Methods for checking/auditing pipe flanges, pressurized connections and other critical fastened joints

White Paper

Follow Mountz on Twitter: @mountztorque

Mountz, Inc.
P: 408.292.2214
F: 408.292.2733
1080 N. 11th St.
San Jose, CA 95112
www.mountztorque.com

Contributors:
Brad Mountz
Chris Morris

White Paper

Methods for checking/auditing pipe flanges, pressurized connections and other critical fastened joints

Abstract
The Clean Air Act requires refineries to develop and implement a Leak Detection and Repair (LDAR) program to control fugitive emissions. Fugitive emissions occur from valves, pumps, compressors, pressure relief valves, flanges, connectors and other piping components. A study conducted by the Pressure Vessel Research Council (PVRC) in the USA indicated that a significant percentage of flange joint failures resulting in leaks were due to loose bolts.

Improper torque of high-pressure vessels can be attributed to safety incidents that cause financial loss, loss of property and even loss of life. The more volatile and dangerous the substance the more critical it is to take precautions to ensure flanges and bolts have been properly torqued and most importantly, properly audited.

Given the ever more challenging environmental, legislative and economic demands facing plant operators, while always striving to ensure maximum operational efficiency, joint integrity must be seen as a crucial element of any maintenance program. Effective management of critical pressure-containing joints can reap rewards in terms of cost-savings and operational efficiency, not to mention removing risk.

In Arita, Wakayama Japan a leakage and fire of naphtha and hydrogen was attributed to uneven tightening torque of five to twenty-five bolts at the inlet flange of the reactor, where a “creep” phenomenon caused them to loosen.

Numerous incidents of leakage are recorded by the International Occupational Safety and Health Information Centre (CISDOC) and published as a Hazardous Installations Directorate to assist inspectors in assessing and inspecting accidents.

The purpose of this paper is to bring awareness to practical and innovative methods that can be used to limit the high cost of failures and make working conditions safer when using threaded fasteners as a means of joining. It is also intended to provide a basic background in the technology of threaded fastening and auditing to ensure understanding of their function.

Threaded fasteners – purpose and advantages

The threaded fastener is a prime joining system, recognized for its cost effectiveness and wide practical application. The combination of cost and the ability of joining and disassembly make it one of the most useful methods for many applications, especially those that require ongoing maintenance. Threaded fasteners are capable of joining dissimilar material in uniform or unusual joint configurations. Fasteners, though simple in appearance, are highly sophisticated mechanical products subject to rigid standardization. They are highly interchangeable due to the range of sizes, lengths and materials.

The ability to assemble a product that uses male or female joining elements allow multiple components that expands product design options. The differing material options (stainless, brass, plastic and exotics) further expand the options for making unique products.

The primary objective of a fastener is as a structural or load-carrying element – a device that holds, clamps and ensures that two or more parts stay together.

What Is A Joint?

A joint is all of the components that make up a joined assembly, including the fastener, washers, gaskets and all mating material and parts that are to be held in tension.

Joint design takes into consideration where and how fasteners are to be used. The term joint comes from the concept of joining parts together, which is the purpose of a threaded fastener. This document is not intended to discuss proper joint design, but suffice it to say everything starts with the proper selection of a threaded fastener that is intended and capable of handling the load that a product will endure over its life. If maintenance is a part of extending product life, proper fastener selection is even more important.

Exact standards do not exist for uniform joint design. However, it is known that proper joint design includes study and analysis of working forces that act on the joint. These forces or loads would include tension, shear, bending and fatigue.

Joints are sometimes categorized as hard or soft (and of course somewhere in between) and it is the angle of their movement after initial mating of joint surfaces that determine this categorization. For understanding, a hard joint is largely a metal-to-metal connection whereas a soft joint incorporates material that causes a longer fastening time and more energy to fasten properly (a gasket for sealing purposes is an example).

Torque and Tension

For the purpose of this document we will assume that the actual definition of torque is not all that important. What is important is that threaded fasteners need to be torqued or pulled in order to put them into tension. Practically speaking, torque (turning) of a bolt by hand or with semi or automated power tools is a useful and inexpensive method of creating tension in a joint.

