg-group.com



HGG's Profiling shape terminology

This introduction page defines the terminology which will be used in this document to explain the basics of 3D profiling and to highlight features of the various profiling shapes.



Parts and location of zones

Parts

Branch pipe

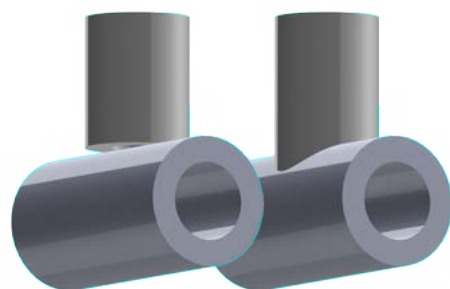
Sprouted member, mostly with an 'end' profiling shape.

Main pipe

Stem member, mostly with an 'intermediate' profiling shape. Also called 'run pipe'.

Zones

The joint of a saddle connection for example is split up into zones in order to comply with multiple welding requirements. The names of these zones are inspired by foot analogy which is shown in the figure above.



Example without and with calculated shape

Intersection geometry

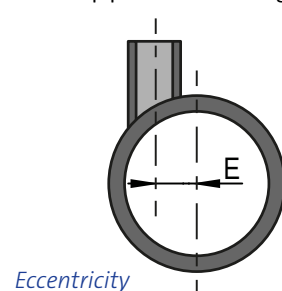
Data to calculate the shape to fit another part over the full section (saddle, etc).

Slope

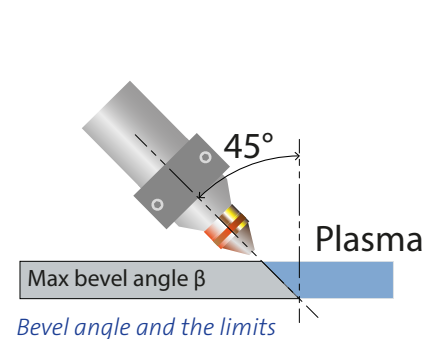
Acute angle between the main member and branch member axes.

Eccentricity

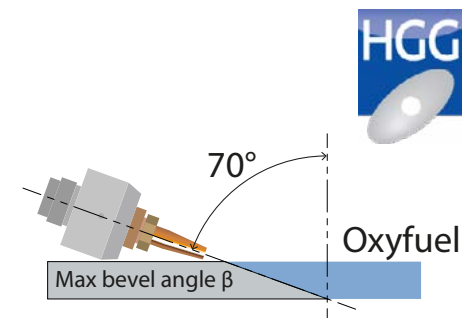
The offset between the centrelines of the current pipe and the mating pipe.



Eccentricity



Bevel angle and the limits



Bevel angle β

The angle formed between a centre line perpendicular to the wall and the cut face of the wall. Equal to cutting angle and can be negative or positive.

- A perpendicular cut has $\beta=0^\circ$;
- Largest β oxyfuel 70° (- or +);
- Largest β plasma 45° (- or +).

Dihedral angle ψ

Angle between the outer faces of the connected pipes. Calculations for optimal weld preparation are based on ψ .

Transition zone

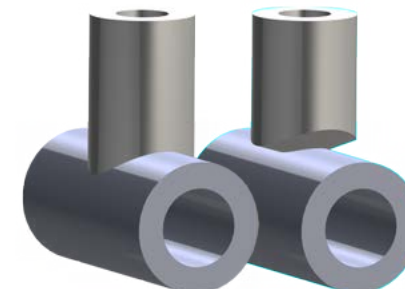
The best type of weld (fillet, groove, butt) depends on the angle between two walls (ψ). On small sloped connections this angle differs strongly from heel to toe zone. In this case two different weld types can save weld volume and will be easier to weld. A transition zone is needed to change from one weld type smoothly to another.

Root opening (R)

The separation at the joint between the pipes after fitting. Technique to increase the joint penetration for stronger connections.

Shrinkage (S)

A length compensation of the pipe to correct shrinkage of the weld.



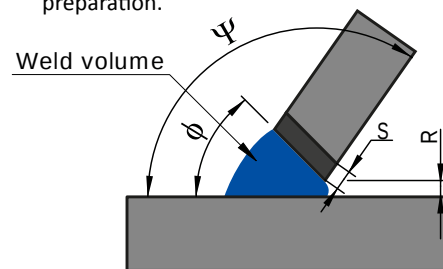
Example without and with groove

Weld preparation

Adaption for welding which will be defined by parameters and profiling shape specific settings.

Groove angle ϕ

The angle between opposing faces of the connected pipes which create a groove to be filled up with weld materials. Can be an inside or outside groove angle for weld preparation.



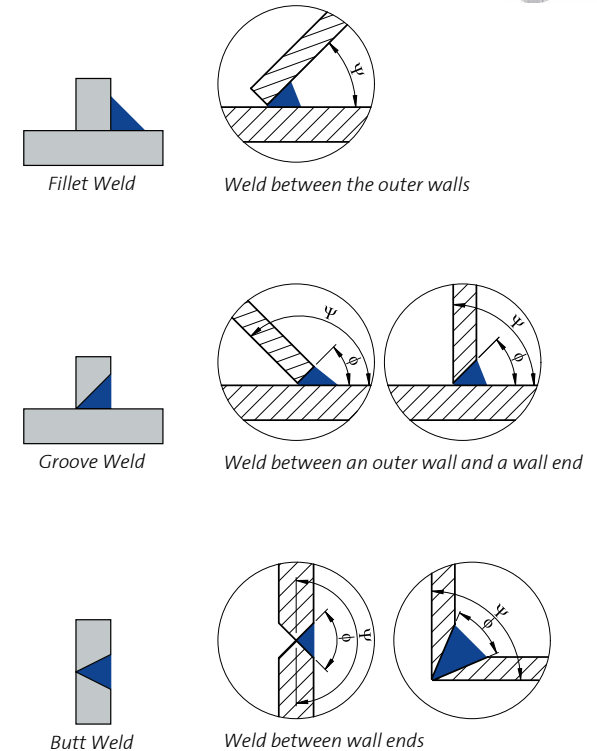
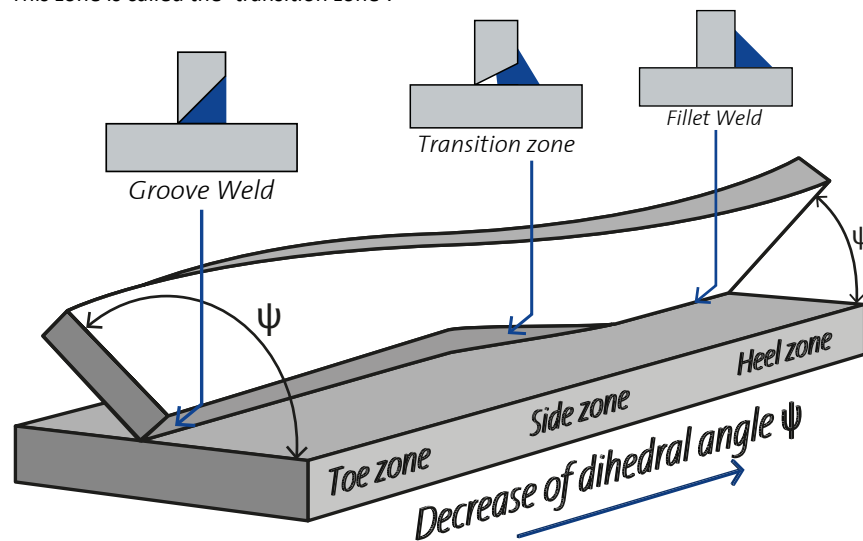
Weld detail (section view)

Weld types and application

The picture below is a simplified view of the variation in dihedral angle on a small sloped pipe to pipe connection from toe zone to heel zone. The dihedral angle at the toe zone is too large for a fillet weld. A groove weld is the best option for a strong connection with a minimum of weld volume.

At the heel zone the dihedral angle is much smaller. A groove opening here needs a lot of weld volume to create a strong connection. A better option here is a fillet weld. It needs less weld volume, easier to weld and easier to cut.

Somewhere between these weld types along the joint is a zone where the change from one weld type to the other occurs. This zone is called the 'transition zone'.

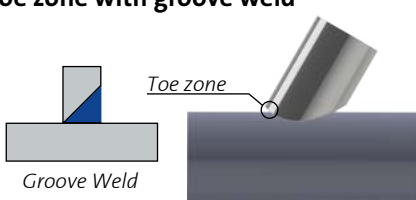
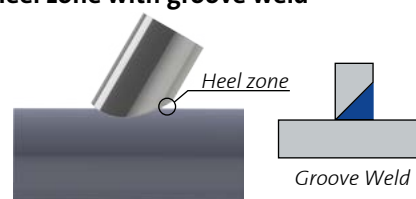
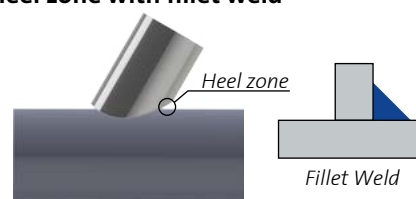


Overview of used weld types for wall joints.

The best weld type is determined by the dihedral angle.

Optimised weld preparation

A few practical examples of how HGG's profiling shapes achieve strong connections who are easy to cut and weld with a minimum of weld volume. The accuracy and the 3D cutting freedom of HGG's machines guarantees a quality cut in all circumstances.

		Slope $\pm 90^\circ$	Slope $\pm 60^\circ$	Slope $\pm 30^\circ$
Toe zone with groove weld 	Weld volume Joint strength Operator skills Weld difficulty	Low High Medium Medium	Low High Medium Medium	Low High Medium Easy
Heel zone with groove weld 	Weld volume Joint strength Operator skills Weld difficulty	Low High Medium Medium	High High Experienced Medium	High High Experienced Complicated
	Weld volume Joint strength Operator skills Weld difficulty		Low High Medium Medium	Heel groove reduction off/on*. Example 'Saddle' and 'Chamfer'.
Heel zone with fillet weld 	Weld volume Joint strength Operator skills Weld difficulty	Medium Weak Simple Easy	Low Medium Simple (1 cut) Easy	Low Medium Complicated (2 cuts) Medium
			Example 'Saddle PJP' and 'Chamfer PJP'	Example 'Saddle Offshore' and 'Chamfer Offshore'**

*Heel groove reduction to 0,5ψ: Reference: Structural Welding Code AWS D1.1/D1.1M:2010; page 72, Table 3.6.

**Reference: Structural Welding Code AWS D1.1/D1.1M:2010; page 121-123, Figure 3.8, 3.9 & 3.10

Chamfer

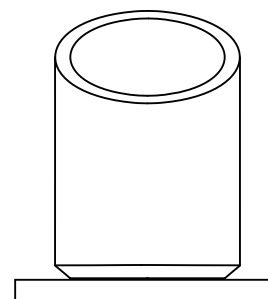
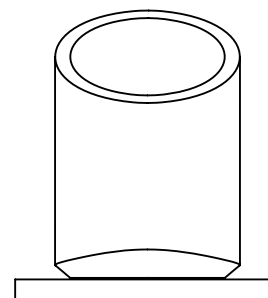
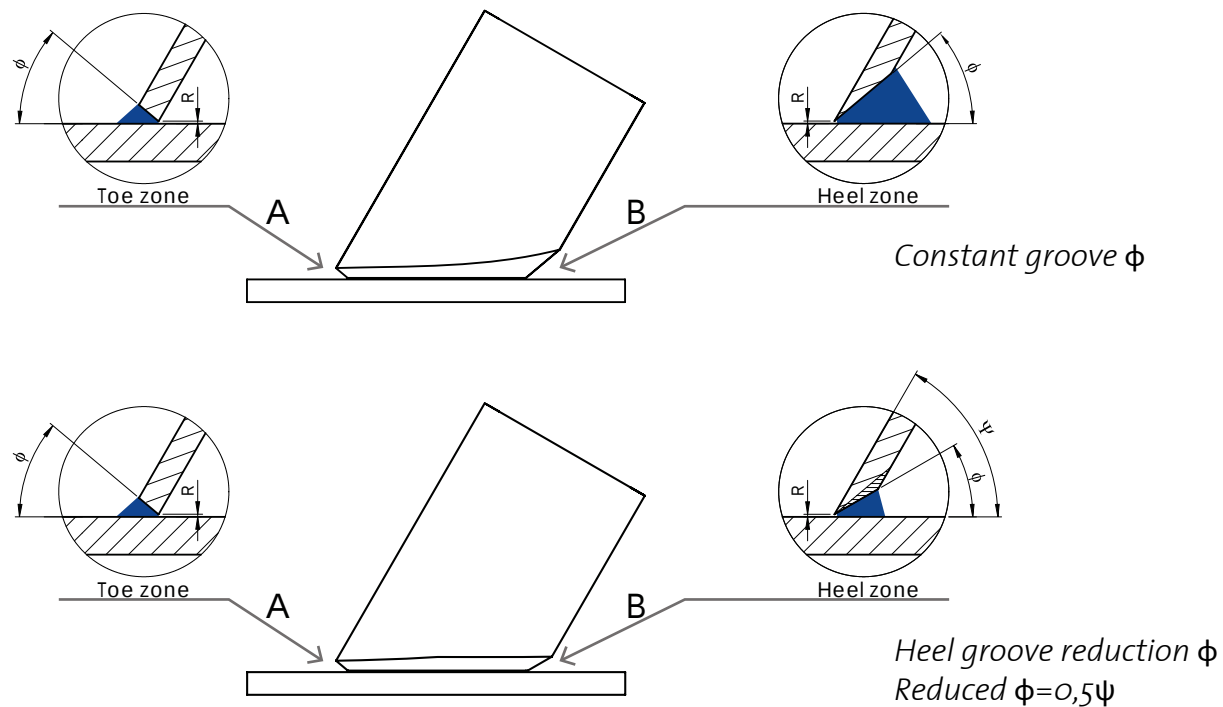
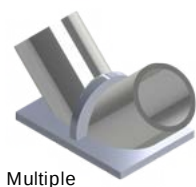
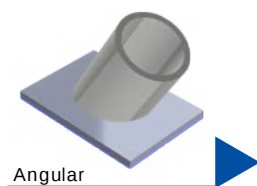
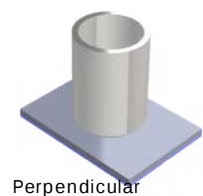
A pipe to plate connection.

Intersection geometry

- Adjustable slope.
- Multiple chamfer feature.

Weld preparation

- Adjustable groove angle (ϕ).
- Adjustable root opening (R).
- Shrinkage compensation.
- Heel groove reduction available to reduce weld volume (expert level).*



*Heel groove reduction by $0,5\psi$ (if reduced $\phi < \text{defined } \phi$) Reference: Structural Welding Code AWS D1.1/D1.1M:2010; page 72, Table 3.6.

Chamfer Intermediate

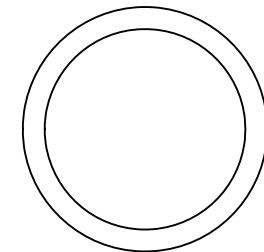
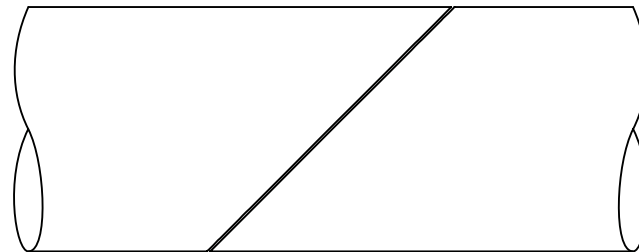
Profiling shape to cut off a part without scrap*. Because the scrap side will be the first cut of the next part.

Intersection geometry

- Adjustable slope.

Weld preparation

- Groove angle = 0



*This single cut to end and start a part affects the surface condition and accuracy. A lead-in and lead-out is not used.

Chamfer Offshore

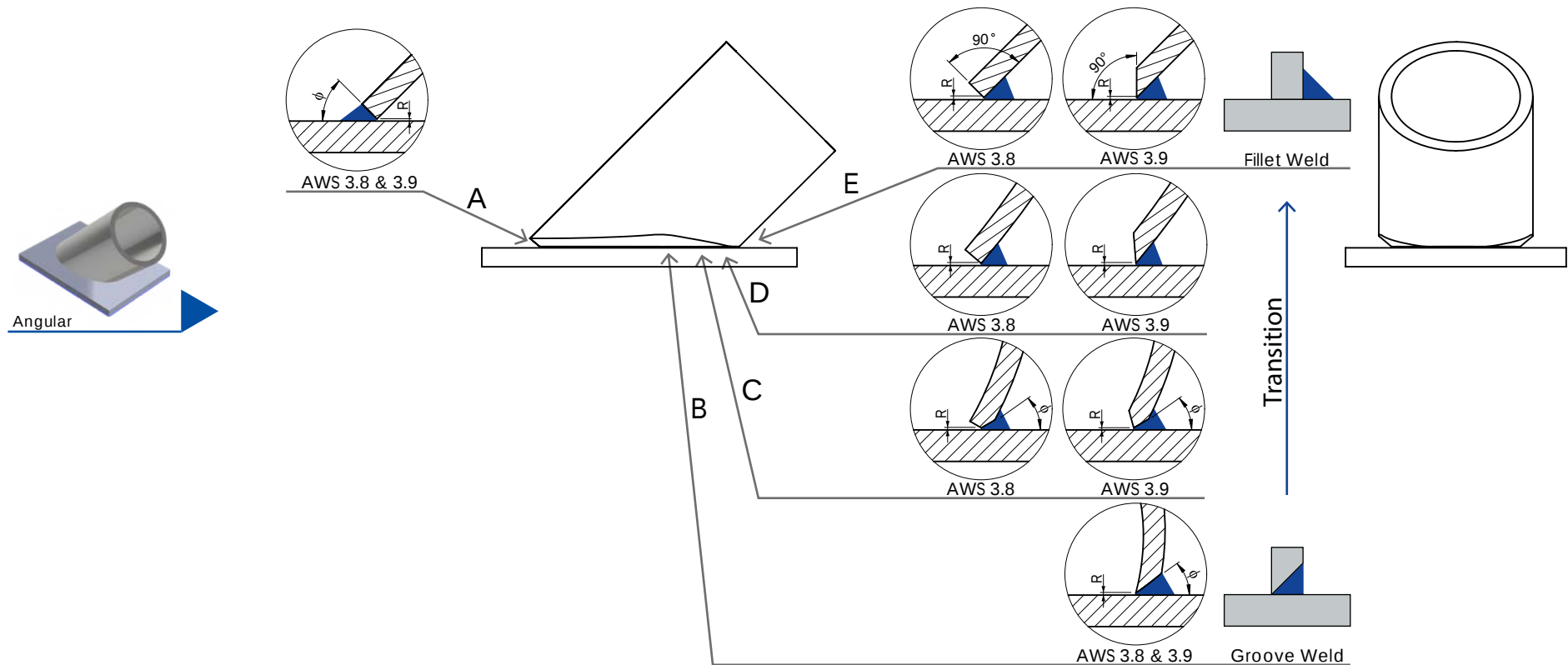
A pipe to plate connection with a slope less than 50° based on AWS for offshore industries.

