BOLTING PROCEDURES

The best way to obtain uniform bolt loading is by following well documented bolting procedures. Regardless of the equipment used to load the bolts in a joint, a prescribed method for doing so is of the utmost importance. Developing good bolting procedures can be a monumental task if you do not establish some criteria. A procedure for bolting should include specific instructions for:

1. Joint, Bolt and Gasket Preparation.
2. Method of Applying Torque or Tension.
3. Documentation of Results.

The following is a sample bolting procedure using a manual or hydraulic torque wrench:

CASE I
BOLTING PROCEDURE MANUAL OR HYDRAULIC TORQUE WRENCH

THIS PROCEDURE IS TO BE USED IN THE FOLLOWING SITUATIONS:

1. Joints in vibrating service.
2. Joints in cyclical service.
3. Joints with ring joints or solid metal gaskets of SOFT IRON.

THE FOLLOWING DATA, TO BE RECORDED ON THE JOB DATA SHEET.

1. Unit
2. Joint Identification and Alignment Check
3. Bolt Material
4. Bolt Diameter
5. Number of Bolts
6. Nut Size ATF
7. Gasket Type
8. Gasket Material
9. Condition of Bolts
10. Condition of Washers
11. Lubricant
12. Torque Wrench Data
13. Torque Settings
14. Friction Factor (K Factor)
15. Percentage of Yield
16. Date and Time Initial Tightening Completed
17. Date and Time Final Tightening Completed
18. Completed Alignment Check
19. Supervisor's Signature
20. Notes

• Allentown, Pa, 18104
Fax Toll Free: • Phone: 484.539.9022 • Toll Free Fax: 866.780.9316
Email: bolting@nibtorque.com • Web: www.NIBTORQUE.com

1. Thoroughly clean the flange faces and check for scars.

2. Check studs and nuts for proper size, piping material specifications and cleanliness; and any rust, paint or corrosion to be removed by wire brushing or bead blasting.

3. Remove burrs from all threads.

4. If one stud is replaced, all must be replaced.

5. Gaskets are to be checked for proper size and specifications. Metal gaskets to be free of grease, rust or burrs.

6. Check flange spot face where nut makes contact. This area must be clean and smooth. Use 1/4" thick hardened steel washers on both ends of studs when installing new bolts.

7. Check flange alignment: alignment of parallelism tolerance shall be limited to 3/32" per foot of pipe

8. diameter measured at any point on the flange circumference.

9. The bolts (or the flange) shall be numbered with the cross-bolting pattern sequence to be used. Refer to numbering specifications.

10. Lubricate the thread area of both stud and nut. Also lubricate the face of the nut in contact with the flange. Apply lubricant thoroughly to all surfaces.

11. Where applicable, the flanges will be pulled together and snugged with hand wrenches. When working with heavier flanges that have no support, it is acceptable to use an impact to lightly snug a maximum of 8 bolts beginning with bolt #1 and following the bolt pattern.

NOTE: When using an impact wrench, only enough pressure shall be applied to hold the flange stable.

TORQUE PROCEDURE

1. The bolts shall be then tightened (torqued) to the First Torque Level shown on the Flange Torquing Table, using the cross-bolting sequence marked on the flange or bolts (1/3 of the full torque).

2. This sequence shall be repeated as necessary at this torque level until all the nuts cease to move when the torque is applied.

3. The bolts shall then be tightened to the Second Torque Level, using the same cross-bolting sequence (2/3 of the full torque). The sequence shall be repeated until the nuts cease to move when the torque is applied.

4. The bolt shall then be tightened to the Full Torque Level, using the same cross bolting sequence. The sequence shall be repeated until the nuts cease to move when torque is applied.

5. Full torque shall then be applied to all the bolts in rotational order. This shall be continued until all the nuts cease to move when the torque is applied.

1. Unit _______________ 2. Flange _______________

Starting Alignment Checked _______________

3. Bolt Diameter _______________ 4. Bolt Material _________________

5. Number of Bolts _______________ 6. Nut Size ATF ________________

7. Gasket Type _______________ 8. Gasket Material ______________

9. New Bolts _______________ 10. New Washers _______________

11. Lubricant Manufacturer_________ Lubricant Name or Number__________

12. Torque Wrench Data:

Manufacturer _______________ Model _______________

Torque Range _______________ Ft-Lbs. to_______________ Ft-Lbs.

13. Torque Settings:

First Pass at 30% ______ Ft-Lbs.

Second Pass at 70% ______ Ft-Lbs.

Third Pass at 100% ______ Ft-Lbs.

Fourth Pass at 100% ______Ft-Lbs.