Clearly there is a difference between torque and tension. Tension is the result of torque. And even if it is done perfectly it is possible to be in error. Investigation of joints over time have fairly well established that 90% of applied torque is used to overcome friction in threaded fasteners. Friction is found in the bolt head, under the nut and in the threads of the fastener. Change in material, plating, lubricants and sealants all change the torque coefficient in the accepted formula for creating tension preload:

> T=KDP: where,
>
> T= installation torque
> K= torque Coefficient
> D = nominal bolt diameter
> P = clamp load objective

All joints are subject to the phenomenon known as joint settling, joint relaxation or the physical phenomenon known as “creep”. Creep can be particularly evident with joints that incorporate gaskets - flexible joints also known as soft joints as discussed above. On such joints it can take a long time before the joint settles, which results in a reduction in clamping load until the condition has stabilized. This can also be exacerbated if the joints are subject to high temperature, pressure or vibration. For a flexible joint to be effective, it is important for all fasteners that make up the joint to be uniformly loaded (consider a cylinder head of a engine or motor). Sometimes this loading needs to occur in steps, following a logical fastening pattern until the nominal torque is reached.

Vibration or fatigue, corrosion and improper installation are also other occurrences that can cause fasteners to loosen, crack or fail.

Auditing of Threaded Fasteners To Prevent Failure

Fastening error can never be eliminated if proper technique and tools are not used. Audit discussion must begin with an understanding that a process is under control, until such time as variances in expected result are found. That does not imply that there should be a lack of auditing; in fact, the contrary is true.

Now for the critical question or premise of this paper:

If proper joint design and proper torque application still do not guarantee that effective tension has been achieved, how can we know if the installed fastener meets the specification intended by the designer?

The answer is in **Auditing**, a process used to validate, inform and confirm. Depending on how the word is used as a noun or a verb, the term ***audit*** has similar definition and meaning.

(n) the inspection or examination of a building or other facility to evaluate or improve its appropriateness, safety, efficiency, or the like: An energy audit can suggest ways to reduce home fuel bills.

(v) to make an audit of (a building or other facility) to evaluate or improve its safety, efficiency, or the like.

Even the most sophisticated fastening systems require calibration to ensure their accuracy or repeatability. Therefore, auditing is a necessary interrogatory to gain information about how a job was performed even when the process is being controlled perfectly. Clearly auditing is a preventative quality measure to help eliminate possible failure. Without an audit process we leave open the possibility of error that cause leakage in flanges, safety incidents and unwanted emission or other costs.

Because of the variation in joints and the difficulty to create exact tension, it must be expected that **Torque Auditing** also have its pros and cons.

Traditionally there are there three main audit methods. These include first movement in the fastening direction, first movement in loosening direction (breakaway) and determining the rotation angle by marking the fastener; loosening it and determining the torque required to move the fastener back to the original position. While these methods can achieve the intended purpose they have drawbacks.

First Movement

1. First movement testing in the fastening direction is performed with a hand torque device. It is necessary to load the fastener and observe the movement. The problem is that it is difficult to perform as first movement is difficult to "feel" with a measuring tool and it is extremely difficult to observe movement. First movement can be done by hand with a dial or digital tool, it can be done with an outboard transducer with angle encoder, but this requires fixturing of the transducer that is often challenging. This method provides an estimate of the current torque but gives no indication of how much movement is required to achieve the desired torque if the current torque is less than the desired torque. Further, if done incorrectly, it can radically increase the joint load.

Breakaway – Loosening Direction

2. Breakaway is a loosening test of the fastener and as a rule is always less than the actual torque. Breakaway provides data on what it will take to "break loose" a fastener under load. Loosening the fastener is not practical where a system is being audited "live" and loosening the fastener could cause leakage. Further, if done incorrectly, it can cause the joint to be incorrectly tightened, creating more problems than answers. If locking compounds or other joint security devices are used, this is not an effective method of testing as the audit results will be inconsistent.

Mark, Loosen and Retighten

3. Mark, Loosen and Retighten is a test where the bolt and application is marked with chalk or similar, then the bolt is loosened and retightened to the original marking. This is often not practical and again it gives no indication of how much torque is required to achieve the desired torque if the current torque is less than the desired torque.

Advanced Equipment for Auditing and Data Collection

The goal of auditing is to improve process results. To do this it is necessary to gather information for evaluation and analysis. An audit that fails to provide relevant information to improve the fastening process is worthless. Sometimes achieving proper torque requires practical experimentation. In order to experiment data is required. Depending on the audit strategy or information desired different techniques should be considered.