Intersection geometry

- Adjustable slope <50°.

Weld preparation

- Adjustable groove angle (ϕ).
- Transition zones: fixed start and end point by dihedral angle (ψ).
- Heel zone; choice between AWS 3.8 & 3.9. AWS 3.9 represents also figure 3.10.*
- Adjustable root opening (R).
- Shrinkage compensation.



*Reference: Structural Welding Code AWS D1.1/D1.1M:2010; page 121-123. Figure 3.8, 3.9 and 3.10
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Chamfer Offshore ATB

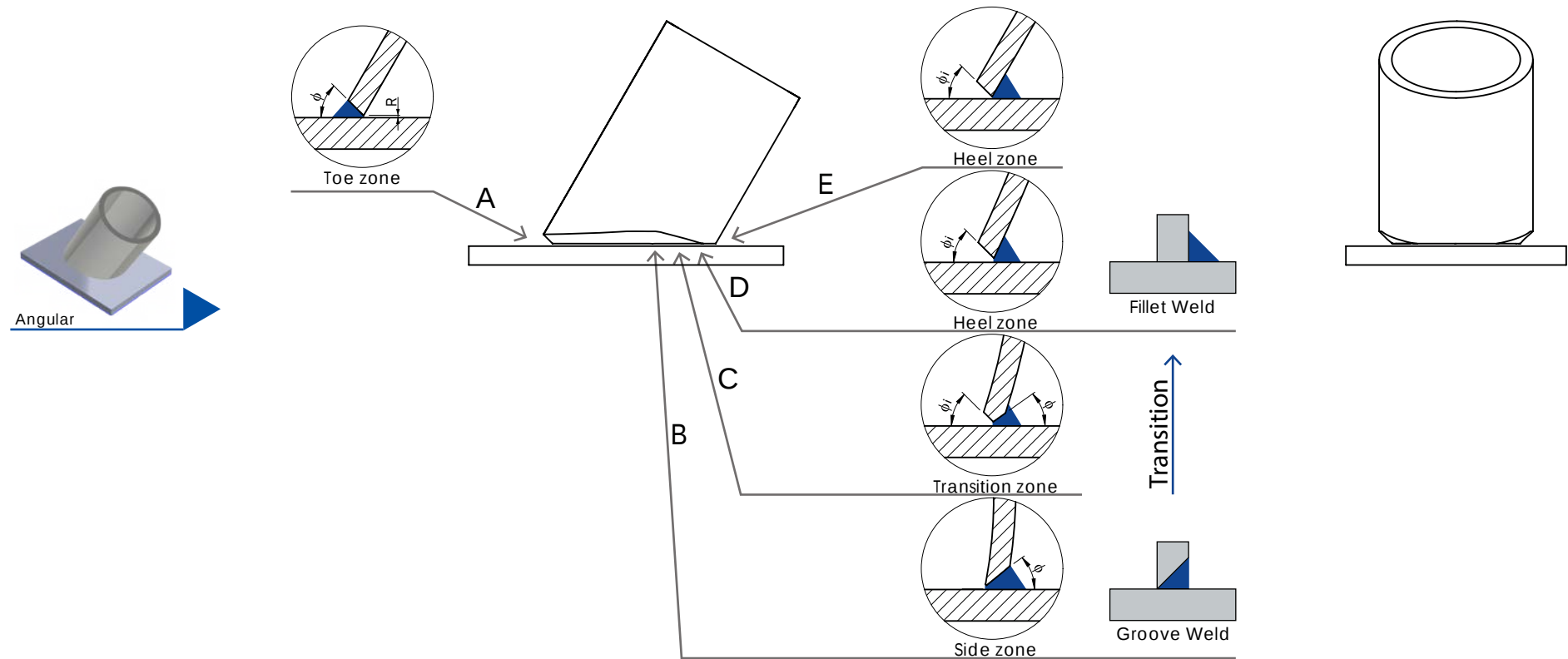
A pipe to plate connection with extended weld preparation features for offshore industries.

Intersection geometry

- Adjustable slope <60°.

Weld preparation

- Adjustable groove angle (ϕ).
- Transition zones: Adjustable start and end point by dihedral angle (ψ).
- Adjustable inside groove angle (ϕ_i).
- Adjustable root opening (R).
- Shrinkage compensation.



Chamfer PJP

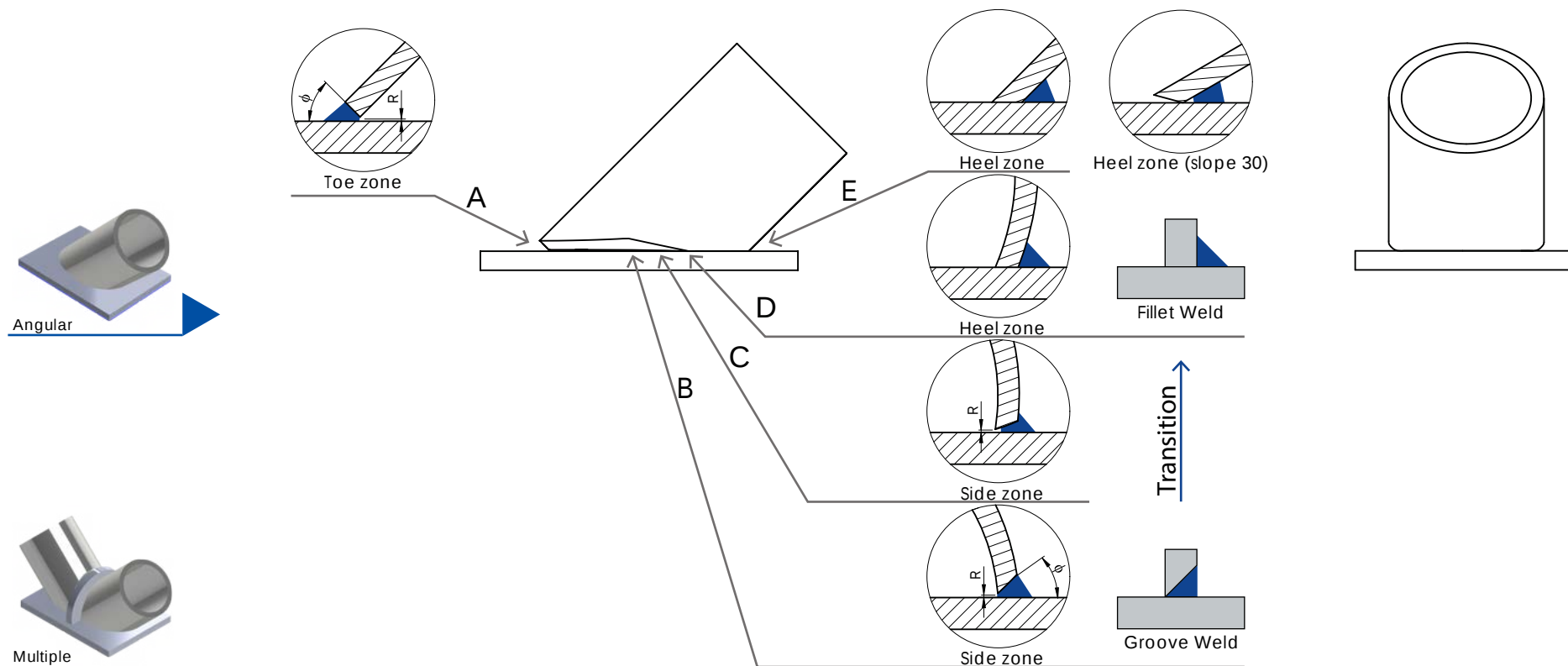
For small sloped and highly dynamic pipe to plate connections. Easy cutting, fitting and welding.

Intersection geometry

- Adjustable slope.
- Multiple chamfer feature.

Weld preparation

- Adjustable groove angle (ϕ).
- Transition zones: predefined start and end point by dihedral angle (ψ). ($95^\circ - 70^\circ$).
- Adjustable root opening (R).
- Easy fitting: no need for spacers to create the root opening and the slope. The large heel zone will fixate the correct position.



Chamfer X-cut

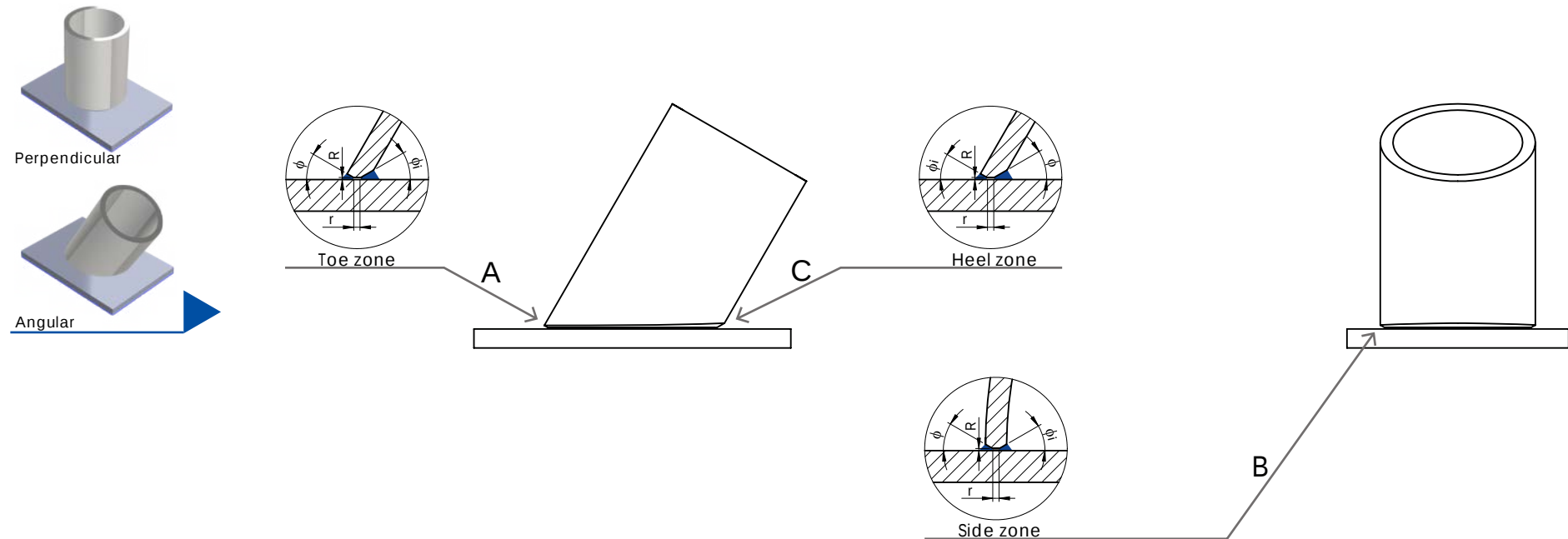
A pipe to plate connection with advanced bevelling options for weld volume reduction and taper cuts.

Intersection geometry

- Adjustable slope.

Weld preparation

- Adjustable groove angle (ϕ) and depth of groove.
- Adjustable inside groove angle (ϕ_i) and depth of groove.
- A total groove depth ($\phi + \phi_i$) less than the wall thickness will automatically generate a root face (r)*.
- Adjustable root opening (R).
- Shrinkage compensation.



*minimum length to cut a root face is 3 mm.

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Cone Saddle

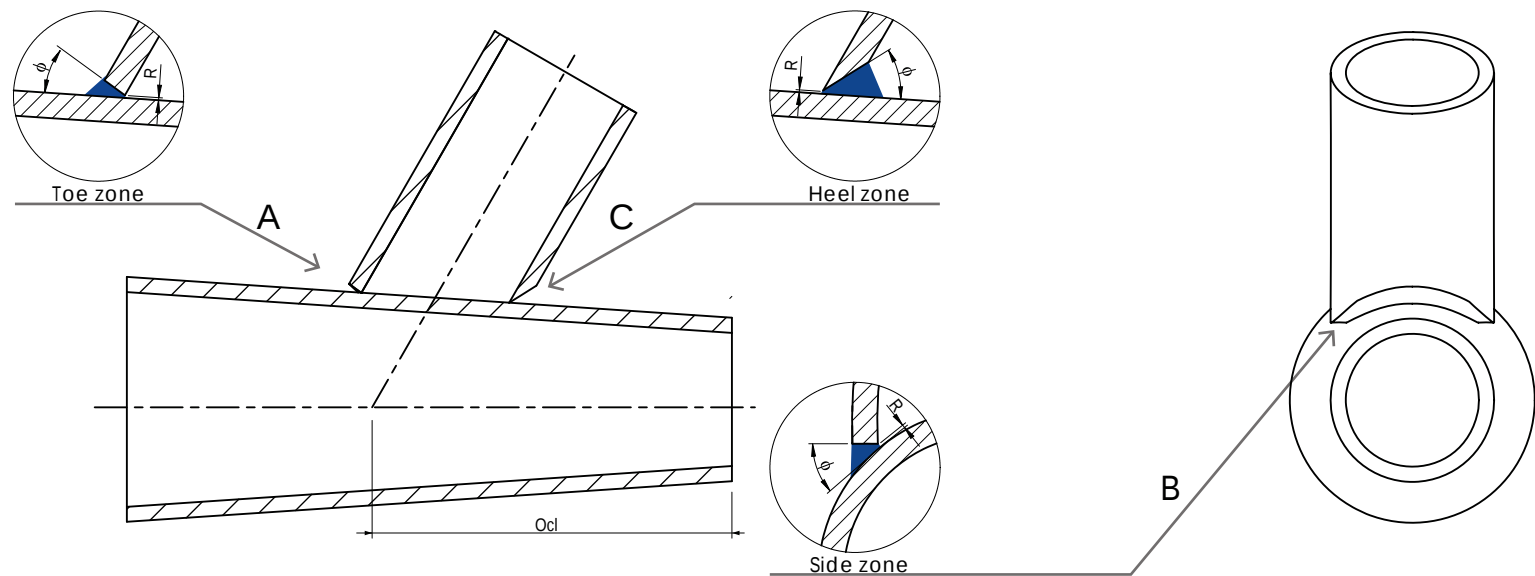
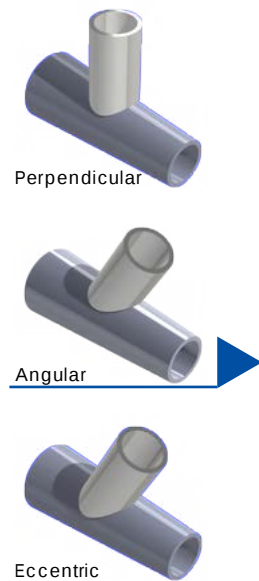
For a pipe to cone connection for piping industries or steel structures.

Intersection geometry

- Adjustable slope.
- Adjustable eccentricity.
- Adjustable centre line offset (Ocl).

Weld preparation

- Adjustable groove angle (ϕ).
- Adjustable root opening (R).
- Shrinkage compensation.



Cone Saddle X-cut

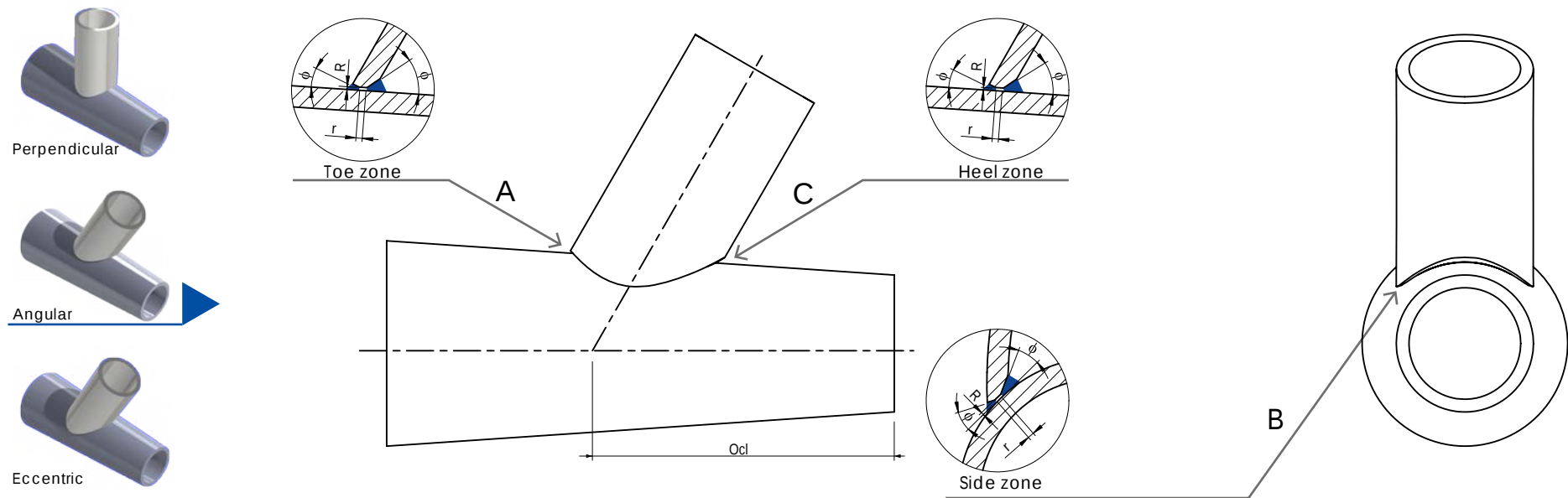
A pipe to cone connection with weld volume reduction for thick walled pipes.

Intersection geometry

- Adjustable slope.
- Adjustable eccentricity.
- Adjustable centre line offset (Ocl).

Weld preparation

- Adjustable groove angle (ϕ) and depth of groove.
- Adjustable inside groove angle (ϕ_i) and depth of groove.
- A total groove depth ($\phi + \phi_i$) less than the wall thickness will automatically generate a root face (r)*.
- Adjustable root opening (R).
- Shrinkage compensation.



*minimum length to cut a root face is 3 mm.

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Crossing Saddle

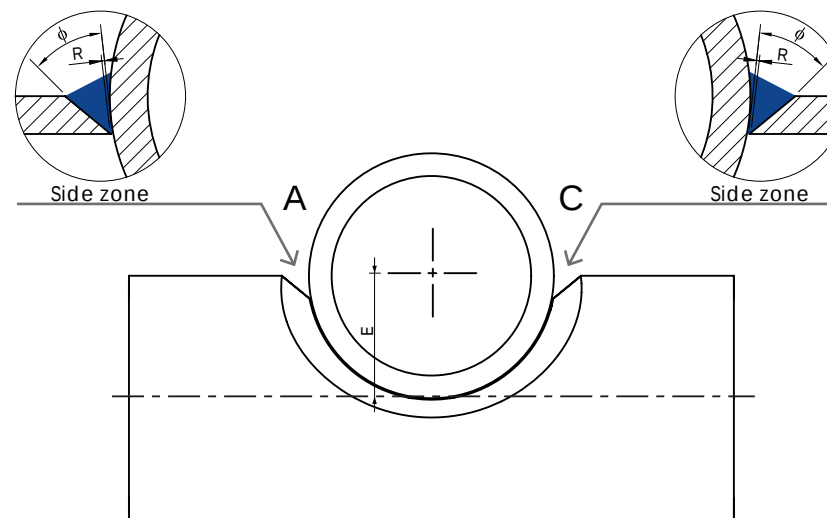
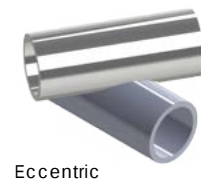
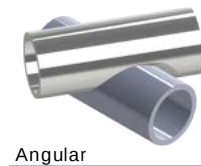
Eccentric and intermediate pipe to pipe connection that continues on both sides.

