Mooring Chain and Assemblies

Today the range and variety of chains and fittings, used in mooring/marine applications, is probably wider than ever before and to compound the selection problem, almost all components are available in various grades. Different strengths for otherwise identical items are achieved through the use of different steels and heat treatments, some more suited to the marine environments than others.

Grades

Chain and fittings are manufactured in different strength grades for specific applications, and the strongest component is not necessarily the best for the job in hand. It could be unsuitable for galvanising, or made from a steel which corrodes more rapidly and it may be disproportionately expensive. As will be seen later, weight is as important as strength in moorings and the lowest and cheapest strength grade usually offers the best combination of properties. Internationally, there are standards covering chains and most fittings and these recognise the following grades:

Grade 3 (L)
This is the lowest grade with components made from mild steel without heat treatment.

Grade 4 (M)
Normally manufactured from low carbon steels and heat treated, this is the lowest grade recommended for lifting applications.

Grade 8 (T)
The highest strength in normal use; components are usually made from alloy steels and hardened and tempered.

With the exception of stud link chain cable, chains are generally supplied in the grades detailed above. Stud link chain is normally supplied in grades U1 (mild steel), U2 (high tensile) and U3 (heat treated alloy steel) as specified by Lloyd's Register of Shipping.

Chains

Short Link Chain

Internationally, this is accepted as chain with a link of outside dimensions not exceeding 5 times the material diameter in length and 3.5 times in width – e.g. 10mm chain cannot have links larger than 50mm x 35mm outside dimensions. Excluding stud link chain, short link chain, size for size, is the strongest, heaviest and most flexible of chains, and as such is the best choice for mooring and anchoring. Unfortunately the links are too short to accept shackles of reasonable size, necessitating the fitting of large end links. In effect, short link chain needs to be assembled into a ‘bespoke’ mooring assembly. William Hackett have the ability to do this by means of an ‘all-welded’ assembly negating the need for joining components such as shackles.

Mid Link Chain
These chains have a link of outside dimensions not exceeding approximately 6 times the material diameter in length and 3.6 times in width – e.g. 10mm chain, generally would not have links larger than 60mm x 36mm outside dimensions. Mid link chains are a good compromise, as they offer most of the benefits of short link with the advantage that they will accept like sized shackles without the need for special end links.

**Long Link Chain**

These chains have a link of outside dimensions not exceeding approximately 8 times the material diameter in length and 4 times in width – e.g. 10mm chain, generally would not have links larger than 80mm x 40mm outside dimensions. Long link chains are also a popular choice for mooring applications, as they offer greater internal dimensions to facilitate a wider range of associated fittings without the need for special end links. They also offer a lighter weight to ultimate breaking strength ratio, which can often be an issue when choosing the correct mooring buoy.

**Stud Link Anchor Chain**

Originally studs were added to chain to stiffen the links, preventing them from severely deforming when overloaded. They have an added advantage in that they prevent chain from knotting up when twisted, thus avoiding problems when the chain is retrieved with a windlass. Most chain of this type is used on larger vessels, off-shore mooring systems or used as a ‘ground chain’ for a mooring system.

**Other Components**

There is a wide range of other components which could be used in a mooring system and it is important to ensure that those used are of equivalent strength to the chain. Using components which will fit a chain, with no regard for relative strengths, is all too common. As an example, given similar materials, a conventional shackle which will fit directly into short link chain can, at best, be only about half the strength of the chain. Compatibility of materials is vital too – the problems of dissimilar materials and electrolysis are only too well known, where a reaction occurs leading to excessive and rapid corrosion.

**Shackles**

There are three main types of shackle in common use and a wide range of pin designs.

**Dee and Bow Shackle**
By far the most popular shackle types are dee and bow shackles to BS 3032, screw pin, although similar shackles to US Federal Specification are also commonly used as a means of connection. Care needs to be taken when choosing shackles to these standards as there are many poor quality imitations currently in the market place. These can range from incorrect material used, lack of correct heat treatment and poor manufacturing / machining processes leading to inferior quality products and ultimately potential failure in service.