The Mountz Bolt Auditing System for large bolted applications consists of a Torque Multiplier with embedded strain gauges to measure torque as well as an angle encoder to measure angle. The multiplier is connected to a Portable Torque Meter (PTT 2000) designed specifically for torque/angle analysis and data collection. The tester is capable of both torque and angle measurement and has the ability to store up to 5000 readings. In addition the system includes PC based Windows software to configure the meter for measurement tests. The stored data can be downloaded to a PC for use with quality control software or for analysis in Excel. A barcode scanner can be used with the system to enhance its function. The system provides two main modes for Auditing; the first is an " Enhanced First Movement" mode the second is a Torque vs. Angle Audit mode. These modes provide different information depending on the application requirements.

Technically speaking, the angle can be setup for either 360 or 720 pulses per revolution for use with various encoders. It is designed for use with quadrature angle signals so it can resolve either 0.25 degrees, if used with 360 pulses per revolution, or 0.125 if used with used with 720 pulses per revolution. In addition it can be set for "Normal" encoding where Trail follows Lead or with "Reverse" encoding where Lead follows Trail.

<u>Audit Mode 1 for Enhanced First Movement</u>

The multiplier is equipped with a reaction foot that provides for fixturing. This allows for a detection of a small angle movement programmed into the meter. When the fastener moves, the angle encoder detects this movement and the torque value is reported on the meter. This method will show the amount of torque achieve at first movement. The result can be compared to the actual desired torque. A series of fastenings can be recorded and all data is stored on the meter. This method allows an Auditor to validate that a joint is properly tightened. The information gathered in this test is very valuable. This test validates the residual torque.

Assume an application calls for 1000 N.m and an auditor finds that the joint moved at 500 N.m, an analysis surrounding why this occurred should ensue. It could be human error, improper fastening method, improper tools, incorrect parts or components, or joint relaxation to name a few variables. Finding the root cause to solve the problem can eliminate failures, improve safety and reduce cost.

Audit Mode 2 for Determining the Angular Movement

The object of this feature is to determine the amount of angular movement required to move from an initial torque value to an expected torque value. Further, this can be done without having to loosen the fastener. The audit device is programmed with a minimum torque value and an expected torque value. Beginning at the minimum value, the audit device starts to count angle. Once the expected torque is obtained, the device "locks" on angle degrees required to move from minimum torque to desired torque. This auditing information is very valuable because it allows an auditor to validate joint relaxation in degrees. It also allows joint designers and quality control to experiment with different amounts of torque and angle as a means to set proper fastening procedure.

Benefits

The ability to Audit joints such as flanges with gaskets is important for critical applications where leakage or rupturing of the connection can have disastrous, costly or environmental implications. Auditing is a preventative quality measure and is a required part of an ISO or other quality management system.

Auditing large bolts is very difficult. Use of a proper auditing tool can make life easy for an auditor.

Torque is an inexact science with a lot of differing variables. Resolving or isolating these variables is the key to improve torque errors and fastening procedure. This is done with data. Auditing provides data to help make improvements to quality.

Attachments/Exhibits

Exhibit #1 – Advanced First Movement of Bolt (Residual Torque)

