# Anchor chains made of stainless steel – this should be considered when buying

## Anchor chains play a heavy role in anchoring

The use of anchor chains goes back to the Bronze Age. However, they did not really gain acceptance in shipping until the 18th century, when it was increasingly understood that an anchor chain - in contrast to an anchor rope - improves the anchor's holding power due to its own weight and also improves the anchor's holding power in strong winds and rough seas whereby the ship's movements are dampened.

Anchoring is all the rage these days. Many sailors enjoy ending their sailing day anchoring in nature, away from the hustle and bustle of the marina. It is of fundamental importance that you can rely on your anchor gear one hundred percent. In addition to the anchor, the bow fitting and the anchor winch, the anchor chain is of central importance.

## Which factors play a role in the choice of anchor chain?

But beware! Not all anchor chains are created equal. A multitude of aspects play a role in choosing the “right” chain. On the one hand it is about the material and the quality of the workmanship and on the other hand the design and weight of the anchor as well as the size and weight of the yacht are important. But also, the sailing area, the possible water depth at the anchorage and the wind strengths to be expected have an influence on the selection of the anchor chain.

That seems complex and it is to a certain extent - especially when it comes to choosing the right material. Then it usually comes down to the question of “galvanized steel chain or rustproof stainless steel chain?”.

## The material of the anchor chain: galvanized steel chain or rustproof stainless steel chain?

Due to the alloy elements used (chrome, nickel, molybdenum, etc.), the stainless steel chain is of higher quality than the galvanized chain and therefore has a higher purchase price. If the right quality is chosen, it is worth the investment.

The advantage of stainless steel chains is that they do not rust and that they are very smooth when they have undergone a high-quality surface treatment. As a result, they sort themselves into the anchor locker as if by magic, while a galvanized chain is rough and when lifting the anchor builds chain towers that, if they get too high, can block the winch.

A smooth surface allows the chain to fall nicely in the anchor locker (left) - in contrast to a non-surface-treated anchor chain variant (right). ©cromox

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This also applies to the fall line. There are suppliers who guarantee a calibration of the anchor chain during manufacture. This leads to an even dimensioning of the individual chain links and thus also to a straight fall line and smooth and safe running of the stainless steel anchor chain on the pocket wheel of the anchor winch.

If you prefer to use a galvanized chain for price reasons, you have to be aware that this is a game for time, because frequently used galvanized steel chains on the seabed in the sand, on stones or on corals wear out over time. The zinc coating is damaged with every contact and it usually only takes one season for rust to become visible for the first time. If it lasts for a long time, the chain diameter is reduced! This aspect is of great importance for long-haul sailors.

The reduced holding force of the anchor chain is only one aspect. A rusty anchor chain is also not a particularly nice sight and it inevitably leads to unsightly soiling on the hull and deck up to discoloration in the area of the chain.

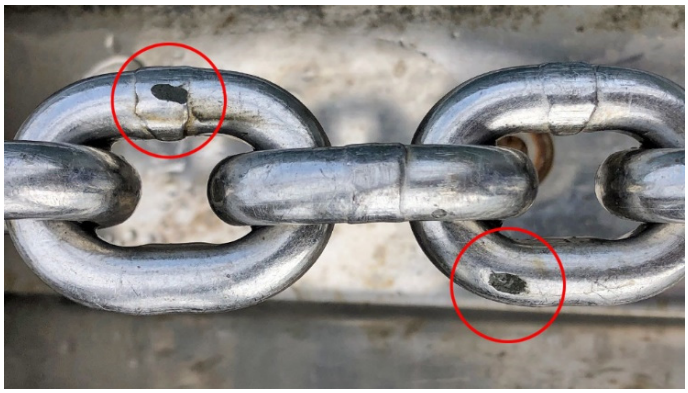
Of course, you can re-galvanize a galvanized chain. That may well be possible in the home port. However, anyone who undertakes a blue water trip will quickly find that a rusty chain, usually weighing at least 100 kilograms, cannot be transported from A to B. This makes "galvanizing" a logistical and financial challenge.

## Quality features of stainless steel chains

Anyone who opts for a rustproof stainless steel chain will find a large number of offers on the market in terms of quality. At first sight, the chains on offer are all made of stainless steel, but the problem lies in the detail when the individual materials are examined more closely.

