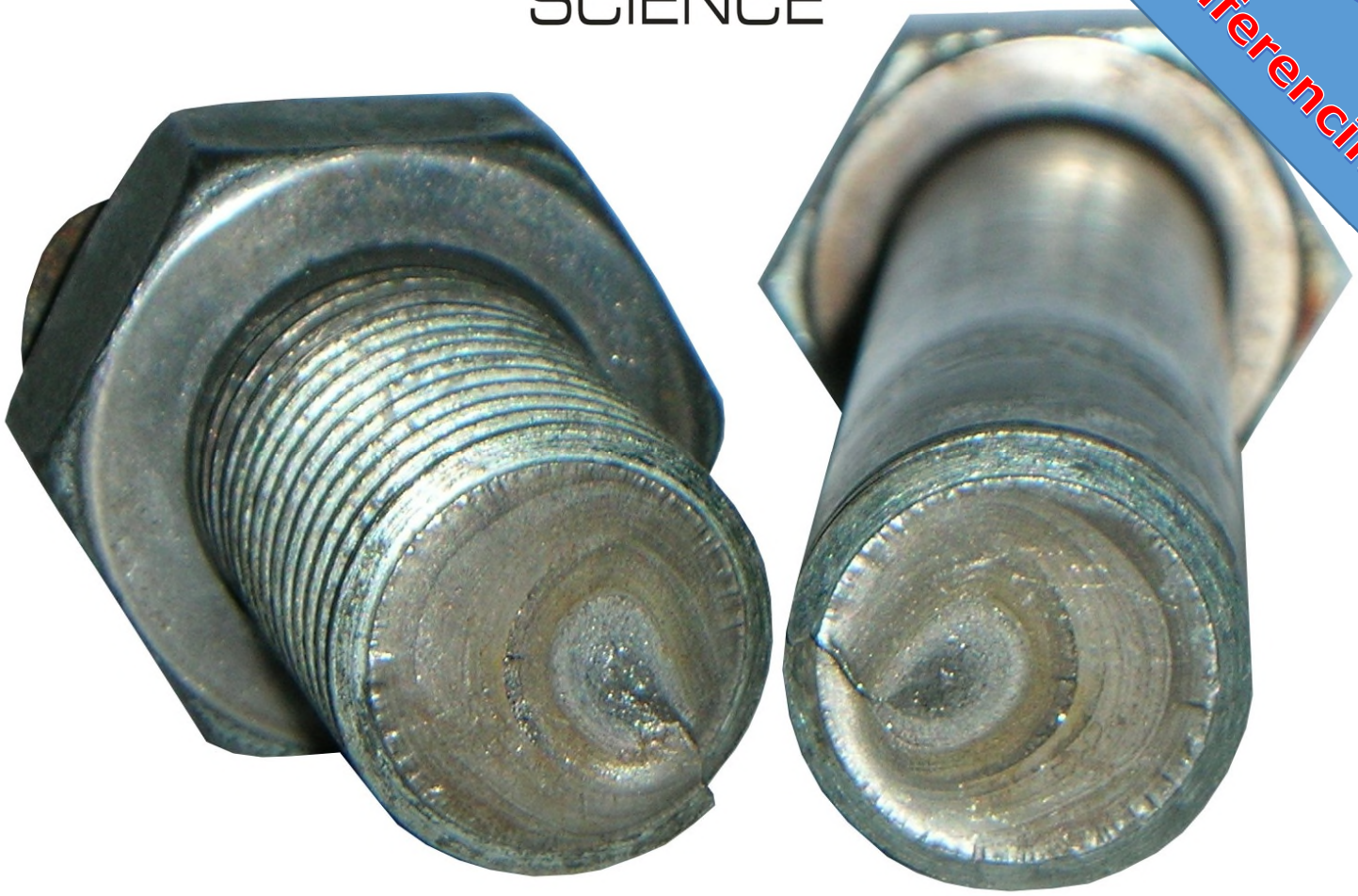
BOLT SCIENCE

Training via Video Conferencing



Bolting Technology for Engineers and Designers

A training course delivered using video conferencing for Engineers and Designers who are responsible for the specification and design of bolted joints.

