WHITEPAPER

SS 304L AND 316L: DISCOVER THE UNIQUE ADVANTAGES OF THE 'L' VARIANT

In this white paper you will discover, among other things, the unique advantages of 304L and 316L grades.

Arcus DYNAMIC IN STAINLESS

INTRODUCTION

Dear Reader,

In the world of stainless steel, grades 304 and 316 are known for their exceptional corrosion resistance and versatility. But what makes the “L” grades, such as 304L and 316L, so special?

In this white paper, we dive deeper into the unique properties and benefits of these steel grades.

We begin with an overview of stainless steel, a special carbon alloy known for its high level of corrosion resistance. We then explore the different variants within the 304 and 316 grades and explain why the “L” designation plays a crucial role when welding stainless steel.

Whether you are an engineer, manufacturer or just an interested reader, this white paper offers valuable insights into the world of 'L' variants. Find out why reducing carbon content has such a positive effect on weldability and which applications best benefit from the unique properties of 304L and 316L.

Read on to learn more about the benefits of these 'L' grades, the impact of weldability and mechanical properties, and how to make the best choices for your projects.

Enjoy reading!

Team Arcus Group.

STAINLESS STEEL

In the white paper “The difference between grades 304 and 316,” we discussed the difference between stainless steel grades 304 and 316. We also explained what exactly stainless steel is and why this special alloy containing carbon is so special that it offers a high level of corrosion resistance.

Stainless steel is a widely used alloy because of its durability and resistance to rust and corrosion. The two most common and popular types of stainless steel are the 304 and 316 grades. Both have unique properties that make them suitable for different applications.

Within these two grades of stainless steel, several variants have been developed to meet specific requirements and applications. In this white paper, we focus on these variants and explain the differences between them.
A common feature you'll encounter in practice is the addition of the letter “L” after the grade designation, as in 304L and 316L. This means that these variants have a lower carbon content, which greatly affects their weldability and performance in certain conditions.

In this white paper, we will explain what differentiates these “L” variants from their standard counterparts, and why they are preferred in certain applications. We will discuss the properties, benefits and typical applications of 304L and 316L stainless steels so that you can gain a better understanding of these materials and their use in industry.

CARBON

Stainless steel is an alloy, which means it is a mixture of different elements. The main elements in stainless steel are chromium and nickel, which are added to the basic element iron. These elements provide the excellent corrosion resistance that stainless steel is known for.

In addition to chromium and nickel, carbon and manganese are also added to the iron alloy to improve the strength properties of the steel. When iron is combined with carbon, steel is created. This addition of carbon makes the steel stronger and more durable.
However, there is a significant drawback to adding carbon to iron: it reduces the weldability of the steel. This means that it becomes more difficult to weld two pieces of steel together without causing problems. Indeed, unwanted chemical reactions can occur during welding, such as the formation of chromium carbides, which can affect the strength and integrity of the weld.

In short, while carbon is a crucial element that contributes to the strength of stainless steel, it also presents challenges, especially when welding. It is this delicate balance between strength and weldability that makes the design and selection of the right stainless steel variety so important for different applications.

WELDABILITY

When welding steel, a melt is created to join 2 metals together. With or without an additive material. A number of chemical reactions take place in this melt or also called flux bath. For example, oxygen will always want to penetrate this liquid metal and connect with carbon.
The resulting CO2, carbon dioxide disappears into the air and thus extracts carbon from the metal. The CO2 can also cause inclusions.

The gas is trapped in the weld, creating porosity and resulting in a poor weld and introducing defects. The best known is the “weld spoilage” or too unmixing of the composition. Chromium carbides can also form in the weld pool. In this process, the chromium combines with the carbon. This can lead to very high stresses between the weld and the base metal resulting in a stress crack, also known as knife-line attack.
Proper shielding of the weld is an absolute must. Often welding is done with, for example, a 309 grade. This grade has a higher percentage of chromium to compensate for the burning of the chromium during welding.