Forelock Shackle

The forelock shackle is normally used for more specific larger mooring applications and each size is designed to be used with a specific size of chain, generally stud link chain or larger open link chain. The pin is generally oval and is secured by a split pin where the pin protrudes through the body of the shackle itself.

Kenter Shackle

The Kenter shackle is really a mechanical connecting link solely designed for joining two lengths of stud link chain.
Swivels

There are various designs of swivel available and the user should ensure that the one chosen will accept the correct size shackle or shackle pin or, of course, unless incorporated into an all-welded assembly that William Hackett have the capability to do.

Rings, links and other fittings

The range and variety of fittings which may be used in a mooring and anchoring system is far too wide to cover comprehensively. Rings, egg links, bridle plates, slip hooks, stoppers, eyebolts, ringbolts – all have their places. Suffice to say that compatibility in materials, strengths and dimensions is essential.

Laying a Mooring

When any type of permanent mooring is assembled, there are a few basic rules to bear in mind. Unless the mooring is a complete all-welded assembly, shackles or some other form of mechanical connectors will have to be used. These are almost invariably weaker, size for size, than the chain and although in a well designed system, loads should be modest, it makes good sense if all components are of roughly comparable strength. Therefore shackles (and swivels) should be chosen which are at least one size larger than the chain. Rings, often used between bridle and pendant, need to be substantially larger to achieve equivalent strengths. Shackle pins are another problem area. Screw pin shackles are by far the most popular but the threads can corrode more rapidly and the pins work loose. There is no easy solution, but at the least, all shackle pins should be very securely moused (wired). A thick solid wire should be used for mousing and never wire rope, where deterioration is rapid and possibly hidden from view.

Before finalising your choice of mooring position with your local authority or club, consult your local mooring contractor as to whether the area is safe for your vessel and that the mooring chain, shackles and swivels are adequate in relation to the size of your vessel, the prevailing conditions and that there is sufficient depth of water.

Before purchasing mooring tackle, please take into consideration the following points:

- Mooring chain must have been manufactured for the purpose of mooring use, i.e. low carbon steel and must be guaranteed as such.
- We recommend that genuine BS 3032 shackles, manufactured from low carbon steel, are used for securing chain. Commercial shackles, although new, may be unsuitable because of poor thread and manufacturing processes.
- Modern, loose laid three strand rope (soft rope) must not be used as a bridle on a swinging mooring because it may unlay.
Maintenance

Although every system of maintenance must be based on regular inspection, the precise procedure to be followed for any mooring depends upon local conditions. If a mooring is exposed to strong tides and rough weather, it will naturally wear more rapidly. Normal wear and tear is not however the only cause of damage to mooring components. Corrosion, erosion and electrolysis can all be responsible for rapid and dramatic removal of metal. Consequently, moorings on new sites need to be carefully monitored until a wear pattern can be established.

If possible, moorings should be lifted for winter storage, or alternatively the riser may be sunk and marked with a buoy. Either of these procedures can double a mooring’s effective life. Another useful tip is to position the swivel, which wears quite rapidly, at the top of the riser, where it can be easily inspected in situ. Finally, no time should be lost in making an inspection of a mooring where movement has been detected or is suspected.

Permissible wear

The degree of wear that can be safely permitted before replacement again varies with individual circumstances. A ground chain will often be far larger than strength requirements dictate, as it is bought primarily for its weight. Risers, however have to be supported by a buoy and so tend to be nearer to the minimum acceptable size. As a guide, one should not allow anywhere more than a 15% reduction below the chains material diameter. Remember that the ends of a link (where adjacent links are in contact) wear more rapidly, so particular attention should be given to these areas. Badly rusted chain should never be used, particularly if the surface has been removed to expose the grain of the metal.

Chain versus Rope

Strength

One of the difficulties with rope is that of establishing the correct size for the application. The problem of calculating forces exerted on a mooring have already been emphasized. With chain, provided that there is sufficient scope and weight, these are largely academic, as the catenary curve will absorb whatever loads are likely to be generated. A rope is too light to create this curve however, and one that is too strong will pull the anchor loose before it stretches enough to get any spring action. Conversely, if it is too weak it could stretch to breaking point.