14. Friction Factor _______________ 15. Percent of Yield _______________

16. Third Pass Completed: Date: / / Time: __________

17. Fourth Pass Completed: Date: / / Time: __________

18. Completed Flange Alignment Checked _______________________________

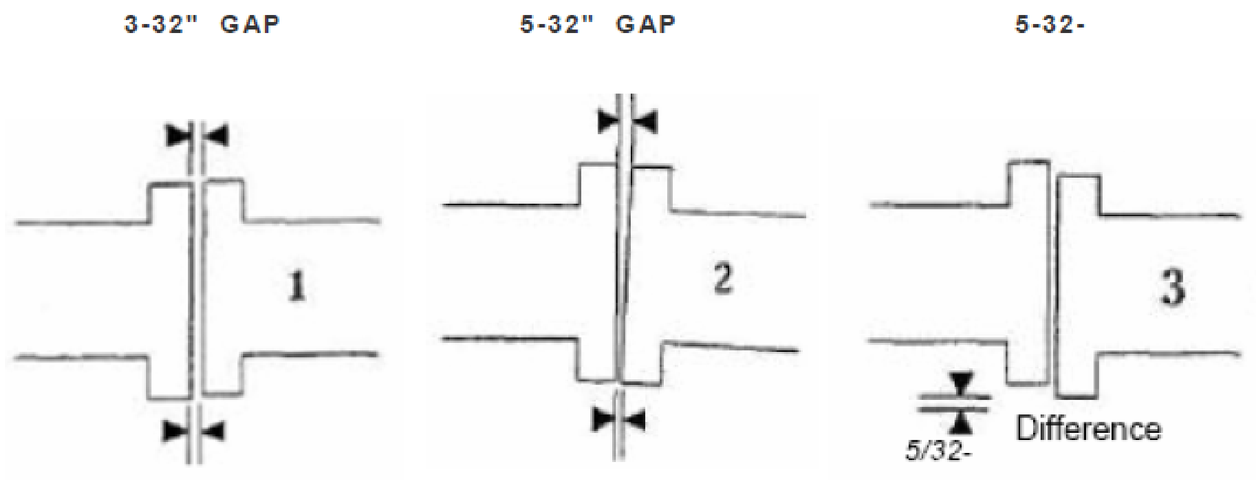
19. Supervisor's Signature ____

20. Notes:[i]

• Allentown, Pa, 18104
Fax Toll Free: • Phone: 484.539.9022 • Toll Free Fax: 866.780.9316
Email: bolting@nibtorque.com • Web: www.NIBTORQUE.com

BOLTING PROCEDURES – ALIGNMENT

FIGURE 1-32" GAP



The three sets of flanges in the diagram above are three examples of such tolerance.

Joint number 1 is in alignment.

Joint number 2 is not in alignment. Notice that the gap at the top of the flanges is 5/32" and the bottom 1/32". When we subtract the bottom gap from the top gap the solution is 4/32" (5/32 - 1/32 = 4/32). This number is greater than the allowable tolerance 3/32". Therefore, the flanges are considered not to be within the parallelism tolerance.

Joint number 3 is within the parallelism tolerance, but there may be problems when trying to install the bolts. The holes in most flanges will allow 1/8" clearance around the stud. Joint number 3 is offset by more than this amount (1/8 = 4/32 and 5/32 > 4/32). If the studs do not slide into the holes of the flanges without interference, do not force them! Thread damage may result. When assembling a joint, always make sure that the bolts, gasket and flanges are not forced into place. Damage to any of these components could result in unsealable leaks.

BOLTING PROCEDURES – LUBRICATION

Lubricating the bolt was mentioned earlier as one of the variables that would reduce the K Factor. Actually, just lubricating the bolt is not enough. The lubricant must be the correct one for the bolt material being used. It must also be able to withstand the temperature and pressure to which it will be subjected. A lubricant is not effective if it breaks down or is pushed out from between the threads of the fastener. It must remain between the threads, nut faces and washers to be effective.

TABLE 1

CONDITION OF BOLTS	K FACTOR	REQUIRED TORQUE
New Xylan Coated Bolts with Moly Paste and Hardened Steel Washers	0.095	926
Used Xylan Coated Bolts with Moly Paste and Hardened Steel Washers	0.105	1,027
New Bolts with Moly Paste and Hardened Steel Washers	0.11	1,076
Used Bolts with Moly Paste and Hardened Steel Washers	0.15	1,468
Used Bolts without Lube or Hardened Steel Washers	0.20	1,957

The bolts used to obtain the K Factors in Table 1 are B7, 1-1/2" studs. The lubricant is molybdenum disulfide paste containing at least 70% solids.