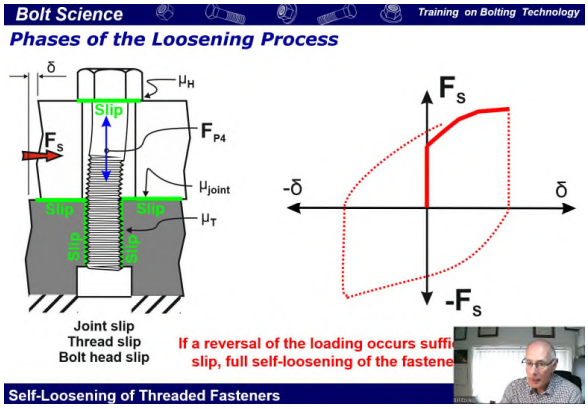
Training using Video Conferencing

The training course: Bolting Technology for Engineers and Designers can now be delivered using video conferencing technology, such a Zoom. This training can be provided to individuals independent of their geographic location, so long they have a broadband Internet connection. This is the same training that has been delivered physically world-wide and receives very positive feedback.

Introduction

Advances in technology has made the wide-spread use of live streaming commonplace. Lockdowns, home working and social distancing have made the use of webinars and virtual classrooms in organisations the norm rather than a novelty.

Video conferencing provides the capability to provide individualised instruction with a personal connection while reaching a larger audience than ever before.



Collaborative problem solving

Video conferencing can allow a short specialised fragment of training to occur that would otherwise be cost prohibitive. For example, bring a team up to speed quickly on the state of the art on a particular topic to assist in the solution of service and production issues related to bolting. For example, a two-hour training on the causes of the self-loosening of fasteners to facilitate a team solving a service problem.

Advantages of Training using Video Conferencing

The rise of online teaching has transformed the way we can learn and work together. With the ability to reach larger audiences, there are a number of advantages offered by video conferencing:

- **Flexibility.** One of the advantages of this type of training is that it provides more flexibility when teams are dispersed. A user can still easily participate in training delivered via video conferencing on a laptop, smartphone, iPad or other mobile devices.
- **Effective communication.** In many situations, learning face to face is still preferable. Training via video conferencing allows participants to ask questions in real time and also pick-up on non-verbal communication which can assist the learning process.
- **Enhanced staff training.** By eliminating time and space barriers, training can be facilitated in what would otherwise be lost time and can facilitate on-going education.
- **Higher productivity and efficiency.** By eliminating time and space barriers, training using video conferencing can lower costs on business travels and staff training.

For more information and a quote, contact Bill Eccles at Bolt Science on +44 1257 411503 or via email at training@boltscience.com

Bolting Technology for Engineers and Designers

The material covered in this training course is presented below. Each person will be provided with a training course handbook and work, either in PDF or physical format. These will allow you to log onto the training from wherever you have an Internet connection, at whatever time, on whatever device provides web access.
The course is made up of a number of presentations, quizzes and other material.

Included in the training are case studies. These case studies are drawn from various industry sectors. Catastrophic accidents have occurred as a result of the failure of bolted joints, they illustrate what can go wrong when bolted joints fail and what lessons can be learned. There is a course handbook provided as part of the training that can be viewed online and downloaded and printed.

Introduction to Threaded Fasteners

- *Some thread terminology.*
- *Background to modern threads - the roles of Whitworth and Sellers and the development of the metric thread.*
- *The difference between a fine and coarse thread and the advantages/disadvantages of each.*
- *The basic profile of Unified and metric thread forms.*
- *Thread tolerance positions and grades and the different tolerance classes that are available.*
- *The stress area, what it is and how is it derived.*

Strength of bolts

- *The principles of bolt elongation, bolt stress and load.*
- *Yield, tensile strength and proof load properties.*
- *Details of common bolting specifications.*
- *Upper and lower strength limits for bolts.*
- *Bolt and nut head markings and identification of correct components.*
- *Stainless steel fasteners ISO 3506, Duplex and Super Duplex stainless steel fasteners*
- *Nut/bolt combinations, nut strength versus bolt strength.*
- *Upper and lower temperature limitations of common bolting materials.*

Why bolts should be tightened

- The "Bolted Joint Enigma“ and why is tightening a bolt important?
- How a preload joint sustains an axial load.
- Joint separation – what is it and why is it important.
- Why tightening bolts is important for shear loaded joints.
- Explanation of why the bolt usually sustains a small proportion of an axial load.
- A case study of bolt failure in which part of the fastener was not tightened.

