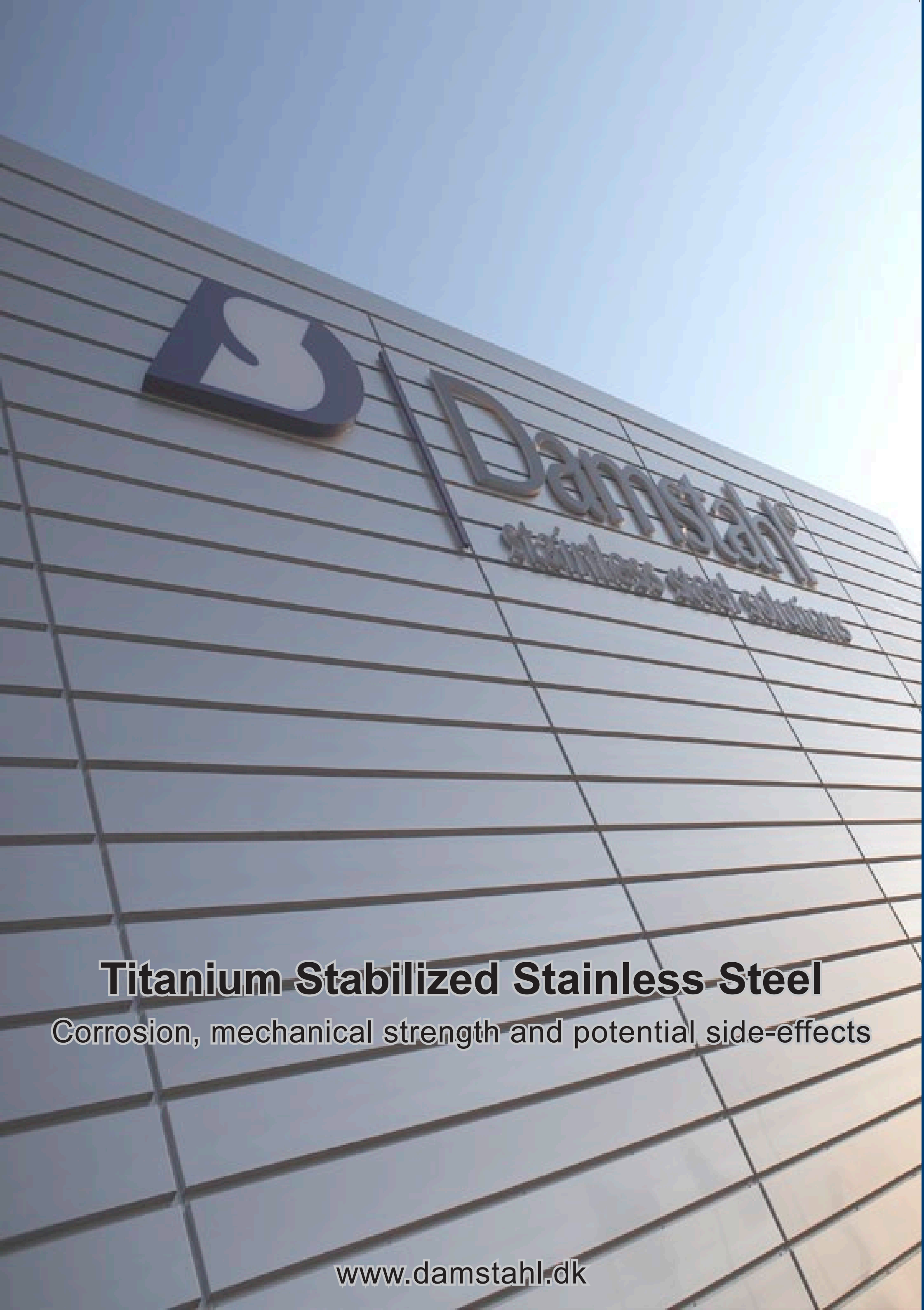


# Titanium Stabilized Stainless Steel

## Corrosion, mechanical strength and potential side-effects

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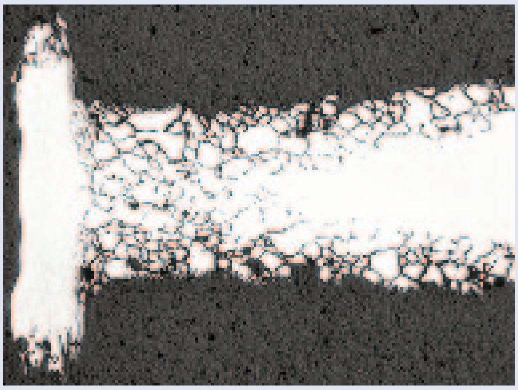
Apart from the martensitic steel types where carbon is essential in order to perform a proper harden-ing, this element is generally unwanted. In austenitic, duplex and ferritic steels, carbon is nothing but a harmful pollution, and although the mechanical strength may increase with the carbon content, the steel works do whatever possible to reduce the concentration of carbon.