Intersection geometry

- Adjustable slope.
- Adjustable eccentricity (E).

Weld preparation

- Adjustable groove angle (ϕ).
- Adjustable root opening (R).



Crown

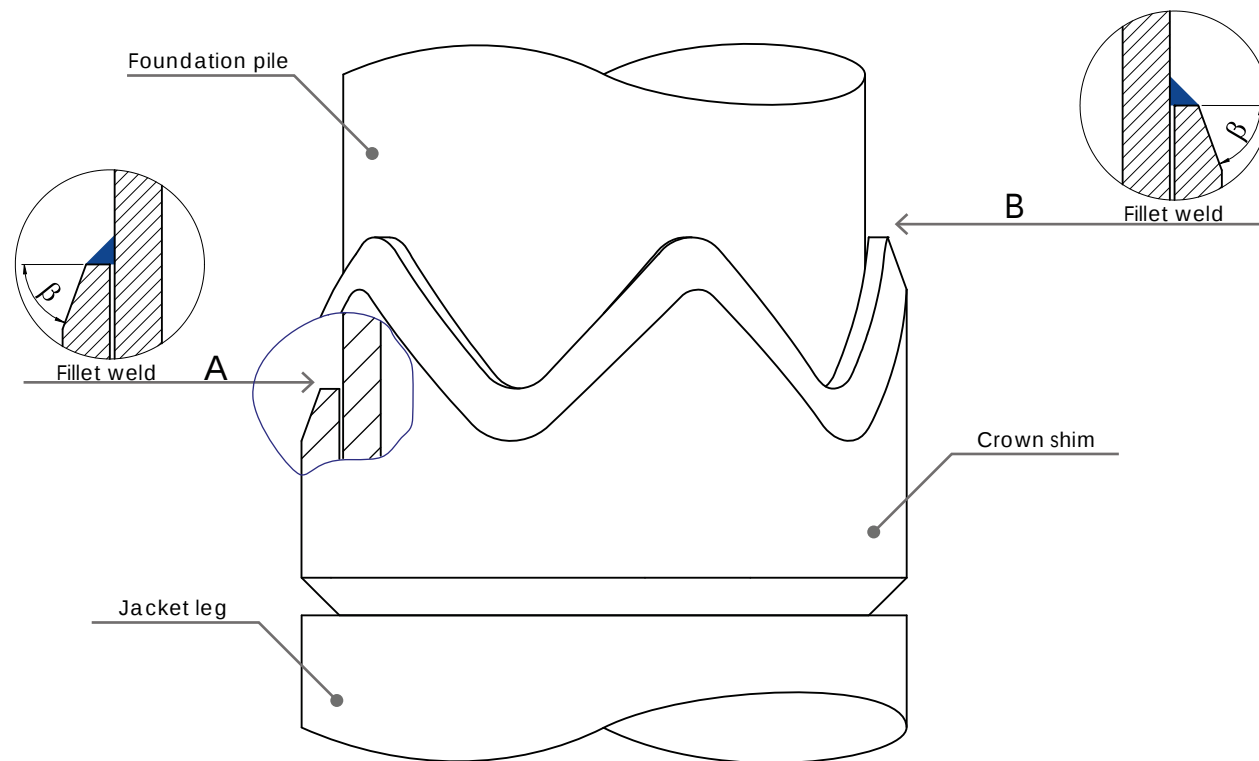
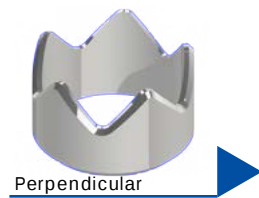
Offshore specific profiling shape for crown shim cutting to secure foundation piles on the top of a jacket leg.

Intersection geometry

- Adjustable amount of teeth.
- Adjustable teeth amplitude.
- Adjustable teeth radius.

Weld preparation

- Adjustable bevel angle (β)
- Add a second crown with bevel angle to create a tapering (please see picture).



Edge Cone Saddle

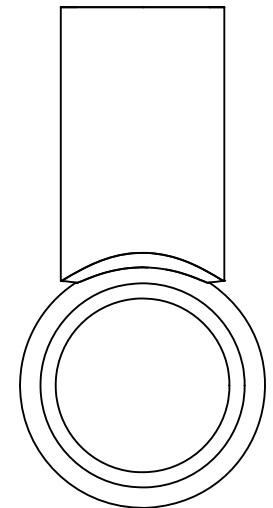
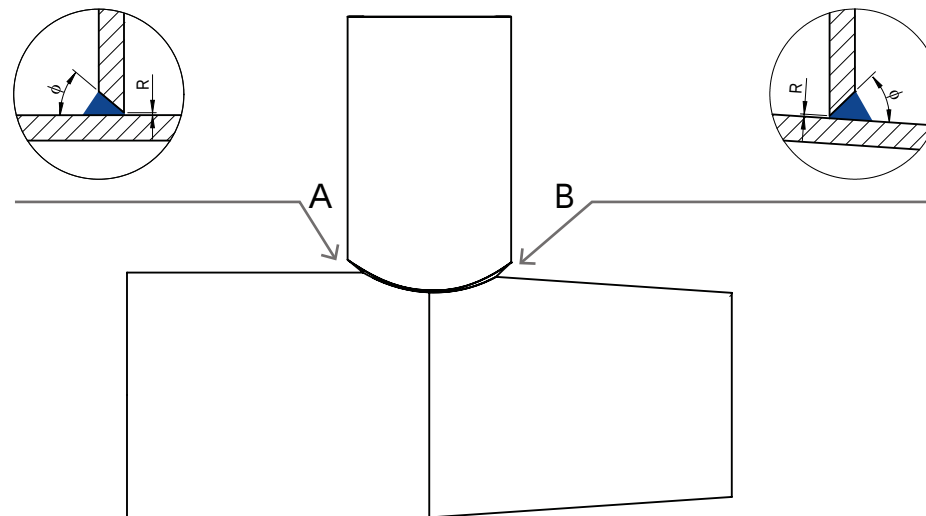
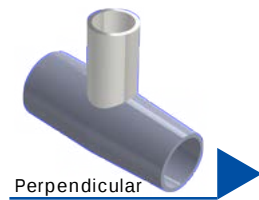
A pipe to cone edge connection for piping industries or steel structures.

Intersection geometry

- Adjustable slope.
- Adjustable eccentricity.

Weld preparation

- Adjustable groove angle (ϕ).
- Adjustable root opening (R).
- Shrinkage compensation.



Edge Saddle

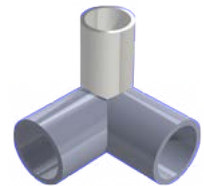
Profiling shape to create a double saddle to connect with two connected pipes which will not run through (both colliding).

Intersection geometry

- Adjustable Slopes.

Weld preparation

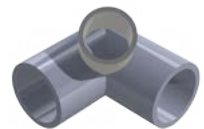
- Adjustable groove angle (ϕ).
- Adjustable root opening (R).
- Shrinkage compensation.



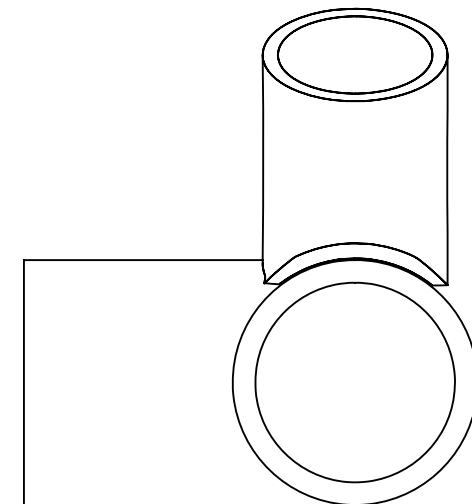
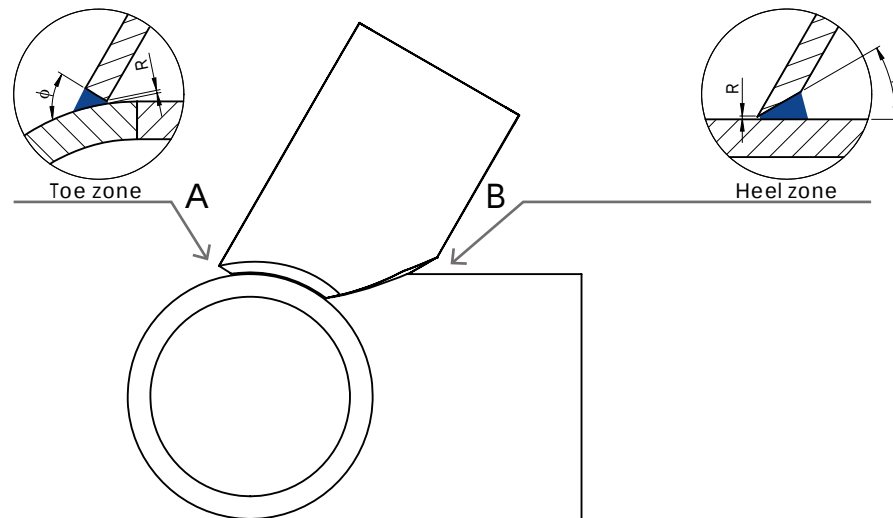
Perpendicular



Angular single slope



Angular double slope

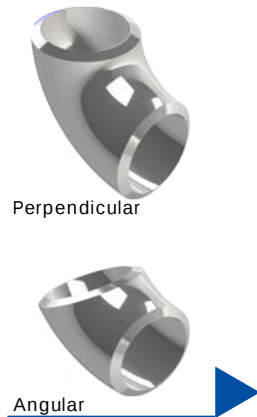


Elbow Chamfer

To shorten elbows to a certain angle including bevel. Ask your supplier for more information about the required accessories and suitable machines.

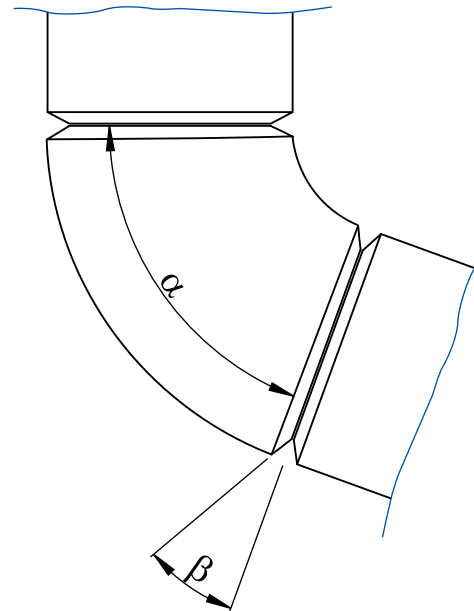
Intersection geometry

- Adjustable elbow angle (α).



Weld preparation

- Adjustable bevel angle (β).
- Adjustable root opening (R).
- Shrinkage compensation.



Elbow Saddle

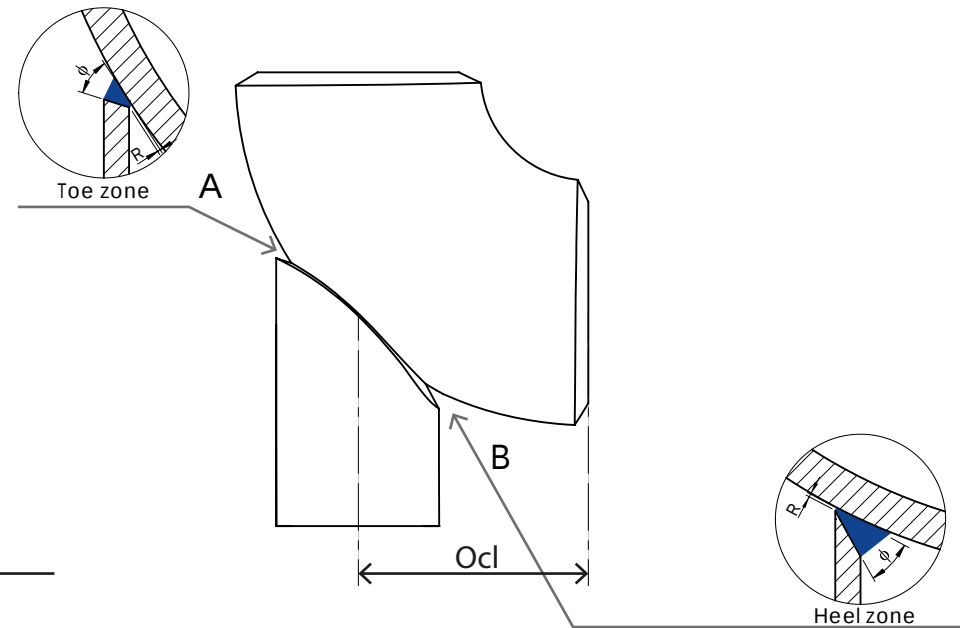
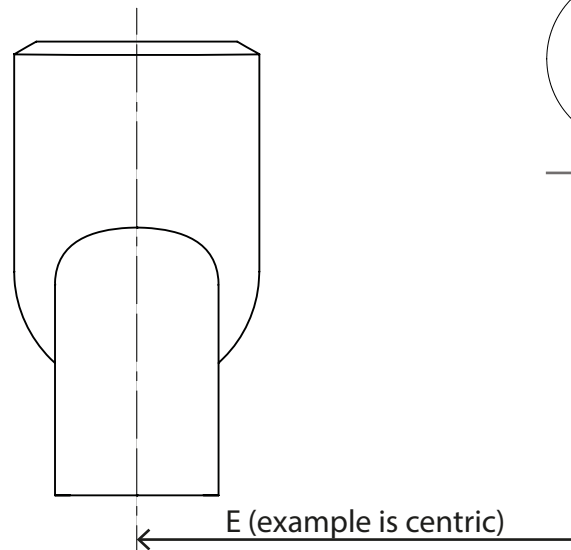
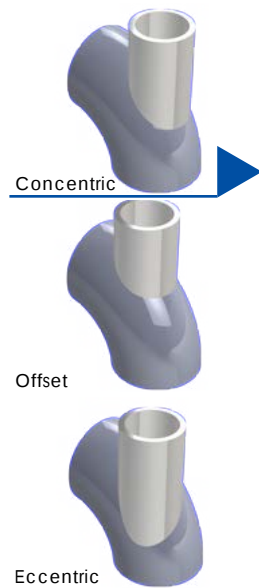
Elbow support against gravity for piping industry.

Profile

- Adjustable eccentricity (E).
- Adjustable centre line offset (Ocl).

Weld preparation

- Adjustable groove angle (ϕ).
- Adjustable root opening (R).
- Shrinkage compensation.



Elbow Saddle Offshore

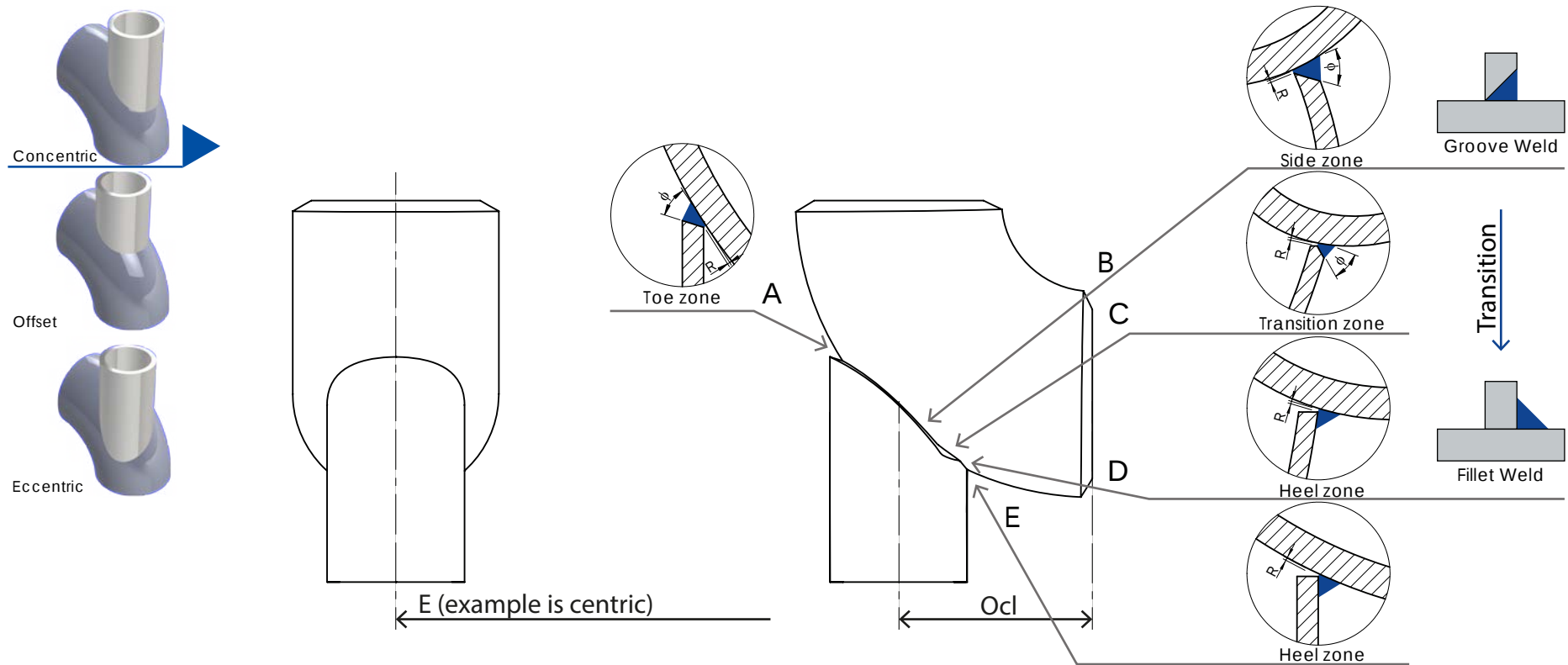
Elbow support against gravity for offshore piping in based on AWS.

Intersection geometry

- Adjustable eccentricity (E).
- Adjustable centre line offset (Ocl).

Weld preparation

- Adjustable groove angle (ϕ).
- Heel zone: fixed inside perpendicular bevel angle.
- Adjustable root opening (R).
- Shrinkage compensation.



