Exafast Pty Ltd

When is "Tight" Tight Enough?

The complexity of the simple bolt and nut is often underestimated. A properly tightened bolt can survive millions of load cycles in an application in which an untightened bolt would fail literally within seconds. This is because a fully tightened bolt carries only a small proportion of any externally applied load in a bolted joint. Although the physics of this phenomenon is beyond the scope of this article, in general terms the integrity of a bolted joint is dependent upon achieving the appropriate amount of *preload* in the bolt. Preload is the stress induced in the bolt by the stretching that occurs upon tightening.

There are numerous ways to control the preload of a bolt but by far the most common, and the one we shall concentrate on here, is torque control. When an assembly is tightened, torque is applied to the nut, the nut turns, the bolt stretches and preload is created. Torque tables are available to provide an indication as to the required tightening levels for a bolt of a given diameter and strength. These tables are calculated using a formula relating torque and the resulting bolt tension. The recommended torque is intended to induce stress at a set percentage (often 65%) of the yield point. The yield point is the stress at which the bolt will stretch permanently rather than behave elastically.

There is an inherent problem in torque control as a means of controlling bolt preload; *friction*. It is a surprising fact that friction typically accounts for around 90% of all torque applied to a nut. This means that only 10% of the effort is used to stretch the bolt and create preload. Therefore, anything that changes the frictional characteristics of the assembly will have a significant effect on the preload. Torque tables usually assume clean, lightly oiled black bolts. Factors including the presence of lubricants, zinc plating or galvanizing, the use of washers or nylon insert lock nuts, surface irregularities, hole clearance and speed of nut tightening (eg use of a rattle gun) are all going to change the frictional characteristics. Most sources claim torque control using a torque wrench is suitable only where a variation in bolt tension of up to plus or minus 30% is acceptable.

Ways to maximize the accuracy of the torque control method include:

- Use of friction stabilizers (lubricants)
- Bench testing to determine correct tightening torque often by use of a strain gauge on the bolt or by determining the torque required to reach the yield point of a bolt in the assembly in question and applying the appropriate percentage of that value to determine correct tightening torque
- If testing is not feasible, use the best information available to determine tightening torque taking into account friction altering factors mentioned above. Computer programs are available to assist (try an internet search but make sure the Source is reliable)
- Avoid use of plain washers as they can significantly alter the torque-tension relationship during tightening
- Use a high quality, calibrated torque wrench

An internet search will return dozens of sources of information on the design of bolted joints and tightening of bolts; but as always, satisfy yourself as to the bona-fides of the source.