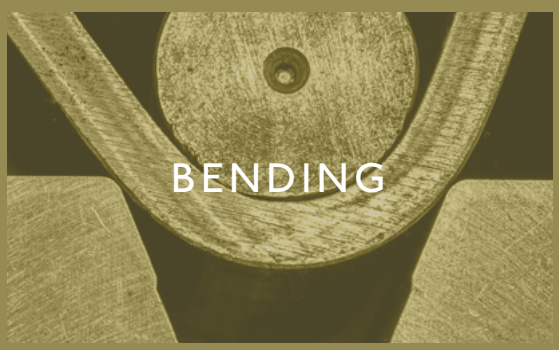
PROTAC

WORKSHOP RECOMMENDATIONS









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PROTAC

CUTTING

PROTAC steel grades are classified as high-strength steels. Because of their relatively high CEV value, take special care when cutting the plates into final parts. We recommend three cutting methods.

WATERJET CUTTING

Waterjet cutting is the preferred cutting method for PROTAC plates of all thicknesses. Waterjet cutting applies no heat to the material, so no heat-affected zone (HAZ) is present on the plate. When cutting with waterjet, check the cut-edge quality and ensure the striated cutting lines are removed from the cut edge.

LASER CUTTING

Laser cutting is a thermal cutting method that creates a HAZ up to 2 mm wide. Because of microstructural changes and increased hardness, remove this area before further processing. Elevated hydrogen levels in the cut-edge area further increase the risk of cracking. Special attention is therefore required, as cut-edge cracks may develop within hours or even several weeks after cutting.

OXY-FUEL OR PLASMA CUTTING

This method is less advisable. Gas cutting generates an even wider HAZ. The large temperature differences increase the risk of cracking, which increases with plate thickness.

HOW TO PREVENT CUT-EDGE CRACKING

The best way to reduce the risk of cut-edge cracking is by preheating before cutting. Preheating reduces the temperature difference and thus lowers the risk of cracking. The maximum recommended preheating temperature depends on the PROTAC steel grade and should not be exceeded, as higher temperatures may reduce hardness. Additional controlled cooling of the plates is also recommended – if possible, it is best to cool the plates by piling.

Table: Recommended preheat temperature range

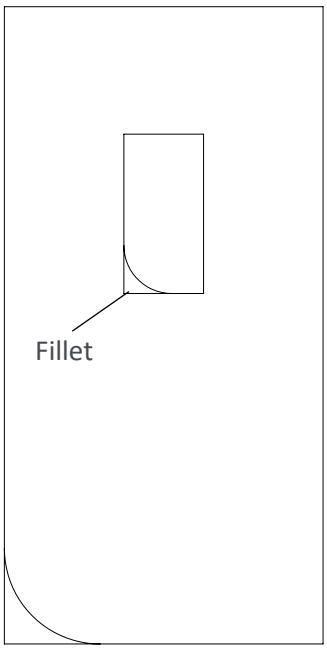
Steel grade	Min. temperature [°C]				Max. temperature [°C]
	6–15 mm	15.01–25 mm	25.01–30 mm	30.01–40 mm	
PROTAC 500	Room temp.	125	140	150	180
PROTAC 550	120	140	140	140	160
PROTAC 600	140	140	140	140	160
PROTAC 650	120	120	-	-	150

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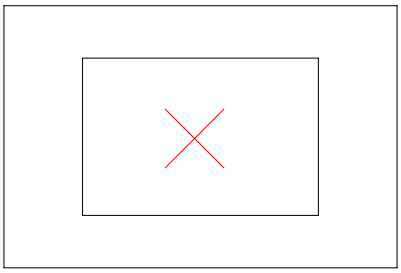
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CUT DESIGN

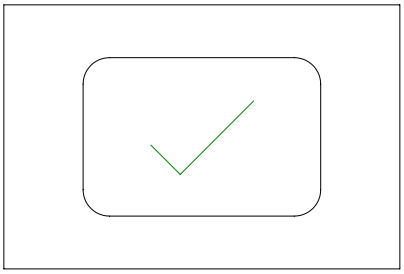
When cutting shapes out of plates, avoid sharp corners and use fillets instead. As shown in the figure, cutting fillet corners in slots is much more advisable than cutting sharp corners, as it avoids a notch effect. Moreover, we recommend avoiding chamfered slot corners and using circular slot corners instead.