**Sensitization and Intergranular Corrosion**

The main problem with carbon is that it tend to bind chromium. Carbon is almost insoluble in the austenite phase, and therefore congregates in between the steel grains - i.e. along the grain boundaries – not unlike the cement in between the bricks of a house. Heating the steel to a temperature in between 550 and 800 ºC (i.e. in connection with welding), the carbon binds the useful chromium. This Cr has to come from somewhere, and this “somewhere” is the zone right beside the grain boundaries. This de-chroming close to the grain boundaries is called sensitization, and the result is a severe reduction in the corrosion resistance in the affected zones. A subsequent exposure to an acid environment will tend to produce corrosion along the boundaries – so-called “intergranular corrosion”.



*Micro-section of intergranular corrosion in austenitic stainless steel, type EN 1.4301. The cause of the sen-sitization is heating of the steel combined with oil stick-ing to the surface. The subsequent pickling caused corrosion of the chromium depleted zones, so-called intergranular corrosion.*

The risk of sensitization and thereby IG is increasing significantly with the increase in the carbon con-tent of the steel, and this is the main cause why carbon should be avoided in stainless steel. Techni-cally, the harmful carbon can be eliminated is two ways:

- Removal of the carbon
- Binding the carbon, so that it does not play any role

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Traditionally, the Swedish steel works, for example, have always chosen to focus on a complete re-moval of the harmful carbon while their German counterparts have chosen the second solution. By adding small amounts of metallic titanium (Ti) to the steel, they bind the carbon as titanium carbides (TiC) before the carbon binds the useful chromium. This method is referred to as titanium stabilized steel, and even today, a lot of Germans prefer this type of steel compared to the low-carbon (LC) types. It is not always easy to persuade a client to use the 4404 when the age-old blueprints say 4571 even though the two types, in most cases, can be regarded as 100 % interchangeable.

### Parallel Steel Types

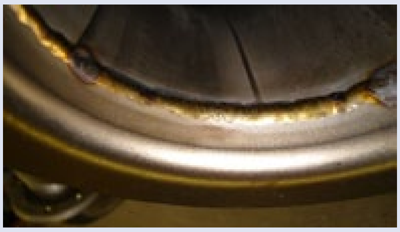
In most cases, it does not matter how the carbon is neutralized. Complete removal of carbon (i.e. 4404) or additions of Ti (i.e. 4571) gives the same good result, and the table below shows the parallel LC and Ti steels. Please note that the 4571 specifies 2.0-2.5 % Mo, which equals that of the 4404. In contrast, 4435 specifies 2.5-3.0 % Mo, which does not have any Ti stabilized parallel.

| Low-carbon (LC) | | Ti stabilized |
|---|---|---|
| 4306 / 4307 | ≈ | 4541 |
| 4404 | ≈ | 4571 |
| 4435 (2,5-3,0 % Mo) | ≈ | ÷ |

### Side-effects by using Ti Steel

However, differences do exist in between the LC and the Ti stabilized parallel steel types. Mechani-cally, the Ti steels are marginally stronger than the LC types, in particular at higher temperatures where cree-ping may be a problem. On the negative side, the Ti steels are much harder (= impossible) to polish. The titanium carbides formed inside the steel are extremely hard and during polishing, these hard particles will form thousands of micro-scratches on the surface. Similarly, Ti steels are harder than the LCs to electro polish, so if surface roughness is important, Ti steels should be avoided.

Finally, Ti forms yellowish nitrides when heated together with nitrogen. By welding Ti steel with Form-ier as purge gas, yellowish welds may occur, and although they do not affect the corrosion resistance of the steel, they are annoying anyway, as they make evaluation of heat tinting a bit more difficult. Using argon on both sides eliminates this problem.



*Yellowish weld formed by welding Ti steel (EN 1.4571) with Formier gas. The color doesn't affect corrosion resistance.*