In addition, stories are repeatedly discussed among sailors in which anchor chains made of stainless steel are the main topic; the quality of which is doubtful and whose chain links are broken due to the welding quality or due to corrosion. This is a circumstance that must be avoided, as it can endanger the crew and ship in serious danger.

The process of corrosion is also known as pitting. The following applies: the higher the salt content of a body of water and the warmer it is, the greater the risk that the anchor chain material will decompose by pitting.



Two spots with pitting (red circle) are noticeable on this chain. ©cromox

Stainless steel is generally very robust. However, this does not mean that the rustproof stainless steel is resistant to all external influences. For example, the so-called passive layer of the anchor chain can be attacked by mechanical, thermal or chemical influences, which adversely affects the corrosion behaviour of stainless steel.

Possible causes for this are, for example, severe damage to the surface due to mechanical loads (abrasive processing and overloading) or contamination due to a direct connection to other iron products such as shackles or connecting links. In addition, strong oxidizing agents, especially in combination with high temperatures, can have a detrimental effect on the corrosion behaviour of stainless steel.

It should also be noted that corrosion can occur where electrical current flows between different metals. This happens, for example, in salt water, as this has a conductive effect due to the salt content. For example, faulty electrical circuits and / or a lack of insulation can lead to an electrochemical reaction.

Severe anodic corrosion has occurred on this stainless steel chain. ©cromox

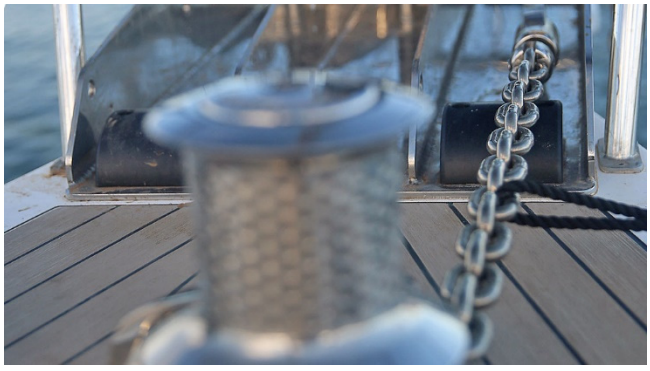
Corrosion can be prevented by choosing the right material. It is therefore advisable, depending on the area of travel, to take a closer look at it and to know the various materials from which stainless steel chains are made.

Anodic corrosion: This chain was exposed to a typical yacht voltage of 13.7 volts. ©cromox

## Materials for anchor chains made of stainless steel

The material is decisive for the resistance to pitting corrosion and the quality of a rustproof stainless steel chain. Each material has a number that classifies it in terms of its composition - for example 1.4401 or AISI 316. While 1.4401 comes from DIN (German Institute for Standardization) or EN (European Standard), the Americans use AISI (American Iron and Steel Institute). These values can often be found in the catalogues of yacht outfitters.

One aspect that is important in anchor chain materials is the carbon content of the material. A higher carbon content promotes the formation of chromium carbides, which can lead to intergranular corrosion. For saltwater sailors it is therefore important to pay attention to a low carbon content in the alloy when buying. Many anchor chain manufacturers use stainless steel with the material designation 1.4301 (AISI 304) or 1.4401 (AISI 316) for their chains.



The material plays a role: Stainless steel is not just stainless steel. ©cromox

However, anchor chains made of stainless steel with the material designation 1.4404 (AISI 316L) are better recommended for yacht use. Compared to 1.4401, 1.4404 has a lower carbon content, which has a positive effect on corrosion resistance. Incidentally, this is also evident from the letter “L” at AISI. The "L" stands for "Low Carbon".

For use in warm and salty waters, such as the Mediterranean or the South Seas, it is advisable to go a step further and use anchor chains made of duplex (1.4462 / AISI 318LN) or super duplex stainless steel (1.4507 / AISI F255). Due to its different alloy components, duplex material is even more heat and corrosion resistant than 1.4404 (AISI 316L).

Two ASTM (American Society for Testing and Materials) test methods can be used to determine the PREN (Pitting Resistance Equivalent Number) and CPT (Critical Pitting Temperature) values for pitting corrosion, which provide information on resistance in warm and salty waters allow.

Test procedures for the PREN value are specified in ASTM G48. It is a measure of the corrosion resistance of a stainless steel. In general, the higher the PREN value, the more corrosion-resistant the steel is. Stainless steel with a PREN value above 35 is considered to be seawater resistant.

