Application Note AN308

Autogen Cutting of High Strength Steel

High-strength steel is low-alloy type of steel (HSLA) that provides better mechanical properties or greater resistance to corrosion than common carbon (mild) steel. Different properties compared to other steels are reached by different fabrication process and by specific chemical composition. They have a carbon content between 0,05 and 0,25% to retain formability and weldability. Other alloying elements include manganese, copper, nickel, niobium, nitrogen, vanadium, chromium, molybdenum, titanium, calcium, rare-earth elements, or zirconium. These elements are intended to alter the microstructure of carbon steels to produce a very fine structural grain size. The final effect is the high level of the tensile strengths, hardness and toughness. They are used in cars, trucks, cranes, agricultural, forestry and mining machines, bridges and other structures that are designed to handle large amounts of stress or need a good strength-to-weight ratio. Typical example of HSLA steel is the Strenx®, Hardox® or COR-TEN® ranges of SSAB.

The complexity of the chemical composition makes HSLA steels difficult for Autogen cutting technology. As is commonly known, not all materials can be cut by oxygen. Most of the alloying elements in steel makes cutting technology as more difficult as higher their percentual content in steel is. EN ISO 9013, Annex B, points B3.1 and B4.1 describes conditions which shall be fulfilled by material to be able to cut it with oxygen (Autogen). Chemical composition of HSLA steel is usually in the range when the standard Autogen cutting process is not applicable. The cutting speed needs to be reduced, also other process parameters adjusted and cut quality is usually lower than with standard carbon steel. Plate piercing is difficult because HSLA steel creates heavy metallic slag, not just light oxides. The slag causes also bigger amount of dross and burrs at the bottom edge of the cut than usually. Consumption of cutting consumables increases and the frequency of the equipment maintenance (especially torches) is increasing as well. Depending on the material composition, even the situation can happen when the Autogen cutting does not work anymore and other cutting method needs to be used.

There are not any general recommendations leading to 100% success. But very important factor for the successful HSLA steel cutting process is temperature of the material before we start. It helps to arrange preheating of the material and keeping it on higher temperature during cutting. Following chart shows critical % amount of the elements in the steel. Material preheating before cutting is always needed in case when % amount of element is higher than the value in the chart.

Element		Max. Content	Addition
C	Carbon	0,5%	0,5% - 1,6% with preheating
Si	Silicon	2,5%	along with max. 0,2% C
Mn	Manganese	13,0%	along with max. 1,3% C
Cr	Chromium	1,5%	
W	Tungsten	10,0%	along with max. 5,0% Cr, 0,2% Ni and 0,8% C
Ni	Nickel	7,0%	to max. 35% along with min. 0,3% C
Mo	Molybdenum	0,8%	not possible to cut along with high content of W, Cr and C

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Carbon Equivalent is used to summarize influence of all alloying elements. It is the factor defined by steel manufacturer who guarantee its value similar as he guarantees the content of individual elements. Then according to Carbon Equivalent value, the preheating temperature range is to be selected from following chart.

Carbon equivalent %	Preheating temperature	
	Small thickness, straight cut	Big thickness, shaped cut
< 0,3	no preheating	no preheating
0,3 – 0,4	no preheating	< 100°C / 212°F
0,4 – 0,5	< 100°C / 212°F	100°C – 200°C / 212°F – 392°F
0,5 – 0,6	100°C – 200°C / 212°F – 392°F	200°C – 350°C / 392°F – 662°F
> 0,6	200°C – 350°C / 392°F – 662°F	350°C – 500°C / 662°F – 932°F

Preheating of the material at e.g. 200°C / 392°F means that still before starting cutting we can measure that temperature at any point of entire plate or tube which we are going to cut or at least in the large area around the future cut. Only local preheating at the starting point or in the near area close to cut curve is not efficient enough.

Attention: The term “preheating” here should not be mixed-up with the standard cutting operation called also “preheating” which is part of the each cut start on any type of the material.

Example:

HSLA steel Strenx® 700 E/F produced by SSAB.
Source: material datasheet https://www.ssab.com/

Chemical Composition (ladle analysis)

C *) (max %)	Si *) (max %)	Mn *) (max %)	P (max %)	S (max %)	Cr *) (max %)	Cu*) (max %)	Ni*) (max %)	Mo*) (max %)	B *) (max %)
0.20	0.60	1.60	0.020	0.010	0.80	0.30	2.0	0.70	0.005

The steel is grain refined. *) Intentional alloying elements.

Maximum Carbon Equivalent CET(CEV)

Thickness (mm)	4.0 - 5.0	5.1 - 30.0	30.1 - 60.0	60.1 - 100.0	100.1 - 130.0	130.1 - 160
700 E CET(CEV)	0.34 (0.48)	0.32 (0.49)	0.36 (0.52)	0.39 (0.58)	0.41 (0.67)	0.43 (0.73)
700 F CET(CEV)	0.38 (0.57)	0.38 (0.57)	0.39 (0.58)	0.39 (0.58)	0.41 (0.67)	-

We could read from the charts very generally that depending on the steel type and plate thickness the preheating temperature should be between 100°C – 500°C / 212°F – 932°F. The exact temperature needs to be counted from exact Carbon equivalent value which is defined for each particular material delivery by producer e.g. in 3.1b Material certificate.

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