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# Washers - a critical element of successful bolting integrity

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A technical article  
presented by  
James Walker



## Why use washers?

Approximately 50% of the torque applied when tightening a bolt is absorbed by under-head friction where the mating surfaces of a nut and flange are being forced together. This makes the interface between the nut and the flange a crucial bearing surface and means that washers play a vital role in accurate tightening of bolted joints.

A washer is beneficial for several reasons:

- Ensures proportionate load distribution throughout the joint
- Protects the flange ring from galling and nut embedment
- Provides a hard clean surface for a more consistent coefficient of friction



*Photographs show nut galling of the flanges*

## ASTM F436 - general and structural use

The ASTM F436 specification covers the material grade, chemistry and hardness requirements for structural and general use washers. They are through-hardened making them less susceptible to cupping, which could result in inaccurate torque readings versus actual bolt stress.

Utilising through-hardened washers disperses the applied load of the fastener assembly across the face of the flange. This allows a uniform stress to be applied to the gasket contact area potentially reducing any leak paths.

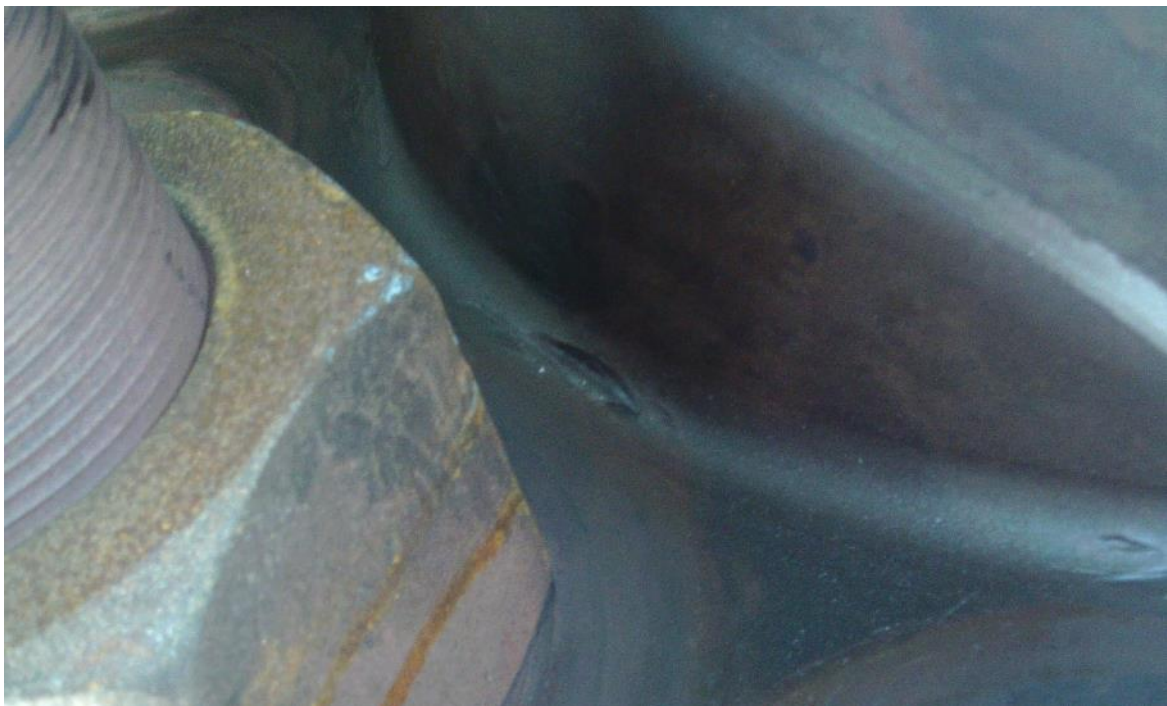
Through-hardened washers also prevent embedding of the nut against the flange face – a phenomenon that can result in large variations between applied torque and actual preload achieved on the bolt.

## ASME PCC-1 Appendix M – pressure boundary flanges

ASME PCC-1 2010 Appendix M Washers are specifically designed for pressure boundary bolted flanged connections and are part of the route to compliance for any plant using ASME PCC-1 as a flange management methodology.

Importantly, the material property specification for the ASME washers is the same as the material used to manufacture the studs. It therefore has the same mechanical and chemical properties, responding to operational conditions in the same ways and at the same rates as the studs and flanges.

ASME washers also take into consideration fastener dimensions, diameters and material operating conditions specifically encountered in pressure boundary flange joints.



*Nut glancing the web of the flange, no room for ASTM F436 washers*

Achieving the correct design tension on installation and the long-term integrity of your bolted joints is a combination of a number of factors but the importance of using the correct washers should not be overlooked. Your fastener supplier should be able to advise on the particular type of washer to use for any specific application.

## A word of caution

The use of washers of any type is not a singular solution to flange management issues and does not in any way guarantee correct engineering practice.