Chafe

Chafing is by far the most common cause of rope failure and it is surprisingly difficult to prevent. Anti-chafing gear is essential wherever the rope is likely to be abraded and frequent careful inspection is imperative. Danger areas are where it passes through a fairlead, where it is connected to a buoy or swivel and, of course, where it can rub on the bottom. With regard to the latter, the only safe way is to make sure that even at low water springs, it never touches the sea bed. This almost invariably means that a length of chain has to be used to connect the rope to the bridle or anchor. As an additional safeguard the chain/rope junction could be buoyed, or the rope could be protected by a
plastic sleeve.

**Scope**
The one critical factor which affects holding power is the angle of the pull on the anchor. However it is achieved, it must be near to horizontal and this is much more difficult to ensure when anchoring with rope. To achieve the desired angle of pull it is common practice to use a length of chain between the anchor and the rope. This has the added advantage of lessening the likelihood of the rope chafing on the bottom, but even with this, greater scope is required. As a rough guide, such an arrangement needs a 5 : 1 minimum scope compared to 3 : 1 for chain. The weight of chain hanging from a boat reduces sheering and its shorter scope demands less swinging room, giving it a distinct advantage over rope in confined harbours.

**Connections**
Rope also presents some problems in joining it to other components. Even a skilfully executed eye splice will weaken a nylon rope by up to 15%, whereas a badly made one, like most knots, will effectively halve its strength. Other ropes will present other difficulties; some modern synthetic types, for example, are particularly 'slippery' so knots and splices are more suspect. Laid ropes may be spliced to chain quite easily or can be fitted with thimbles to facilitate the use of shackles, but braided or plaited ropes are more difficult to work with.

**Conclusions**
Chain, of course, has its drawbacks too. It will wear, rust, and is generally awkward, heavy and dirty to handle. In its favour are the facts that it stows easily, worn sections can be easily replaced, and it offers the overriding benefit of distributed weight. Finally, it does not deteriorate in sunlight, so maintenance can be safely limited to a periodic visual inspection. All things considered, chain surely remains superior for this application.
Product Quality

Excluding wear, chains break in service for one of four reasons: poor quality, brittle material, misuse or excessive loads being applied. Quality is the responsibility of the original manufacturer and can only be assured by careful control of the manufacturing processes and by thorough testing of the finished product. Virtually all chain is sold with an EC Declaration of Conformity or manufacturer’s certificate stating that a certain proof load has been applied, but this alone is not enough. Most grades of chain should not break until subjected to a load of at least double the proof load. By then the chain will have stretched and this combination of high breaking load, with stretching, ensures good resistance to shock loads. At William Hackett, we take samples for destruction tests as a regular part of our ongoing quality assurance process.

The second cause of chain fracture is brittle material, which is by no means uncommon. One cause of brittleness must be emphasised, however, as it is of particular relevance to the marine user. Galvanizing an alloy chain can, unless carried out with expert knowledge, render it useless and liable to fracture and fail without prior warning. The problem of chain breaking through excessive loads is easily avoided. The importance of scope and weight in moorings has already been stressed. Sufficient shock absorption from the catenary curve is essential and for both security and economy, it makes sense to use the heaviest and longest chain that is practical.

Corrosion and Abrasion

It is all too common for marine chains to erode very rapidly, although this is rarely due solely to corrosion. In certain conditions electrolytic action can remove material at an alarming rate. Semi-colloidal suspensions of sand and silt will cause chain links to literally grind themselves away. Severe turbulence can actually sandblast the chain and will aerate the top layers of water creating a scrubbing action to shorten chain life. Local waters may be contaminated by effluents with similar effect. In some instances electrolytic action can be somewhat reduced by fitting sacrificial anodes to moorings, but the other problems remain. All that can be done is to select materials which experience and research suggests are those most suitable, and this alone can substantially increase chain life.

Conclusions

Considering all these factors, it is obvious that the best compromise is a mild steel chain manufactured from steel in which the carbon and manganese contents have been kept as low as possible. Acceptable steels should contain no more than 0.3% carbon and 1.5% manganese and the lower the better. This range permits the use of grade 40 higher tensile steel chains for specific applications or where mild steel is not available.