Materials and grades

Anchor chain is available in both galvanized and stainless steels of varying grades (strengths).

Galvanized

Galvanized chain is the economical choice for most boaters. It represents good value and offers a good range of grades. However the zinc galvanizing wears off over time, and eventually must be replaced (see below).

Different manufacturers use different systems by which to label chain grades. Distributors and resellers can confuse matters more. Grades equate at some point to a tensile strength figure, usually in metric units (megapascals).

- Low tensile chain is G3 or **G30**, which is to say it is formed from steel with a tensile strength of 300 MPa. This is commonly labeled as '**BBB**' or '**proof coil**'. This type is also referred to as grade '**L**' in Australia.
- Medium tensile chain is G4 or **G40** (tensile strength of 400 MPa). In the United States and some other regions, this is commonly branded as '**high test**', which is **not the same as high tensile**. This type is also referred to as grade '**M**' in Australia.
- **High tensile** chain is that made of steel with a tensile strength much above 500 MPa. This true "high tensile" is not the same as "high test". The galvanized versions from the principle manufacturers are G7 or **G70*** (tensile strength of 700 MPa), although the galvanizing process can reduce the strength slightly (the manufacturer should adjust the Working Load Limit accordingly, e.g. down by 10%). Commonly labeled as '**transport**' chain in the US.

More on 'high test' and high tensile

As above, *high test* does **not** mean the same thing as *high tensile*. The equivalent abbreviations from the two terms create much confusion, particularly in the United States where manufacturers and resellers exacerbate matters. American outlets referring to 'HT' chain are typically conflating the abbreviation for High Tensile with the marketing term High Test. Moreover, because the chain is 'high tested', it is sold with a WLL (Working Load Limit) which is calculated from a lower ratio to the break load, typically about 3:1 (instead of the international standard of 4:1). Note how the US WLL figures in the table below are far higher than the metric equivalents.

This does not detract from the chain, but it is misleading and does not change the ultimate strength of the steel! A particular size of American high test chain may look to be stronger than the same sized non-American G40 because the WLL is calculated differently, but in fact they are next to identical. The proof certificate using a different system of numbers does not change the physical properties of the steel.

Just to confuse matters further, G40 / G43 / high test is now *also* being explicitly described by some American sources as high tensile. These are just words, so when in doubt stick to the numbers, which are more difficult to confuse.

Re-galvanizing

After a number of years of use, galvanized chain will typically need to be either replaced, or its life may be extended by getting it re-galvanized. A hot dip galvanizing facility is required, and costs vary.

Non heat-treated chains (G30 and typically G40) can be re-galvanized without too many complications. Strength can be decreased marginally, although this should be negligible in the hands of a competent galvanizer. It is wise to not re-galvanize too many times. A good galvanizing plant will advise you based on the type of chain and its history.

High tensile G70 chains introduce a few more complications when it comes to galvanizing. In addition to the heat of the bath, there is a theoretical danger from embrittlement. Hydrogen embrittlement is often quoted as a concern, a problem caused in high strength steels by hydrogen placed in the steel's crystal lattice structure by the hydrochloric acid pickling process prior to galvanizing. Although chain manufacturers and resellers warn against re-galvanizing G70 chain, there is little evidence or data available to support this theory, and most independent expert sources are of the consensus that only very high strength steels (equivalent to a Grade 100 or higher) are vulnerable to hydrogen embrittlement. Nonetheless, proof testing the entire length of chain after galvanizing may restore some peace of mind. A procedural solution to hydrogen embrittlement is 'baking' the steel after dipping, to remove the hydrogen from solution before embrittlement can occur – this however elevates costs and is likely to make the recycling process uneconomic compared to the purchasing of new chain.

Regardless of the chain type, it would be wise to investigate the cost of replacement chain. Depending on the location and circumstances, it is common for new chain to be the easier and ultimately more economical solution.

Stainless chain with stainless anchor.

Stainless

Stainless chain offers a number of advantages over its galvanized sibling, one of which is simple aesthetics. For most boaters however the cost is prohibitive.

Stainless chain avoids the issues concerning galvanizing and wear covered above. It also stows nicely, because unlike galvanized chain it does not 'cone' in the chain locker (simply because the links are smoother).

Stainless is fine for anchor chain but like all stainless should not be used permanently, for example with mooring installations.

Grades available are fairly equivalent to galvanized chain, although the highest tensile options are typically lower. G50 stainless is about the best available.

Misconceptions about stainless steel

It is common to see incorrect ideas about stainless steel make their way about the rumor mill in the boating world. It is variously disparaged as weak, generally subject to sudden failure, or being guilty of other crimes.

Stainless steel is not one grade, and varies in quality and properties as much as regular steel. Having said that, the vast majority of anchor chain is 316L or similar, and it is difficult or impossible to find superior grades such as duplexes.

316 is a good grade of stainless for most marine uses, but is not ideal for prolonged submersion, and particularly not in the oxygen starved environment of the seabed. Without oxygen, the steel cannot reform its protective chromium oxide film, which is what gives stainless its reduced corrosion properties. This is the reason for the advice above against using stainless in permanent set-ups such as moorings.

