Processing information

Cutting

DILLIDUR

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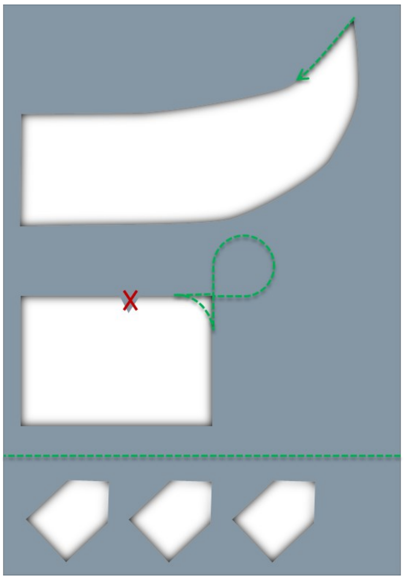
Wear resistant DILLIDUR steels are very suitable for processing due to their exceptional homogeneity as well as their cleanness. Increasing plate thickness requires higher alloy components and careful treatment of the plates. In the following, Dillinger provides information on autogenous cutting, plasma cutting, laser cutting as well as water jet cutting.

The information on DILLIDUR cutting has been developed to the best of Dillinger's knowledge and experience. It is intended to support the manufacturer in developing his own processing procedure for our material. The proper working method must be carried out with suitable tools. Since different manufacturers have developed varying tools, the instructions should be observed carefully (nozzle selection, gas pressures, working method, speed, etc.).

In addition to the selection of the appropriate cutting process, the suitable cutting path and the cutting sequence also determine the subsequent quality of the contour piece: We recommend avoiding sharp edges or notches facing inwards and possibly cutting an additional curve, especially with large plate thickness and high hardness (see graphic 1).



Keep the contour piece connected to the plate as long as possible.

Sharp contours should be avoided, sufficient radii e.g. ≥ 25 mm

If the plate is processed on the next working day, a clean separation cut should be considered.

Graphic 1 Cutting path

Cut component DILLIDUR 550

Thermal cutting

During thermal cutting, the heavy plate is strongly heated close to the cut edge. This results in a so-called heat affected zone (HAZ) close to the cut edge. The width of the zone varies depending on the cutting process. Due to the short and intensive heating followed by rapid cooling, a softening zone is created under the hard cutting edge of the DILLIDUR plates. It varies depending on the process and cutting parameters. Just like the actual cutting process, the delivery condition (heat treatment) and the chemical analysis affect the properties of the HAZ.

Table 1 Thermal cutting processes

Method	Description	Plate thickness	Kerf
Oxy-fuel	Burning with oxygen, blowing out oxygen compounds (oxides)	> 10 mm*	Approx. 2 up to 9 mm
Laser	Vaporisation (in small thickness) or burning with oxygen	Up to approx. 30 mm	< 1 mm possible
Plasma	Melting using gas, Blowing out using gas nozzle	Up to approx. 60 mm	Approx. 2 up to 7 mm

*Typical

Effect of different flame cutting methods on the heat affected zone

Metallographic section of the HAZ of a 10 mm thick plate after laser, plasma, oxy-fuel cutting

