Fine or coarse-threaded, hard or soft?

A small bolt customer
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Bolts can be found everywhere, yet we hardly notice them in everyday life. We have become so used to their ubiquitous presence and rightly so, as they are the most commonly used, removable connecting element of our time. Almost everyone is familiar with bolts in one form or another. They are often underestimated. A small steel bolt can absorb enormous forces. This becomes particularly apparent when calculating the retaining force, for example.

Whether it's wood or carriage bolts or machine screws; bolts with hexagonal, raised or countersunk heads; bolts with a square neck or head drive; bolts with a hex drive, Torx, cross or slot drive recess. There are so many different types of bolts that it is easy to loose track. But there is one aspect that is universal to all bolts.
They all have a minimum tensile strength and a yield point. They also have what's known as a pre-tension force and an associated tightening torque. Calculating these values is often a time-consuming process. This is why there are tables where you can find the corresponding values for your bolts. The rest of this text mainly refers to machine screws as they can be found everywhere in the agricultural sector.

1. Nominal size and thread pitch

The nominal size of metric bolts is standardised. The nominal diameter of a bolt is preceded by a capital M to indicate that the bolt thread is metric. Therefore, a metric bolt with a diameter of 12 mm and a standard thread (coarse) has the following designation: M12.
In addition to standard threads, bolts can also have fine threads. With these bolts, the threads are closer together than on a standard bolt with the same diameter. As a result, the bolt has a greater self-retaining effect. This means that the nut is less likely to loosen by itself during the work. In this case, in addition to the nominal diameter, the distance between the bolt threads is also indicated in mm: M12x1
If the usable length of the bolt also needs to be specified, it is shown in mm: M12x45

2. Bolt quality

As a general rule, machine screws are made from steel. The quality of the material used is usually stamped on the head of the bolt or screw. The number used to indicate the quality consists of two or three digits, usually separated by a decimal point. The most common qualities used in the agricultural sector are 8.8, 10.9 and 12.9. These numbers can also be used to calculate the minimum tensile strength and the yield point of the bolt or screw.

3. The bolt and its nut

One of the most important rules when choosing a bolt is making sure that you use the right nut. The most important thing to remember is: the bolt should always have a higher quality than the nut! For example, if the bolt has a quality of 12.9, you should use a nut with a quality of 10.9. If the bolt only has a quality of 8.8, the nut should be 6.8.
The reason for this is that the nut is the smallest and cheapest part of bolt connections. As such, if the load becomes too heavy, the nut should be the part that is damaged and not the bolt.
An important tip when using self-locking nuts:
the thread of the bolt should protrude from the nut by at least one turn, otherwise the locking effect of the poly ring or metal clamping part will not work. If you expect the nut to be exposed to higher temperatures, always use an all-metal nut. In certain situations, poly rings can melt and then no longer provide a locking effect. As such, you should NEVER use a locking nut more than one!
Another tip: If the bolt and nut are made from stainless steel you may notice some “fretting” when the bolt connection is loosened. This is caused by the thread of the bolt and nut rubbing against each other. This is due to the high amounts of chrome in the material. If this happens, sometimes the bolt connection can only be removed if it is completely destroyed (e.g. snapped/separated). To prevent this “fretting”, simply apply some graphite paste to the threads before assembly.

4. Areas of application for different bolt qualities

The quality of a bolt determines its area of application. When attaching a cultivator, share above a wing share, a 12.9 bolt should be used if possible. Due to the large lever in front and the long shaft length, the bolts in this area are often subject to very large loads. The most important thing here is to make sure that the bolt has a high pre-tension force in order to keep the static alignment of the component on the tine constant. The high yield point is an advantage here and the only slightly higher minimum tensile strength does not pose a problem as the dynamic momentum is usually absorbed elsewhere. For example, in this case it would be absorbed by the shear bolt and the spring overload protection. It is different with lateral wings that must be bolted in horizontally or vertically. Here, the bolt is located close to the leverage point so a bolt quality of 10.9 is usually sufficient. The only thing that may require a stronger bolt to be used is if the bolt head is worn due to abrasion with the soil.