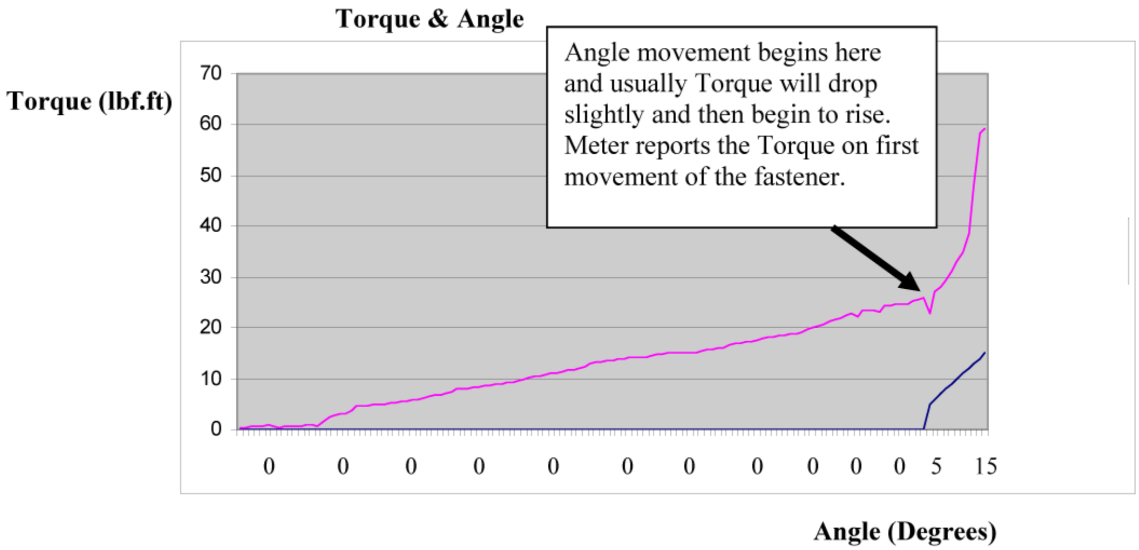
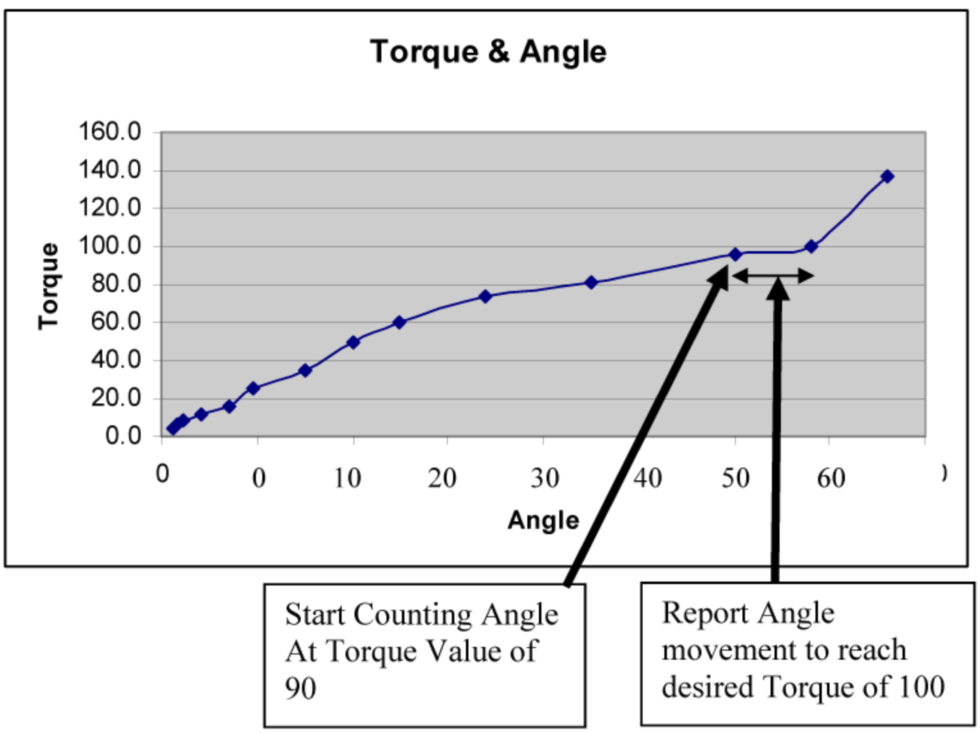


Exhibit #2 – Angular Movement of Bolt from a Minimum Value to a Nominal Value



About Mountz, Inc.

For more information about Mountz visit our website at ***About Mountz, Inc.***

San Jose, California based Mountz Inc. produces a wide variety of torque tools, including torque analyzers, torque testers, torque sensors, torque wrenches, electric screwdrivers, pneumatic screwdrivers, torque screwdrivers, torque multipliers, assembly tools, pulse tools, screw counters, tool balancers and special torque applications. Mountz has multiple global locations and hires and trains competent employees who are owners in our business.

Since 1965, Mountz Inc. has proven its in-depth knowledge of torque and torque solutions by consistently developing, producing, marketing and servicing highly sophisticated, cutting-edge tools. Mountz Inc., known to industry as the nation's premier torque tool supplier, is an ISO 9001 registered and ISO 17025 accredited company. Mountz tools comply with ISO6789:2003 and are constructed from high quality materials, engineered for superior reliability and safety and backed by an industry leading warranty. Look for the Mountz hexagon logo – it's a stamp for quality tools, service and knowledge in the field of torque control.

For more information about Mountz visit our website at www.mountztorque.com
For more on torque, including HOW TO, Videos and other useful resources visit Learning Center