SECURE
Protection Steels

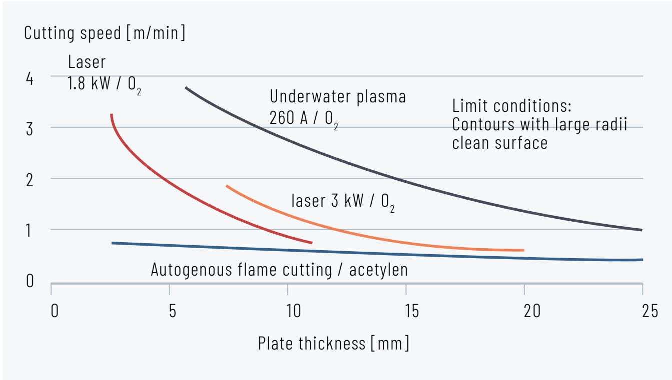
RECOMMENDATIONS FOR

CUTTING OF ARMOUR STEELS

ILSENBURGER GROBBLECH
A Member of the Salzgitter Group

1. GENERAL

Ilsenburger Grobblech produces heavy plates for ballistic protection with the brand name **SECURE**. These steels are primarily used for civilian vehicles and buildings. The ballistic protection and high hardness of the steels **SECURE 400, 450, 500** and **600** result from the special chemical composition of the compound with a coordinated heat treatment by water quenching and tempering. Due to their alloy composition and high hardness, certain measures must be considered to ensure safe processing.



Thinner sheets should predominantly be laser cut. 40 mm or thicker sheets should be plasma cut. This delivers highest cutting speeds. Thicker sheets may be autogenous flame cut with preheating and post heating.

Recommended cutting processes for SECURE

Sheet	Preferred
up to 12 mm	laser cutting underwater plasma cutting
> 12 – 40 mm	underwater plasma cutting abrasive waterjet cutting autogenous flame cutting *)
over 40 mm	abrasive waterjet cutting autogenous flame cutting *)

*) with preheating and, if necessary, post heating

As an alternative to thermal processes, abrasive waterjet cutting is an excellent way to produce even difficult contours without cracks or loss of hardness. In individual cases, abrasive cutting may be applicable.

2. LASER BEAM CUTTING

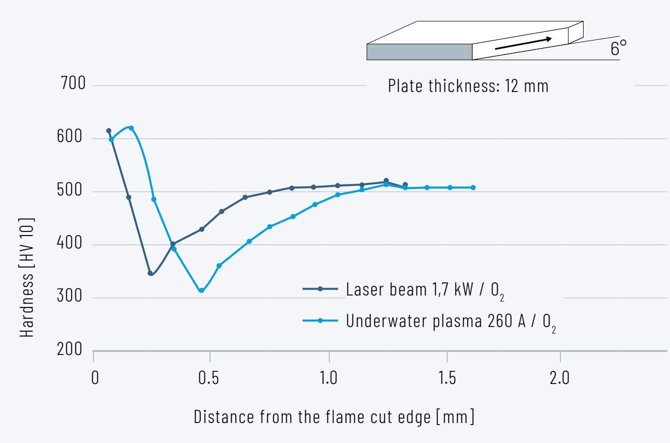
Laser cutting has become a standard process. CO_2 lasers with a power of 3 kW now cut up to 20 mm sheets. The achievable cutting speed depends on the intensity of the laser light and is therefore influenced by focusing the radiation. High purity oxygen is preferably deployed as cutting gas. The formation of the gas flow is also crucial for the quality of the cut. When cutting closely adjacent components, a suitable cutting sequence should be applied to prevent the sheet from heating up excessively (> 120 °C) during cutting.

The condition of the material surface also has an important influence on the quality of the cut. Corrosion, strong roughness (sandblasting), contamination or damage to the plate surface should be avoided. Thin, firmly adhering scale layers do not interfere with the cutting process. On the other hand, paint coatings with an excessive layer thickness can be disadvantageous for thinner plates. When coating heavy plates, an inorganic silicate store primer with a low zinc content is used as standard. If the cutting parameters are finely tuned, the top cutting quality according to DIN EN ISO9013 can be achieved also when cutting primed plates.

