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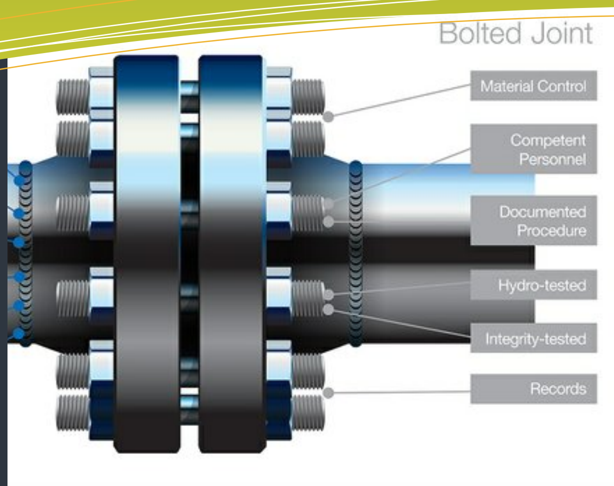
TechTimes



this issue

ECITB MJI Training

Petracarbon (Thailand) Co., Ltd is a hi-tech company with their primary goal to promote advanced repair & maintenance technioligies for oil & gas, chemical, petrochemical, oil refining industries in Thailand and in neighbouring countries.

Beside the usual services, we are also an approved training provider from ECITB (Engineering Construction Industry Training Board) for delivering the Mechanical Joint Integrity (MJI) training courses, that is in line with industry standards and practices.

This ECITB MJI course which focus on skills in perfoming various techniques using range of bolting tools, which enable delegates to learn isolation, dismantling, alignment and tightening techniques on various type of flanges, as well as inspection of components as per industry requirements.

- MJI10: Hand Torque Bolted Connection
- MJI18: Hydraulically Tensioned Bolted Connections
- MJI19: Hydraulically Torqued Bolted Connection

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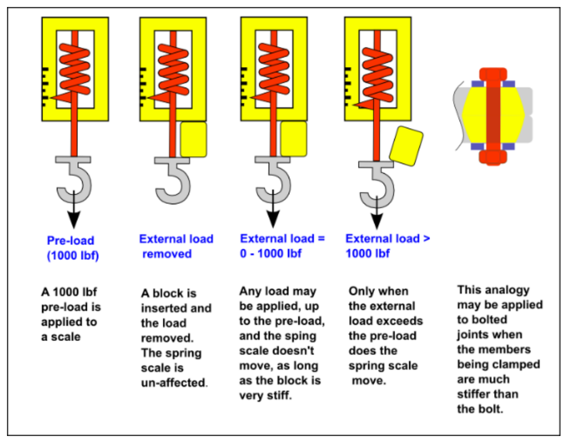
Bolted Joint Theory

Function of Bolts and Nuts

Threaded fasteners are used across industries to assemble products ranging from pipelines to heavy-duty earthmovers and from cranes and bridges, wind towers, and many more applications. Their principal function is to create a clamping force (preload) across the joint which is able to sustain the operating conditions without loosening.

Correctly tightened bolts make use of their elastic properties, to work well they must behave like springs. When a fastener is torqued, a tension preload develops in the bolt and an equal compressive preload develops in the parts being fastened. This can be modeled as a spring-like assembly that has some assumed distribution of compressive strain in the clamped joint components. When an external tension load is applied, it relieves the compressive strains induced by the preload in the clamped components, hence the preload acting on the compressed joint components provides the external tension load with a path (through the joint) other than through the bolt. In a well-designed joint, perhaps 80-90% of the externally applied tension load will pass through the joint and the remainder through the bolt. This reduces the fatigue loading of the bolt.



When the fastened parts are less stiff than the fastener (those that use soft, compressed gaskets for example), this model breaks down and the fastener is subjected to a tension load that is the sum of the tension preload and the external tension load.

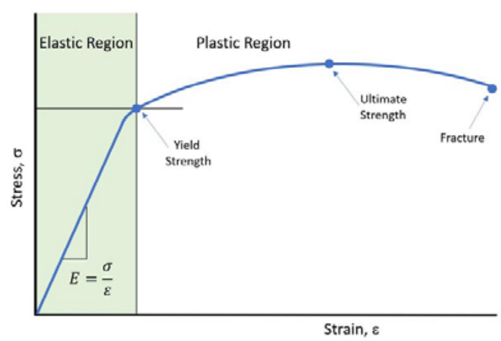
In some applications, joints are designed so that the fastener eventually fails before more expensive components. In this case, replacing an existing fastener with a higher strength fastener can result in equipment damage. Thus, it is generally good practice to replace old fasteners with new fasteners of the same grade.

ECITB MJI Trainings

Behaviour of Bolts and Nuts

Elasticity is defined in Hooke's Law of Physics. The stress in a bolt is directly proportional to its strain. The stress strain of a bolt has an elastic range and a plastic range. In this elastic range, Hooke's Law is true.

