Quard®

ABRASION RESISTANT STEEL

Quend®

HIGH YIELD STRENGTH STEEL

CUTTING

If you want to calculate the optimal parameters for your operations on Quard and Quend, download our **Q Calculator** app!

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1. Introduction

Cutting **Quard**® and **Quend**® can be performed by any of the conventional cutting methods, using both cold and thermal cutting.

Cold cutting means cutting by shearing, sawing, abrasive grinding and abrasive water jet cutting. The thermal cutting methods referred to in this manual are oxygen fuel cutting, plasma cutting and cutting by laser.

Cutting Quard and Quend does not differ substantially from cutting conventional steel grades. When cutting thicker gauges, there are, however, some aspects that must be considered.

This manual will give you a better understanding of how Quard and Quend operate during thermal processing and how to avoid mistakes during various cutting operations.

2. Cracks in cut edges

If thermal cutting of Q&T steels of thicker gauges and/or in grades exhibiting a sufficiently high carbon equivalent, cracks may form and propagate from the cut edges. These cracks are caused by similar reasons as cold cracks when welding, being :

- **Hydrogen content in the steel ;**
- **Cut edge residual stresses ;**
- **A high carbon equivalent.**

Cut edge cracks in Q&T steels are a delayed cracking phenomena, which means cracks may first appear and only become visible days, or even weeks, after the cutting process.

Cut edge cracking can be avoided if the following aspects are carefully considered :

- **Cutting method ;**
- **Preheating requirement ;**
- **Cutting speed ;**
- **Slow cooling/post heating.**

During thermal cutting, the plate edge exposed will be subjected to a thermal cycle, from the melting point of the steel down to ambient temperature. This area, referred to as the heat-affected zone (HAZ), is very limited and extends just a few millimetres. The HAZ width all depends on the cutting method and thickness of the plate. Since the mechanical properties in the HAZ are affected by cutting, it is important to consider the consequences when selecting the cutting method and procedure to be used.

If applying any of the cold cutting methods, no heat-affected zone will be developed, while the mechanical properties of the edge will be unaffected.

3. Preheating

The best way to avoid problems with cut edge cracking is to preheat prior to cutting. Preheating is most commonly applied during oxygen fuel cutting, since this method creates the widest heat-affected zone. The need for preheating and to which temperature, depends on the steel grade and plate thickness. Table 1 shows the preheating requirement for Quard.

Table 1. Preheat recommendations when oxy-fuel cutting of Quard.

Steel grade	Plate Thickness, mm	Preheating temperature, °C
Quard 400	⩾50	100 - 125
Quard 450	⩾40	100 - 125
Quard 500	⩾30	100 - 150
Quard 550	⩾20	125 - 150

Remark : In the thickness range up to 50 mm, Quend does not need any preheating prior to thermal cutting.

When starting up the thermal cutting process, the temperature of the plate should have an ambient temperature of min. 0°C.

After cutting, let the cut parts slowly cool down to room temperature. Never accelerate the cooling of the parts. A slow cooling rate will reduce the risk of cut edge cracking.

4. Cutting speed

If, preheating can not be applied, another option to reduce the risk of cut edge cracking is available. By reducing the speed during oxygen fuel cutting, the heat generated during the cutting process will act as preheating to the adjacent steel ahead. This method is not as reliable as the preferred preheating method to prevent cut edge cracking. To further reduce the risk of cut edge cracking, preheating and slow speed cutting can be combined. The option of reducing the cutting speed should be applied from the same plate thickness preheating is recommended to be used ; see Table 1. The restricted speed to use equates to 50% of the speed normally* applied when cutting the actual plate thickness.

*By normal speed we refer to the speed recommended by the cutting equipment supplier, usually given by the burning torch used.

5. Hardness gradients in cut edge

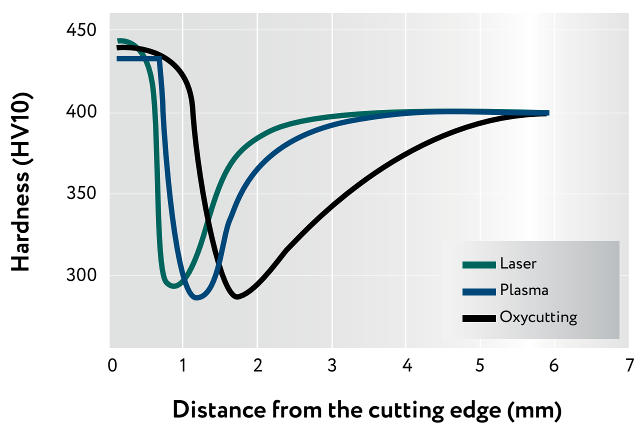
Depending on the cutting method used, the amount of heat added and accumulated in the plate differs. The more heat that is transferred to the plate, the larger the heat-affected zone. The widest heat affected-zone is generated by oxy-fuel cutting and the narrowest by laser cutting.

