# Preventing Future Fastener Failures

預防未來扣件失效

## Static Loads

**Fasteners do not fail too often in static loads but when they do, it will either be from a tension load, prying load or a shear load.**

**A tension load will cause the fastener to become longer.** If it is a ductile fracture, the threads will exhibit a reduction in area which resembles a 'dog bone'. The fracture will exhibit a 'cups and cone' surface. Non-ferrous fasteners may begin to have a reduction of area in the body of the fastener instead of the threads. The final fracture will cause an axial fracture across several planes. Check the strength of the fastener with the work loads.

**Shear loads occur due to joint looseness or sudden transverse loading.** Ideally, the two joint pieces in a single shear connection will contact the full diameter shank of the fastener. If the two planes contact the threads, failure will occur at a much lower amount of force. Double shear is where three joint surfaces are connected and offers almost three times the shear resistance of a single shear connection.

Fasteners may fail during tightening. For example, consider a flange connection with a gasket. If the gasket is not properly compressed during tightening the flange may leak. A mechanic uses a wrench to tighten some or all of the fasteners. After tightening several of the fasteners by the same person or a different mechanic several times, it is noticed that there are more threads of one fastener sticking beyond the end of the nut than others. This is a sure indication that the fastener has been tightened into yield. Remove the fastener, check the length and thread pitch. If either has changed, the fastener has been stretched into yield.

Make sure the proper strength fastener and nut, if applicable, are used. There may be a mix of products in the storage bins or the incorrect products may have been ordered due to a miscommunication between maintenance, the purchasing agent or the supplier.

## Dynamic Loads

**A dynamically loaded joint is one that receives either constant or intermittent loads.** This would include everything from conveyors and shaker screens to heavy equipment.

**The failure mode in this case is almost always due to metal fatigue**. Metal fatigue will occur in any hardened steel above 34 Rc and is the result of a joint that has lost a significant amount of clamp load. When clamp load is lost or reduced, the threads of the fastener must absorb the extra shock loading. In time, a stress raiser develops at the weakest areas of the fastener, either the last incomplete thread at the head or the first unengaged thread at the end of the nut. If the fillet radius under the fastener head becomes damaged from a burr or other metal contact, a stress raiser can develop and the head will separate very suddenly.

The mechanism for this type of failure is similar to the repeated bending of a coat hanger wire. The metal becomes 'tired' or fatigues due to this repeated movement. A certain amount of 'cold working' occurs and the metal develops a stress rupture. This ruptured stress raiser continues to propagate through the grain boundaries of the metal until there is very little cross-sectional area left to support the service load or next impact, and then it suddenly fractures.

**The fracture surface is relatively flat and smooth. It will exhibit conchoidal markings which are caused by the loads and load variations.** That is, high frequency rapid loading will create fine lines whereas low frequency vibrations and impacts will have darker lines. If the fastener and / or nut were used several times, there may be a secondary stress raiser developed with new conchoidal lines coming from another location.

**Fatigue fractures may be reduced or eliminated by using a fastener that maximizes the number of unengaged threads in the joint.** These threads act as shock absorbers in the event some clamp load is lost. Proper torque and tightening sequence for multiple fasteners in the joint will provide for a secure and safe connection.

## Loosening

There are many different ways a fastener joint may become loosened which will ultimately cause the fastener to fail in tension or from metal fatigue. **Loosening could be due to non-matching parts, joint surfaces and installation variables.**

**Non-matching parts would include mixing different grades of nuts and fasteners.** While some grade mixing may be compatible using different surface finishes together will present problems, especially in multiple fastener connections.

Some examples would be galvanized nuts with non-galvanized fasteners. Sometimes the nuts may have over tapped threads to accept the heavy coating or are tapped after coating. Both would have an effect on thread engagement and thread strength.

Mixing plated or coated fasteners with non-coated nuts or nuts with a different coating will change the coefficient of friction during assembly that will be different than what is expected. Expected clamp loads may be exceeded or not even realized.

**Be sure joint contact surfaces are clean.** Painted or greasy surfaces will make it easier for transverse loads to cause loosening when the joint parts begin to slide against each other.

**Make sure contact surfaces are free from burrs or other irregularities.** Tightening against a metal burr will cause relaxation of the fastener and joint. A relaxation of only 0.001” will cause a loss approximately 30,000 psi of clamp load.

**Torquing the head of a fastener then torquing the nut at the other end of the fastener in a multiple fastener joint will cause a loss of clamp load and joint looseness.** It will require more torque to tighten the fastener by turning the head than the nut. This is because when tightening the head, torque causes the body and threads of the fastener to twist in torsion. When tightening stops, the fastener untwists itself a certain amount producing less clamp load than expected. When the nut end is tightened, it produces a direct stretch to the threads. Any torsion is minimal and dissipates when tightening stops.

## Tightening

Neglecting correct fastener grade and size, fasteners can fail during tightening due to the length of the fastener and technique used.

**If the length of a fastener is very long in a joint, that means there will be an extra amount of threads protruding from the end of the nut and not very many threads in the joint.** What will occur is additional stresses on the few unengaged threads in the joint that will cause torsional fracture at the thread run-out of the fastener if the hand wrench is applied quickly or an air impact tool is used. Use a fastener length suitable for the joint thickness.

**The faster the nut or fastener are tightened, the greater the relaxation of the joint and loss of clamp load.** The increase in speed causes a rapid and deeper compression of the joint, then the relaxation of the joint due to the rebound effect when tightening stops.