

*Essential skills training for Engineers*

# ***Analysis of Bolted Joints***

*A concentrated one-day course on the skills and techniques for the successful analysis of bolted joints and threaded fasteners.*

*The course is designed for Designers and Engineers who are responsible for the specification and design of bolted joints. This is a practical course, in that methodologies are presented for solving everyday bolting problems encountered in mechanical engineering.*



# Analysis of Bolted Joints

## Why you should attend this seminar?

Threaded fasteners are a notable cause of service and other related problems. Besides possible safety implications, fastener failures can represent a significant proportion of a product's warranty costs. This training seminar presents key knowledge and facts to an Engineer to enable bolted joints to be designed and fasteners sized so that they will not fail.

Besides presentations on the latest theoretical aspects of the subject, a hands on practical approach is used to enable delegates to apply the knowledge gained to the design of bolting and fastener problems.

## Who should attend?

This seminar is designed for:

OEM Designers  
Design Engineers.  
Project Leaders.  
Engineers with responsibility for solving service problems.  
Engineering Supervisors  
Engineering Managers

## Eight key benefits of attending this seminar

This seminar will help you to

1. Determine the appropriate size and strength of fastener to be used in an application.
2. Understand the common modes of failures of fasteners and how each mode can be prevented.
3. Be able to calculate the loading acting on individual bolts given the forces acting on the joint.
4. Avoid the pain of making very costly, unnecessary mistakes.
5. Learn the differences between a manufacturing and design quality defect in relation to threaded fasteners.
6. Be able to identify whether a failure is due to a fault in the design specification or is manufacturing related.
7. Be able to establish the length of thread engagement needed to prevent thread stripping.
8. Appreciate the key principles involved in the calculation of bolted joints.

## Course Documentation

A training course handbook is provided to all delegates. The handbook contains background information to the material presented on the course together with tables of thread stress areas, thread shear areas and fastener material strength details.

## Course Director

Bill Eccles is a consultant mechanical engineer with 30 years experience in mechanical engineering with the last 16 specialising in bolted joint technology and analysis. He is a Chartered Engineer, a member of the Institution of Mechanical Engineers and a registered European Engineer.

Bill has written several articles on bolting technology and has developed bolted joint analysis software that is used by major organisations around the world.



### Tailor-made training for your organisation

This seminar can be tailored to meet your specific requirements.

To discuss your needs and find out what Bolt Science can offer you please ring Bill Eccles on +44 1257 411503.



*“When you can measure what you are speaking about, and can express it in numbers, you know something about it, but when you cannot express it in numbers your knowledge is of the meagre and unsatisfactory kind.”*

*Lord Kelvin 1824-1907*



**A one-day Bolt Science workshop and seminar**

# Workshop Agenda

## Introduction to Threaded Fasteners

- ❑ Know the meaning of thread terminology.
- ❑ Learn when it is appropriate to use a fine rather than a coarse thread.
- ❑ Be aware of the principal bolt and nut strength property classes and how they should be specified.
- ❑ How to match the nut strength to that of the bolt so that thread stripping problems are prevented.
- ❑ Why bolt tensile fracture is preferable to the threads stripping.
- ❑ Learn what the proof load is and why it is used.
- ❑ Be able to identify the meaning of the markings on bolt heads and nuts.
- ❑ The thread stress area and how it is derived and used.
- ❑ Be able to calculate the tensile strength of a threaded fastener.
- ❑ Understand how a pre-tensioned bolted joint sustains an applied load.

## The size and strength which a threaded fastener must be to avoid failure

- ❑ Learn how to establish what forces need to be taken into account to allow the bolt size to be determined.
- ❑ Distinguishing between direct and shear loads.
- ❑ Establishing the clamp force needed to prevent shear movement.
- ❑ How embedding affects the joints structural integrity.
- ❑ Clamp force loss from gasket creep.
- ❑ How the assembly method affects the bolt size.
- ❑ The tightening factor for the various assembly methods.
- ❑ Learn how to use bolt sizing equations to allow for the effects of embedding, the fastener assembly method and fatigue considerations.
- ❑ Perform calculations so that you have confidence to use them in practical applications.
- ❑ Learn to use the BoltSIZE program provided on the course to establish the required size and strength of bolt in a given application.