Ellipse Hole

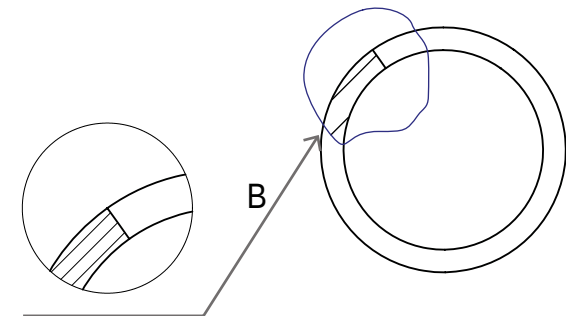
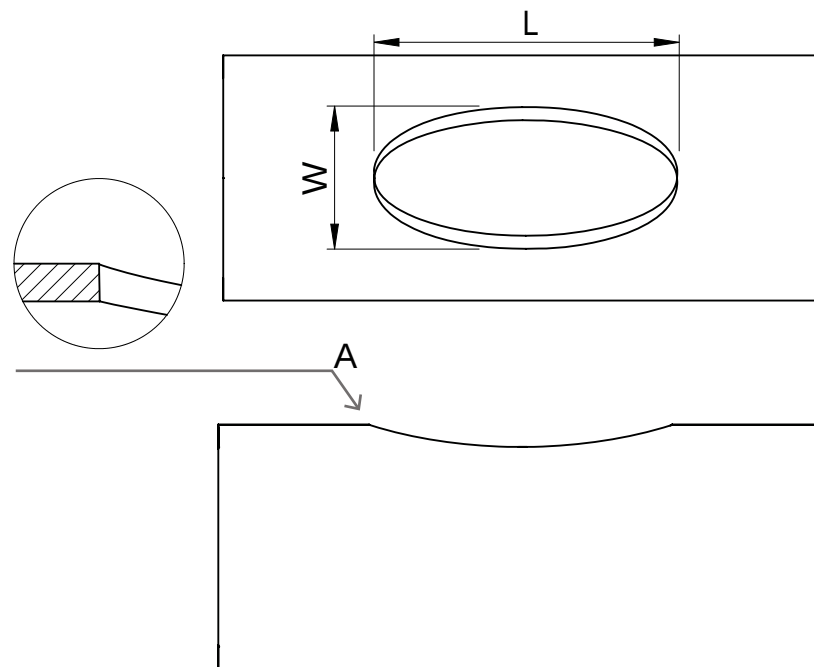
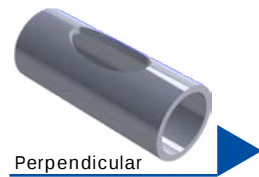
Ellipse hole with bevel angle 0.

Intersection geometry

- Adjustable width (W) and length (L) of hole.

Weld preparation

- The bevel angle along the cut is 0°.



Ellipse Hole set-in

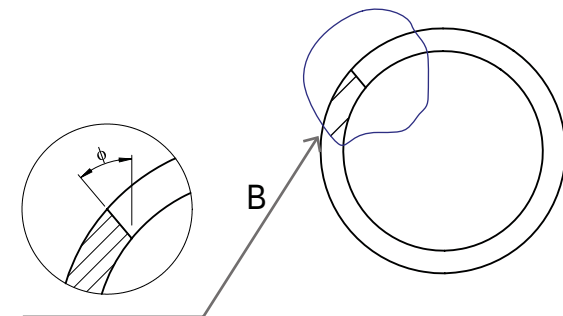
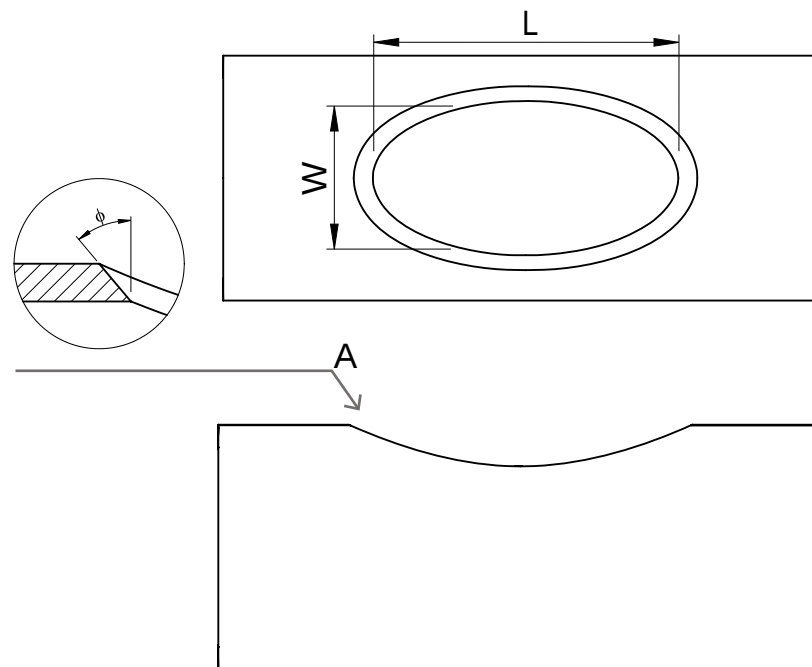
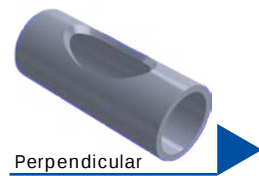
This intermediate shape enables to cut out an ellipse shape with weld preparation to insert a lifting eye for example.

Intersection geometry

- Adjustable eccentricity.
- Adjustable width (W) and length (L) of hole.

Weld preparation

- Adjustable groove angle (ϕ).
- Adjustable root opening.



Helix

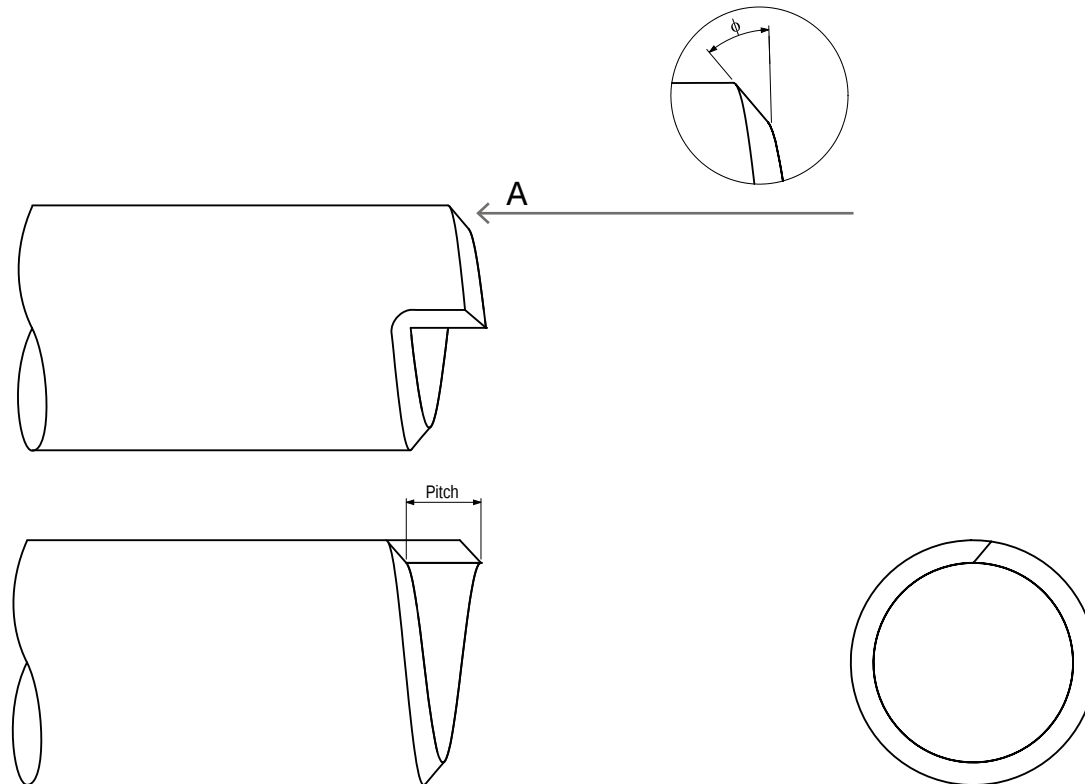
Specific shape to create helical foundation piles.

Intersection geometry

- Adjustable pitch.

Weld preparation

Adjustable groove angle (ϕ).



Lobster Back

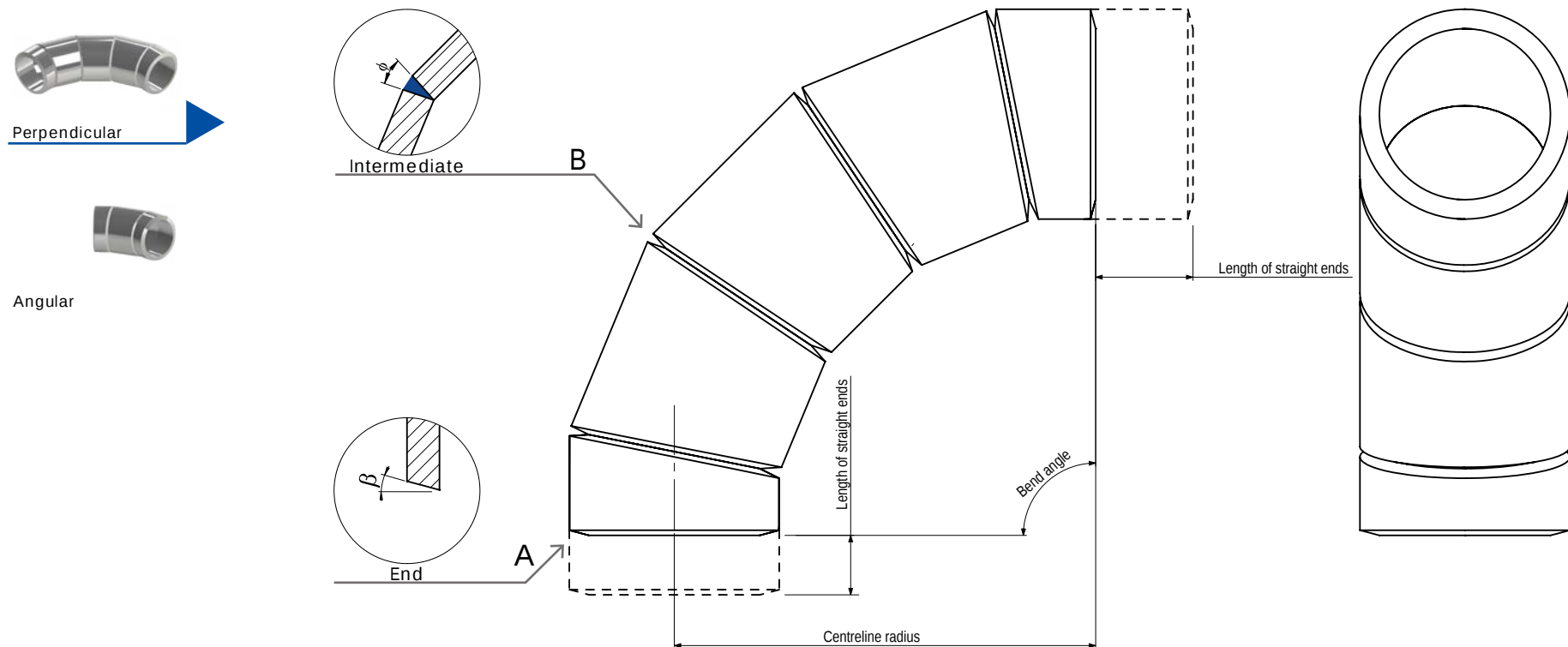
Tool to create series of closely spaced mitre bends.

Intersection geometry

- Adjustable angle of total bend.
- Adjustable centre line radius.
- Adjustable amount of segments.
- Adjustable length of straight ends on both sides.

Weld preparation

- Adjustable end bevel (β).
- Adjustable intermediate groove angle (ϕ).



Lobster back is a derivative of:

ASME B31.1-2012 Power Piping, MANDATORY APPENDIX D

ASME B31.3-2012 Process Piping, par. 304.2.3 Miter Bends, page 21-22 and MANDATORY APPENDIX D

ASME B31.4-2012 Liquid Transportation Systems

ASME B31.8, Gas Transmission and Distribution Piping Systems

Mitre

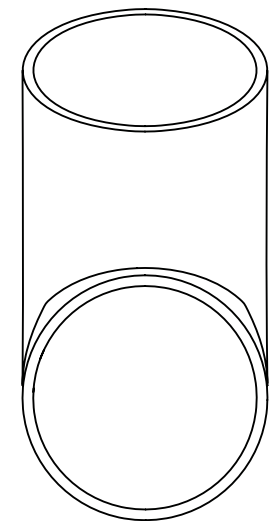
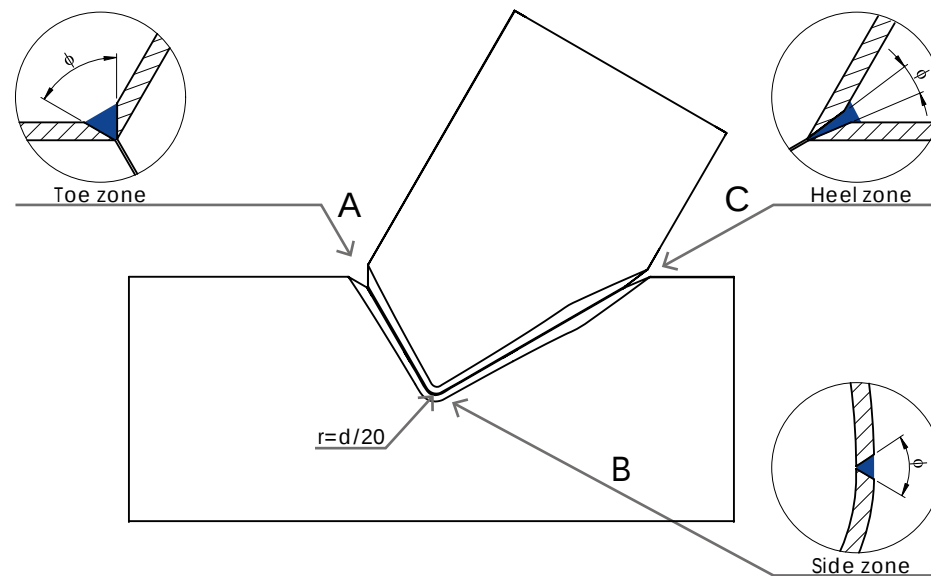
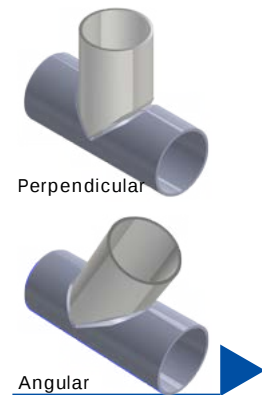
To make equal diameter pipe to pipe connections for low pressure piping.

Intersection geometry

- Adjustable slope.

Weld preparation

- Adjustable groove angle (ϕ)*.
- Adjustable root opening (R).
- Mitre Saddle: shrinkage compensation.



* When the maximum bevel angle is reached the groove angle could decrease. See detail C.

Strainer

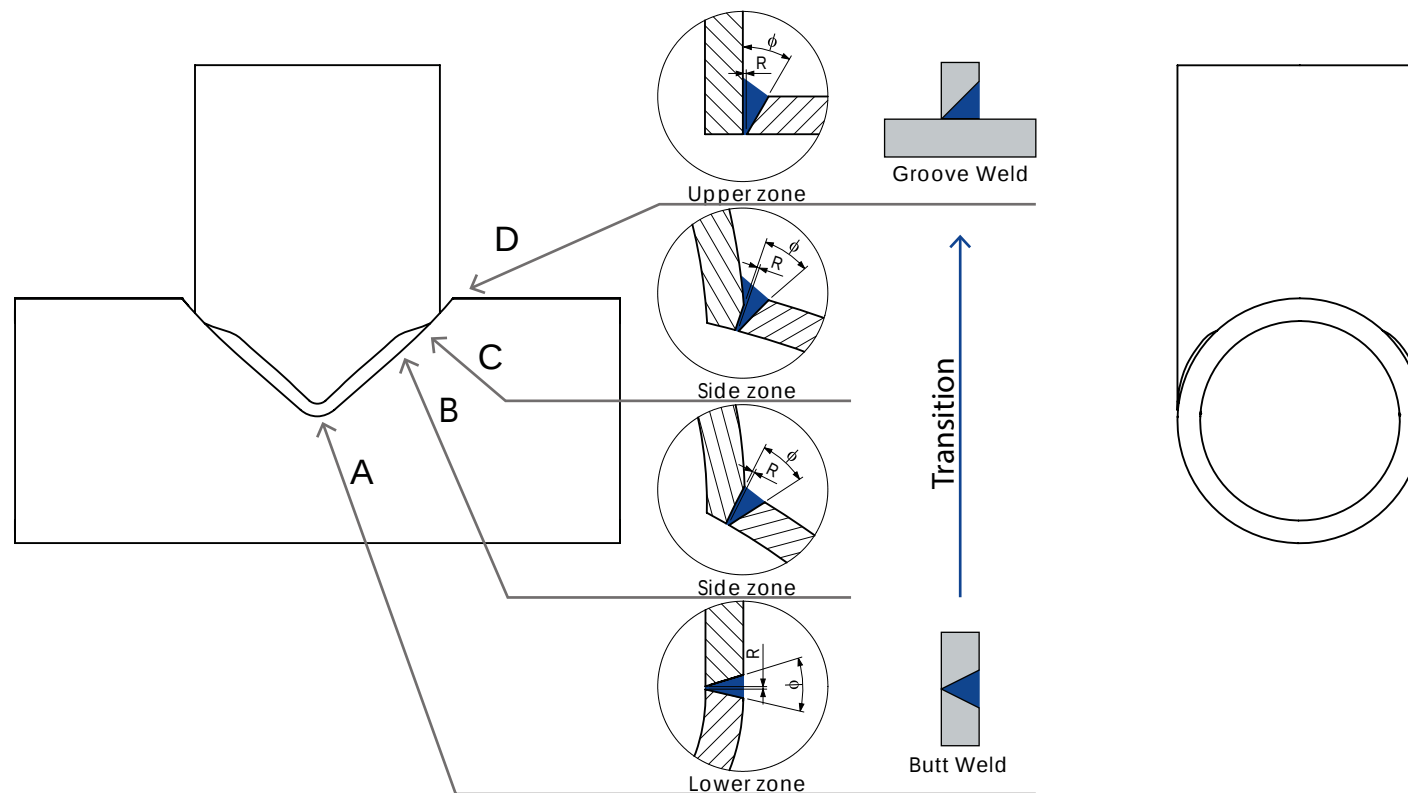
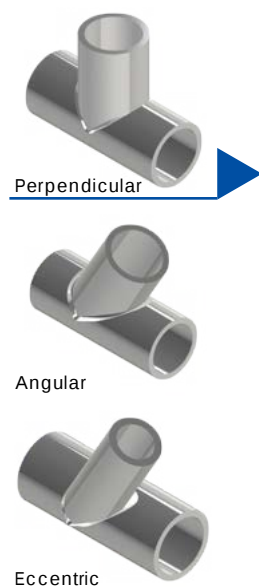
This profiling shape is named due to its application in piping systems. A strainer is a part which mechanically removes solids from flowing steam, gas or liquid piping systems to protect equipment.