laser

plasma

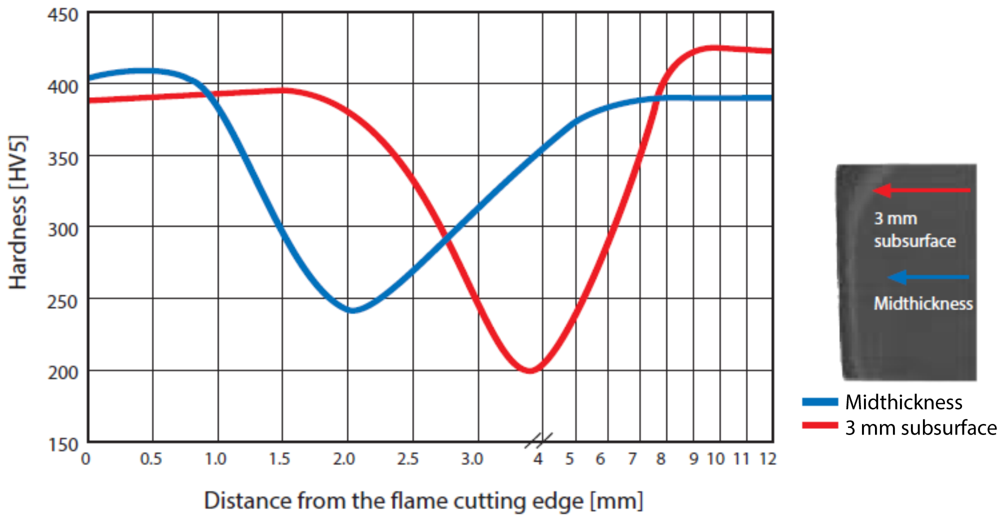
oxy-fuel cutting

The surface condition of the plate also has a significant influence on the flame cutting conditions and the achievable quality of the cut surface, especially in laser cutting. Where high demands are placed on the quality of the cut face, it is necessary to clean the top surface of the workpiece in the cut area to remove scale, rust, paint and other impurities.

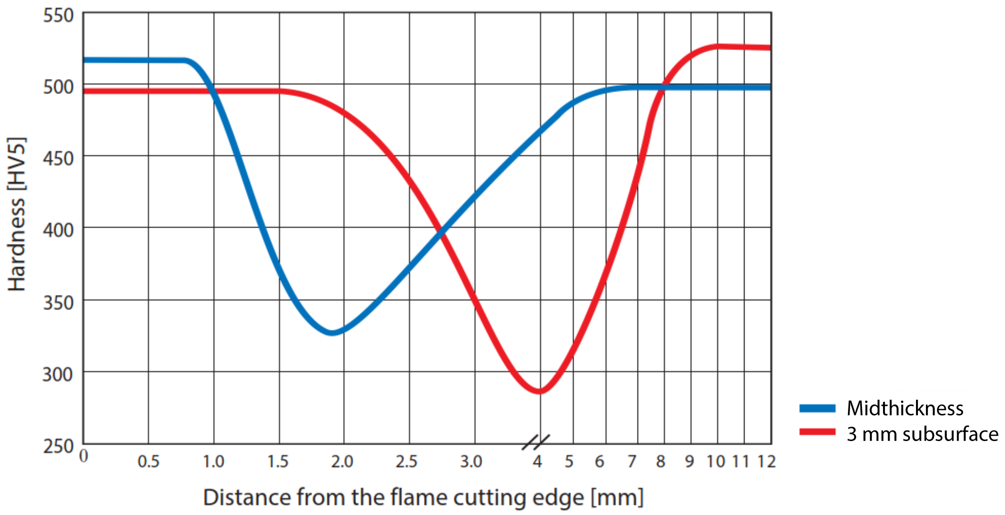
For DILLIDUR 400, DILLIDUR 450, DILLIDUR 500, DILLIDUR 550 and DILLIDUR 600, the flame-cut edge again reaches the hardness of the water-hardened base material. In between there is a narrow, softened zone, which is rather wider near the upper plate surface due to the heating flame (see graphics 2 and 3).

Influence of the cutting processes on the hardness of the HAZ

Hardening of DILLIDUR close to the flame cut edge (auxiliary values for 20-30 mm plate thickness)