In addition, the pitting corrosion of stainless steels can be characterized by the critical pitting temperature (CPT). The test is carried out in accordance with ASTM G150 and the lowest temperature at which pitting corrosion begins to occur is determined.

Stainless steel anchor chains have different grades. ©cromox

## Quality grade classes for anchor chains made of stainless steel

Another characteristic is the quality grade. Due to the high demands on the materials used, which inevitably exist in the yacht sector, it is possible for chain manufacturers to specify quality grade G60+ for their anchor chains. This means a higher tensile strength and breaking strength with the same diameter of a comparable chain of quality grade G50 or below. As a result, a smaller chain can often be used for the anchor gear and thus weight can be saved.

| Material | 1.4404 | 1.4462 | 1.4507 |
|---|---|---|---|
| AISI | AISI 316L | AISI 318LN Duplex | AISI F255 Superduplex |
| Grade | 60 | 60+ | 70+ |
| Breaking force at 8 mm chain thickness (optimum value) | 63 kN | 66 kN | 80 kN |
| PREN | 23,1 – 28,5 | 30,85 – 38,07 | 37 – 44 |
| CPT in °C | 24 – 27,5 °C | 27,5 – 34,5 °C | > 70 °C |

Material comparison with regard to quality class, CPT and PREN. ©BLAUWASSER.DE/cromox

## Material fluctuations in anchor chains made of stainless steel

It is also helpful to understand that there can be variations in the exact chemical composition of the respective materials. If you want to purchase a rustproof stainless steel chain for your sailing yacht, you should make sure that the supplier can demonstrate strict requirements for his suppliers in terms of material quality. They should be able to provide certificates which confirm the material used. They should have their own test equipment or laboratory 3rd party tested or certified.

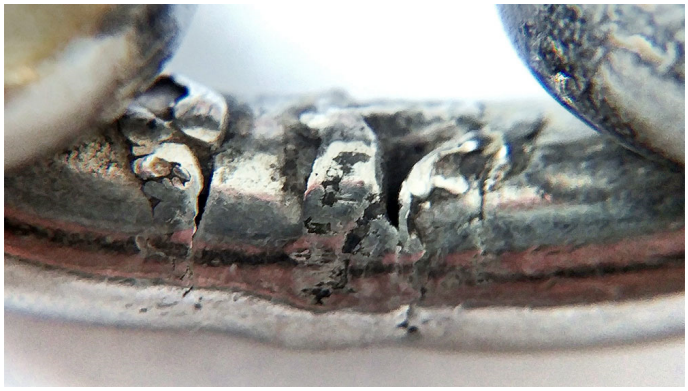
## Discoloration of stainless steel anchor chains

The discoloration of the anchor chain material is mostly caused by contact with organic compounds such as silt, sand or algae. They should not be misleading or a cause for concern, as they will in most cases disappear once anchored in other areas. The colour tones of the discoloration range from bluish to gold, orange and ocher to greenish shades.

Depending on the substrate and environment, there may be discoloration on the chain. ©cromox

## The welding seam on stainless steel anchor chains

There are two ways to weld a stainless steel anchor chain: by machine or by hand. Welding by hand means that the quality of the seams varies greatly and air pockets can arise due to uneven weld seams. Since the chain is only as strong as its weakest link, this has a significant effect on the load-bearing capacity and reliability of the chain.



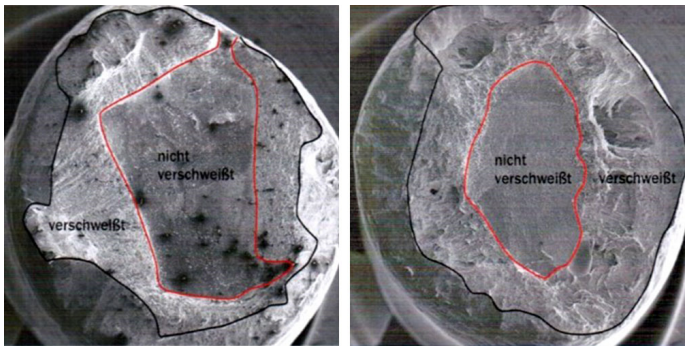
Example of a non-uniform weld. ©cromox

A uniform appearance and a consistently high quality of the weld seams can only be guaranteed through approved machine welding processes. There are standards for this which specify the welding processes permitted in each case. In many cases, inexpensive mass-produced goods do not meet these requirements.