As for all thermal cutting methods, the hardness in cut displays a peak at the vicinity of the surface, followed by a hardness minimum at some 1-3 mm into the plate.

It is easy to understand that variation in hardness generates a certain stress condition in the HAZ that may encourage micro cracks to appear (especially if hydrogen is present).

Another effect from high peak cut edge hardness is found when performing milling operations of the cut edge.
To prevent extensive wear of the cutting tool, it is important that the feed rate during milling is set at a distance exceeding the depth of the hard surface layer.

Figure 1. HB vs. distance from edge surface / using different cutting methods.



6. Slow cooling and post heating

As mentioned earlier, slow cooling of thermally cut parts should always be applied.
To further slow down the cooling rate, it is recommended to stack the cut parts (still warm) together and cover the parts with insulating material.

If needed, post heating of the cut part can be performed. Post heating should be performed after finalising the cutting. The temperature used should be between 100 and 200°C and the time of heating should correspond to five minutes per mm plate thickness. The post heating is best performed in a heat treatment furnace but could also be done using oxy burners.

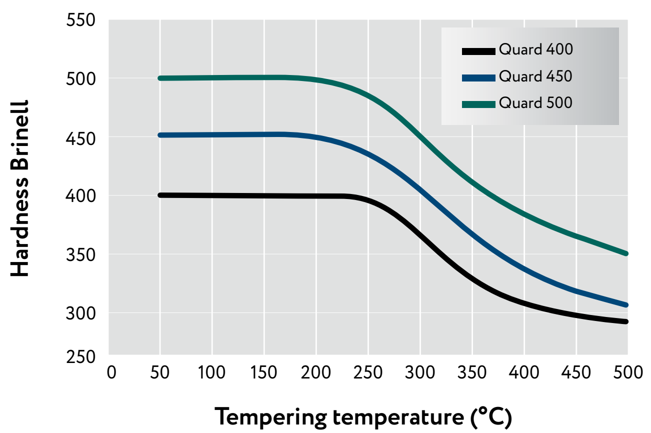
By applying slow cooling or post heating, the residual stresses in the cut will be reduced and, at the same time you extend the time for hydrogen to diffuse out of the cut area. These actions will further prevent cut edge cracking occurring.

7. Cutting small components of Quard

When cutting small-sized components, the heat generated during the cutting process will be accumulated in the component being cut. The smaller the part and/or the larger the plate thickness, the greater the risk of over tempering (softening) the part.

The temperature resistance of Quard is given in Figure 2, showing the hardness in relation to the tempering temperature.

Figure 2. Tempering resistance / Quard.



To preserve the hardness and thus the wear resistance when cutting small components, it is important to limit the heat accumulated in the cut part.

Minimising the accumulated heat when cutting small components can be achieved by :

- selecting the proper cutting method, such as laser cutting or abrasive water jet cutting, therefore minimising the heat generated ;
- performing plasma or oxygen fuel cutting as submerged in water, using a water cutting table. In so doing, the water will effectively transfer the heat out of the plate.*

*Submerged cutting does not comply with what has been said about slow cooling. When cutting under water the heat-affected zone will be narrower than when cutting in air. Thus the harmful effect from the HAZ can be limited. When conducting submerged cutting the cutting speed is reduced by about 30 to 50% compared to normal cutting in air. This complies with the recommendation of applying slow cutting speeds for preventing cut edge cracking.

8. Laser cutting

Both **Quard** and **Quend** are suitable for laser cutting.

Quard and Quend can be delivered as primer coated or as quenched (black). Depending on the surface condition, the laser cutting performance may differ slightly between the two delivery conditions.

The primer used at NLMK Clabecq is of low zinc silicate type and is designed in such a way that limits the negative impact on the laser cutting performance, normally related to primer-coated plates.

When laser cutting on a primer-coated plate surface, targeting a high cut edge surface quality, the cutting speed may need to be reduced by 5 to 10% compared to laser cutting on a non-primer-coated plate.

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NLMK Europe – Plate

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