During thermal cutting, a very high temperature is briefly reached in the area of the cut edge, followed by very rapid cooling. The resulting material changes manifested in the hardening on the cut edge and an adjacent tempering zone (softening zone).

In addition to its extraordinary precision, the advantage of the laser beam cutting lies primarily in the low thermal influence on the cut edges. In terms of energy density, it is superior to all other thermal cutting processes. The low heat input is evident from the hardness profile of the cut edge. The hardening zone and tempering zone are extremely narrow. Due to the low heat input, only low residual stresses are formed, resulting not only in very low distortion but also in high crack resistance.

Laser and underwater plasma cutting of SECURE 500 hardness profile in the heat-affected zone

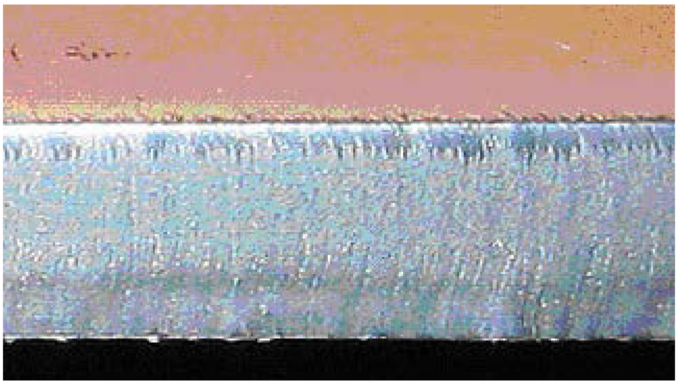


3. PLASMA CUTTING

Under water plasma cutting offers favorable conditions regarding the lowest possible thermal influence on the cut edge and low distortion when processing thin plates. In addition to the good heat dissipation in the water bath, the high cutting speed results in a very narrow zone affected by heat. The use of oxygen reduces the viscosity of the molten material in underwater cutting, but also in the other process variants. This results in dross-free cut edges. **Dry plasma cutting** is becoming increasingly important. Special fine-jet plasma torches allow higher concentration and stabilization of the plasma jet through effective secondary gas guidance (swirl gas). This improves the straightness or squareness of the cut edges and in many cases achieves a cut quality comparable to
laser cutting.

The formation of the heat-affected zone depends not only on whether plasma cutting is performed dry or in a water bath. The power, i.e. the cutting current intensity of the system, is also decisive.

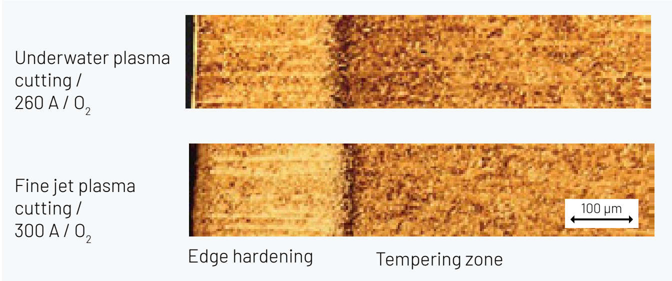
Tests on dry fine-beam plasma cutting of **SECURE 500** and **600** steels show that thinner sheets (up to 6 mm) can generally be processed without problems. More powerful systems (approx. 300 A) should be used for sheet thicknesses of approximately 10 mm and above. In this case, the high cutting speed (approx. 4 m/min) allows the critical hardening zone to be significantly limited. The hardness profile is almost comparable to that of underwater cut edges.



Fine-jet plasma cut edge on 12 mm plate

When cutting on smaller systems (current 100 A / cutting speed < 2 m/min), material separations in the wider, hardened edge layer cannot be ruled out. The cut edges must be checked before further processing. Dye penetrating and magnetic particle inspection are equally suitable for this purpose. If necessary, the cut edge should be ground off.