For this purpose, the DIN 766 standard refers to the DIN 685 standard with regard to production, test methods and other requirements. According to this, only two special welding processes are permitted for the production of round steel chains: resistance butt welding and flash butt welding. In addition, according to DIN 766, chains must also be "subjected to test force" and "calibrated".

Anchor chain with chain links welded according to the standard. ©cromox

Unfortunately, a number of manufacturers of inferior mass-produced goods can immediately be recognized on product images where precisely these higher quality welding processes were not used. This can be recognized, for example, by a weld seam that is too smooth or does not exist - without a deburring pattern.




Examples of faulty incomplete welds. ©cromox

Sometimes you can read in sailor reports or the trade press that anchor chains made of stainless steel would break without warning. That is not right. If stainless steel with a properly welded seam is used, the chain link deforms under heavy tension before breaking and takes on a shape similar to the number 8.

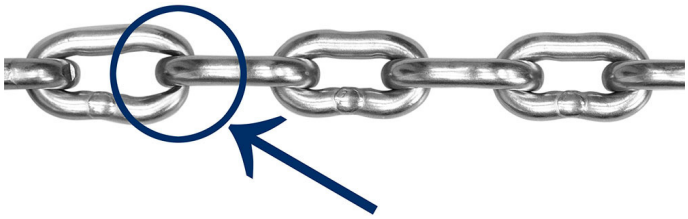

This anchor chain was stretched 32 percent. The links begin to deform. ©cromox

If the weld seam was not carried out professionally, the - usually inexpensive - products burst at the weld seam. The break is therefore not due to a weakness in the material, but to the poor quality of the weld seam. Therefore, the following applies: With high-quality, stainless chain links welded according to the standard, the base material always breaks - but never the weld seam.

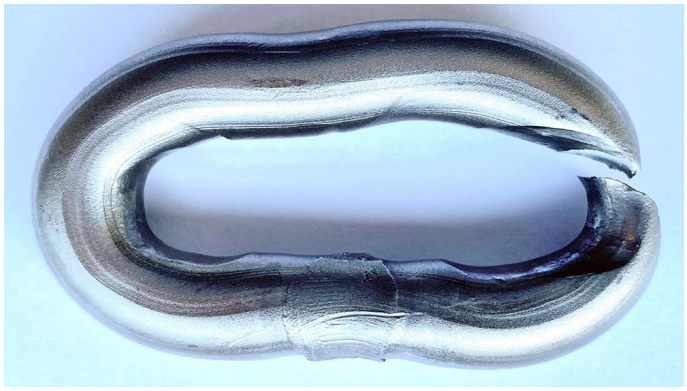
https://youtu.be/u4yTZ7GFGbY

Please note: The material only breaks when it is heavily stressed above the permissible load and has reached the required elongation!

To clarify, the following pictures show how a high quality stainless steel anchor chain behaves under extreme overload. It can clearly be seen how the chain is stretched and deformed. As soon as the load limit is reached and the chain can no longer be stretched, it breaks. As explained, high-quality anchor chains do not break at the weld seam, but in one of the curves of the chain link.



Ideal breaking behaviour in the curve of a chain link in this overload test. ©cromox

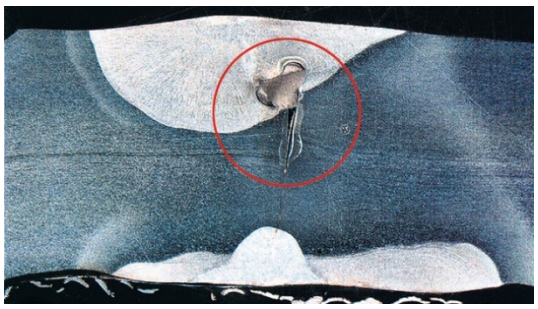


The break in the rounding can be clearly seen in the close-up. ©cromox

## Examples of material defects in stainless steel anchor chains

The following microscope images were taken as part of a test by BOOTE magazine (12/2008 issue). They show metallurgical axial sections through the weld seams on the chain links of anchor chains from various manufacturers (chain diameter 10 millimetres).

It is easy to see how important the machine welding process (butt welding) according to the standard is in the manufacturing of the chain. It is also interesting to see at what load and at what point high quality chains broke. Unlike the hand-welded chains, chains that were butt-welded using an approved mechanical process broke significantly later and, as explained, on the base material and not on the weld seam.