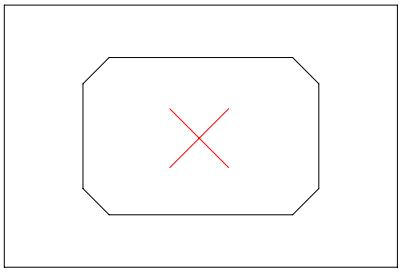
Avoid sharp corners



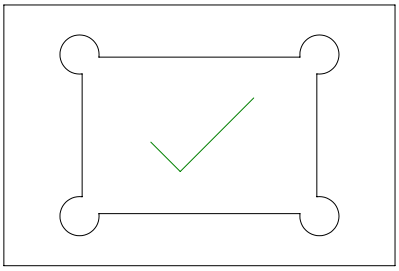
Slot sharp corners



Slot fillet corners



Slot chamfer corners



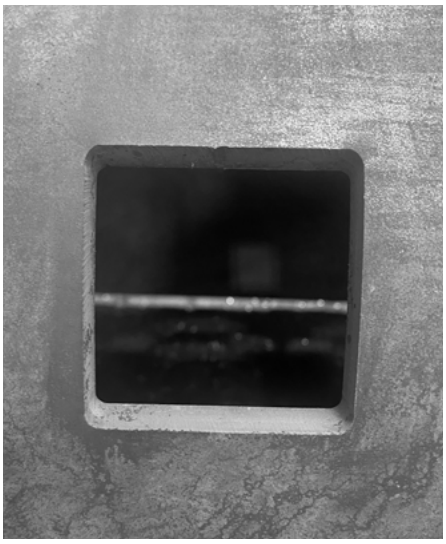
Slot circular corners

Adjust the cutting machine parameters to prevent striations on the cut edge. If striations do appear, the edge must be ground after cutting.

After cutting, ensure that the cut edge is of good quality. We recommend grinding the edge to remove any imperfections that could initiate cracking.

Photo: Same plate – big difference. Sharp corners (left) result in a notch effect and cracking after bending. Slot fillets (right) allow for bending without cracking.





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BENDING

PROTAC steels are bendable. However, certain parameters and guidelines must be considered. The following recommendations help end-users achieve high-quality bends, prevent cracking and improve safety.
Bending PROTAC 650 is not recommended.

BENDING RADIUS

Use the recommended **bending radius** for the relevant PROTAC steel grade and plate thickness, as specified in the table below. A smaller radius increases the risk of cracking.

If possible, **bend transverse** to the plate rolling direction, as shown in the picture. Keep the bending angle as low as possible, especially for higher-hardness grades.

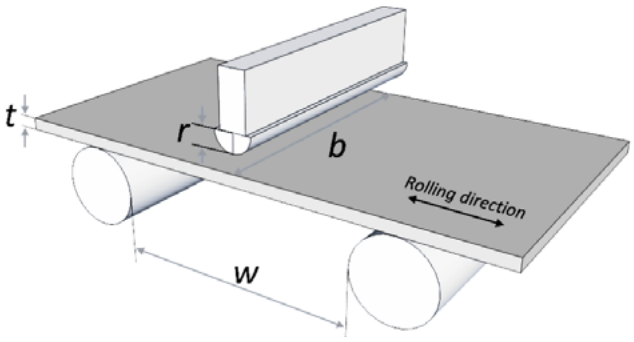


Figure: Schematic representation of bending with the indicated bending parameters (b – bending line, t – plate thickness, r – punch radius, and w – die opening width).

Table: Recommended punch radius, die opening width and maximum bending angle.

Steel grade	Thickness [mm]	r/t Transverse	r/t Longitudinal	Min. w Both directions	Max. angle [°] Both directions
PROTAC 500	≤ 8	6	7	$w = 2r + 5t$	90
	8.01–15	7	8		90
	15.01–22	8	9		90
PROTAC 550	≤ 10	15	16		20
PROTAC 600	≤ 10	15	16		20
PROTAC 650	bending PROTAC 650 is not recommended				

Use a **low punch speed** with intermediate stops (multi-stop) during bending. This reduces stress accumulation in the workpiece, lowers the risk of cracking, and improves safety.