With plough parts, a bolt quality of 10.9 is sufficient as the bolt is only subjected to a limited amount of tensile stress and usually multiple bolts in different places ensure that the system is connected to the plate on the plough body. As the heads of the bolts are often sunk into the plates there is little abrasion here. Of course, there are cases in which standard bolts regularly tear or shear too. If this does happen, you should check the settings of your equipment first before using a harder bolt.

There are even cases where damage is wanted. For example, a shear bolt should always be the weakest element so that it is the first part to be destroyed before others around it can be damaged. As a general rule, a bolt with a quality of 8.8 rather than 10.9 should be used here. However, this depends on the lever length of the tine and the desired shear force. It is sometimes worth actually digging out a pen and paper to make a quick calculation. Otherwise, you can always carry out a few practical trials to see what the most suitable bolt quality would be for your application. Some machine manufacturers also offer shear bolts with notches around the head that allow you to precisely define the shearing position and force.

5. Coatings and corrosion protection

As bolts are used in all weathers, they often need to have a protective coating. The most common form of coating is galvanising. Sometimes you can also find painted or blued bolts. The most common design, after galvanising, is the so-called “blank” surface. This does not necessarily mean that the bolts are shiny or polished. “Blank” bolts are bolts that have not been coated with a long-term corrosion protection. These bolts may also have a black surface or be scaled.

6. Calculating the yield point, minimum tensile strength and retaining force

The yield point is the force at which the bolt starts to deform plastically. The minimum tensile strength is the force at which the bolt starts to shear. As the bolt should only deform elastically during the work, the yield point is the more important value. The minimum tensile strength is only decisive for “shear bolts” as here you usually want the bolt to be destroyed in the event of an overload. It is easy to calculate both values and the same process can be used for all bolt qualities. To determine the minimum tensile strength, the number before the decimal point is multiplied by 100. To calculate the yield point, the number before the decimal point is multiplied with by number behind the point and the total is then multiplied by 10. You can then convert these values to find the diameter of the bolt. To do this, calculate the cross-section in mm^2 and multiply it by the yield point.

6.1 Formulae and calculations

The formulae needed for the calculations are listed in the following diagrams in relation to the calculation method.

To convert bolt quality into yield point and tensile strength:

Bolt 10.9

Yield point: 10 x .9 x 10 = 900 N/mm²

Tensile strength: 10 x 100 = 1.000 N/mm²

To convert yield point into bolt cross-section:

Bolt M12

Cross-section: 12 mm x 12 mm x ¾ = 113 mm²

Retaining force: 113 mm² x 900 N/mm² = 101.700 N

This is equivalent to a weight of 10.17 tonnes

From the calculation, you will be able to see the forces that an individual bolt with a diameter of 12 millimetres and a quality of 10.9 can absorb. For example, you could attach a medium-sized tractor and cultivator with a three-point linkage to just one of these bolts and it would hold.

7. Tightening torques and pre-tension force

As the pre-tension force is only a theoretical value and can only be proven in a bolt connection with a special measuring device, the actually important value is the tightening torque. This can be directly set and applied with a torque wrench. The following table contains a list of the tightening torques for the most common bolts with standard threads. The tightening torques are stated in newton-metres (Nm).

Nominal diameter	Quality 8.8	Quality 10.9	Quality 12.9
M6	10 Nm	14 Nm	17 Nm
M8	25 Nm	35 Nm	42 Nm
M10	50 Nm	70 Nm	85 Nm
M12	87 Nm	122 Nm	147 Nm
M16	210 Nm	299 Nm	357 Nm
M20	411 Nm	578 Nm	696 Nm
M24	710 Nm	1000 Nm	1196 Nm

8. Summary

It is clear that the humble bolt - as inconspicuous as it may be - has a lot to offer. When putting something together, it is always worth checking which bolt is best suited to each individual application. Using bolts with the correct dimensions can help you save a lot of money, not to mention the hassle and the amount of time that you spend replacing a broken bolt. You will definitely not regret taking a little more time to make sure that you are using the right bolt before starting your work!