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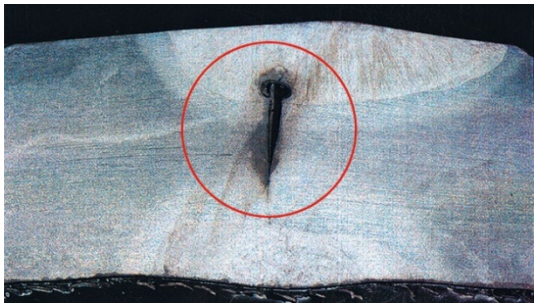
Example of a hand-welded seam that is not OK because it contains a cavity (red circle). The material is 1.4401 / AISI 316. The first deformation occurred at a load of 43.2 kilonewtons (kN). This chain broke under a load of 76.7 kN.



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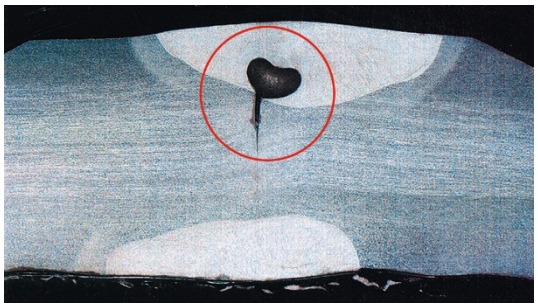
Example of a hand-welded seam that is also not OK. Compared to the previous example, it has an even larger cavity (red circle). The material is also 1.4401 / AISI 316. The first deformation occurred at a load of 42.0 kN. This chain broke under a load of 75.0 kN.



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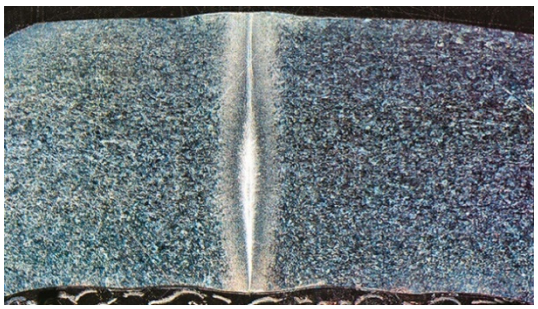
Another example of a hand-welded seam that is not OK. It also contains a large cavity (red circle). The material is again 1.4401 / AISI 316. The first deformation occurred at a load of 36.8 kN. This chain broke under a load of 73.4 kN.



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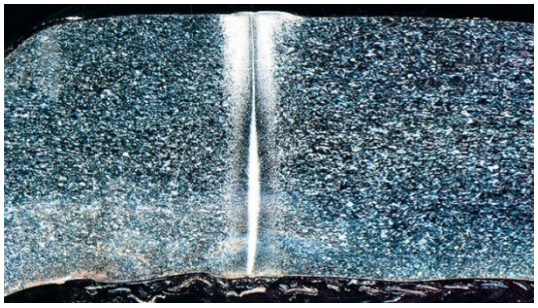
Example of a butt-welded seam that is OK. The material is 1.4571 / AISI 316 Ti. The first deformation occurred at a load of 33.6 kN. This chain did not break at the weld seam, but at the base material at a load of 79.2 kN, which corresponds to an average breaking load.



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And another example of a butt-welded seam that is fine. The material is 1.4404 / AISI 316 L. The first deformation did not occur until a load of 50.0 kN. This chain is also broken at the base material - but only with a load of 95.2 kN. That corresponds to a very high breaking load!

## Conclusion

In addition to the anchor, the bow fitting and the anchor winch, the anchor chain is a central component of the anchor gear. If you want to use a rustproof stainless steel chain with all its advantages, you should not blindly choose any material, but check very carefully which material is the right one and which quality features it has.

If the decision for a stainless steel anchor chain has been made, it is recommended, for the reasons detailed above, to purchase a high-quality, tested anchor chain made of selected stainless steel from a renowned, experienced manufacturer.

Such an anchor chain may initially seem more expensive than other products on the market. However, with consistently high demands on the quality of the material, verified workmanship and, calibration and other final tests, this is a good investment in the safety whilst anchoring for the crew and for the ship.

It should not be forgotten that a high-quality stainless steel anchor chain has a significantly longer service life when properly treated and cared for than is the case with inferior or even galvanized chains.

That can quickly pay off in more ways than one.