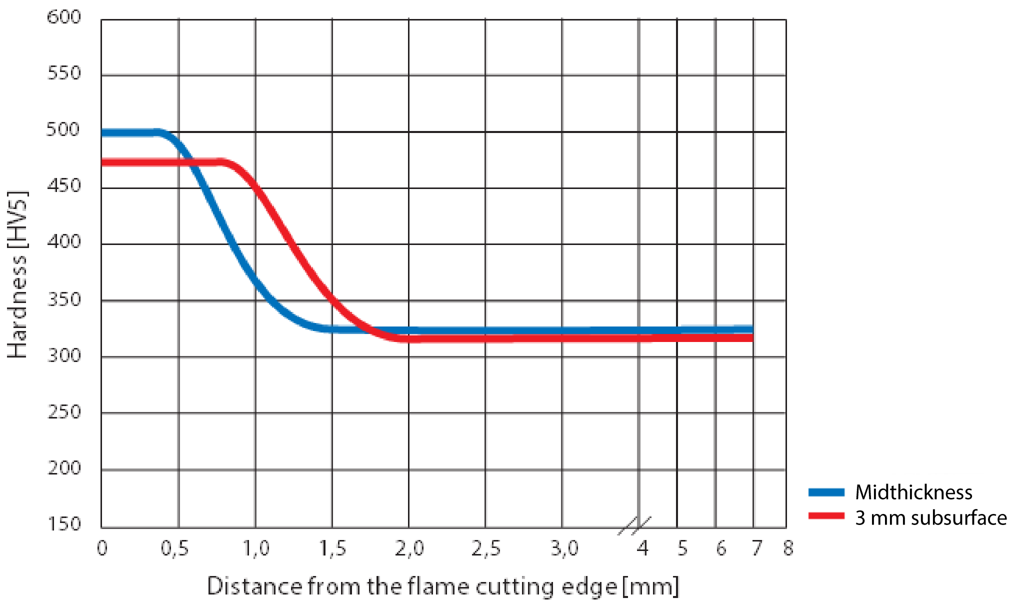


Graphic 2 Typical hardness gradients of DILLIDUR 400 close to the HAZ at plate edge



Graphic 3 Typical hardness gradients of DILLIDUR 500 close to the HAZ at plate edge

DILLIDUR 325 L Significant hardening at the cut edge with a drop down to the hardness value of the plate in delivered condition (see graphic 4).



Graphic 4 Hardening of DILLIDUR 325 L at the flame cut edge

Oxy-fuel cutting

The oxycutting of DILLIDUR is almost without limits, at least in terms of plate thicknesses when processed properly. Oxy-fuel cutting is used in a wide thickness range from approx. 10 mm up to very high thickness. DILLIDUR is designed for high hardness and wear resistance combined with excellent workability, however, in comparison to conventional structural steels, it is more susceptible to so-called cold cracks. A suitable cut helps to avoid stress cracks (see graphic 1).

In general, the temperature of the work piece during oxy-fuel cutting should not be below room temperature (15 °C) and at the same time the recommended preheating temperatures should not be understepped during the entire cutting process. The entire component must be heated through.

DILLIDUR steels are not allowed to be heated above the maximum temperatures given in table 2. They will otherwise lose their hardness.

Table 2 The following preheating temperatures for DILLIDUR should be observed

<table>
<tr><th>Plate thickness* [mm]</th><th><10</th><th>10 ≤ t < 20</th><th>20 ≤ t < 30</th><th>30 ≤ t < 40</th><th>40 ≤ t < 70</th><th>70 ≤ t < 100</th><th>100 ≤ t < 150</th><th>Max. Temp.</th></tr>
<tr><td>DILLIDUR 325 L</td><td></td><td colspan="5">120 °C</td><td></td><td>500 °C</td></tr>
<tr><td>DILLIDUR IMPACT</td><td colspan="3"></td><td colspan="2">50 °C</td><td colspan="2">100 °C</td><td>500 °C</td></tr>
<tr><td>DILLIDUR 400</td><td colspan="3"></td><td>75 °C</td><td colspan="2">100°C</td><td>150 °C</td><td>250 °C</td></tr>
<tr><td>DILLIDUR 450</td><td colspan="3">50 °C</td><td>100 °C</td><td colspan="2">125 °C</td><td></td><td>200 °C</td></tr>
<tr><td>DILLIDUR 500</td><td colspan="3">60 °C</td><td colspan="2">120 °C</td><td>150 °C</td><td></td><td>200 °C</td></tr>
<tr><td>DILLIDUR 550</td><td></td><td colspan="5">175 °C</td><td></td><td>200 °C</td></tr>
<tr><td>DILLIDUR 600</td><td colspan="2"></td><td colspan="3">175 °C</td><td colspan="2"></td><td>180 °C</td></tr>
</table>

