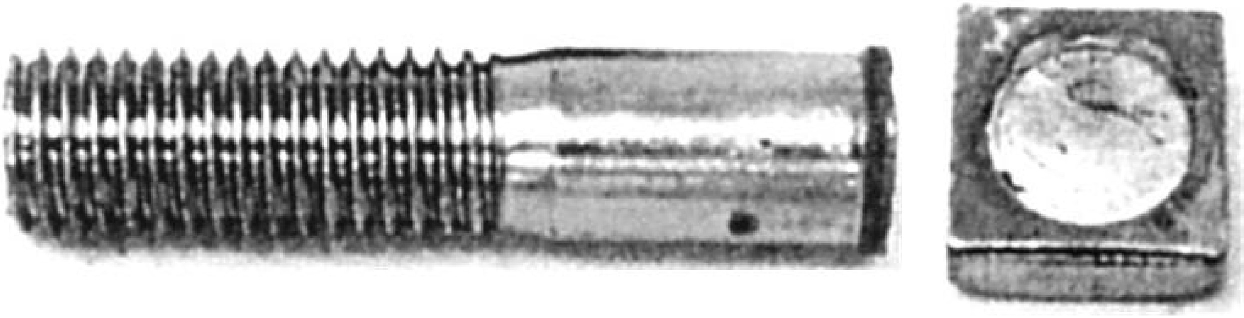
# Bolt Head-to-Shank Failures Are Prohibited



The manner in which a bolt or screw breaks during testing is as important as to whether or not it meets or exceeds its minimum strength requirements. Even if a bolt breaks at twice its minimum strength requirement, but the break is where the head connects to the shank the bolt is unacceptable.

**All applicable standards organizations prohibit head-to-shank failures.**
The primary standards organizations dealing with commercial grades of bolts are the American Society for Testing and Materials (ASTM), the Society of Automotive Engineers (SAE), and the International Standards Organization (ISO). All of these standards setting bodies agree that bolts and screws must not fail at the location where the fastener's head joins its shank.

Below are the specific prohibitive statements from these standards:

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| **ASTM F606** (inch) and **F606M** (metric) | Section 3.4 *Axial Tension Testing of Full-Sized Product*<br><br>3.4.3 To meet the requirements of the test……………the tensile fracture shall occur in the body or threaded section with no fracture at the juncture of the head and shank.<br><br>Section 3.5 *Wedge Tension Testing of Bolts*<br><br>3.5.1 …….To meet the requirements of this test the bolt shall support a load prior to fracture not less than the minimum tensile strength specified in the product specification for the applicable size, grade, and thread series. In addition, the tensile fracture shall occur in the body or threaded section with no fracture at the juncture of the head and shank. |
| **SAE J429** (inch) | Section 6.5 Axial Tensile Strength ……… |


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| | To meet the requirements of Section 5, the bolt, screw, or sems shall not fracture before having withstood the minimum tensile load specified for the applicable size, thread series, and grade in Table 5. In addition for bolts, screws, and sems with regular heads, the ultimate failure location shall occur in the body or threaded section and not at the junction of the head and shank.<br><br>Section 6.6 Wedge Tensile Strength………..<br><br>To meet the requirements of Section 5, the bolt, screw, or sems shall not fracture before having withstood the minimum tensile load specified for the applicable size, thread series, and grade in Table 5. In addition for bolts, screws, and sems with regular heads, the ultimate failure location shall occur in the body or threaded section and not at the junction of the head and shank. |
| **SAE J1216** (metric) | Section 3.5 Axial Tensile Strength<br><br>3.5.5 To meet requirements, the specimen shall support the load, prior to fracture, not less than the minimum tensile strength specified for the applicable size and class in the product standard. In addition for bolts and screws (except for flat and oval head machine screws) the fracture shall occur in the body or threaded section with no failure at the junction of the head and shank.<br><br>Section 3.6 Wedge Tensile Strength<br><br>3.6.1.2 To meet requirements, the specimen shall support a load not less than the minimum tensile strength specified for the applicable size and class in the product standard. In addition for bolts and screws (except for flat and oval head machine screws) the fracture shall occur in the body or threaded section with no failure at the junction of the head and shank. |
| **ISO 898-1** (metric) | Section 8.5 Test for strength under wedge loading of full-size bolts and screws (not studs)<br><br>…………..To meet the requirements of this test, the fracture shall occur in the shank or thread of the bolt, and not between the head and the shank. |