Table 1 shows the torque required to obtain 52,500 psi stress for each K Factor. It is easy to see the linear relationship between the K Factor and required torque. As the K Factor increases, so does the torque required to achieve the same amount of stress in the fastener. The amount of torque is drastically increased for the bolts without lubrication (shaded row in Table 1). Compare this with the row just above for lubricated bolts of the same type. Almost 500 ft-lbs. more torque, about 20% more, is necessary to achieve the same bolt load.

01 Jameel Road, Suite 180 • Houston, TX 77040
Toll Free: 866.345.8484 • Phone: 281.449.9994 • Fax: 281.449.9996
Email: sales@TitanTi.com • Web: www.TitanTi.com

TABLE 2

• Allentown, Pa, 18104
Fax Toll Free: • Phone: 484.539.9022 • Toll Free Fax: 866.780.9316
Email: bolting@nibtorque.com • Web: www.NIBTORQUE.com

LUBRICANT	MAXIMUM TEMP. RESISTANCE	SOLIDS COMPOSITION	% SOLIDS	K FACTOR
72	2500"F	Nickel based	72	0-15
70+	750T	Molybdenum disulfide	70	0.11
AG	550T	PTFE (no metals)	72	0.08
Copertorq 30+	I800"F	Cooper based	30	
Dry				0.20

Table 2, lists K Factors for its Lubricants. The bolts are new, Grade 8, 1/2" steel with Grade 5 nuts. Note: K Factors will be different for each application. K Factors are for comparison only.

In this example we will use Titan's numbers as K Factors. The higher the K Factor, the greater the amount of torque that must be applied to achieve the desired preload. Again, it is easy to see the difference between bolts without lubricant (shaded row in Table 2) and bolts with lubricant. Remember from the previous example how a difference in the K Factor as little as 0.05 can make in the required torque. Unfortunately, this only describes torque requirements related to the lubricant in the tightening process. What about disassembly? When joints are torn-down for maintenance, the bolts are usually bone dry. A good lubricant should leave enough residue between the mating surfaces to reduce the time and effort required to disassemble a joint. This residue is important not only at the time of tearing-down the joint but while the joint is still in service. Heat, moisture, vibration and other factors in the bolt's environment can cause damage to the bolt that a good lubricant will minimize. A molybdenum disulfide based lubricant is good for general use. Of course, each application has different requirements. It is essential to know which lubricant is right for each bolted joint.is right for each bolted joint.

• Allentown, Pa, 18104
Fax Toll Free: • Phone: 484.539.9022 • Toll Free Fax: 866.780.9316
Email: bolting@nibtorque.com • Web: www.NIBTORQUE.com

In the sample bolting procedure, item 15 on the Job Data Sheet asks for "Percent of Yield". Yield is the yield strength of the bolt material in this case. The yield strength of a material is the point at which the amount of load causes permanent deformation of the fastener to take place. When a bolt is tightened beyond this point, it is no longer elastic (out of the elastic range).

It will not spring back to its original shape. If it is tightened beyond this point, it will continue to stretch. This is the plastic range. Finally, it reaches its tensile strength and then its rupture point. The bolt will break at this point. In most cases, it is impossible to achieve proper bolt load with bolts that have been over stressed. Therefore, it is very important to pay attention to the yield strength of the bolt.

SPECIFICATION	GRADE	DIAMETER (IN INCHES)	MINIMUM YIELD (IN PSI)
ASTM AI93	B5		80,000
B6		85,000	
B7	< 2-1/2	105,000	
2-1/2 -4	95,000		
> 4 - 7	75,000		
B7M	< 2-1/2	80,000	
B8-CL 1		30,000 - 55,000	
B8-CL 2		50,000- 100,000	
B16	< 2-1/2	105,000	
> 2-1/2 -4	95,000		
> 4 - 7	85,000		

The table above shows the yield strengths of some bolting materials. The example we will use is an ASTM A193, B7, 2" bolt (see shaded area in table).

Bolting materials are not always consistent. Even with new bolts it is difficult to predict the exact point at which permanent deformation will take place. Therefore, specified loads for fasteners are usually well below their yield strengths. Typical applications for percentages of yield for fasteners usually range from 40% to 80%. The recommended percentage of yield is usually around 50%.yield is usually around 50%.

BOLTING PROCEDURES – GASKETS

It is also important to remember that gaskets also have tolerances for tightening. It is possible to be within the elastic range of the bolt and exceed the maximum seating load of the gasket. In order for a gasket to seat properly, it must be compressed. Too little compression could cause the joint to leak. Too much compression could also cause joints

to leak. Gaskets are designed to be pliable to an extent in order to obtain a good seal between the mating surfaces. If the designed capacity is exceeded, by applying too much load to the fasteners, the joint may leak. Gaskets are also designed to be the only material between the flange surfaces.