SPRINGBACK

Springback occurs due to the relaxation of elastic stresses in the material and must be considered during bending. Overbend the material by 10–15° to achieve the required final angle. The higher the yield strength, the greater the springback angle (PROTAC 500 < PROTAC 550 < PROTAC 600).

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RECOMMENDED PROCESSING TEMPERATURE

The workshop temperature affects the bending process. For optimal bending, ensure that the plate remains at room temperature or higher. This is especially important during winter and in colder environments.

Do not exceed the maximum temperatures, as higher temperatures may reduce hardness and impair mechanical and workshop properties, including bendability.

Steel grade	Min. temperature [°C]	Max. temperature [°C]
PROTAC 500	20 °C	180
PROTAC 550		160
PROTAC 600		160
PROTAC 650		130

EDGE PREPARATION

Plate edges can act as weak points for crack initiation. Keep them free of cutting-related imperfections. We recommend grinding the edges and the tensile side of the plate directly under the punch. Grinding the edges removes the HAZ created by laser, oxy-fuel, and plasma cutting, reducing the risk of cracking.

PART DESIGN

Avoid bending over potential crack initiators, such as sharp edges, corners, and cutouts, and minimise them where possible. These features become increasingly critical as the steel hardness increases.

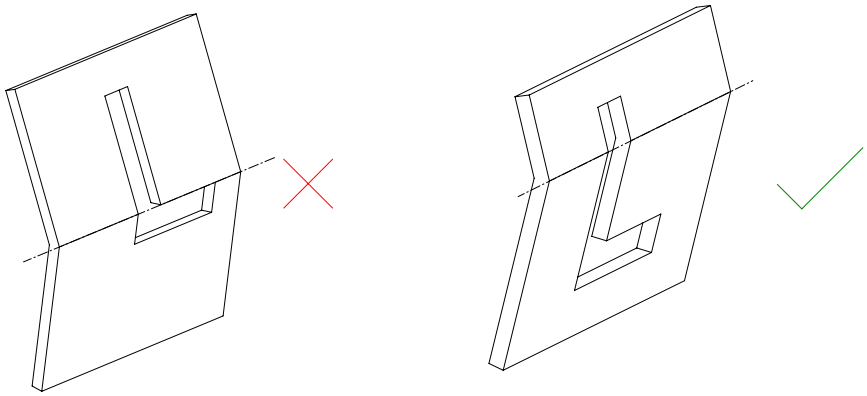


Figure: Schematic illustration of incorrect (left) and correct (right) bending of PROTAC steel.

STRAIGHTENING

PROTAC steel plates may become distorted during processing, welding, cutting, transport or handling. If necessary, straighten the plates using suitable mechanical methods. Avoid hot flame straightening and hammering.

Ensure that the plate remains at room temperature or higher during straightening. If heating is required, do not exceed the maximum allowable temperature for the relevant PROTAC grade, as specified in the Recommended Processing Temperature table above.

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WELDING

PROTAC steel plates are produced with the chemical composition necessary to achieve high hardness and ballistic protection. PROTAC plates can be welded using all conventional arc welding processes. Keep the heat input during welding as low as possible to minimise softening in the HAZ and preserve high hardness and ballistic resistance.

GMAW (MIG/MAG) is the preferred welding process, as it results in very low hydrogen content in the weld metal and, consequently, low susceptibility to cold cracking. Both conventional and pulsed GMAW are suitable for welding PROTAC steel plates, with pulsed GMAW generally preferred for better heat-input control.

A recommended alternative is GTAW (TIG), as it provides very low heat input to the weld joint and has very low hydrogen content.

MMAW (MMA) is allowed only when the welding electrodes are properly dried according to the electrode manufacturer's recommendations.

PROTAC can be welded to other structural steels. When PROTAC steel plates are part of a structure, always prepare the welding procedure according to the PROTAC grade.

