DELTA SIGMA
BY RESONIC INSTRUMENTS

Why use the Delta Sigma?

Joint Reliability

A very important factor in achieving bolted joint reliability is that all bolts are “tightened” accurately. We must, while using a chosen assembly method, achieve an acceptable window of preload (also called tension, clamping or spring) force in the fastener to overcome the external forces working against the fastener. This includes static and dynamic forces, vibration and thermal cycles.

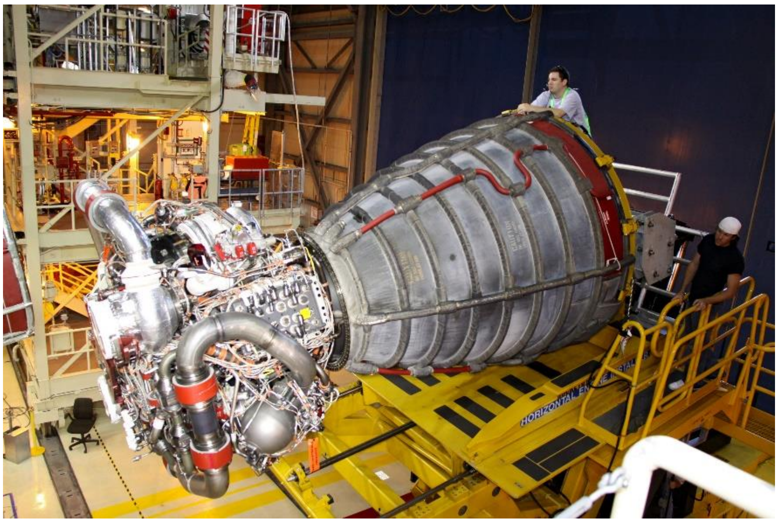
A bolt is really just a very stiff spring. This spring needs to be stretched in a controlled manner to serve its purpose: Providing a clamping force great enough to resist any forces trying to loosen it, without damaging the bolt or any of the joint members, which can occur when a bolt is overtightened.

As practical examples, consider a pipeline flange, pressure vessel, engine or other application that depends upon bolts to provide sealing pressure for gaskets, O-rings, or simply just holding two or more components together. If the bolts do not apply enough clamping force to seal the joint, the following results can be expected: Pipelines, pressure vessels or engines will leak releasing anything from water to dangerous liquids or gasses, there will be risks of injury or death to persons nearby, as well as, equipment damage, production losses, and potential damage to the environment.

Engineering case histories, documented experiences, laboratory experiments, and statistics has taught us repeatedly, and without question, that an applied torque or even direct applied tension force may not provide an accurate indication of the actual achieved bolt load after the tightening process has been completed. A fully torqued or tensioned bolt according to a tool setting or hydraulic pressure gauge value could still be completely loose after an assembly procedure has been carried out.

Torque studies typically return results of bolt load scatter up to +/-35% even with a calibrated torque wrench and proper procedures. Improper use of the torque tool and or procedures can dramatically increase the scatter levels. One mining project in North America had a torque specification of 7,600 lbf-ft (10,304 Nm), yet due to galling in several bolts, those bolts could not even close the gap between underside of the bolt head and the washer even after reaching the recommended torque specification.

Used on the Space Shuttle



A tensioned bolt on the Space Shuttle liquid hydrogen connection was little more than hand tight after the hydraulic tensioner suffered internal damage and was not able to rotate the nut properly, leaving it little more than hand tight. Each time fuelling began, hydrogen gas was detected and the processed had to be stopped. Finally, after several attempts with the same results, the shuttle had to be returned to the Vehicle Assembly Building and the launch was delayed by weeks. The costs of these delays and testing to discover that the bolt was loose due to a damaged tensioner were in the millions of dollars. Had the leak not been detected, the results would have been catastrophic.

Placing our emphasis on applying the “right torque”, or “right force” in the case of a tensioner, can lead to a very inaccurate assumption for perceived accuracy, safety and integrity of bolted joints. We have all seen pictures of tumbling or falling windmills and tower cranes, leaking pipelines, exploding refineries and aerospace accidents. These images are frequently the outcome of a failed bolt or group of bolts. Fatigue failures. Self-loosening.

Regrettably, it is an almost universally accepted belief that as long as calibrated torque or tension tools are used to assemble bolted joints, the desired tightness (tension, clamping or spring force induced) will be achieved. This assumption is causing injuries, loss of lives and the loss of vast resources on a daily basis worldwide.

Imperative for this statement is the necessity for the reader to understand that torque and tension force, that is the force generated when using a torque wrench or a tensioner tool in the common colloquial sense only refers to the *applied* force, rather than the *resulting tension or clamp force, stress or spring force actually achieved or induced into the fastener and the joint members*. This implies that when one “torques” or “tensions” a fastener, one must faithfully conclude and can thus only hope that the desired bolt load will be the outcome of using the tool to some pre-determined setting.

Safety Factor

As we very well know, there is not a colloquial acceptance in the world of relying on hope, as a safety factor; therefore, the specified torque or tension application procedures accepted by the vast majority of individuals, manufacturers, societies, associations and authorities are usually incomplete as they often fail to specify a method of verifying the clamping force actually achieved. That means that if we desire the safety factor that the design engineer had in mind, an independent method of accurately measuring the bolt load must be applied to validate the results of torqueing or tensioning fasteners.

The most practical, viable and sensible way of performing this verification is to use a Delta Sigma instrument to test and verify the elongation and subsequent load achieved in a fastener group upon installation and during service life. This not only verifies that the correct fastener load has been applied at the time of assembly but has the added benefit of permitting periodic checks and determining whether there has been any loss of fastener load over time. Should a loss of fastener load occur additional torque or tension can be applied to bring the fastener load back to the original level.

The principle behind the Delta Sigma has been long established: The relationship between bolt elongation and bolt load are very predictable, based on Hooke’s Law and Young’s Modulus of Elasticity, meaning that measuring bolt elongation is a quick method of verifying the bolt load. Through the use of the most advanced ultrasonic measuring technology, the Delta Sigma greatly simplifies the process of measuring fastener elongation and load at an affordable price.

The correct use of the Delta Sigma will reduce or eliminate the risk of bolt and fastener failure and prevent accidents, save lives and help protect the environment.

A current example of a total failure to an asset as a result of not using a Delta Sigma was just published from the Swedish accident investigation authority, and is highlighted below:

Statens haverikommission
Swedish Accident Investigation Authority

SUMMARY IN ENGLISH



"Lemnhult wind farm is located about 20 kilometers south of the city of Vetlanda in Jönköping County. The wind farm consisted of 32 wind turbines, of the same type and height. On 24 December 2015, one of the turbines collapsed. The wind turbine that fell, tower 15, was 129 meters tall, and had a turbine diameter of 112 meters. The wind turbine had been in operation for almost three years."
«The cause of the fatigue in the bolts was that the pre-tension force in the joint was too low."

"Settlement had not been taken into account, either in the joint or in the softer materials, which always affect the pre-tension force."

"During different time periods the wind turbine was exposed to vibrations and additional loads due to the software used in the control unit of the wind turbine. The manufacture has stated that these additional loads, under the condition that the specified pretension was achieved, were within the design limitations of the wind turbine. In a bolted joint with low pre-tension force these additional loads may lead to a decrease in lifetime."

"The authorities who inspected the wind turbine from a safety perspective did not request the technical documentation for the tower construction.
The municipality and the control manager limited the inspections to the foundations.»

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