FLUID SEALING ASSOCIATION FSA

From the voice of the fluid sealing industry

SEALING SENSE

What fasteners should I use for my bolted flange connection?

This month's *Sealing Sense* was prepared by FSA Member Roberto Araujo

The bolted flange joint assembly is a complex mechanical device that requires proper selection of components and use of correct installation procedures to ensure leak-free service in a specific application. The interaction of these components and procedures must be controlled to have reliable performance in a bolted flange joint assembly. Many factors must be considered, such as gasket specification, appropriate torque, tightening sequence, flanges surface finish and fasteners.

Fasteners

While all factors are important and should be considered for a successful installation, field observation shows that fasteners are one of the most neglected components in this process. As a consequence, fasteners are a frequent cause of joint leakage. While the principal fastener components include either bolts or studs and nuts, washers are also an important part of the system.

Fasteners are a key component in a flange connection. They work like a spring controlling the internal as well as the external forces while still keeping the required sealing stress on the gasket. Therefore, any problem related to the fasteners can result in serious consequences.

To avoid failure, compliance with the following must be verified for the fastener:

- Material specification
- Correct thread type and finish
- Sound physical condition
- Correct surface lubrication

The purpose of this article is to show the importance of selection of the appropriate fastener standard and specification.

Material Properties

A fastener standard must define a series of properties that are required to meet the application needs. The most important fasteners properties are:

- Yield strength
- Chemical composition
- Hardness

For the fastener to operate like a spring, the fastener yield strength must be in balance with the joint. Fasteners that apply loads higher than necessary are harmful for the system, as are those that apply insufficient load. Fastener yield strength should be specified so that the target torque ranges from 40 to 70 percent of its limit. Additionally, this value of torque must be sufficient to guarantee the correct gasket seating stress and lower than the flange strength and gasket limit.

Temperature Capability

A correlation exists between the metallurgical and chemical

Table 1. ASTM Specifications for Specific Fastener and Nut Grades

Bolt Grade Designation	Nut Grade Designation	Bolt Yield Strength (1) (Ksi)	Temperature Range (deg F)	Applications
A 193 B7	A 194 2H	75 to 105	RT to 700	General use
A 193 B16	A 194 7	85 to 105	-20 to 950	Higher temperatures
A 193 B8 cl. 2 (2)	A 194 8	50 to 100	-20 to 1000	Higher temperatures and stainless steel flanges
A 193 B8M cl. 2 (2)	A 194 8M	50 to 95	-20 to 1000	Higher temperatures and stainless steel flanges
A 320 L7	A 194 4 or 7	75 to 105	-150 to 700	Cryogenic and low temperature

Notes:
1 - Yield strength varies with fastener nominal diameter.
2 - Fastener A 193 B8 cl. 1 and A 193 B8M cl. 1 have lower yield strength than the cl. 2 listed in the table. This difference frequently is not recognized and has been the cause of failures.

Sealing Sense is produced by the **Fluid Sealing Association** as part of our commitment to industry consensus technical education for pump users, contractors, distributors, OEMs and reps. As a source of technical information on sealing systems and devices, and in cooperation with the **European Sealing Association**, the FSA also supports development of harmonized standards in all areas of fluid sealing technology. The education is provided in the public interest to enable a balanced assessment of the most effective solutions to pump systems technology issues on rational Total Life Cycle Cost (LCC) principles.

The **Gasket Division** of the FSA is one of six with a specific product technology focus. As part of their mission they develop publications such as the *Metallic Gasketing Technical Handbook* as well as joint publications such as the newly revised ESA/FSA *Flange Gaskets – Glossary of terms, Guidelines for safe seal usage - Flanges and Gaskets* as well as the FSA/ESA *Gasket Installation Procedures*, which are available in eight languages. These are intended to complement the more detailed manufacturers' documents produced by the member companies.

The following members of the **Gasket Division** sponsor this *Sealing Sense* series:

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Figure 1. ASTM Grade A193 B7 Bolt

properties of the fastener material and its temperature range capability. The fastener material selection must be based on the yield strength needed as well as the design temperature and flange material. It is crucial to have both fasteners and flanges made of materials with similar thermal expansion for proper performance of the fasteners.

Hardness

This is an important indicator of whether the required metallurgical processes were followed during manufacture of the fastener. Hardness is an important property check because determination of the fastener material's chemical composition alone is insufficient to ensure that bolt properties requirements, such as yield strength, are met.

Industry Standards

The choice of appropriate material standard depends on the industry and application requirements. Many fastener standards are available. For pressure vessel and industrial piping applications, ASTM International standards are the major industry reference. Among them, the most representative are:

- *ASTM A193/A193M* - Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service
- *ASTM A320/A320M* - Specification for Alloy-Steel and Stainless Steel Bolting for Low Temperature Services

Nuts

For each fastener specification, there is an associated nut specification. Since both parts interact, it is important to refer to the nut standard as well. The ASTM standard for nuts related to the above for bolts and studs is:

- *ASTM A194/A194M* - Specification for Carbon and Alloy Steel Nuts for Bolts for High Temperature or High Pressure Services, or Both

While this standard is indicated for high temperature services, it is also applied for low temperature services. This standard can also be used with bolt standard ASTM A320/A320M.

Finished hex nuts are the most common type. Heavy hex nuts are used in high temperature and high pressure applications. This is the most common

type of nut for flanged joints. Heavy hex nuts are slightly larger and thicker than finished hex nuts.

Figure 2. ASTM Grade A194 H2 Nut

Washers

Addition of steel washers to a fastener system is recommended to improve translation of torque input into bolt preload. Washers provide a smooth bearing surface, reducing friction between nut and flange. This effect is greatest when washers are through-hardened. The recently published ASME PCC-1-2010 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* includes guidance on washer usage and purchase specification in Appendix M.

Table 1 (on page 32) shows the designations for bolt and nut grades shown in ASTM specifications that are frequently used in bolted flange assemblies.

Summary

Selection of the suitable bolt or stud and nut is a fundamental step toward a reliable flange connection assembly. Most industrial flange connections are designed in accordance with ASME Codes that reference bolts and nuts following ASTM standards. This association leads to safer flange connections. It is always important to check to ensure that fasteners with the correct specification are used before assembling the joint. To confirm that the bolts and nuts are correct, check their grade identification mark, as noted in Figures 1 and 2. All bolts and nuts must have a grade identification mark on one face.

Selection of the correct fastener system is just a first step. The proper tool must also be used to apply the specified torque. All the effort and caution with bolts and nuts will be lost if this is not done. At a minimum, calibrated torque wrenches must be used to tighten the flanges.

Next Month: *What is the energy footprint of sealing systems?*

We invite your questions on sealing issues and will provide best efforts answers based on FSA publications. Please direct your questions to: sealingsensequestions@fluidsealing.com.

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