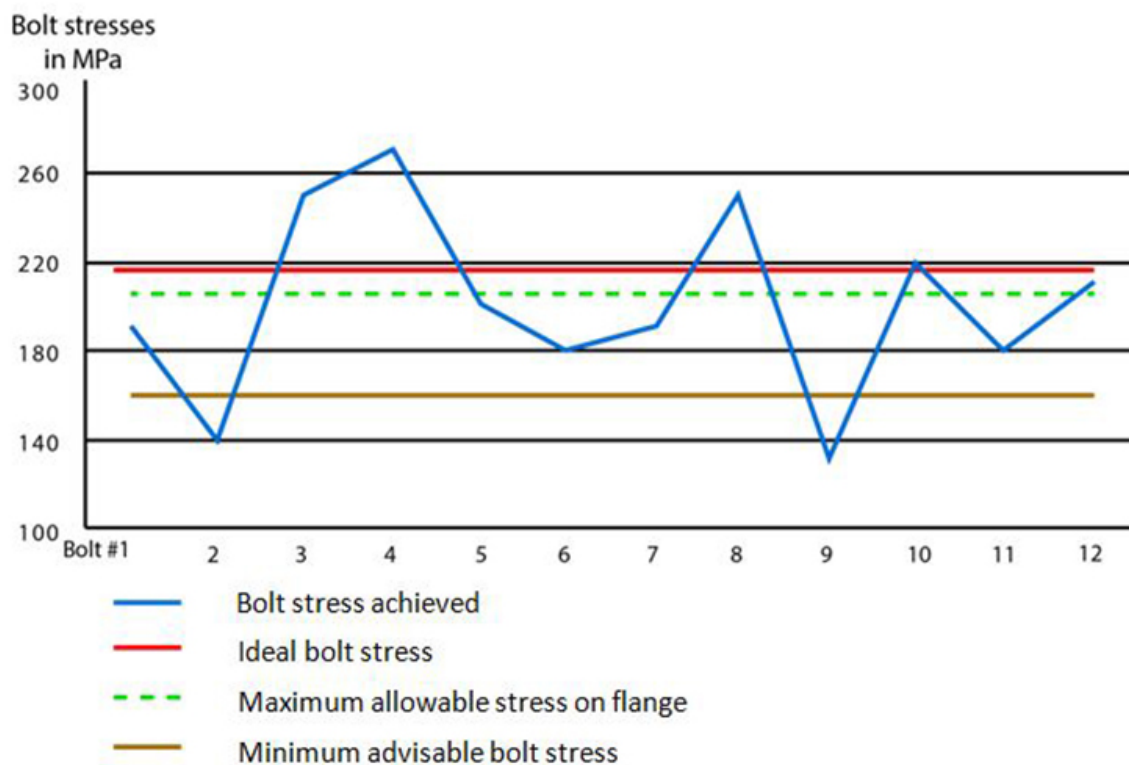
As we have mentioned earlier in this document, suitable washers are crucial aids in helping to achieve the correct bolt tension across any bolted joint by providing an homogenous surface with a consistent coefficient of friction against which to tighten flange bolts.

Achieving the correct bolt tension will however still be dependent upon other key factors;

**Flange condition** – in terms of suitable design, correctly matched materials, alignment and general condition of faces and bolting surfaces.

**Lubrication** – as mentioned earlier, thread friction can account for 45% of the tightening force being applied so correct lubrication can be a major influencing factor in achieving the desired bolt tension.

**Bolt / stud performance** – applying the same tightening force to a series of 'identical' bolts doesn't necessarily result in an even load across the joint. Material and manufacturing differences in the studs / bolts can cause large variances in achieved bolt tension, as illustrated in the chart below. (Based on standard B16 bolts and traditional torquing on a 12 bolt 6" 900# RTJ flange)



This sort of result will be commonplace using a torquing method because only the tightening load and not the achieved bolt tension is known on installation unless some type of tension measurement fastener or system is utilised.

***Correct gasket selection, placement/alignment*** – different gaskets types and materials react to assembly and joint tightening procedures / patterns in different ways. Allowance must be made for this in order to ensure a leak-free joint on start-up.

***Bolt assembly patterns*** - Joints should always be tightened evenly in at least three, or even four, stages using an opposed-pattern. Be aware that “cross-torque” exists between bolts during the tightening process so that as one tightens and the gasket compresses, another bolt may loosen.

## **Recommendations**

### ***For critical flanges and all pressure boundaries***

Employ ASME PCC-1 as a flange management methodology as this will not only ensure the most suitable components are used but also that the best engineering practice is also employed in their installation.

As an integral part of ASME PCC-1, ensure that ASME PCC-1 Appendix M washers, in the correct material, are utilised with all bolts on appropriate flange connections.

In partnership with ASME washers, ensure the correct gasket material and design is specified and used.

To ensure the integrity of critical flanges, employ a bolt tension measuring system such as RotaBolt®, which measures and ensures that the design tension is achieved on each and every bolt in the flange joint, to provide even loading of the gasket. This optimises initial sealing performance and maintains operational joint integrity.

### ***For general flange and bolting operations***

Use appropriate washers on all bolted joints to aid in achieving correct bolt tension and uniform gasket loading.

Using washers such as ASTM F436 through-hardened washers will also prevent embedding of the nut against the flange face and, as they are less susceptible to cupping, will aid more accurate bolt tension to be achieved.

Benefits can still be derived from the use of a tension measuring system such as RotaBolt even on non-critical flanges and joints, particularly where the following situations are in play;

***Heating / cooling cycles*** – bolts should be of the similar material as the flange to ensure there is no loosening during heating and cooling cycles due to differential rates of expansion and contraction. Installation to the correct design tension will then maintain the joint's integrity through operational cycles.

***Vibration / shock*** – achieving the correct design tension on installation optimises friction grip of the bolt head / nut faces and thread surfaces and resists the transverse movement of the vibration forces. This also negates the need for anti-vibration washers etc

***Difficult access for checking and maintenance*** – bolt tension can be monitored by visual, tactile or remote wireless options and only bolts that have lost tension need be adjusted.

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