



**Dr. Fastener-**

## Q1: What is Ultimate Tensile Strength?

**A**: To answer that we must consider what happens to a fastener when we apply an increasing load along its axis. Under increasing load, the fastener initially just stretches like a rubber band). In fact, at this point, if we release the load we are pulling with, the fastener will return to its original non-stretched length. While the fastener is behaving this way, it is described as “elastic.” Let us start pulling it again, but this time we will not let off the load. Eventually we reach a point where the part stops behaving elastically, and the stretching becomes permanent (entering what is known as the plastic region.) Once we make this transition, we can say that the fastener begins to yield. The point where this transition occurs is known as the Elastic Limit of the fastener. The fastener is still completely intact, but once it has reached its Elastic Limit, the stretch is now plastic and on a lower strength bolt may become very visibly obvious. We keep pulling until we reach the ultimate stress that the part can handle before fracturing. This is known as the Ultimate Strength or Ultimate Tensile Strength. Thus, **the tensile strength is the maximum tensile applied stress or force that a specimen or part can support prior to or coincidental with its fracture.**

# Understanding Tensile Strength

## Q2: Why can an M6 Bolt have the same Tensile Strength as an M39 Bolt? Isn't the M39 Bolt much stronger than the M6 Bolt?

**A**: To answer this, we must put a couple of concepts into context. When we generate a universal standard, we want to be able to specify properties/characteristics that are universal across many different parts. With fasteners our standards usually define anywhere from a single strength grade or class to several grades or classes. ISO 898/1, the standard that defines strength classes for externally threaded metric fasteners defines about a half dozen different strength classes, but only three primary ones, Property Class 5.8, 8.8, and 10.9. These can be associated with describing the fastener, respectively, as low strength, medium strength, and high strength.

The next concept that is important to understand is regarding mechanical properties. Properties are characteristics about the material or part and are categorized as mechanical, physical, electrical, thermal, chemical, and magnetic. For fasteners, we usually are primarily interested in the mechanical and physical properties. The best definition of a property that I have encountered defines a property as “something you can measure about a part that doesn't matter how big it is.”

The last concept is understanding the difference between stress and strength. Stress is defined as the “internal resistance per unit area developed by the part to resist deformation”. In engineer's vocabulary, stress is the force divided by the cross-sectional area. Since stress is a value determined by size, it cannot be a material property. On the other hand, strength is defined as “the maximum ability of the material to withstand the load without causing failure.” Clearly this value is independent of part size and helps one to understand why an M6 bolt can possess the same strength as an M39.

Thus, if we pull it all together, we can see that **two parts of significantly different size can possess the same strength. However, because they have different cross-sectional areas, their load capacity at the same strength level will be vastly different.** In the example above, let us assume that both the M6 and the M39 possess a strength of Property Class 8.8. In this instance, the tensile load which a standard pitch M6 part can sustain is 16,100 Newtons while the M39 is 810,000 Newtons. So, to answer the question, both parts are equivalent strength BUT the tensile load carrying capacity of the M39 is 50 times greater than the M6.



**Q3:** *If you know the strength class and size of a bolt, can you figure out what the minimum tensile load will be to satisfy the strength level of the bolt?*

**A:** Yes, there are two ways to go about approaching this question. The easiest way is to simply reference the standard. The performance standards make it easy for us and usually include a table (or series of tables) that provide the minimum tensile loads and proof loads of different fastener sizes at different strength classes. It is as simple as matching three pieces of information, nominal thread size, strength class, and thread pitch. However, if a table is not readily available, or you prefer to figure such values for yourself, this can be easily calculated. Remember that stress is defined as force (load) divided by cross sectional area. In the case of a fastener part, the smallest diameter on the part is usually the minor diameter of the threads. Keep in mind, however, that threads must be inclined to allow them to advance. This means that the cross section through the threads is not as simple as one might suppose because it's not perfectly round. In fact, it is more elliptical. We refer to this as the Tensile Stress Area. Once again, **the standard will usually publish the equation used to derive the Tensile Stress Area, but it is usually also published with the same tables that illustrate the loads. Therefore, one can rearrange the strength equation around to solve for load using the Tensile Stress Area.**

**Q4:** *How does one evaluate tensile strength?*

**A:** **The best method to evaluate tensile strength is to perform a full-size Axial Tensile Test on the bolt.** This is accomplished by fixturing the part in a tensile tester and applying an axial load until the part breaks. The point at which it breaks is the Tensile Load. This test load can be compared with the load to meet the minimum tensile strength to verify that the part meets the standard requirement. In most cases the part must break in the threads.

**Q5:** *Is this the only test for tensile strength?*

**A:** **No, one can also conduct a Wedge Tensile Test.** It is like an Axial Tensile Test except a wedge made to an angle prescribed by the standard is placed underneath the head. Once again, it is fixtured in the tensile tester and pulled in an axial direction until the part breaks. Acceptance is the same as in the Axial Tensile Test, the break should be in the threads, and the head must not separate from the body. The Wedge Tensile Test is far more severe than the Axial Tensile Test because the introduction of the wedge is not only verifying the part meets the required minimum tensile strength but also a measure of head soundness and ductility.

**Q6:** *What happens if the parts are too big or too small for Tensile Testing?*

**A:** Both scenarios are addressed in the standards. **If the part is too big for the available load frame, a test specimen can be machined from the larger part and used to make the tensile test.** The standards usually provide guidance for this test with specific information regarding required performance and guidance on producing the machined specimen. **If the part is too small for the test frame, the tensile strength can be predicted from the part hardness.** For steels, the relationship between hardness and tensile strength is reliable. It should be noted that in both the case of using hardness or a machined specimen, **the results may not be as good as using a full-size part.** The reason is that both the machined specimen and the hardness collect results at a localized section of the part rather than across the entire cross section. Thus, a full-size test will always be considered the referee method should there be any dispute.

## Wrap-up

Tensile Strength is an important value used to qualify the quality of fasteners. Although designers may be more interested in other material properties such as yield strength or shear strength, Tensile Strength remains the strength value most important to the average user of the fastener. ■

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