Fastener Failure Modes

- *Overview of the ways threaded fasteners can fail.*
- *Manufacturing Related Quality Defects.*
- *Design Related Quality Defects.*
- *Failure by insufficient preload - examples including joint slip, joint separation and gasket sealing failures.*
- *Fatigue failure of bolts.*
- *Thread Stripping Failures - internal and external threads.*
- *Bolt overload from applied forces.*
- *Bearing stress under the bolt head or nut face.*

Methods of Tightening Threaded Fasteners

- *Overview of the methods used to tighten bolts.*
- *Load-angle of turn graph for a bolt tightened to failure.*
- *Torque controlled tightening method.*
- *Torque-angle tightening below the yield point.*
- *Projected angle tightening method below the yield point.*
- *Yield point tightening using incremental angle method.*
- *Yield point tightening method using slope measurement.*
- *Torque-angle tightening method into the plastic region.*
- *Yield control tightening plus an angle increment.*
- *Limited re-use of bolts sustaining plastic deformation.*
- *Bolt tensioning using hydraulic tensioning method.*
- *Tightening by elongation measurement.*
- *Heat tightening of large bolts*
- *Tension indicating methods using load indicating bolts and washers.*
- *Use of ultrasonic's for bolt tightening.*

Torque Control

- *What is meant by a tightening torque. Units used to measure torque.*
- *What are the consequences of not applying sufficient torque to a bolt.*
- *How torque is absorbed by a nut/bolt assembly.*
- *The torque-tension graph.*
- *The relationship between the tightening torque and the resulting bolt preload (tension).*
- *The factors which affect the torque-tension relationship.*
- *The nut factor method of determining the correct tightening torque.*
- *Using the full torque-tension equation to determine the appropriate tightening torque.*
- *Example calculation of how to determine the correct tightening torque.*
- *Scatter in the bolt preload resulting from friction variations.*
- *Determining the bolt preload (tension) resulting from a tightening torque.*
- *Prevailing torque fasteners (such as those containing a nylon insert) and how it affects the torque distribution and what is the correct torque to use.*
- *Tests to determine the coefficient of friction of threaded fasteners.*

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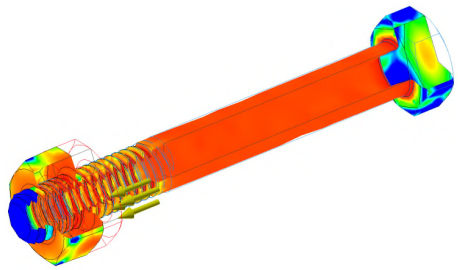
Self-Loosening of Threaded Fasteners

- *Non-rotational loosening (relaxation) and rotational loosening (self-loosening).*
- *Have an overview of the research completed over the last 50 years into establishing the cause of the self-loosening of threaded fasteners.*
- *Appreciate the forces that are acting on the threads that tend to self loosen a fastener. Why fine threads can resist loosening better than coarse threads. The inclined plane analogy.*
- *Learn about the work completed by Goodier and Sweeney into loosening due to variable axial loading.*
- *The work completed by ESNA and the theory of shock induced loosening and resonance within fasteners.*
- *The MIL-STD 1312-7 vibration test for fasteners.*
- *Junker's theory on self-loosening of fasteners and why fasteners self-loosen.*
- *The Junkers/transverse vibration test for fasteners.*
- *The influence that vibration amplitude has on the fastener self-loosening rate.*
- *Preload decay curves and the effectiveness of various fastener types in resisting vibrational loosening.*
- *The findings of Haviland and Kerley and how fasteners can come loose as a result of bending, shock or impact and differential thermal expansion.*
- *Conclusions from the research and how loosening can be prevented.*



VDI 2230 Systematic Calculation of Bolted Joints

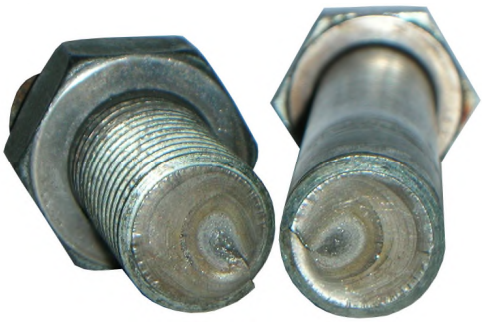
- Why are systematic methods important?
- Development of Joint Diagrams.
- VDI 2230 Background and range of validity.
- Key concepts of VDI 2230, failure modes of bolted joints
- VDI 2230 - The Calculation Steps
- Initial bolt sizing
- Determining the Tightening Factor
- Determining the minimum clamp load
- Determining the load factor
- Relaxation/embedding loss in bolted joints
- Effect of temperature change.
- How to determine the minimum assembly preload
- Determining the maximum assembly preload
- Establishing the bolt assembly stress
- Determining the bolt working stress
- Establishing the alternating stress in the bolt
- Importance of the bearing stress under the nut
- Thread stripping checks
- Joint slip and bolt shear stress
- Limitations of VDI 2230
- Software of VDI 2230 calculations

Preload Requirement Charts

- How to prevent the majority of bolting issues.
- Determining the maximum and minimum preloads.
- How to calculate the likely embedding loss.
- Establishing the axial force requirement.
- Establishing the shear force requirement.
- Determining the total force requirement for the joint
- Example calculations
- Ways in which a bolting design problem can be resolved.
- Example problems for the student to resolve.