Intersection geometry

- Adjustable Slope.
- Adjustable eccentricity when the branch pipe has a smaller diameter.

Weld preparation

- Adjustable groove angle (ϕ) and depth of groove.
- A groove depth less than the wall thickness will automatically generate a root face*.
- Adjustable root opening (R).
- Shrinkage compensation.



*minimum length to cut a root face is 3 mm.

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Nozzle set-in

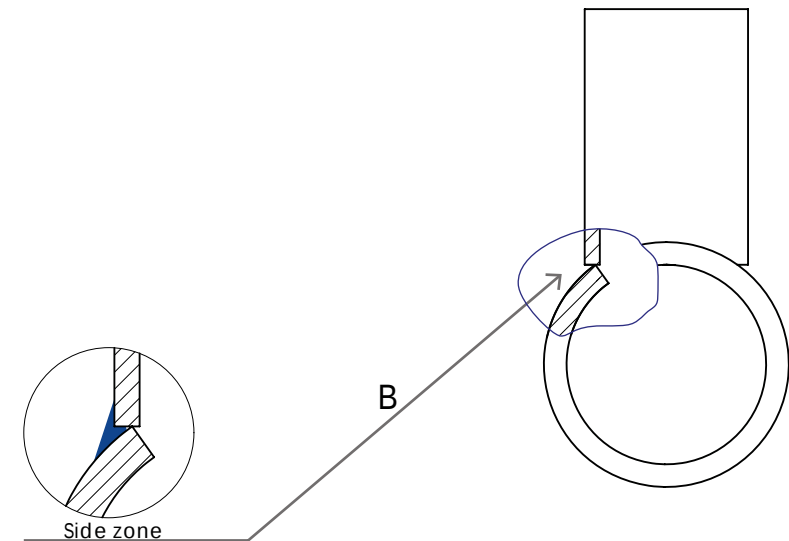
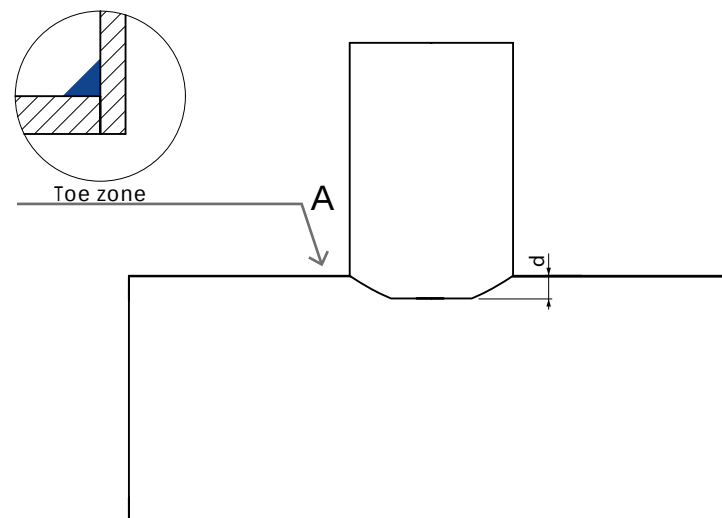
A quick fit method for perpendicular piping connections.

Intersection geometry

- Perpendicular connection.
- Adjustable nozzle depth (d).

Weld preparation

- No profiled nozzle needed to weld.



Oblong Hole

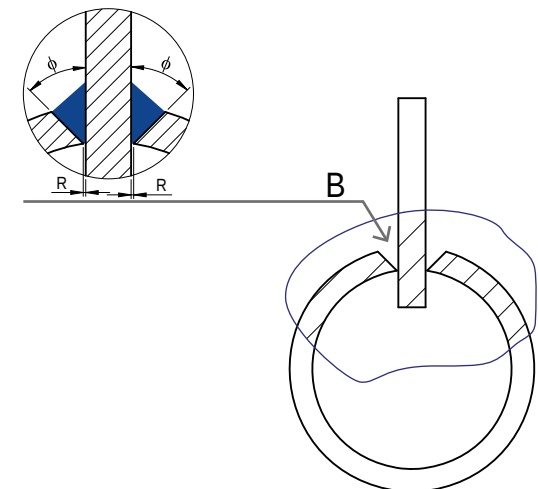
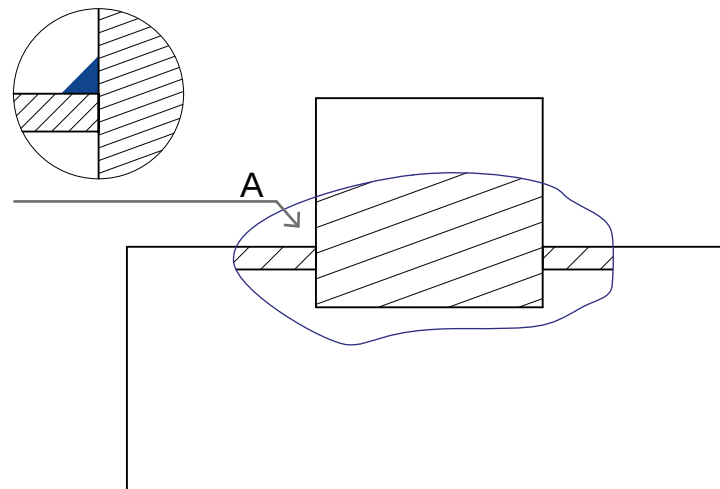
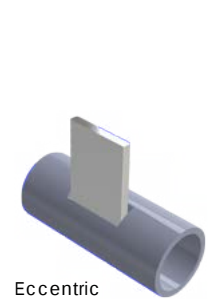
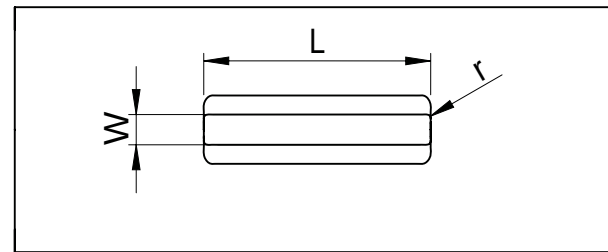
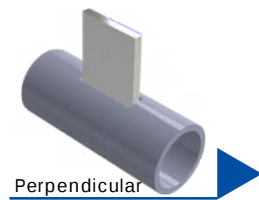
To fit inserted plates at pipe ends or to create intermediate oblong holes.

Intersection geometry

- Adjustable eccentricity.
- Adjustable width (W) and length (L) of hole.

Weld preparation

- Adjustable groove angle (ϕ) along length sides.
- Adjustable root opening (R) along length sides.
- Adjustable radius (r).



Rotated Oblong Hole

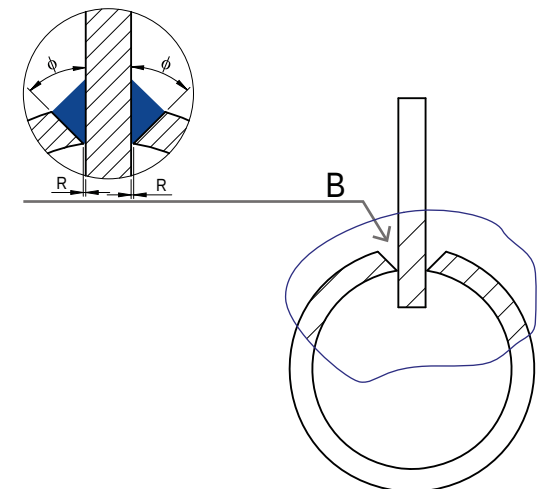
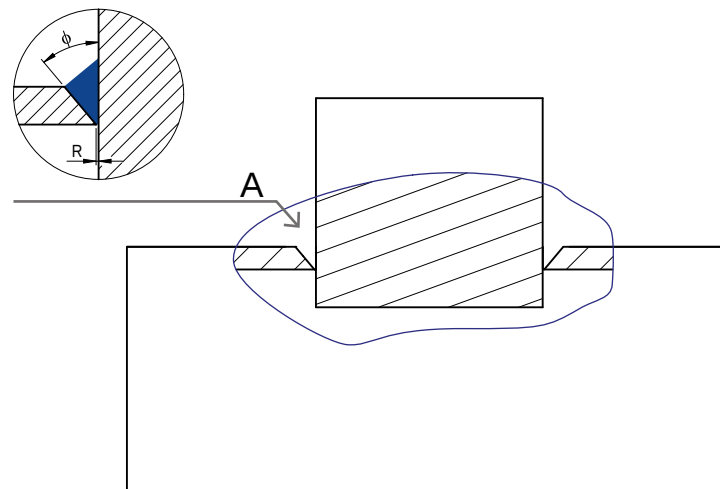
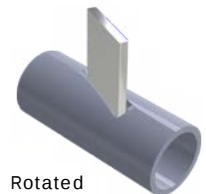
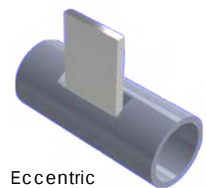
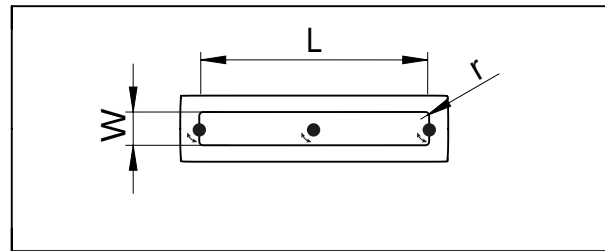
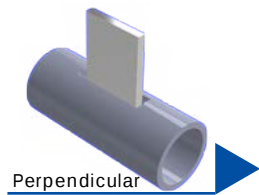
To fit inserted plates at pipe ends or to create intermediate slots.

Intersection geometry

- Adjustable eccentricity.
- Adjustable width (W) and length (L) of hole.
- Adjustable radius (r).
- Adjustable degrees of rotation.
- Definable point of rotation (●).

Weld preparation

- Adjustable groove angle (ϕ) along width and length sides independently.
- Adjustable root opening (R).



Tapered Oblong Hole

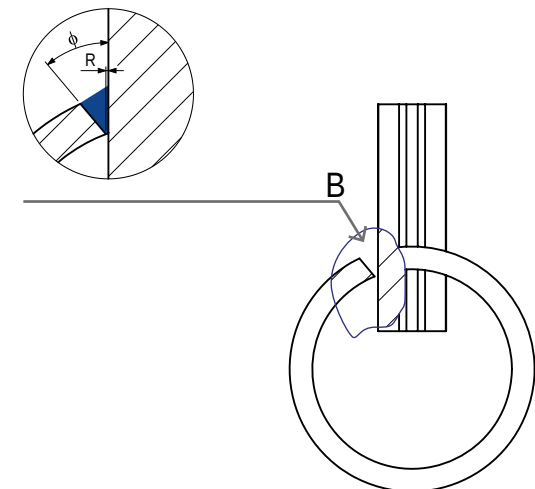
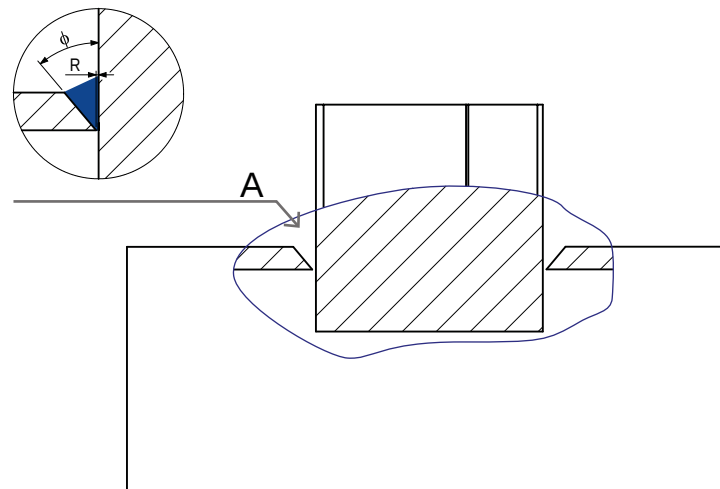
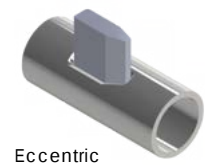
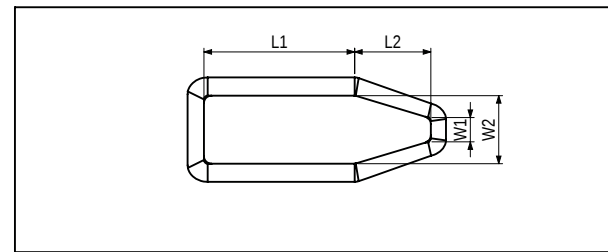
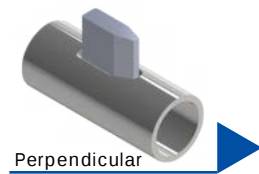
Tapered slot to fit inserted slot pins for example.

Intersection geometry

- Adjustable eccentricity.
- Adjustable widths and lengths of hole.
- Full tapered and half tapered holes.

Weld preparation

- Adjustable root opening (R).
- Adjustable radius (r) to optimise weld preparation.
- Adjustable weld preparation angle (ϕ) along all sides.



Reinforcement Pad

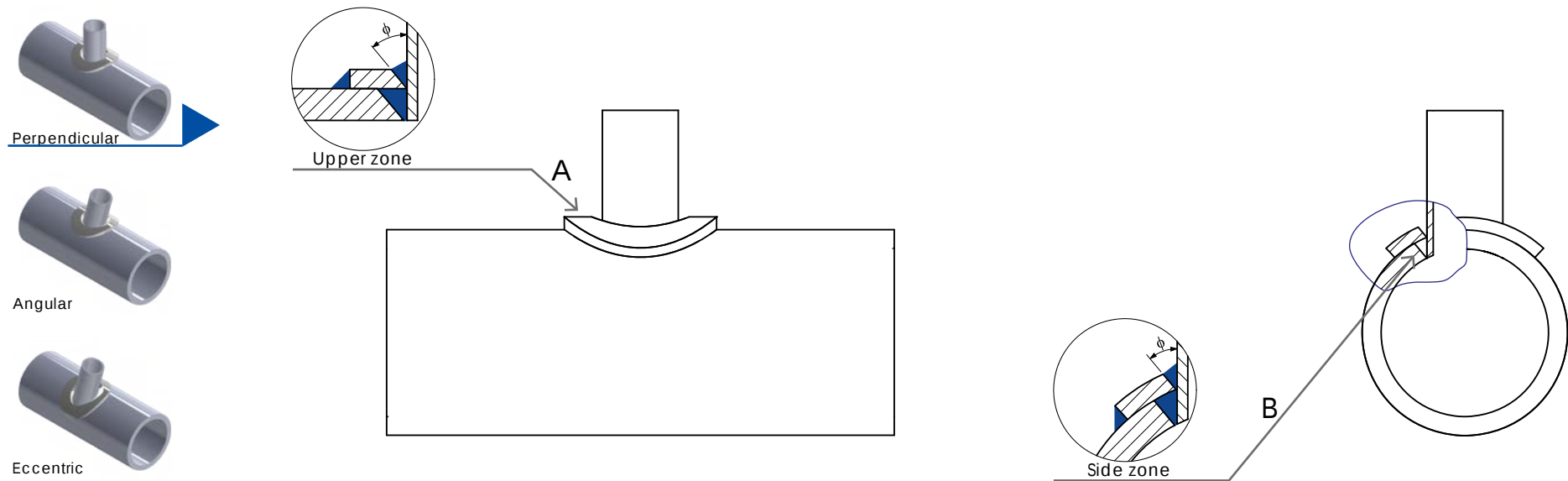
To save material costs by reinforcement of the weakest point on 'Saddle-Hole' connections.

Intersection geometry

- Adjustable slope.
- Adjustable hole width.
- Adjustable flange width.
- Adjustable eccentricity.

Weld preparation

- Adjustable groove angle (ϕ).



Reinforcement pad is a derivative of:

ASME B31.1-2012 Power Piping, paragraphs; 104.3.1 'Branch Connections', 127.4.8 'Welded Branch Connections'

ASME B31.3-2012 Process Piping, paragraphs; 304.3.3 'Reinforcement of Welded Branch Connections', 328.5.4 'Welded Branch Connections'

ASME B31.8-2012 Gas Transmission and Distribution Piping Systems, paragraph; 831.4 'Reinforcement of Welded Branch Connections'

Saddle

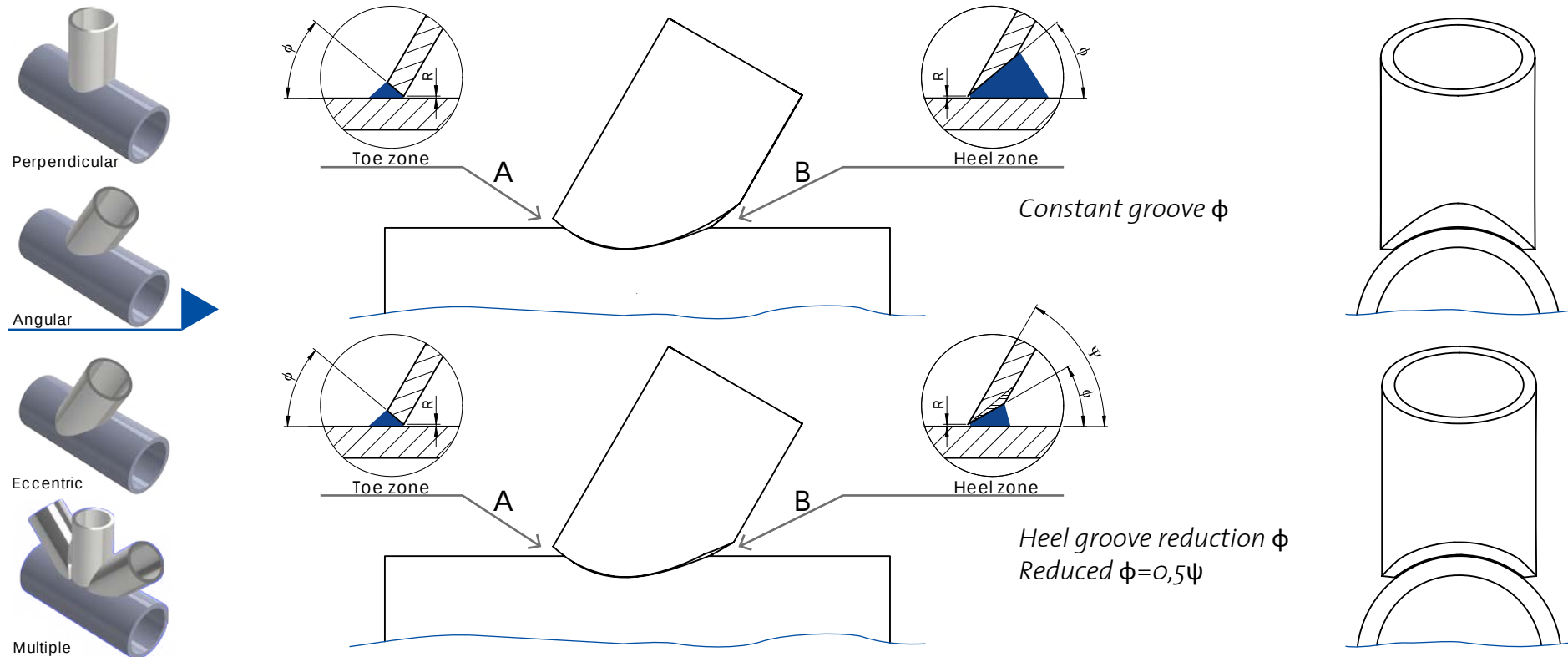
A pipe to pipe connection in tubular structures.