Using tape or grease to hold the gasket in place when assembling a joint may cause the joint to leak after assembly.

The most comprehensive, well-written bolting procedures are not worth the paper on which they are written if people do not follow them. Make sure the bolting crews are well trained in the procedures and use of the equipment. Good supervision is important. Enlist the help of the people on the crew and let them know that good results are dependent on how well they do their job.

Safety is becoming a more and more important part of everyone's job. Do not sacrifice safety for time when performing bolting work. There is a correct tool for every job. Do not take short-cuts in place of getting the right tool. The time you save taking a short-cut could cost you in injuries. Take the time to think about the work you are doing. Prepare for emergencies, and prevent accidents from happening by planning the safest way to perform your work.

A **gasket** is a mechanical seal that serves to fill the space between two objects, generally to prevent leakage between the two objects while under compression. Gaskets are commonly produced by cutting from sheet materials, such as gasket paper, rubber, silicone, metal, felt, fiberglass, or a plastic polymer. Gaskets for specific applications may contain asbestos. It is usually desirable that the gasket be made from a compressible or slightly compressible material such that it tightly fills the space it is designed for, including any slight irregularities.

One of the more desirable properties of an effective gasket in industrial applications for compressed fiber gasket material is the ability to withstand high compressive loads. Most industrial gasket applications involve bolts exerting compression well into the 14 MPa (2000 psi) range or higher. Generally speaking, there are several truisms that allow for best gasket performance. One of the more tried and tested is: "The more compressive load exerted on the gasket, the longer it will last". There are several ways to measure a gasket material's ability to withstand compressive loading. The "hot compression test" is probably the most accepted of these. Most manufacturers of gasket materials will provide or publish these results.

It is also important to remember that gaskets also have tolerances for tightening. It is possible to be within the elastic range of the bolt and exceed the maximum seating load of the gasket. In order for a gasket to seat properly, it must be compressed. Too little compression could cause the joint to leak. Too much compression could also cause joints to leak. Gaskets are designed to be pliable to an extent in order to obtain a good seal between the mating surfaces. If the designed capacity is exceeded, by applying too much load to the fasteners, the joint may leak. Gaskets are also designed to be the only material

between the flange surfaces. Using tape or grease to hold the gasket in place when assembling a joint may cause the joint to leak after assembly.

Always make sure you know the type and material of the gasket being used in a joint. It is also important to make sure the gasket is the right size for the joint. There are 5 easy steps for measuring a flange for a full face gasket:

1. Measure the O.D.
2. Measure the LD (add 1/8").
3. Measure the Bolt Circle.
4. Measure die Bolt Hole Diameter (the diameter of the bolt + 1/8").
5. Count die number of bolt holes.

To be sure that the desired gasket seating load is obtained, it is necessary to calculate the gasket seating stress. There are also computer software programs available, such as "Boltcalc" (which you can order from NIBTORQUE) which calculate the gasket stress for you.

BREAK-DOWN PROCEDURES

1. Prior to your arrival request that the customer spray penetrating oil on all bolts, unless the temperature of studs is too high. If this cannot be done before hand, spray penetrating oil on all bolts and nuts where they make contact with the flange when you arrive at the job. Make sure the bolts have cooled sufficiently and use a wire brush on the threads extending above the nut.

2. Determine how many studs will be required to hold the seal according to flange size and mark the ones that will stay in the flange.

3. Break loose the bolts which were marked. Clean and lubricate. Reinstall the bolts at a torque value corresponding to 50% of minimum yield to maintain the seal. Start breaking the remaining bolts loose proceeding in a clockwise or counterclockwise direction.

4. Use a ratchet wrench only when a solid reaction point can be achieved or a solid reaction bar is provided.

5. A ratchet wrench should only be used on bolts that have previously been loaded to 50% of yield and proper lubricant has been used.

6. Use a Thinline on all bolts that are expected to gall.

7. If you are using a Thinline, break the bolt loose until it is totally loose. If it starts to gall, mark the bolt with a G and continue to the next bolt.

8. Once you have made a complete pass around the flange, use an impact to remove the bolts that did not gall.

9. Finally, use the proper nut splitter to split the nuts that have galled (marked with a G). An impact wrench, perhaps with an oversized socket, can be used to remove the nut from the bolt once is has been split. If the nut will not come off, split the nut on the flat opposite the first split. The nut will then fall off.

• Allentown, Pa, 18104
Fax Toll Free: • Phone: 484.539.9022 • Toll Free Fax: 866.780.9316
Email: bolting@nibtorque.com • Web: www.NIBTORQUE.com