*Indicative values

From a metallurgical point of view, preheating in the furnace is the best solution. However, it is often not feasible in practice. Therefore, please note the following information:

Cold cracks can be prevented by:

- Preheating
- Suitable cut guidance
- Reduced cutting speed (attention: wider HAZ)
- Postheating (allows hydrogen introduced during oxy-fuel cutting to diffuse out)

Decreasing the cooling rate of the cutting edge or the entire cutting piece reduces shrinkage strain. Critical oxy-fuel cut parts should ideally remain in the firing grid after oxy-fuel cutting so that they can cool down slowly in the composite. Stresses introduced there also increase the possibility of cracking. Cold cracks may appear only 48 hours after the flame cut.

Preheating of DILLIDUR

Preheating:
The entire plate should be preheated, preferably by heating the underside with a soft flame and measuring the temperature on the top. The top of the plate can be covered with thermal blankets.
In any case, heating by heating torches must be done carefully:

- No local overheating (see table 2).
- Avoid large temperature gradients to create as minimal thermal stresses as possible.
- Uniform heating is necessary.

Slow cooling of DILLIDUR

Postheating:
After cutting, the cut pieces should cool slowly. For this purpose, it can be covered in thermo boxes or with thermo wool.
Postheating and / or holding at higher temperatures (150 to 200 °C) is recommended especially for thicker plates (>75 mm).

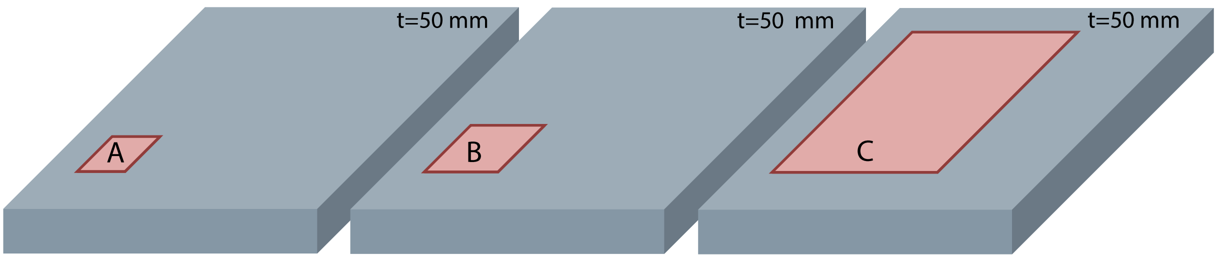
During oxy-fuel cutting, excessive heating of the flame-cut piece can be controlled by maintaining sufficient distance between the cutting edges and the plate edge, as well as between the cutting edge and the next flame cut piece. A distance of 200 mm usually prevents overheating for plate thickness of 30 mm or more.

For smaller distances, laser or plasma cutting are more suitable than flame cutting. For this reason, additional cooling rather than preheating should be used for flame cut parts that cannot dissipate heat quickly enough, such as small components, screen plates, lamellae, knife edges, etc.

Example of heating the flame cut part made of DILLIDUR 450:

	Unit	Cut piece A	Cut piece B	Cut piece C
Plate thickness t	[mm]	50	50	50
Width b	[mm]	100	200	500
Length l	[mm]	100	200	1000
Cutting speed v	[mm/min]	250	250	250
Plate temperature after preheating	[°C]	100	100	100
Expected temp. of the piece after cutting*	[°C]	450	280	150
Expected influence on properties		Significant drop in hardness	Low hardness drop	No hardness drop