WELD EDGE – Safe structures require precise alignment of the plates along the weld joint line. Remove all impurities from the weld area, including scale, anti-corrosion paint, rust, grease, oil and moisture. Prepare the weld edges mechanically by milling or grinding.

TACK WELDING – Tack welds align plates before the main welding operation. Due to their rapid cooling, take care to minimise the risk of cold cracking. Each tack weld should be at least 50 mm long. Adjust welding arc settings to prevent crater cracking, especially when using austenitic electrodes.

PREHEAT AND INTERPASS TEMPERATURE RANGE

Steel grade	Min. temperature [°C]				Max. temperature [°C]
	6–10 mm	10.01–16 mm	16.01–22 mm	> 22 mm	
PROTAC 500	60	125	140	150	180
PROTAC 550	120	140	140	140	160
PROTAC 600	140	140	140	140	160
PROTAC 650	120	120	120	120	130

When using austenitic stainless-steel consumables, lower preheating temperatures than those specified in the table may be used because austenitic stainless-steel consumables are less susceptible to cold cracking. The appropriate temperature depends on the welding procedure and joint configuration. Validate any reduction in the specified preheating temperature through production trials demonstrating crack-free welding under representative production conditions.

Carefully control maximum preheating and interpass temperatures to prevent hardness drop.

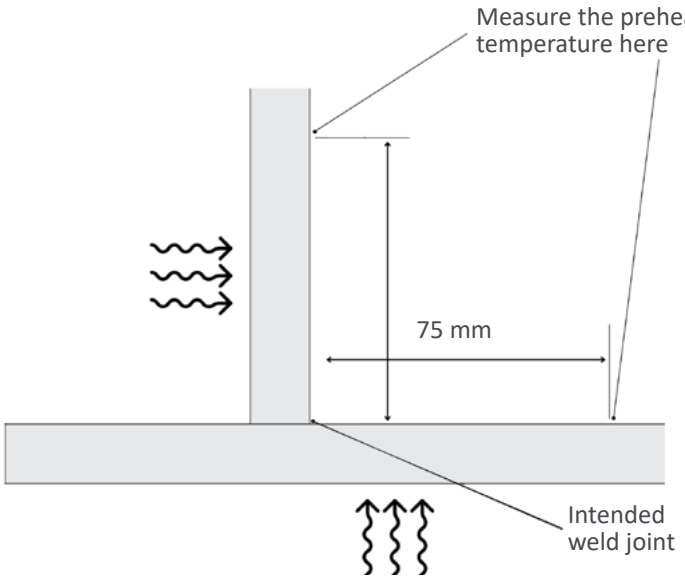
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PREHEATING METHOD AND TEMPERATURE CONTROL

Several methods can be used to preheat the weld area before welding. Open-flame preheating is typically used due to the complexity of welded structures made of PROTAC steels.

Control the temperature using temperature-indicating crayons or contact thermocouples. Measure the temperature at least 75 mm from the weld joint and at least 2 minutes after heating. Perform preheating in accordance with EN ISO 13916.



WELDING CONSUMABLES

Use welding consumables with low tensile properties to achieve high weld-metal toughness. Soft welding consumables with a yield point below 500 MPa produce weld metal with high resistance to cold cracking. Austenitic stainless-steel welding consumables are generally recommended for PROTAC steel plates due to their high toughness and ductility.

As the tensile properties of the weld joint are typically lower than those of the base metal, place weld joints in low-stress areas.

Keep the weld-metal hydrogen content below 5 ml/100 g of weld metal. This can be achieved by using solid welding wires with GMAW or GTAW. For GTAW, low-alloy consumables are not preferred, as they may result in lower weld-metal impact toughness than austenitic stainless-steel consumables.

Avoid coated electrodes when welding PROTAC 550, PROTAC 600, and PROTAC 650 due to the higher risk of hydrogen-induced cracking.

Coated electrodes for MMAW must be stored and dried according to the electrode manufacturer's recommendations.