'L' INDICATION

Especially for welding stainless steels, specific grades have been developed that are designated with the letter “L”. This “L” stands for “low-carbon,” indicating that the carbon content in the steel has been reduced. Specifically, this means that the percentage of carbon has been reduced by about 0.05%. This reduction has a significant positive effect on the weldability of the material, making the welding of stainless steel easier and more reliable. However, lowering the carbon content also brings some consequences. Namely, a lower amount of carbon in the steel can result in a slight decrease in the mechanical properties of the material, such as strength and hardness. To partially compensate for this decrease, manganese is added to the steel. Manganese acts as a reinforcing element and helps maintain the mechanical properties of the steel so that the overall performance of the stainless steel is maintained as much as possible. This creates a balanced combination of improved weldability and adequate mechanical strength, making the material suitable for a wide range of applications.

MECHANICAL CHARACTERISTICS

When welding metal structures, some weakening always occurs in the material. This weakening usually does not occur exactly in the weld itself, but rather in nearby areas. This area is called the HAZ, or “Heat Affected Zone”. The HAZ is the transition area between the base metal and the weld metal.
Demixing and shrinkage stresses take place in this zone, making the material very critical and prone to cracking. De-mixing means that the chemical composition in this zone can change, which negatively affects the mechanical properties. Shrinkage stresses occur due to the cooling of the molten metal, which creates stresses in the material. This makes the HAZ a vulnerable area within the welded structure.

Depending on the specific application and size of the welded structure, heat treatment may be necessary. This treatment helps to reduce stresses and restore the structure of the material, improving the overall strength and durability of the structure.

HEAT TREATMENT

With proper heat treatment, segregation and/or internal stresses can be restored. We then speak of “solution annealing” or “stress-relieved annealing.” The atoms in the crystal structure resume their original positions. If this heat treatment is performed only in the heat-affected zone, we speak of a PWHT, or Post Weld Heat Treatment.
We encounter this for example in welded pipes, where the weld zone is annealed.

APPLICATION

As described, the “L” variants are mostly used for those applications where welding of joints is necessary. The strength, if no additional measures are taken, decreases by about 15%. This must clearly be taken into account when making calculations. Welded structures are also more critical when it comes to dynamic loads.

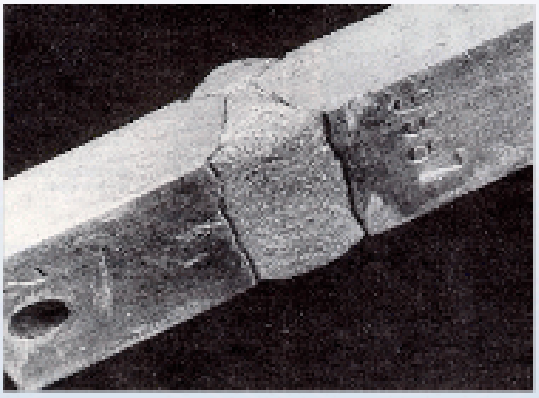

Figure 1:
Knifeline attack

Figure 2:
Browning is removed with polishing or etching.

	WST	CHEM	%C	%Cr	%Ni	%Mo	YS	TS	%E
316	1.4401	X3CrNiMo 17 12 2	<0,03	17-18	10-12	2-3	145	245	45
316 L	1.4404	X5CrNiMo 17 12 2	<0,05	17-18	10-12	2-3	145	245	45

Table 1: The reduction of carbon percentage does not affect mechanical properties.

CONCLUSION

In this white paper, we have discussed in detail the specific properties and advantages of the “L” grades in stainless steels, such as 304L and 316L. The addition of the “L” indicates a lower carbon content, which significantly affects the weldability of these steels. This makes the “L” variants ideally suited for applications where welding plays an important role by significantly reducing the risk of harmful effects such as chromium carbide formation and stress cracking.

Although lowering the carbon content slightly reduces mechanical properties such as strength, this is partially offset by the addition of manganese. As a result, the “L” variants remain a reliable choice for structures where both weldability and durability are important.

When designing and applying these materials, it is important to consider the potential weakening caused by welding, particularly in the Heat Affected Zone (HAZ). Careful heat treatment can partially restore these effects, improving the integrity and service life of the structure.

In short, 304L and 316L offer an excellent balance between weldability and mechanical performance, making them widely applicable in industry. Indispensable for applications where corrosion resistance and weldability must go hand in hand, these variants are an essential component of modern stainless steel solutions.

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