**There are well known reasons why bolts and screws fail where the head joins the shank.**


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The reason for the prohibition against head-to-shank failures is that this type of fracture indicates that either there is a manufacturing fault at this critical location or that the material is too brittle to withstand bending forces and impact loads safely.

Some of the most common manufacturing faults causing head-to-shank fractures are:

1. A material fold is present where the head meets the shank. These folds are created during the cold forming process when the raw material folds over on itself instead flowing evenly outward from the center to form the head symmetrically.
2. The radius at the head-to-shank juncture is too small creating a sharp corner.
3. The bolt or screw was cooled too rapidly when quenched during the heat treat process and a “quench crack” occurs.
4. The improper grade of raw material is used and the material is too brittle at the specified hardness.
5. The material is correct, but the bolt or screw is too brittle because the part was not properly tempered after hardening and quenching.

**Standard sample sizes for testing do not always detect the problems stated above.**

Sometimes these types of problems are not easily detected in normal testing. Material folds created during cold heading and quench cracks frequently occur in only a small percentage of the entire lot. Manufacturing flaws that are present in 100% of a lot are much more easily detected.

The bolt pictured in this article is a case in point. This ASTM A307 bolt was made of the correct material. The hardness was correct. The under-head radius was correct. The bolt manufacturer did the three piece wedge tensile test as required by the appropriate standard, ASTM F1470, and all three tested parts broke through the threads as required.

Unfortunately, a small percentage of the parts in this manufacturing lot did have a material fold where the head joined the shank due to an error in the cold forming process. Before this fault was detected the bolts were used in assemblies that were very difficult to access after the project they were used in was completed. The safety risk presented by the possible failure of these bolts was very serious.

The existence of the manufacturing flaw was confirmed only after the tensile testing sample size was increased from the required three pieces to 20 pieces. Several sample lots of 20 pieces each were tested by two different laboratories and the presence of the manufacturing flaw were confirmed. All of the tests using the larger sample size found at least one head-to-shank failure. The claim for the cost to replace this faulty lot of bolts was over $2,000,000.

**Head-to-shank failures can be an applications problem.**

Properly made bolts and screws do not break where the head intersects the body due to the application of too much torque. In most cases, bolts that are “over-torqued” break


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through their threads at a location one to three threads above where the bolt engages the internal thread.

There are two applications problems that can cause otherwise good bolts or screws to fail where the head of the fastener joins its shank:

1. If the clearance hole is too small where the fastener goes through in the component that is immediately under the head of the bolt or screw the head-to-shank radius on the fastener can be cut when the part is seated. This cut can cause the bolt or screw to brake when the assembly is put into service.
2. If the edge around the hole in the component that the screw or bolt is seated on is not chamfered that sharp edge can cut the under-head radius of the fastener causing it to fail at the head-to-shank juncture when the assemble goes into use.

These applications problems are easily detected when the failure point on the fastener is visually examined under magnification. The cut in the head-to-shank radius will be obvious.

**Head-to-shank failure complaints should be taken very seriously.**
When a complaint involves a bolt or screw that breaks at the head-to-shank juncture all parties should consider the issue serious. Even if the hardness of the broken part complies with the applicable standard and/or other parts from the same lot pass the applicable tensile tests based on a small sample size the lot should be quarantined and an extensive evaluation of the lot should be undertaken. In particular, a much larger sample then is normally required should be taken from the specific lot in question and tensile tests performed on that entire larger sample lot.

When most of the kinds of manufacturing faults explained above are confirmed there is usually no way to effectively sort out all of the defective parts. Generally, the only prudent response is to scrap the entire lot.


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