All of the elongations applied within the elastic range are relieved when the load is removed. The amount of elongation increases when more load is applied. When a bolt is stressed beyond its proof load (maximum load under which a bolt will behave in an elastic manner), the elastic elongation changes to plastic deformation, and the strain will no longer be proportional to stress.

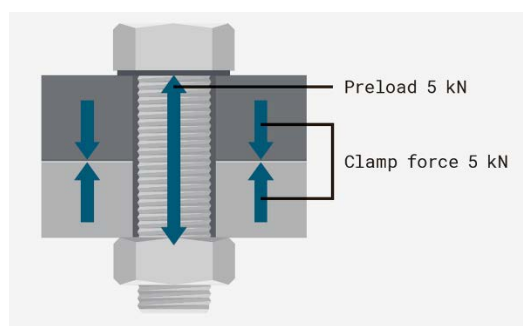


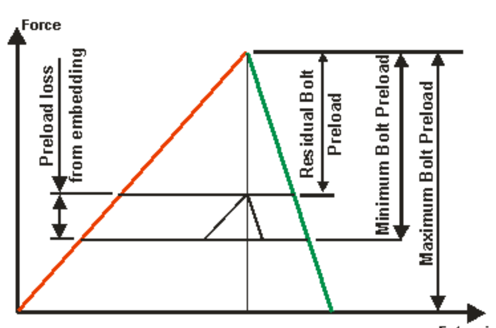
In plastic deformation, a part of the elongation will remain after the load is removed. The point where this permanent elongation occurs is called the yield strength. The further application of load takes the bolt to a point where it begins to fail this is termed its ultimate tensile strength (UTS). At this UTS point, if additional force is applied to the bolt it will continue to elongate until it finally breaks. The point at which the bolt breaks is called the tensile point.

Careful attention must be paid to the grade of the bolt being used as bolt grades differ in the elastic range.

Preload

The main purpose of a bolt and nut is to clamp parts together with the correct force to prevent loosening in operation. Preload is the tension created in a fastener when it is tightened. It is also known as a residual load. This tensile force in the bolt creates a compressive force in the bolted joint known as clamp force. For practical purposes, the clamping force in an unloaded bolted joint is assumed to be equal and opposite of the preload. If proper preload, and thus clamp force, is not developed or maintained, the likelihood of a variety of problems such as fatigue failure, joint separation, and self-loosening from vibration can plague the bolted joint leading to joint failure. The amount of preload is critical as the joint can fail if the load in the bolt is too high, too low, or not uniform in every bolt.

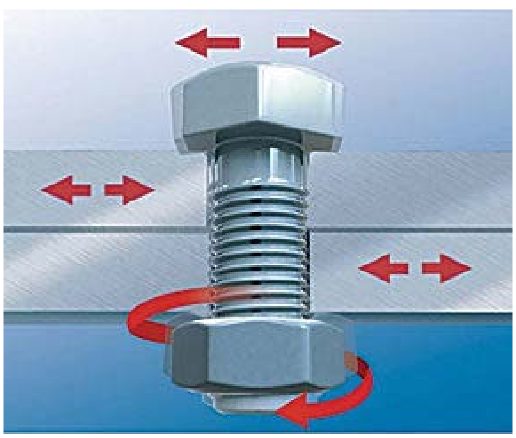




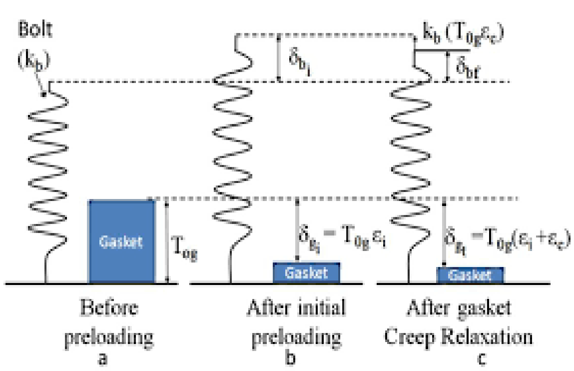
Bolt loosening

There can be many possible causes for bolts to loosen in service. When we say "loosen" here we mean lose their tension, or preload. Here are five major causes:

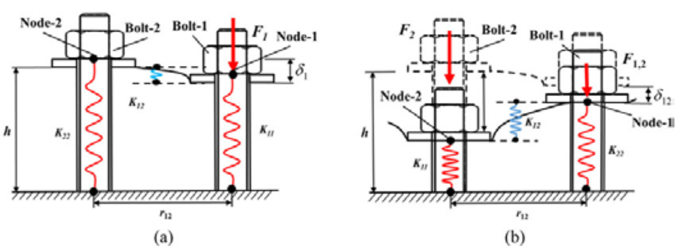
- Vibration which can create relative transverse movement of the bolted materials leading to self-loosening of the nut.