The principle challenge with stainless chain is ensuring quality. Poor quality stainless can and will suffer from the issues that lend it a bad reputation. Even if the basic steel is good quality, stainless chain is typically welded with a filler material, and this process must be conducted by a competent manufacturer. Problems with the weld can lead to intergranular corrosion or "sensitization", which will lead to rapid failure of the weld itself. Poor quality, or lack of, finishing treatments can lead to surface rusting.

Stainless is very expensive. Generally the purchaser should expect the cost to be in the order of 3–5 times the galvanized steel equivalent in terms of performance/function. This is a fundamental reflection of the cost of the steels. If this is not the case, it is best to ask why.

Recommended grades

For the reasons discussed below under 'sizing', we typically recommend high tensile (G70) chain if it is available, practical, and affordable, although high test / G40 is perfectly acceptable; it just means carrying around a bit more weight. For any given boat, because a smaller size can be used, high tensile is not necessarily much more expensive than regular G40 (and in some cases can actually work out cheaper!). We recommend that the lower grades (G30 / BBB / proof coil) are avoided if possible, because larger sizes are necessary to attain the required strength. This implies a pointless addition of weight to the vessel, which is not insignificant with a long length of chain.

The grading numbers

In the section above on galvanized chain, the world's major chain grades are briefly summarized. Various traditions use different nomenclature, but all relate back to a "G" number. This is usually 1 or 2 digits, e.g. G4 or G40.

This figure is 1/100 or 1/10 respectively of the ultimate tensile strength of the specified steel used in the chain (this is mandated in various international standards). G4 or G40 would imply chain the steel of which possesses a UTS of 400 MPa.

Chain fittings and connectors

The type and grade of steel chosen for chain affects some of the choices with regard to shackles, swivels, and other connectors. In general, metals should in contact underwater should be similar, so stainless chain should make use of a stainless shackle or swivel (and preferably a stainless anchor). Otherwise, galvanic corrosion can cause the zinc coated connector (or the end of the shank of a galvanized anchor) to deteriorate in the presence of such a large surface area of stainless.

Moreover, if a high tensile grade of chain is being used, it is all the more critical to select a shackle of a matching grade, because the size possible is restricted by the smaller chain. For more, refer to the **Shackles** page.

Galvanic corrosion occurs more quickly in warm (tropical) and salty water.

Using a stainless connector with galvanized chain and anchor is quite acceptable, as the area of zinc present is large and therefore galvanic corrosion will be slow and any loss of the galvanized coating manageable.

Sizing

Chain should generally be sized by strength; in other words, choose the smallest chain that meets strength requirements (subject to safe working load limits). This implies matching the chain to other elements of the ground tackle, most obviously the vessel itself and how much force it is likely to place on its anchor in a worst case scenario. From our perspective here at Rocna Anchors, naturally enough we tend to start by thinking about the anchor, which is matched to the vessel according to our sizing philosophy. The chain and other elements of the rode can then be matched to the anchor – it must be strong enough to transfer all possible force to the anchor, but not unnecessarily large and heavy.

The strength of chain depends firstly on its grade of steel, whether low, medium, or high tensile steel. Of course, this metallurgical property does not speak entirely to the real world breaking strength of a given length of chain, which should be of a certain standard of quality, not rusted nor badly worn, etc.

Higher tensile grades of steel permit chain to be smaller and thus lighter for a given strength. True high tensile chains do not endure shock loading well, and should be sized with slightly larger margins of error, but are nonetheless the ideal choice for anchor rode. With a large surplus of weight savings, a

fraction of this weight could then be invested back into a larger anchor, so forming a system which is both more conservative *and* lighter in terms of total weight.

Except in very deep water, chain and its catenary has very little effect on the ultimate performance of an adequately sized modern anchor. The chain's effect on lowered pull angle and its shock absorption characteristics disappear in the rough weather when they are most required, and the anchor is best helped in other ways. More on this topic is found in the **Rode optimizations** and **Scope vs catenary** articles.

The table below outlines some recommended chain sizes and properties in both international and US grades. Note that the metric and US versions, although mixed together in the table, are *not* direct equivalents. This is a result of the different rating and testing systems used.

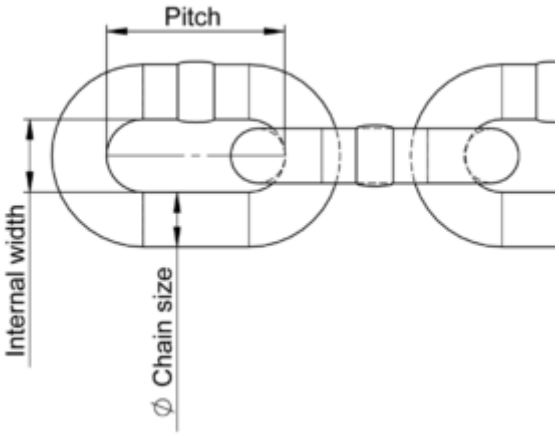
The table lists G40 and G70 in two major columns. G30 (proof coil, BBB, or Grade L) is not listed as it is considered too heavy to attain required strengths and therefore too inefficient in modern anchoring systems.