Intersection geometry

- Adjustable slope.
- Adjustable eccentricity.
- Multiple saddle feature with option to switch off the running trough. in case of one colliding pipe

Weld preparation

- Adjustable groove angle (ϕ).
- Adjustable root opening (R).
- Shrinkage compensation.
- Heel groove reduction available to reduce weld volume (expert level).*



*Heel groove reduction by $0,5\psi$ (if reduced $\phi < \text{defined } \phi$) Reference: Structural Welding Code AWS D1.1/D1.1M:2010; page 72, Table 3.6.

Saddle X-cut

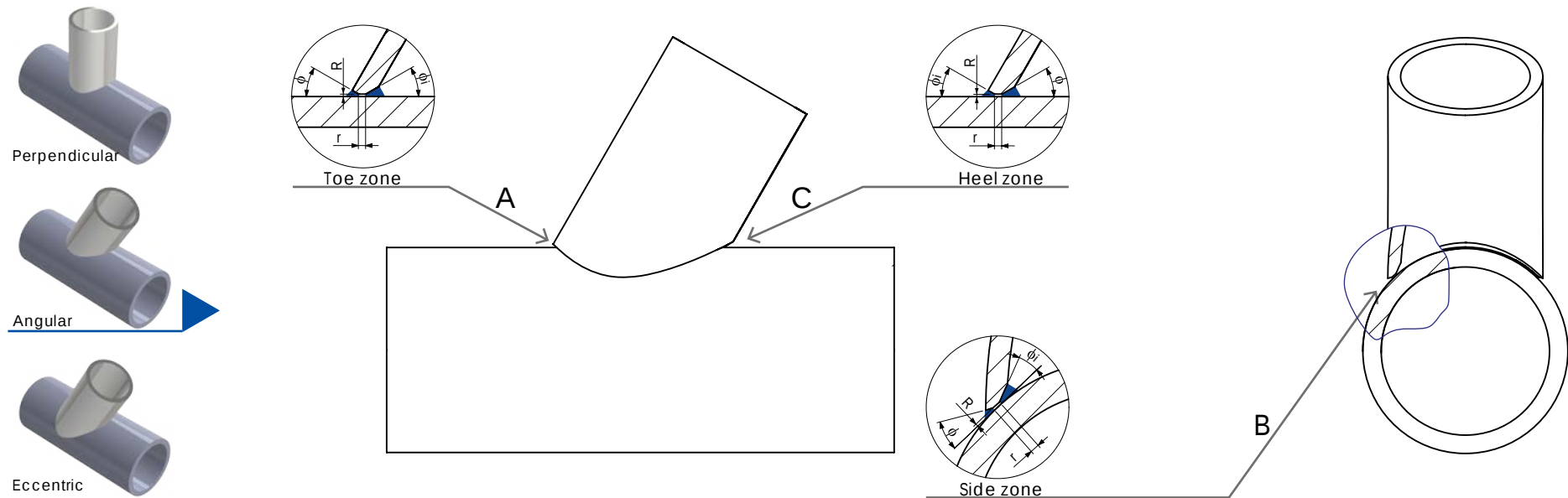
A pipe to pipe connection with Weld Volume Reduction for thick walled pipes.

Intersection geometry

- Adjustable slope.
- Adjustable eccentricity.

Weld preparation

- Adjustable groove angle (ϕ) and depth of groove.
- Adjustable inside groove angle (ϕ_i) and depth of groove.
- A total groove depth ($\phi + \phi_i$) less than the wall thickness will automatically generate a root face (r)*.
- Adjustable root opening (R).
- Shrinkage compensation.



*minimum length to cut a root face is 3 mm.

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Hole set-on

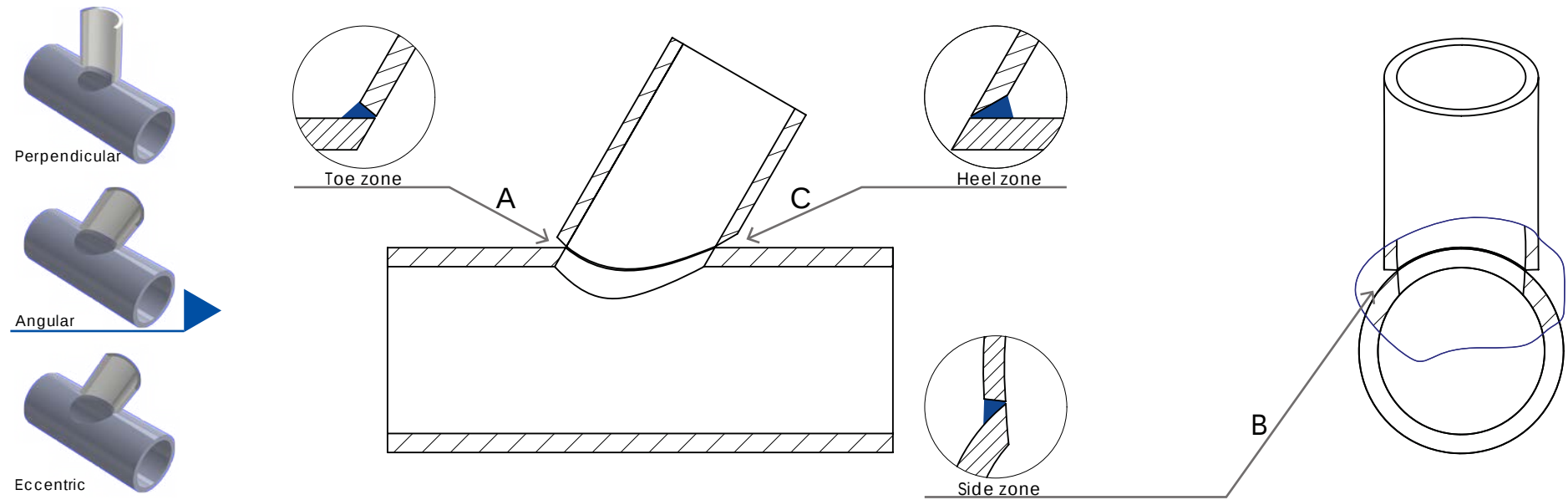
To fit a saddle on a hole for example. Saddle is shown to view an application.

Intersection geometry

- Adjustable slope.
- Adjustable eccentricity.

Weld preparation

- None



Saddle Offshore

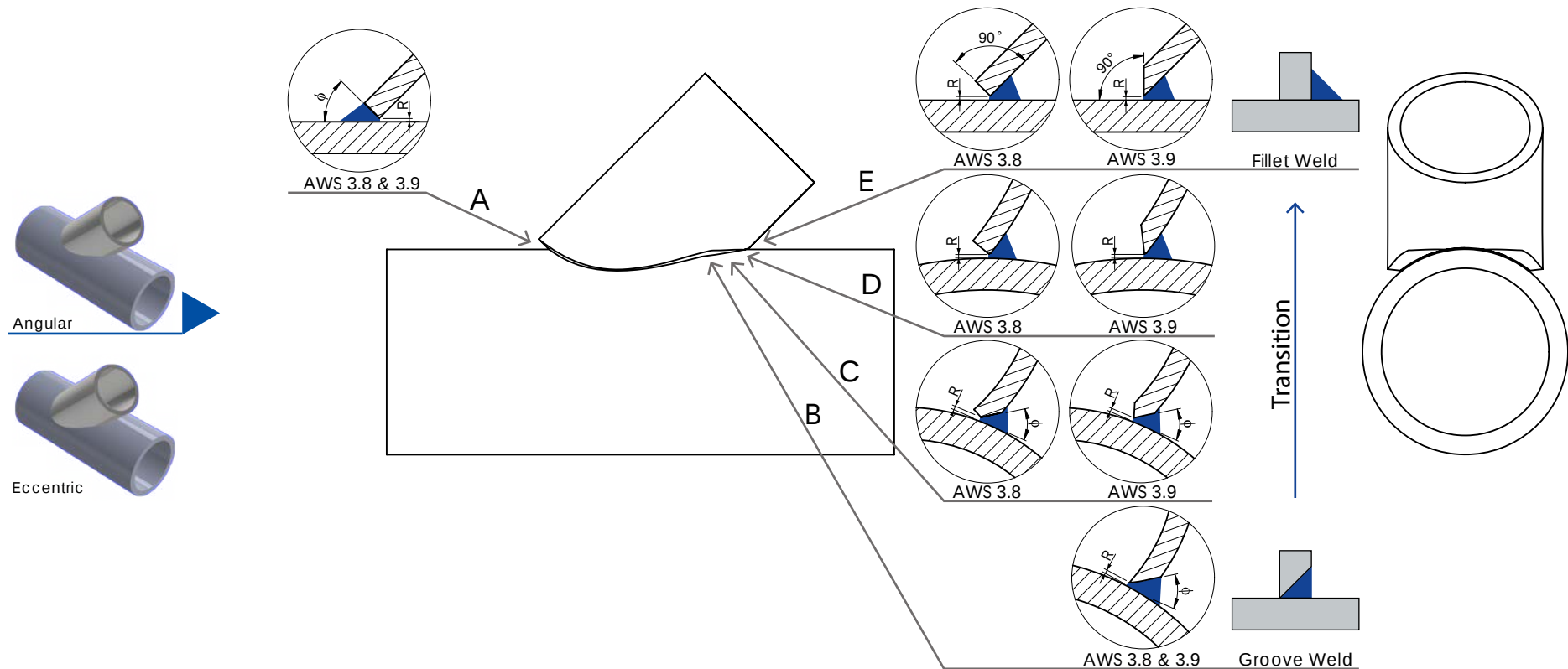
A pipe to pipe connection with a slope less than 50° based on AWS for offshore industries.

Intersection geometry

- Adjustable slope <45°.
- Adjustable eccentricity.

Weld preparation

- Adjustable groove angle (ϕ).
- Transition zones: fixed start and end point by dihedral angle (ψ).
- Heel zone; choice between AWS 3.8 & 3.9. AWS 3.9 represents also figure 3.10.*
- Adjustable root opening (R).
- Shrinkage compensation.



*Reference: Structural Welding Code AWS D1.1/D1.1M:2010; page 121-123. (AWS 1=figure 3.8; AWS 2=figure 3.9 & 3.10)
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Saddle Offshore ATB

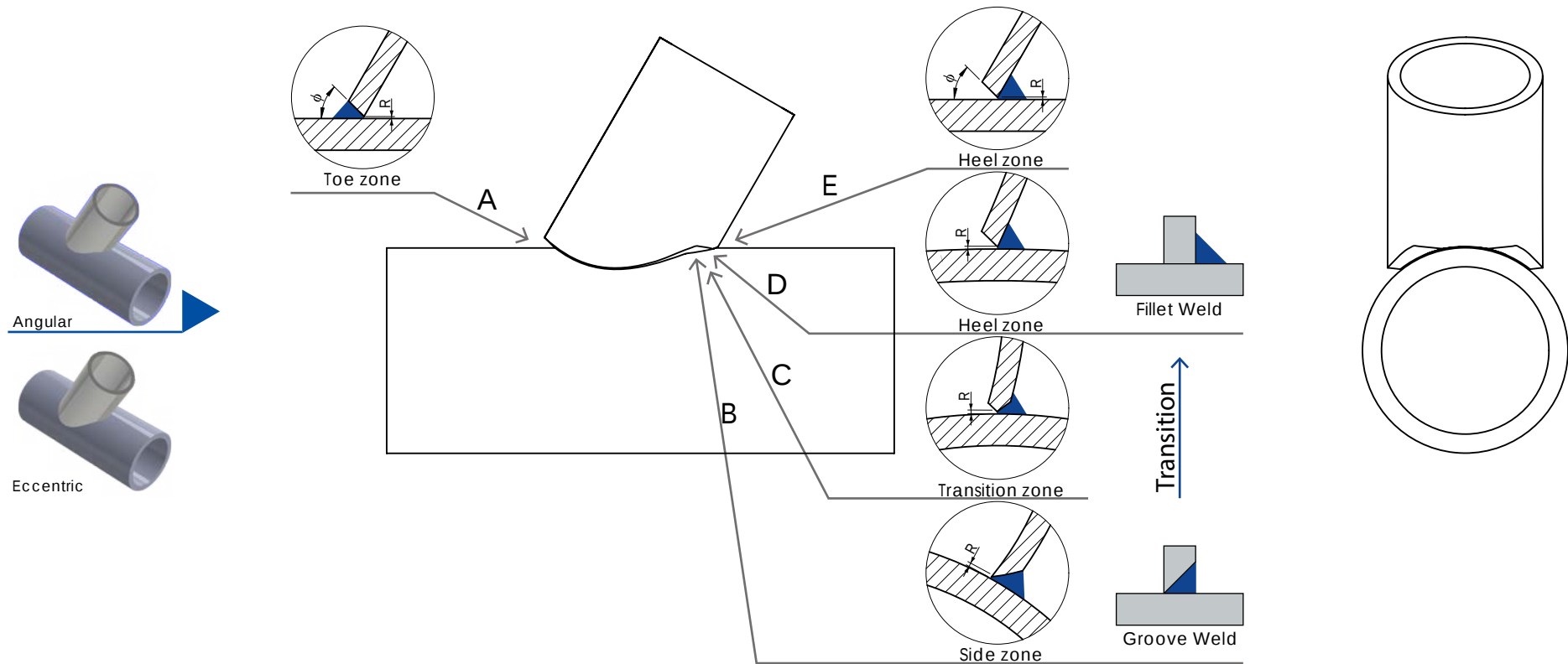
A pipe to pipe connection with extended weld preparation features for offshore industries.

Intersection geometry

- Adjustable slope $<60^\circ$.
- Adjustable eccentricity.

Weld preparation

- Adjustable groove angle (ϕ).
- Adjustable inside groove angle (ϕ_i).
- Transition zones: adjustable start and end point by dihedral angle (ψ).
- Adjustable root opening (R).
- Shrinkage compensation.



Saddle PJP

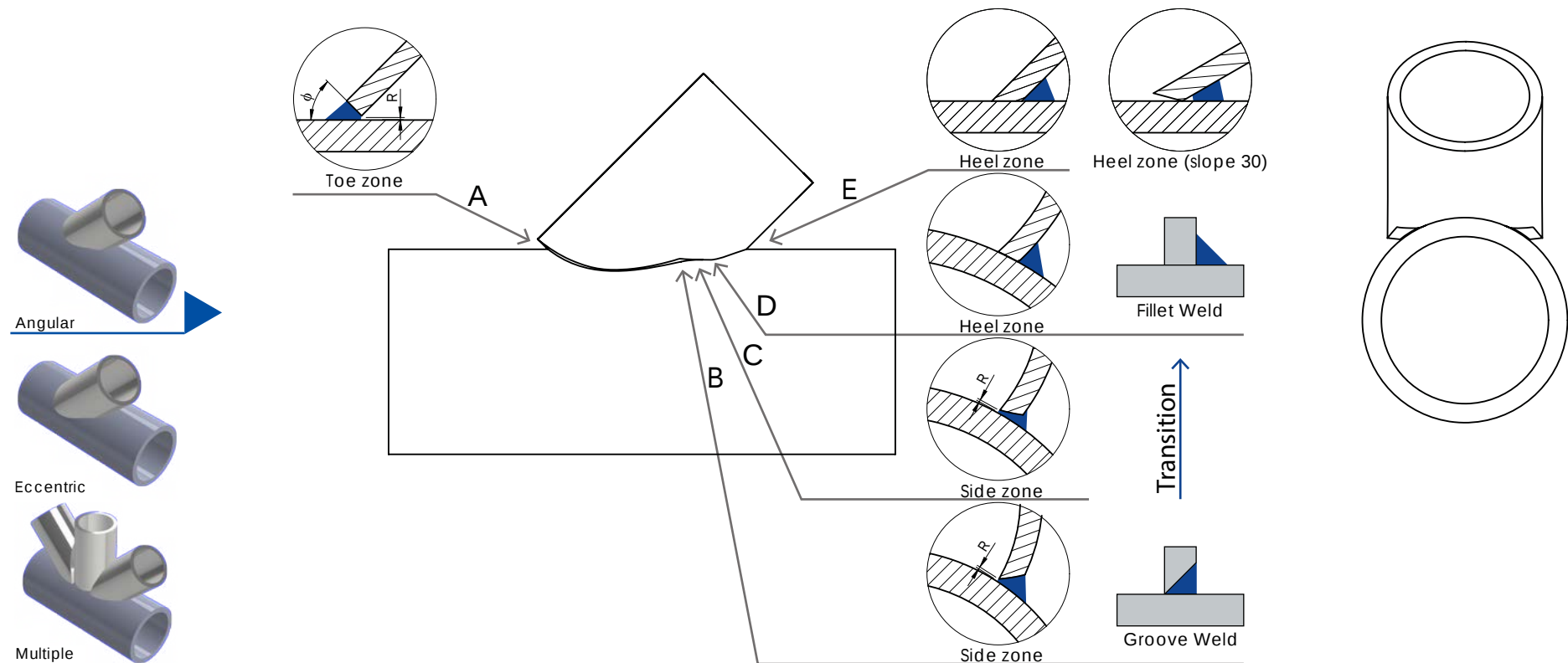
For small sloped and highly dynamic pipe to pipe connections. Easy cutting, fitting and welding.

Intersection geometry

- Adjustable slope.
- Multiple saddle feature.

Weld preparation

- Adjustable groove angle (ϕ).
- Transition zones: predefined start and end point by dihedral angle (ψ). ($95^\circ - 70^\circ$).
- Adjustable root opening (R).
- Easy fitting: no need for spacers to create the root opening and the slope. The large heel zone will fixate the correct position.



