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Flange Bolt Applications in Corrosive and General Environments

by William. M. Huitt

(From a letter dated January 31, 2001, in response to a bolt corrosion issue.)

With regard to the flange bolt corrosion problem currently being addressed, and the possibility of using alternative bolting material, I will begin with a listing of bolting material that is acceptable to use with ASME B16.5 flanges, as defined by ASME B16.5-*Pipe Flanges and Flanged Fittings.* While the fluid service applications in your facility will only require a select few of the listed bolting materials I thought it might be helpful to see the scope of what is allowed by Code, with regard to material.

Bolting Materials (ASME B16.5)

High Strength		Intermediate Strength		Low Strength		Nickel & Special Alloy	
Spec. No.	Grade	Spec. No.	Grade	Spec. No.	Grade	Spec. No.	Grade
A193	B7	A193	B5	A193	B8 CL.1	B164	—
A193	B16	A193	B6	A193	B8C CL.1	—	—
—	—	A193	B6X	A193	B8M CL.1	B166	—
A320	L7	A193	B7M	A193	B8T CL.1	—	—
A320	L7A	A193	B8 CL.2	A193	B8A	B335	N10665
A320	L7B	A193	B8C CL.2	A193	B8CA	—	—
A320	L7C	A193	B8M CL.2	A193	B8MA	B408	—
A320	L43	A193	B8T CL.2	A193	B8TA	—	—
—	—	—	—	—	—	B473	—
A354	BC	A320	B8 CL.2	A307	B	—	—
A354	BD	A320	B8C CL.2	—	—	B574	N10276
—	—	A320	B8F CL.2	A320	B8 CL.1	—	—
A540	B21	A320	B8M CL.2	A320	B8C CL.1	—	—
A540	B22	A320	B8T CL.2	A320	B8M CL.1	—	—
A540	B23	—	—	A320	B8T CL.1	—	—
A540	B24	A449	—	—	—	—	—
—	—	A453	651	—	—	—	—
—	—	A453	660	—	—	—	—

The bolting material specifications that are under consideration here are A193 and A307. The others, A320, A354, A540, etc. are used in cryogenic or specialty services and are out of the realm of this immediate discussion.

Some of the Specs in the above Table will have a Class indication (i.e. B8 CL.1). This is because some of the Grades are represented in multiple Classifications. These Classifications represent various heat-treating requirements.

With regard to the strength categories in the above Table, ASME has assigned these categories based on the minimum yield strength of the bolt specification. The High Strength category includes bolt material with a minimum yield strength of not less than 105 ksi. The Intermediate Strength category includes bolt material with a minimum yield strength of between 30 ksi and 105 ksi. The Low Strength category includes bolt material with a minimum yield strength no greater than 30 ksi.

As defined in ASME B16.5, the High Strength bolting materials "…may be used with all listed materials and all gaskets". The Intermediate Strength bolting materials "…may be used with all listed materials and all gaskets, provided it has been verified that a sealed joint can be maintained under rated working pressure and temperature. The Low Strength bolting materials "…may be used with all listed materials but are limited to Class 150 and Class 300 joints", and can only be used with selected gaskets as defined in ASME B16.5.

ASME B31.3 further clarifies in para. 309.2.1, "Bolting having not more that 30 ksi specified minimum yield strength shall not be used for flanged joints rated ASME B16.5 Class 400 and higher, nor for flanged joints using metallic gaskets, unless calculations have been made showing adequate strength to maintain joint tightness". B31.3 additionally states in para. 309.2.3, "…If either flange is to the ASME B16.1 (*cast iron*), ASME B16.24 (*cast copper alloy*), MSS SP-42 (*valves with flanged and buttweld ends*), or MSS SP-51 (*cast flanges and fittings*) specifications, the bolting material shall be no stronger than low yield strength bolting unless: *(a)* both flanges have flat faces and a full face gasket is used: or, *(b)* sequence and torque limits for bolt-up are specified, with consideration of sustained loads, displacement strains, and occasional loads (see paras. 302.3.5 and 302.3.6), and strength of the flanges.

The most universal bolt listed above is the A193-B7 stud bolt. It is less expensive than the A193-B16 and can be used with all flange Class ratings. The only exception would be the use of a raised face flange against a cast iron, ductile iron or non-metallic flange. In that case, as stated above, a low yield strength bolt would be required.

The purpose for this review of flange bolt material requirements has to do with the problem of using low yield strength, A307-B, bolts in corrosive environments. Currently a protective coat of paint is applied to installed bolts in an effort to prevent this corrosion activity. Subsequently, this makes later disassembly very difficult. It has been recommended that the A307-B bolts be replaced with a bolt material more suitable for corrosive environments. This would alleviate the necessity of having to paint the bolts, and would facilitate disassembly of the flange joint.

In considering the more corrosion resistant 316 stainless steel bolting material available under B16.5 (see the above Table) the more cost effective is the A193-B8M Class 1. This is a low yield strength, 316 stainless steel bolt. Since the majority (it's probably safe to say 95%) of your facility's flange requirements are Class 300 and less this bolt could be used for virtually all flanged joints. For all joint connections above Class 300 the recommended bolt is the A193-B7. I would also recommend, for both applications, using the stud bolt rather than the hex head bolt. It allows for more latitude in assembly and takes up less space in stores.

The A193-B8M (Class 1 must be specified when purchasing), like all stainless steel bolt materials under A193, are carbide solution treated. Austenitic stainless steels do not undergo phase changes like the ferritic steels. And since they remain austenitic at all temperatures normal heat treatment doesn't apply. The cold working of the bolt could result in residual stresses resulting in intergranular stress corrosion cracking which makes the grain boundaries susceptible to attack by the corrosive media. The carbide solution treatment is a process by which the material is heated above its sensitivity range (1950 - 2100°F) to allow the carbides to dissolve and the carbon to go back into solid solution. At that point of the process the material is removed from the furnace and rapidly cooled to prevent the carbon from coming out of solution, thereby restoring its corrosion resistance.

A possible second choice for the low yield strength bolt, in regard to added corrosion resistance, is the A193-B8MLN Class 1. This is a nitrogen bearing, 316 stainless steel bolt with a lower carbon content of 0.030. The B8M bolt has a carbon content of 0.08. The B8MLN bolt is a more expensive bolt and should only be considered should the B8M bolt prove to be unsatisfactory.

END OF LETTER