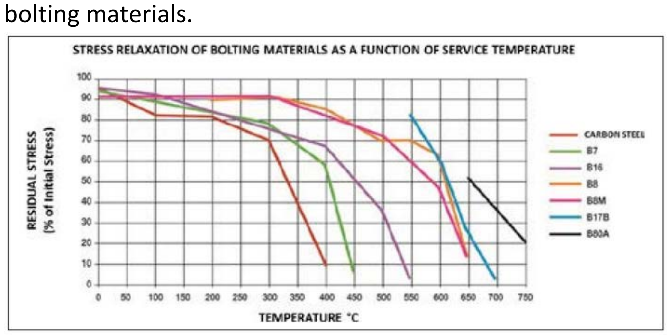
- Relaxation of the bolted joint after tightening due to embedment or gasket creep.



- Elastic interactions occur when multiple bolts are present in a bolted joint. The additional force applied to the joint members by tightening a bolt can affect the amount of tension on the other previously tightened bolts. Elastic interactions can either increase or decrease bolt preload making it even more difficult to predict.



- Temperature fluctuation of the components. Especially the bolting materials.



- Insufficient initial preload developed at installation

The design of the bolted joint can minimize relaxation and embedment and ensuring sufficient preload at installation can reduce the effects of vibration and the likelihood of relative transverse movement. In other words, properly designed bolted joints that are properly preloaded should not self-loosen.

Strength of Fasteners

Each of these is basic mechanical properties that help define the expected tensile strength performance of a specific fastener and can be measured in units of force. In USCS and SI systems, force is measured in pound-force (lbf) and Newtons (N), respectively. Since the strength of fasteners is generally quite large, it is also common to see these forces listed in kilopound-force (klbf) and kilonewton (kN).

Tensile Strength (TS)

Bolts are made of different grades of steel. The grade of a bolt determines the maximum amount of stress (tensile strength) that the bolt can handle. Tensile strength is the amount of pull the bolt can withstand before breaking. The method used for tightening the bolt is also dependent upon the grade of the bolt. The grades are indicated on top of the bolts as raised numbers or dashes. There are three main systems of bolt classification: SAE, Metric, and ASTM.

Proof Load

Proof load is defined as the maximum tensile force that can be applied to a bolt that will not result in plastic deformation. In other words, the material must remain in its elastic region when loaded up to its proof load. Proof load is typically between 85-95% of the yield strength.

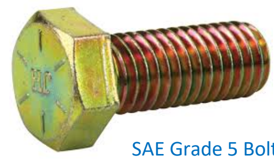
Yield Strength (YS)

Yield strength can be defined as the tensile force that will produce a specified amount of permanent deformation (most commonly 0.2%) within a specific fastener.

Ultimate Tensile Strength (UTS)

Ultimate tensile strength can be defined as the maximum force a specific fastener must withstand before fracture.

SAE Bolt Grades



SAE Grade 2 Bolts

- Head Marking: No marking
- Material: Low or medium carbon steel
- Size Range: ¼” to ¾”
  Proof Load (psi): 55,000
  Min. Yield Strength (psi): 57,000
  Min. Tensile Strength (psi): 74,000
- Size Range: 7/8” to 1-1/2”
  Proof Load (psi): 33,000
  Min. Yield Strength (psi): 36,000
  Min. Tensile Strength (psi): 60,000

SAE Grade 8 Bolts

- Head Marking: Six radial lines
- Material: Medium carbon steel, quenched and tempered
- Size Range: ¼” to 1-1/2”
  Proof Load (psi): 120,000
  Min. Yield Strength (psi): 130,000
  Min. Tensile Strength (psi): 150,000

SAE Grade 5 Bolts

- Head Marking: Three radial lines
- Material: Low or medium carbon steel, quenched and tempered
- Size Range: ¼” to 1”
  Proof Load (psi): 85,000
  Min. Yield Strength (psi): 92,000
  Min. Tensile Strength (psi): 120,000
- Size Range: Over 1” to 1-1/2”
  Proof Load (psi): 74,000
  Min. Yield Strength (psi): 81,000
  Min. Tensile Strength (psi): 105,000

Grade A325 Bolts

- Head Marking: A325
- Material: Carbon or Alloy Steel with or without Boron
- Size Range: ½” to 1-1/2”
  Proof Load (psi): 85,000
  Min. Yield Strength (psi): 92,000
  Min. Tensile Strength (psi): 120,000

Metric Bolt Grades

Class 8.8

- Head Marking: 8.8
- Material: Medium carbon steel, quenched and tempered
- Size Range: All sizes below 16mm
  Proof Load (MPa): 580
  Min. Yield Strength (MPa): 640
  Min. Tensile Strength (MPa): 800
- Size Range: 16mm to 72mm
  Proof Load (MPa): 600
  Min. Yield Strength (MPa): 660
  Min. Tensile Strength (MPa): 830

Class 10.9

- Head Marking: 10.9
- Material: Alloy steel, quenched and tempered
- Size Range: 5mm to 100mm
  Proof Load (MPa): 830
  Min. Yield Strength (MPa): 940
  Min. Tensile Strength (MPa): 1,040

Class 12.9

- Head Marking: 12.9
- Material: Alloy steel, quenched and tempered
- Size Range: 16mm to 100mm
  Proof Load (MPa): 970
  Min. Yield Strength (MPa): 1,100
  Min. Tensile Strength (MPa): 1,220