FILLER METALS

Welding process	Austenitic consumables – Recommended	Low-alloyed consumables – Alternative
GMAW (MIG/MAG)	AWS A5.9: ER 307Si ISO: 18/8 Mn 6	AWS: ER 70 S-6 ISO: G42 5M/C G3Si1
GTAW (TIG)	AWS A5.9: ER 307Si ISO: 18/8 Mn 6	AWS: ER 70 S-6 ISO: W 42 5 W3Si1 [1]
MMAW (MMA)	AWS A-5.4: E 307-15 EN ISO 3581-A: E 18 8 Mn B 22	AWS A-5.1: E7018 EN ISO 2560-A: E 42 4 B 32 H5 AWS A-5.5 E10018-G EN ISO 18275-A: E 69 6 Mn2NiCrMo B 42 H5

[1] For GTAW, austenitic stainless-steel consumables are preferred. Solid ferritic welding wires may result in lower weld metal impact toughness.

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WELD DESIGN

Consider the following precautions when designing parts from high-strength PROTAC steels. Do not weld directly on the bending line, as shown in Solution 1 in the figure below. Welding on the bending line increases the risk of cracking, especially for PROTAC 550 and PROTAC 600, because stress buildup on the tensile side of the bend can exceed the critical point and cause cracks to propagate across the bending line.

For Solution 1, position the weld at least 80 mm from the bending line. Alternatively, add a plate at the bending line and weld onto the add-on plate, as shown in Solution 2.

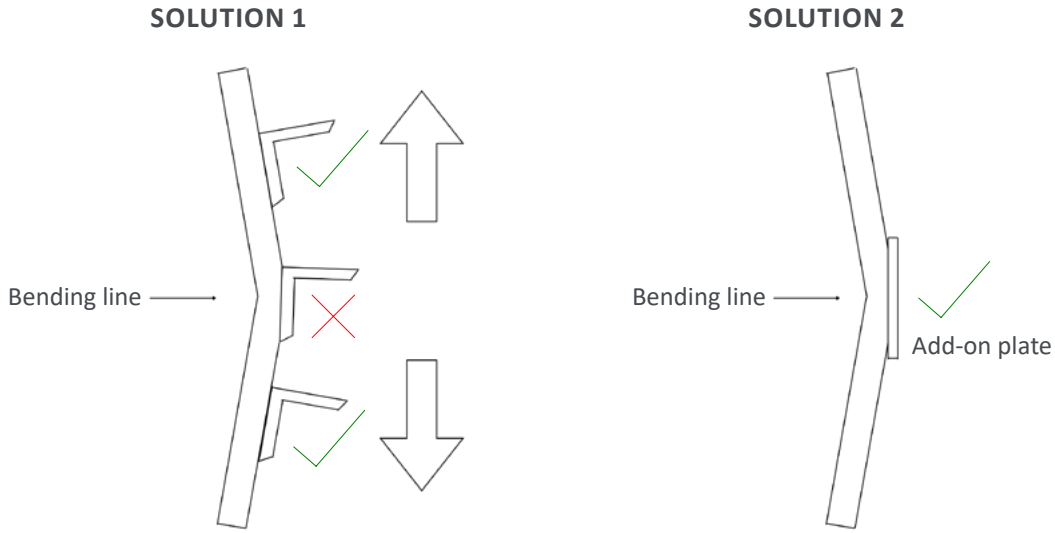


Figure: Schematic representation of alternative design solutions to avoid cracking on the bending line after welding.

If the application requires a higher level of ballistic protection, PROTAC 650 is particularly suitable. We recommend riveting the plate onto the structure instead of welding.

WELD AND HEAT-AFFECTED ZONE

The weld and HAZ are structurally weaker areas of the welded component. Because of local changes in hardness and mechanical properties, these areas should not be expected to provide the same level of ballistic protection as the unaffected PROTAC base material. The width of the affected area depends on the plate thickness, welding process and welding parameters.

The information and data in this manual are intended for informative purposes only and may be revised at any time without notice. Presented typical properties and design recommendations are provided only to help readers make their own evaluations and decisions. It is the user's responsibility to adjust the recommendations in this manual to meet the specific needs of their application. SIJ Acroni explicitly disclaims any liability for the suitability of these recommendations for particular applications.

PROTAC-WR-4/10-2026-EN

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