Saddle set-in & Hole set-in

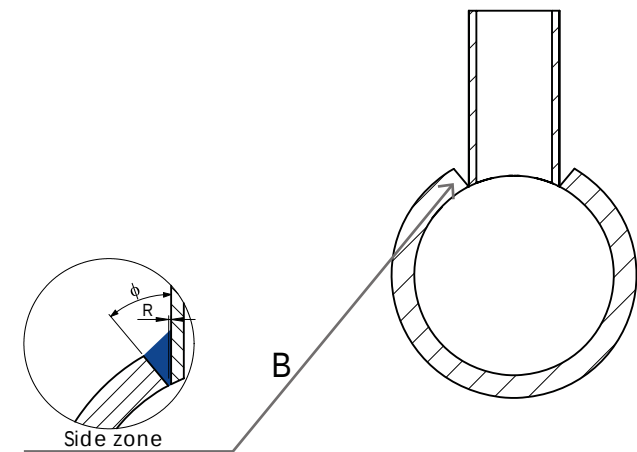
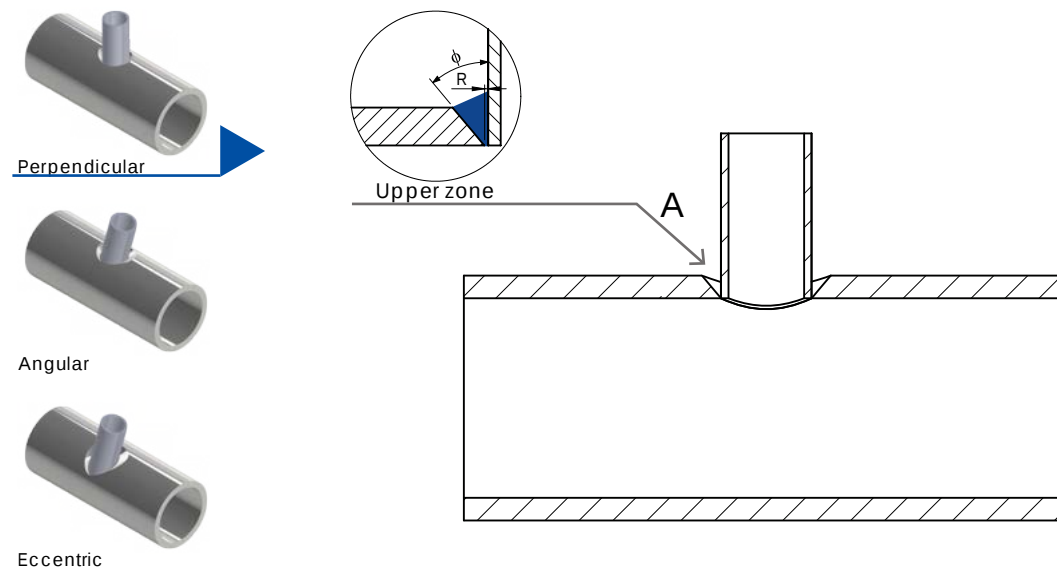
For pressure connections with a much smaller branch pipe diameter.

Intersection geometry

- Adjustable slope.
- Adjustable eccentricity.

Weld preparation

- Adjustable groove angle (ϕ).
- Adjustable root opening (R).



Hole set-in X-cut

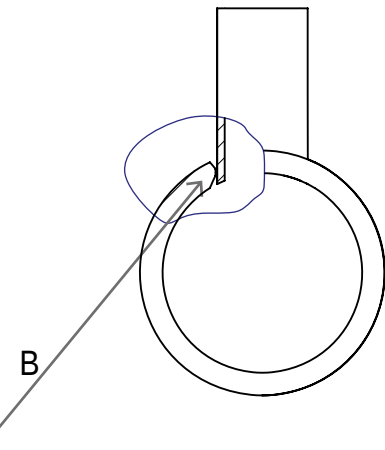
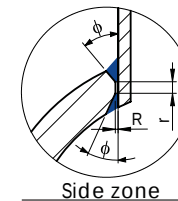
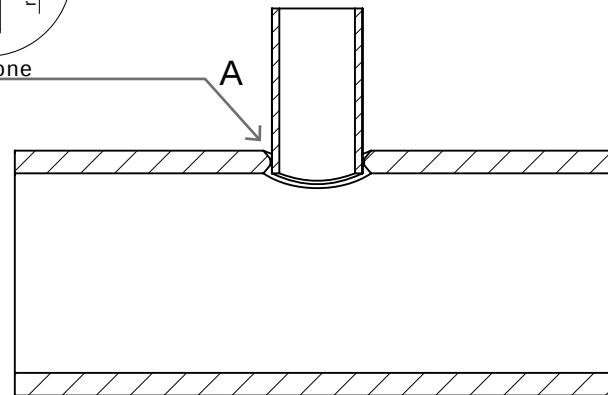
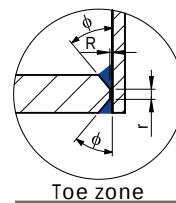
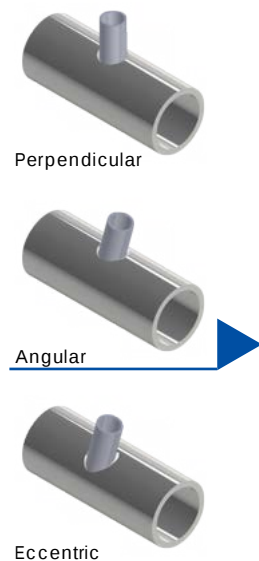
A hole with advanced bevelling options for weld volume reduction on thick walled pipes. Showed with saddle set-in.

Intersection geometry

- Adjustable Slope.
- Adjustable eccentricity.

Weld preparation

- Adjustable groove angle (ϕ) and depth of groove.
- Adjustable inside groove angle (ϕ_i) and depth of groove.
- A total groove depth ($\phi + \phi_i$) less than the wall thickness will automatically generate a root face (r)*.
- Adjustable root opening (R).
- Shrinkage compensation.



*minimum length to cut a root face is 3 mm.
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Slotted Hole

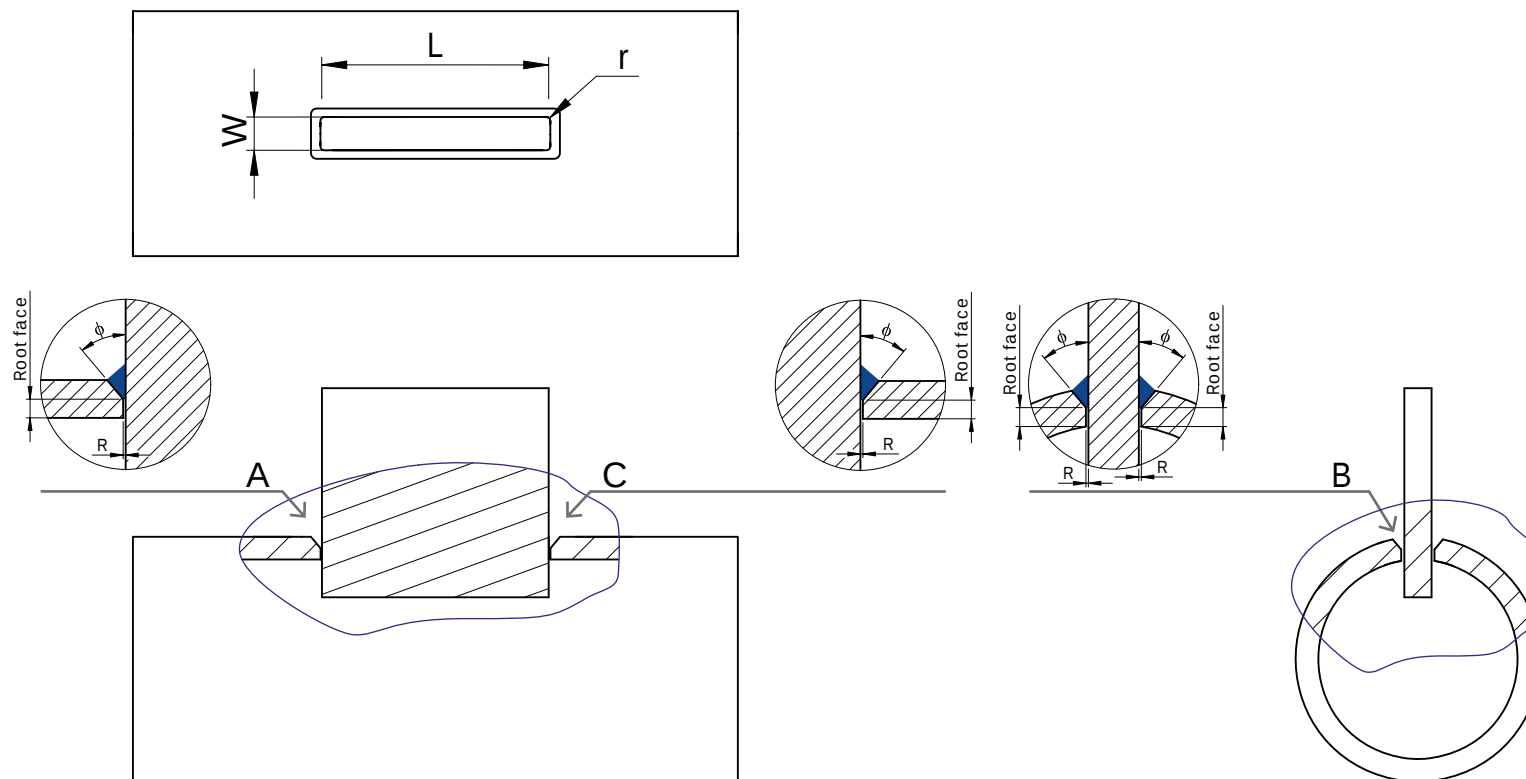
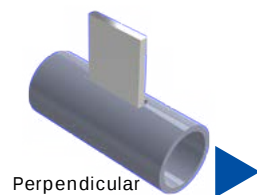
To fit plates centred into a pipe by creation of intermediate slotted holes with root face for weld volume reduction or better fit.

Intersection geometry

- Adjustable width (W) and length (L) of slot.
- Adjustable radius (r).

Weld preparation

- Adjustable groove angle (ϕ) along width and length sides independently.
- Adjustable root face*.
- Adjustable root opening (R).



*minimum length to cut a root face is 3 mm.

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Sphere Saddle

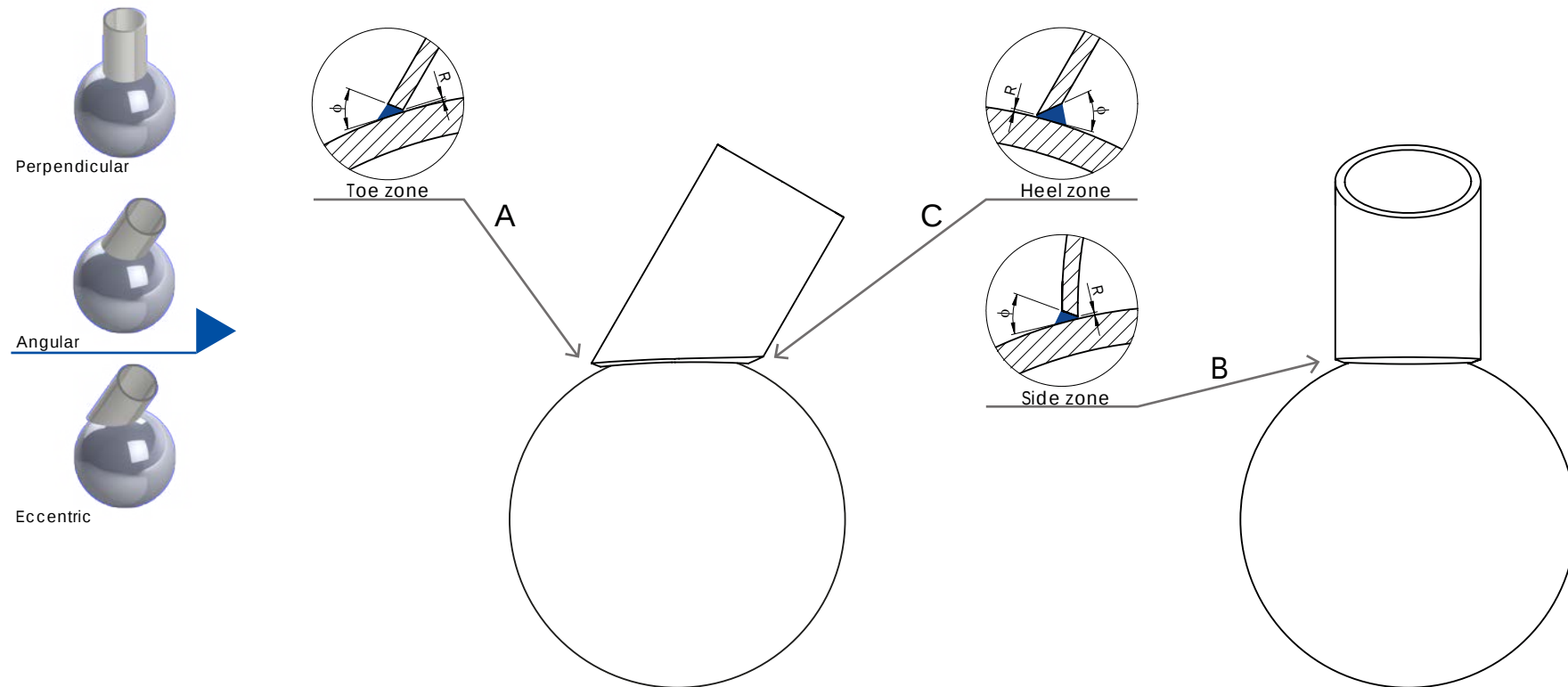
To connect a pipe to a ball.

Intersection geometry

- Adjustable Slope.
- Adjustable eccentricity.

Weld preparation

- Adjustable groove angle (ϕ).
- Adjustable root opening (R).
- Shrinkage compensation.



Y Piece

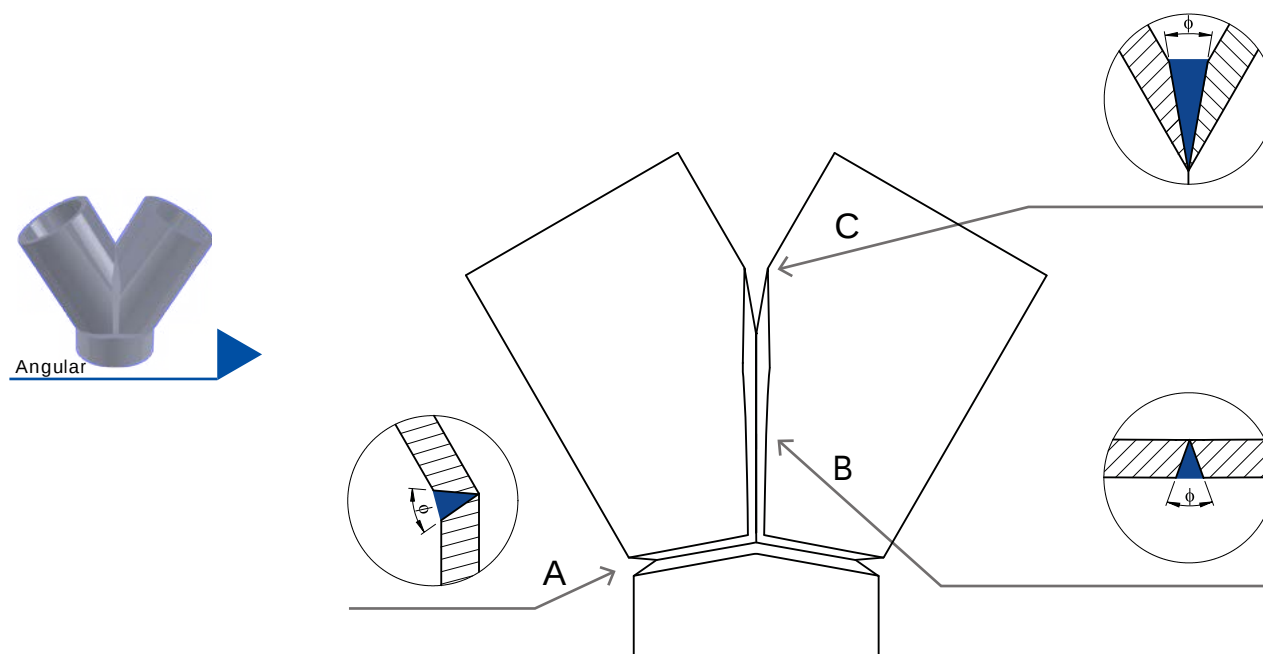
A pipe to pipe connection made of three profiled pipes, to split or combine a flow of liquids or gasses symmetrically.

Intersection geometry

- Adjustable slopes.

Weld preparation

- Adjustable groove angle (ϕ).



Box Section to Pipe, Saddle

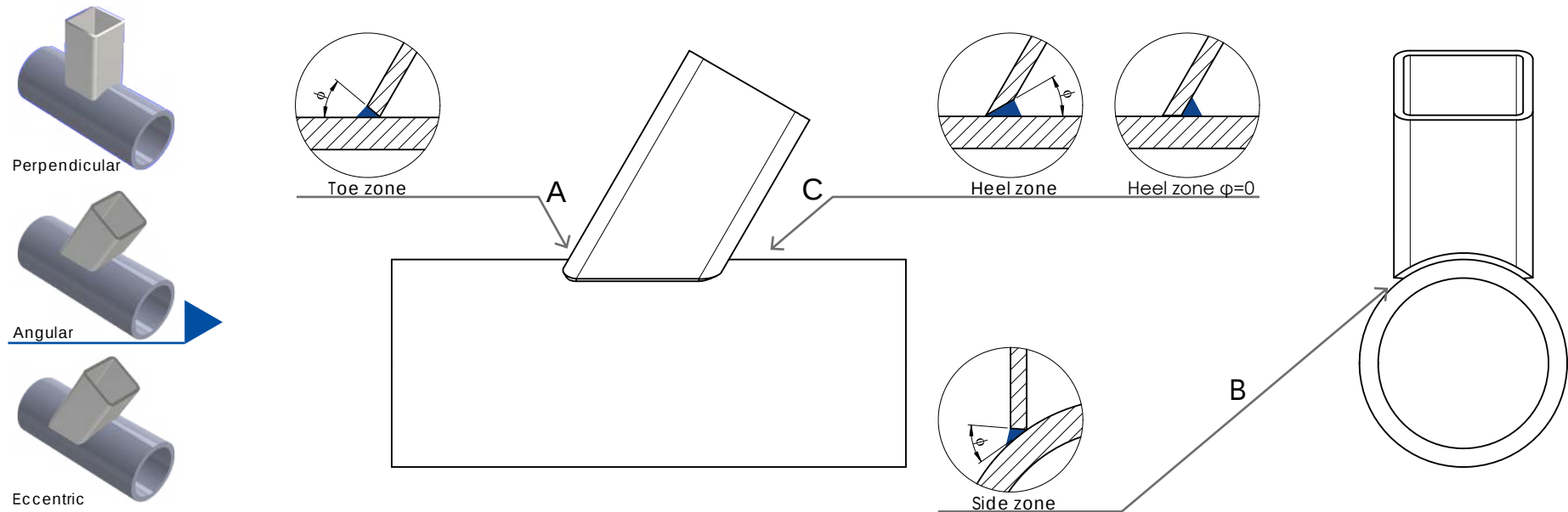
To connect a box section to a pipe.

Intersection geometry

- Adjustable slope.
- Adjustable eccentricity.

Weld preparation

- Adjustable groove angle (ϕ) on all sides independently.
A groove opening of 0 degrees in the heel zone allows a fillet weld for small sloped connections.