* The heating depends on other factors such as the nozzle used



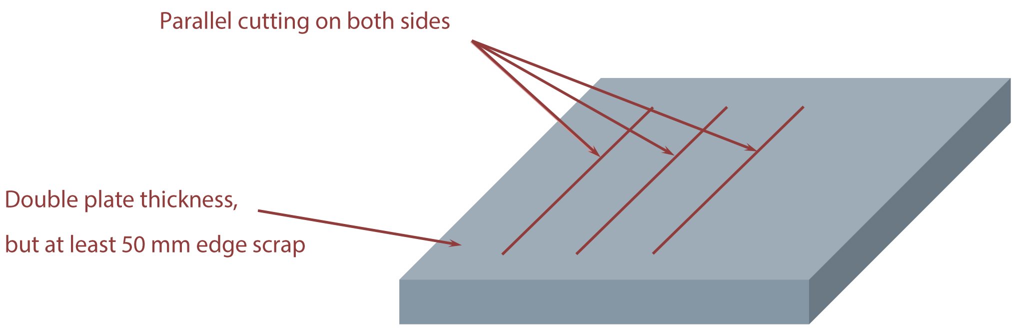
Graphic 5 Cutting DILLIDUR 450

Cutting using second torch for preheating

Experienced users can minimize or avoid the specified preheating temperatures by using additionally torches as shown in the picture for pre- and/or after running and reduced cutting speed. However, preheating and reheating remain the proven methods of first choice. Recommendations for preheating and temperature control during flame cutting based on the actual analysis and further data can be taken from the Dillinger E-Service.

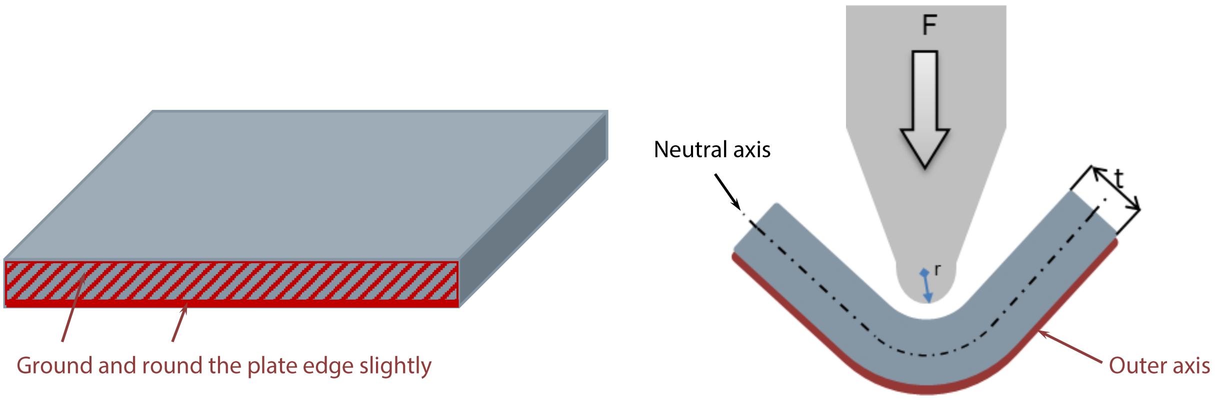
When cutting long narrow flame cut parts, it is state of the art to make certain process adjustments to avoid distortion: On one hand ensur a symmetrical heat flow, e.g. by cutting the lamella parallel on both sides, and on the other hand, providing sufficient edge scrap, e.g. twice the plate thickness, but at least 50 mm.

Before cutting off the lamellae, it is helpful to let the flame-cut parts still connected to the rest of the plate for finally cool down.



Graphic 6 Cutting long narrow flame cut parts

If the cut edges are cold formed during further processing, for example by bending or folding, the hardened cut edge area must be ground in the case of DILLIDUR steels. It is also advisable to round the plate edge slightly on the outer axis, which is on the outside when bending.