Bolts in Direct Shear and Axially Loaded

- The difference between a friction grip and a joint whose bolts are in direct shear.
- The effect of having bolts in direct shear when a friction grip joint is more appropriate.
- Joints in single and double shear.
- The shear capacity of bolts in direct shear and the importance of the location of the shear plane.
- The ratio of shear strength to tensile strength for steel.
- How to determine the shear strength of bolts in direct shear.
- Joints consisting of multiple bolts.
- Joints in direct shear and axially loaded as well.



Fatigue of Threaded Fasteners

- Background to fatigue failures.
- An explanation of what is fatigue.
- The causes of fatigue to be able to recognise this type of failure.
- Beach marking and why fatigue failures usually occur in the threads.
- The S-N diagram and the endurance strength of a threaded fastener.
- The difference between the load acting on a joint and that sustained by a bolt.
- The different approaches that can be used to establish the endurance strength of a pre-tensioned threaded fastener.
- The effect that joint face angularity can have on the fatigue performance of a fastener.
- How the fatigue performance of a bolt can be improved.
- The effect that bolt diameter has on fatigue performance.

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Thread Stripping

- Identify the cause of thread stripping.
- Be able to establish the shear area of an internal or external thread.
- How the tapping drill size affects the strength of the bolt thread.
- How the radial engagement of threads affects thread strength and the failure load.
- Use the information provided on the course to calculate the internal and external thread areas and the force needed to cause the threads to strip.
- Be able to establish the length of thread engagement needed to prevent thread stripping.
- Example problems are presented together with questions for the user to complete are provided – together with full answers. stripping calculations so that you have confidence to use them in practical applications.

Galling of Threaded Fasteners

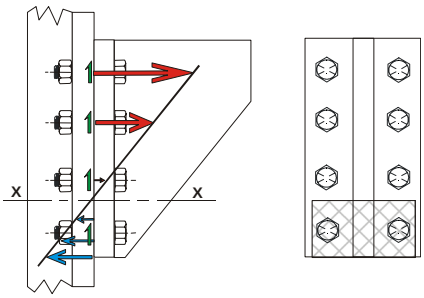
- Background and explanation of galling.
- Types of fastener material and finishes susceptible to galling.
- Examples of thread galling.
- Approaches that are used to prevent/minimise galling.

Shear Loads applied to Bolted Joints

- What is meant by an eccentric shear load.
- Understand the slip process that can occur with shear loaded joints.
- Learn what is meant by the instantaneous centre of rotation for the joint.
- Be able to calculate the reactions of individual bolts when shear forces are applied to the joint.
- Perform example calculations so that you have confidence to use them in practical applications.

Combined Tension and Shear Loading

- What is meant by an eccentric shear load.
- Understand the slip process that can occur with shear loaded joints.
- Learn what is meant by the instantaneous centre of rotation for the joint.
- Be able to calculate the reactions of individual bolts when shear forces are applied to the joint.
- Perform example calculations so that you have confidence to use them in practical applications.
- Learn the methods that can be used to analyze joints subjected to combined tension and shear loads.
- Understand what is meant by prying and its effects.
- Two methods that can be used to determine the neutral axis of the joint when combined tension and shear loads are acting
- Perform example calculations so that you have confidence to use them in practical applications.



The Course Tutor - Dr Bill Eccles

The course tutor is Bill Eccles. Prior to forming his company, Bolt Science in 1992, Bill's original background was in Design Engineering. The company is a provider of independent technical expertise in bolted joint technology. Bill has extensive experience in the design, analysis and installation of bolted joints and has published several technical papers on the subject. The work he has completed includes, among other things, fastener and joint failure investigation and the determination of its causes into a number of catastrophic accidents. His experience covers the automotive, marine, aerospace, plant and machine tool industries. He is a Chartered Engineer and has a Doctorate in Engineering on the self-loosening of threaded fasteners. Bill has delivered training courses around the world on the analysis of bolted joints and bolting technology.

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