Plasma cutting of SECURE 500 (12mm) Formation of the heat-affected zone



4. OXYACETYLENE FLAME CUTTING

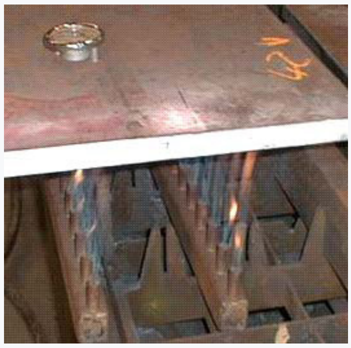
Due to their special chemical composition and hardness, **SECURE 400**, **500** and **600** safety steels increasingly tend to crack during autogenous flame cutting. Cutting is preferably carried out with high-performance nozzles and high oxygen pressures. In contrast to welding, flame cracks are basically not due to the effect of hydrogen. What hydrogen-induced cold cracks have in common is that they can occur with a time delay.

The most effective measure to prevent flash cracking is preheating. This should involve heating the entire plate, however, at least 150 mm on both sides of the intended cut, to the temperature recommended according to the steel grade and plate thickness. For preferential furnace heating, burner lances offer a good alternative for uniform heating. Temperature must be monitored to ensure that the desired temperature is reached on the reverse side, on the one hand, and that the heated side is not overheated, on the other hand. At sheet temperatures below 5 °C, thinner sheets should also be preheated lukewarm before cutting.

For sheet thicknesses above 50 mm, it is recommended to additionally reheat the cutting area to 175 °C immediately after flame cutting. The holding time should be two minutes per mm of sheet thickness, however, not more than four hours.

Insulating mats also help to slow cooling substantially.

In principle, cooling can also be delayed by reducing the cutting speed. However, this method is less effective than preheating the sheet. The risk of overheating the edge area increases by cutting at low speeds. Because of the high heat input during flame cutting (especially on the side of the torch), the microstructure is modified along a wide edge. The adjacent softening zone is particularly pronounced in this cutting process. Depending on the sheet thickness and cutting parameters, the base material hardness is only reached at a relatively large distance from the cut edge.



Adhesion thermometer

Preheating with torch lance

Preheating temperatures for autogenous flame cutting

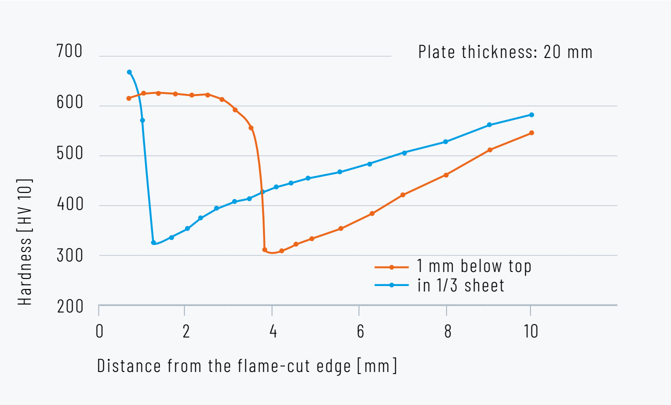
	Thickness t [mm]									
Grade	6-10	≤ 15	≤ 20	≤ 25	≤ 30	≤ 35	≤ 40	≤ 45	≤ 50	> 50
SECURE 400	none		100 °C			125 °C		150 °C		175 °C + NW *)
SECURE 450	none					75 °C		-		
SECURE 500	none		100 °C			125 °C		150 °C		175 °C + NW *)
SECURE 600	100 °C		150 °C		175 °C		175 °C + NW *)	-		

*) Reheat to 175 °C, min. 2 minutes per mm sheet thickness, max. 4 hours.

Depending on the thickness and size of the components and the cutting sequence, heating during cutting may reduce the hardness of the entire component in extreme cases. To prevent this, the following temperatures should not be exceeded. The tempering effect increases with increasing temperature and duration of overheating.

After flame cutting, the cut surfaces must be smooth and free of notches. Deeper local scouring must be ground out or over-welded and grinded over before further processing. Surface crack detection or ultrasonic testing should be performed 48 hours after cutting at the earliest. In the case of **SECURE 600**, further testing is recommended at the earliest two weeks after cutting.

Autogenous flame cutting of SECURE 600 hardness profile in the heat-affected zone



Steel grade	Maximum temperature
SECURE 400	450 °C
SECURE 450	250 °C
SECURE 500	200 °C at t ≤ 50 mm 250 °C at t > 50 mm
SECURE 600	200 °C

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