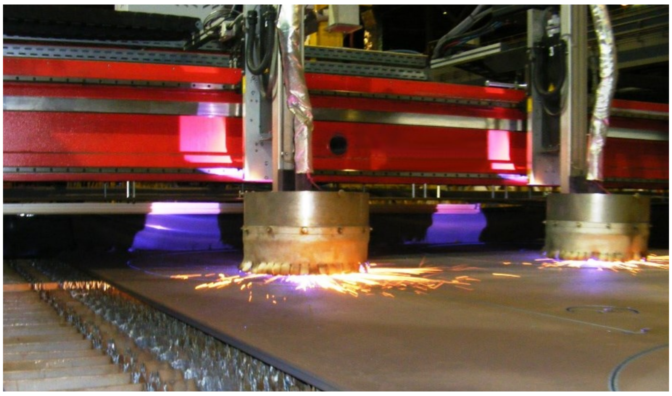


Graphic 7 Bending

Laser and plasma cutting

The major advantages of laser and plasma cutting is the higher cutting performance and the narrower heat affected zone, along with minimum heat input. With both cutting processes, it is possible to cut even the smallest parts, lamellae and screen plates without distortion and with almost no loss of hardness. With these methods, it is also possible to avoid preheating. Exceptions are very large plate thicknesses in the limit range of plasma cutting and DILLIDUR with hardnesses > 500 Brinell. In these cases, the preheating temperatures of oxy-fuel cutting must be used.

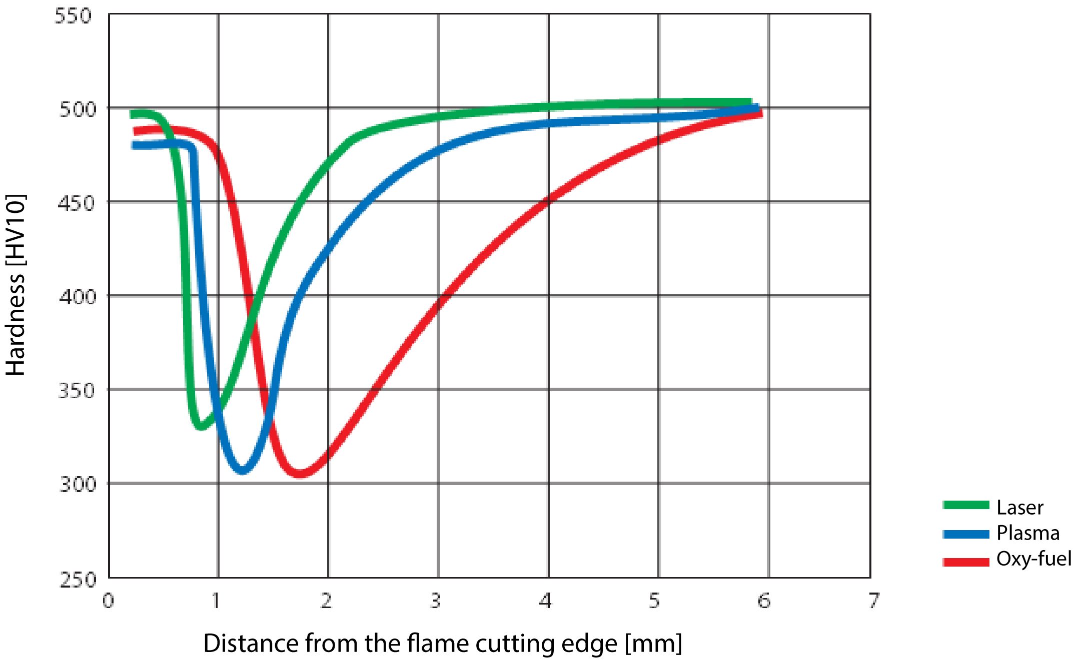
A perfect surface of the plate is a fundamental precondition for successful laser cutting. DILLIDUR can also be supplied shot blasted and shop primered especially for this case on request (please see Dillinger's brochure "Raincoat included").



Plasma cutting

Plasma cutting is also suitable for plate thicknesses up to 60 mm. However, the heat affected zone is somewhat wider.

With plasma and laser cutting, the hardness values can generally be slightly higher than with oxy-gen-acetylene flame cutting due to the higher cooling rates.



Graphic 8 Typical effect of different flame cutting processes on the heat affected zone of a hardened, wear resistant steel.

Water jet cutting

Water jet cutting

The method is particularly suitable for the cutting of DILLIDUR plates because there are no thermal influences that cause changes in the material. Thus, the properties of the component are not affected, even with very small dimensions. However, the cutting speed is relatively low.

Disclaimer

The information and data provided concerning the quality and/or applicability of materials and/or products constitute descriptions only. Any and all promises concerning the presence of specific properties and/or suitability for a particular application shall in all cases be deemed to require separate written agreements.

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