## Failure Modes of Threaded Fasteners

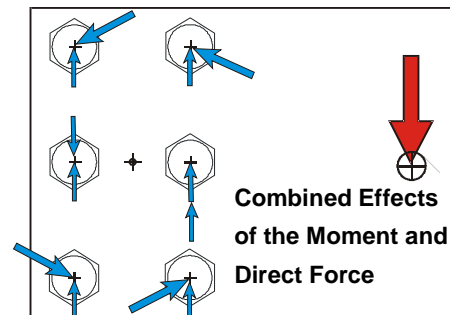
- ❑ Learn the differences between a manufacturing and design quality defect.
- ❑ Be able to identify whether a failure is due to a fault in the design specification or is manufacturing related.
- ❑ Learn the 5 main design related failure modes of threaded fasteners and bolted joints.
- ❑ The critical importance of a fastener's clamp force in ensuring a joint's structural integrity.
- ❑ Why the joint design normally prevents bolt overloading.
- ❑ Learn about fatigue and where failures normally occur on a threaded fastener.
- ❑ Why bearing stress can be crucial in ensuring a reliable joint.
- ❑ The nature of internal and external thread stripping failures.

## 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.

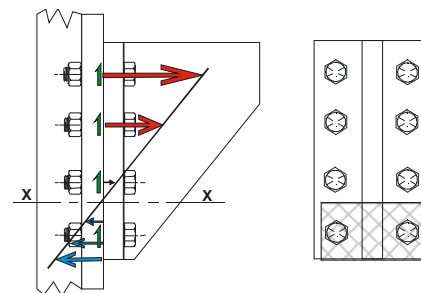
## Thread Stripping

- ❑ 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.
- ❑ The radial engagement of threads and how this 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.
- ❑ Perform thread stripping calculations so that you have confidence to use them in practical applications.



## Combined Tension and Shear Loading

- ❑ 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.



## Fatigue of Threaded Fasteners

- ❑ Understand the causes of fatigue to be able to recognise this type of failure.
- ❑ Learn about the S-N diagram and the endurance strength of a threaded fastener.
- ❑ Understand 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.
- ❑ Learn about the effect that joint face angularity can have on the fatigue performance of a fastener.
- ❑ Learn how the fatigue performance can be improved.
- ❑ The effect that bolt diameter has on fatigue performance.

## Analysis of Bolted Joints

# Training Course on the Analysis of Bolted Joints

## Outline and timing for the day

- ❑ **Introduction to Threaded Fasteners.** This introduction includes basic terminology on threads and bolts.
- ❑ **The Strength of Bolts and Nuts.** Basic strength terminology, property classes of bolts and nuts, markings on bolts and nuts.
- ❑ **The Stress Area of a Thread.** How strong is a thread? What is its effective cross sectional area?
- ❑ **Fastener Failure Modes.** An overview of the ways that threaded fasteners can and do fail.
- ❑ **Methods of Tightening Threaded Fasteners.** An overview of the main methods used to tighten threaded fasteners.
- ❑ **Torque Tightening of Threaded Fasteners** How to determine the appropriate torque value for a fastener. Test and calculation methods commonly employed to determine the torque value.
- ❑ **Preload Variation in Threaded Fasteners.** Variation in the bolt preload and how this can be allowed for in the design of joints.
- ❑ **Basics of Bolt Loading.** How a bolted joint sustains a direct load.
- ❑ **Vibration Loosening of Threaded Fasteners.** What causes threaded fasteners to self loosen? Main theories on the causes of self loosening. The effectiveness of different locking methods. How to design joints so that self loosening will not occur.
- ❑ **An Outline of VDI 2230 – Systematic calculation of high duty bolted joints.** This presentation gives an overview of the methodology of this German standard that is used world-wide.
- ❑ **Preload Requirement Charts** – determination of how to establish the likely cause of a bolting problem and how it can be resolved.
- ❑ **Bolting sizing formula** - how to determine the required size of a fastener - derivation and examples.
- ❑ **Bearing stress.** Importance of bearing stress in bolted connections, embedding losses and bearing stress calculations.
- ❑ **Fatigue Failures.** Explanation of fatigue, the endurance limit and how this applies to threaded fasteners.
- ❑ **Thread Stripping and Thread Stripping Calculations.** Examples of this mode of failure, determination of the shear area of a thread, the shear strength ratio for various commonly used joint materials and the determination of the forces needed to shear internal and external threads. This includes activities/calculations for participants to complete.
- ❑ **Shear Loads Applied to Bolted Joints.** Determination of how to distribute the loads between a bolt group subjected to in-plane forces and moments. Derivation of equations and examples in their use. This includes activities/calculations for participants to complete.
- ❑ **Combined shear and tension joints.** Determination of how to distribute loads between a bolt group subjected to out of plane forces. Derivation of equations and examples in its use. This includes activities/calculations for participants to complete.
- ❑ **Open forum/discussion** - Implementing the lessons learned. Computer aided analysis of bolted joints.

Any questions?

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