Box section set-in

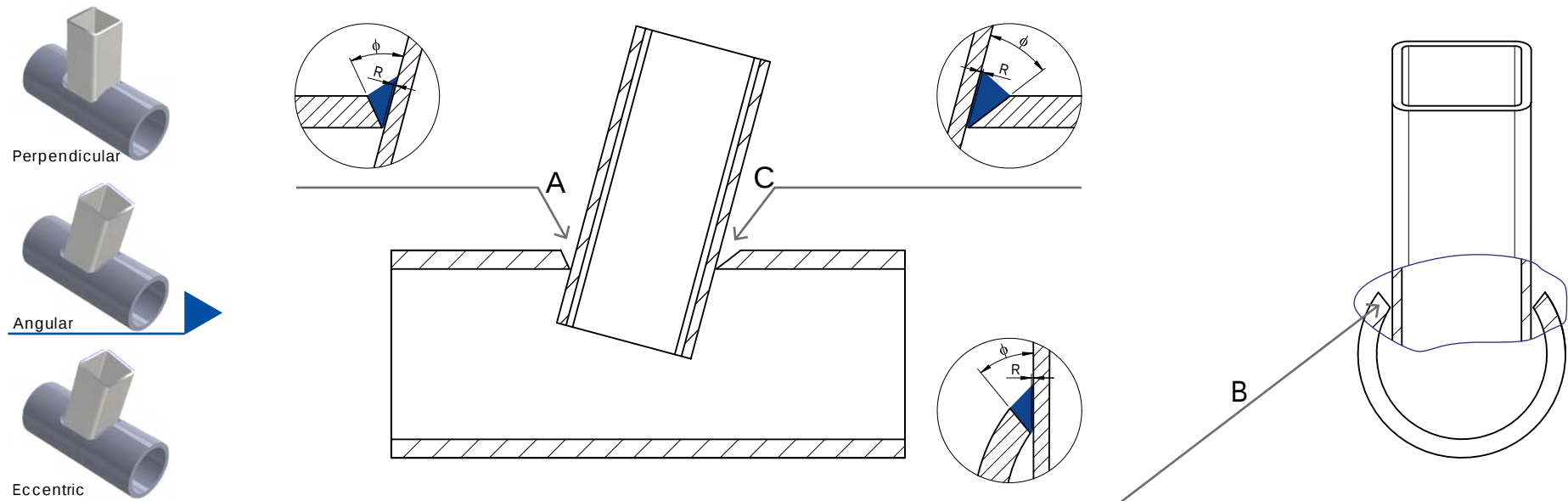
A box section to pipe connection wherefore the box section don't need to be profiled.

Intersection geometry

- Adjustable slope.
- Adjustable eccentricity.

Weld preparation

- Adjustable groove angle (ϕ).
- Adjustable root opening (R).



Box Section, Hole set-in

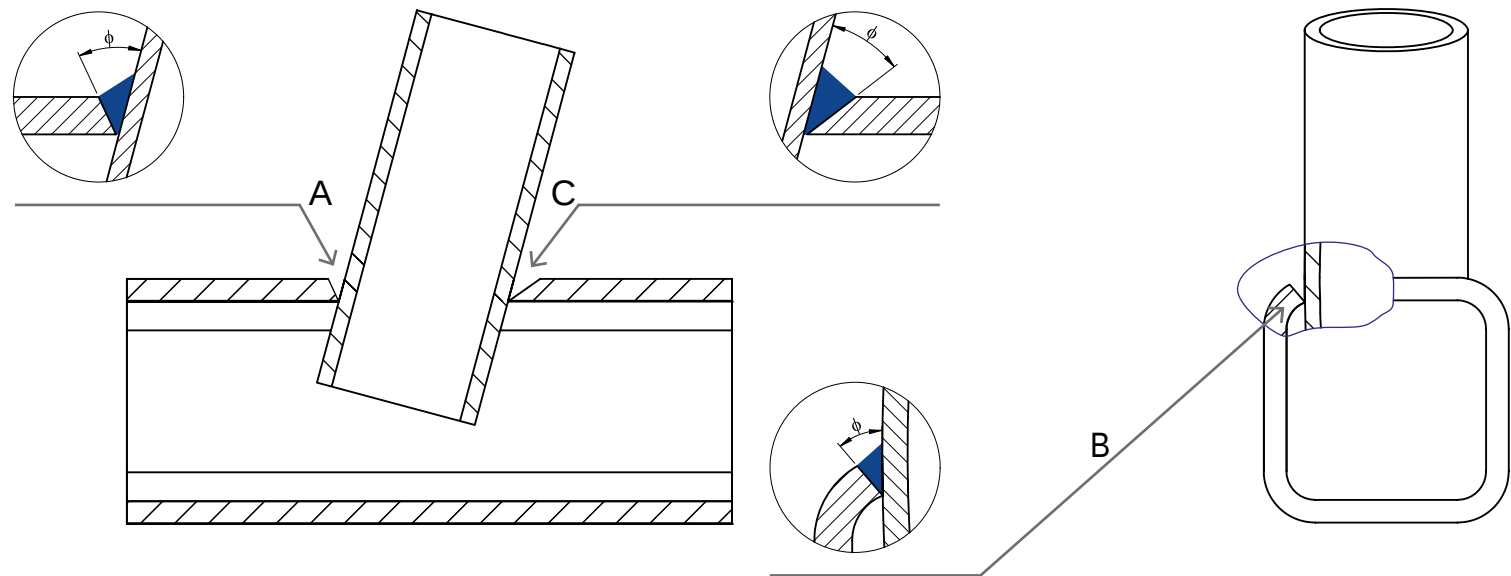
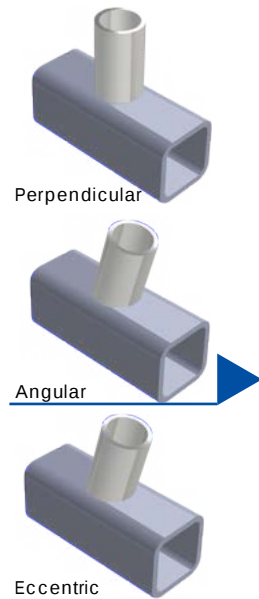
A pipe to box section connection to fit round bars or pipes for example.

Intersection geometry

- Adjustable slope.
- Adjustable eccentricity.

Weld preparation

- Adjustable groove angle (ϕ).



Pipe to Box Section, Edge Chamfer

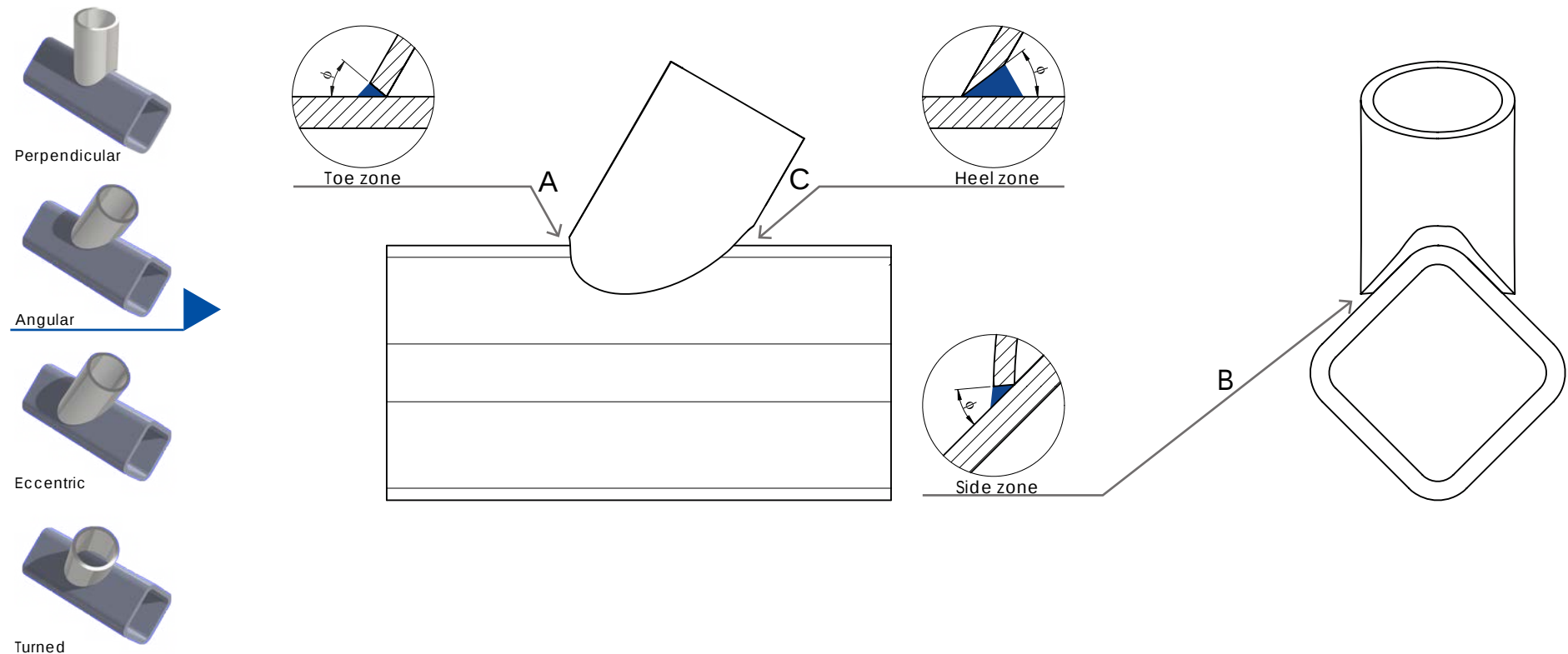
To connect a pipe to the edge or the side of a box section.

Intersection geometry

- Adjustable Slope.
- Adjustable eccentricity.
- Adjustable turn.
- Adjustable box section radius.

Weld preparation

- Adjustable groove angle (ϕ).



Box Section Chamfer

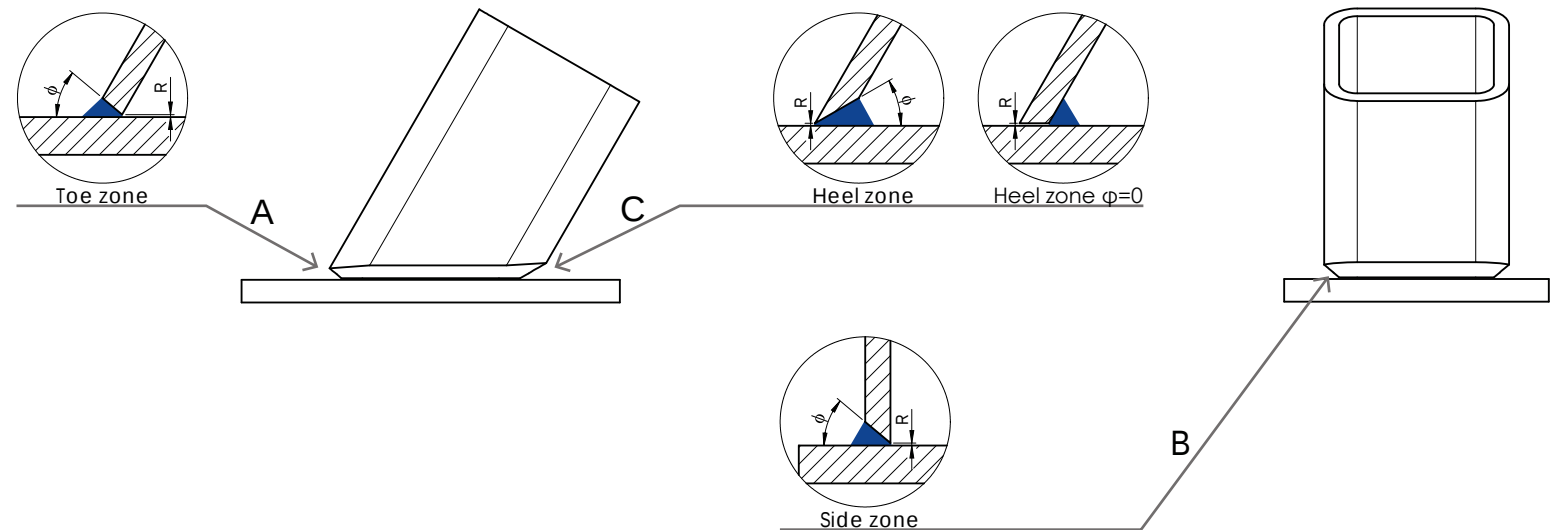
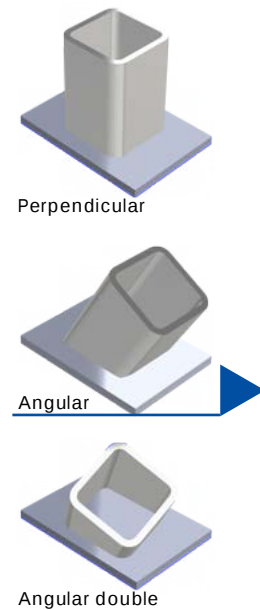
A box section to plate connection.

Intersection geometry

- Adjustable slope in two directions.

Weld preparation

- Adjustable groove angle (ϕ) on all sides independently.
A groove opening of 0 degrees in the heel zone allows a fillet weld for small sloped connections.



Box Section Edge Chamfer

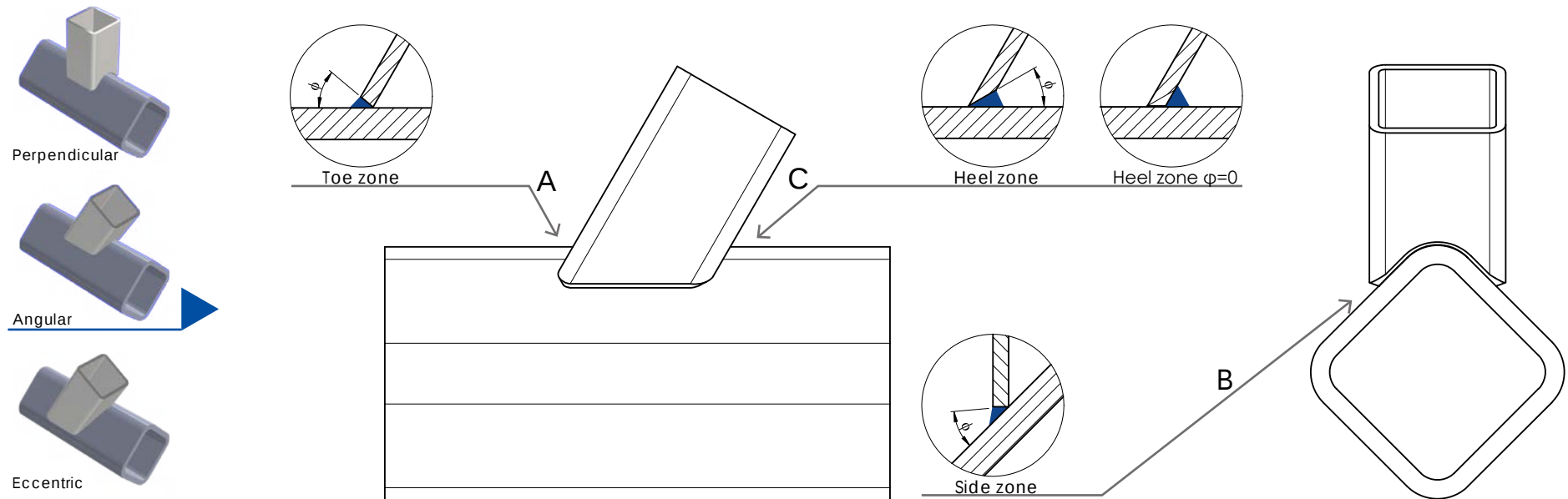
To connect a box section to the edge of a box section or two plates.

Intersection geometry

- Adjustable Slope.
- Adjustable eccentricity.
- Adjustable box section radius.

Weld preparation

- Adjustable groove angle (ϕ) on all sides independently.
A groove opening of 0 degrees in the heel zone allows a fillet weld for small sloped connections.



Box Section Nose

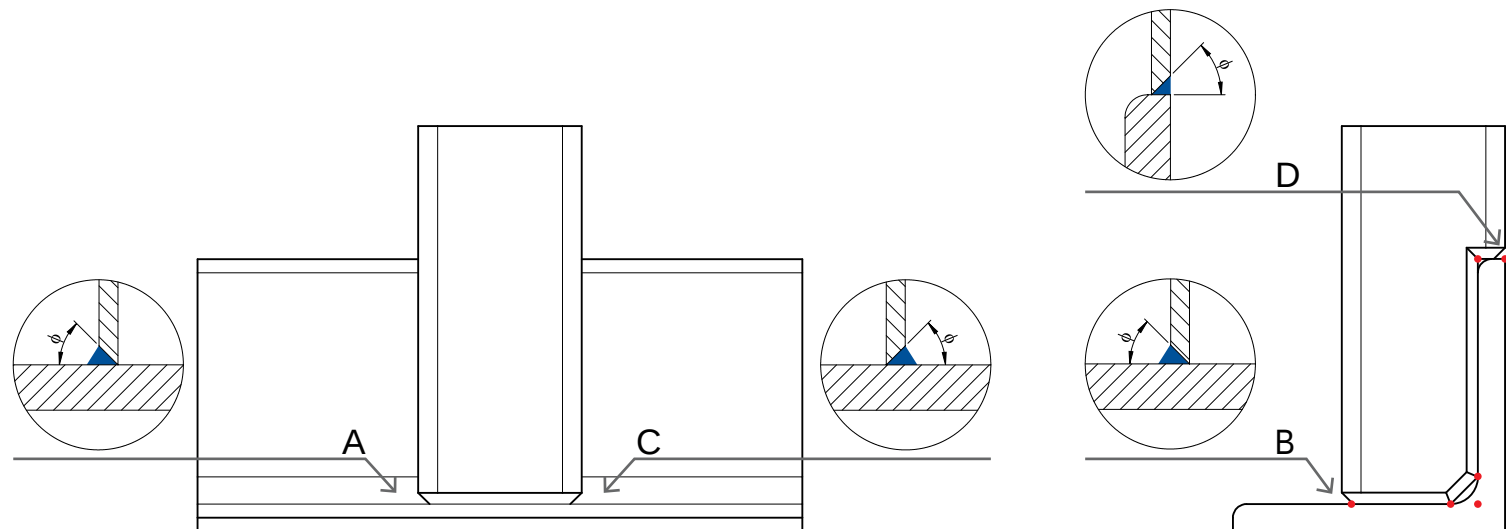
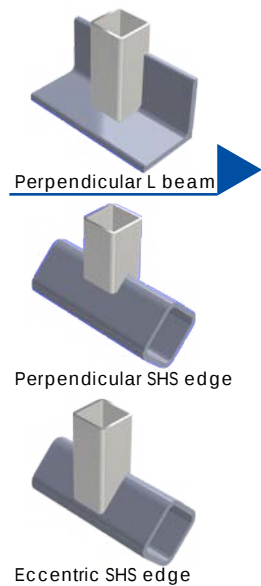
Box section profiling shape with a lot of parameters to fit many different contours.

Intersection geometry

- Highly versatile shape achieved by edge positioning using X and Y coordinates (red dots).

Weld preparation

- Adjustable groove angle (ϕ).



Many other possible

Box Section Slot

To fit inserted plates at box section ends or to create intermediate oblong holes.

Intersection geometry

- Adjustable eccentricity.
- Adjustable width (W) and length (L).
- Adjustable radius (r).

Weld preparation

- Adjustable groove angle (ϕ) along width and length sides independently.