Anchor model	Appropriate med tensile chain (G40 / 'high test')				Appropriate high tensile chain (G70 / 'tran			
	Metric	Approx weight	Typical WLL	Typical break	metric	Approx weight	Typical WLL	Typical bre
Rocna 4	6mm	0.80 kg/m	400 kgf	1630 kgf	NA	-	-	-
Rocna 6	6mm	0.80 kg/m	400 kgf	1630 kgf	NA	-	-	-
Rocna 10	7mm	1.00 kg/m	630 kgf	2548 kgf	NA	-	-	-
Rocna 15	8mm	1.40 kg/m	800 kgf	4030 kgf	NA	-	-	-
Rocna 20	9mm	1.80 kg/m	1000 kgf	4077 kgf	8mm	1.40 kg/m	1400 kgf	7000 kgf
Rocna 25	10mm	2.35 kg/m	1250 kgf	5096 kgf	8mm	1.40 kg/m	1400 kgf	7000 kgf
Rocna 33	10mm	2.35 kg/m	1250 kgf	5096 kgf	8mm	1.40 kg/m	1400 kgf	7000 kgf
Rocna 40	11mm	2.60 kg/m	1600 kgf	6422 kgf	8mm	1.40 kg/m	1400 kgf	7000 kgf
Rocna 55	12mm	3.30 kg/m	2120 kgf	8480 kgf	10mm	2.35 kg/m	2200 kgf	11000 kgf
Rocna 70	14mm	3.90 kg/m	2500 kgf	10000 kgf	10mm	2.35 kg/m	2200 kgf	11000 kgf
Rocna 110	16mm	6.10 kg/m	4100 kgf	16400 kgf	12mm	3.30 kg/m	3160 kgf	15800 kgf
Rocna 150 +	Chain sizes are not provided for the same reason we do not provide anchor sizing recommendations for this range. It is likely you v or local regulations.							

Nb.: this table is a guide only and speaks to very rough matching of chain to anchor. It does not and cannot account for all the variables of your vessel and intended usage environment. Please read our general disclaimer linked to at the bottom.

Link dimensions and size standards

Physical link dimensions



Essential dimensions of chain links.

Listed chain sizes always refer to the link diameter, i.e. the diameter of the rod of steel which forms the chain link.

With regard to anchor chain, only short link is of interest. However, there is no single standard for short link chain which specifies the rest of the chain's important dimensions. The exact pitch is of most importance to windlass gypsies, as mismatched sizing in this regard will cause problems during windlass operation. The link width can also vary widely from one standard to another.

Metric EN and DIN

EN and DIN chain present the same size measurement for the diameter of the link, but vary slightly in pitch and width. It is important to investigate all dimensions to ensure suitability. For compatibility with your windlass gypsy, enquire with either the windlass manufacturer or a chain specialist regarding optimal mating.

EN standards are specified by the European Committee for Standardization (CEN) and reflect a continental metric specification. The alternative DIN standards originate from the Deutsches Institut für Normung (German Institute for Standardization) but are found worldwide.

North American sizing

American chain sizing can quickly become confusing, with even the higher profile brands generally failing to reference standards except an ISO format. The ISO versions are longer (greater pitch) and tend to be wider than chain called G3 or G4 "windlass" chain. Pay particular attention to exact dimensions.

Specifications

Calibrated

Calibration speaks to a higher standard of control of pitch and other key dimensions of the chain links. All anchor chain should be calibrated if it is to be used with a windlass. The chain and windlass gypsy need to be matched to each other – either the chain supplier or the windlass manufacturer can assist you with this.

Working Load Limit / Safe Working Load

WLL or SWL is a rated load for the chain beyond which it should not be stressed. It is typically a predefined ratio of the tested breaking strength of the chain, so providing a safe margin of error. This ratio is commonly around 4:1 (break to WLL) except in North America, but it can vary and a lower ratio can be used to make a chain look better than it really is. Check against the break load if you are unsure.

Proof tested

All quality chain is proof tested; this is where a load is applied to the newly produced chain as a quality control measure. It is not a performance measure, it is only intended to draw the manufacturer's attention to any flaws in the chain. The common load applied is twice the WLL, or half the expected break load. Information on this proof testing should be freely available; if it is not, questions should be raised.

Test certificates

All quality chain from reputable manufacturers can be supplied with test certificates which testify to a number of characteristics of the particular chain. This is mostly useful when the anchor system must meet classification requirements, but because it is generally always available it can be a helpful form of quality control when selecting product. To avoid misleading certification, closely examine the figures on the certificate and make sure they make sense. Lastly, remember that a certificate is only a piece of paper, and you are ultimately dependent on the reputation of the manufacturer.