

Pipe Flange Bolting Guide

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1. Introduction:

In the quest to eliminate leaks in piping and pressure vessel systems, it is necessary to first develop an understanding of the mechanisms that cause leaks, the behavior of the joints where leaks occur, and most importantly, the proper use of the devices that are traditionally employed to prevent leaks in gaskets. Essential to such understanding is the realization of several fundamental facts:

- A. Many different factors contribute to leaks and all must be controlled to some extent in order to achieve reliable closure of a pressurized system. In analyzing leaks, it is all too common to look for a single cause when, in fact there are almost always several mechanisms at work contributing to a leak source.
- B. Joints in pressurized equipment, especially those with resilient gasketing, are highly dynamic and variable systems, constantly moving and changing in response to the conditions around them. These changes come both from within the processes they contain and from the environment around the joints. A seemingly unrelated summer rain shower can drastically affect the integrity of a hot flange exposed to the cooling train. Predicting and allowing for these changeable conditions is often the difference between tight and leaking joints.
- C. Within all the multitude of options available in flange designs, gasket types and sealing materials, there is no perfect choice for any given application. Furthermore, there is no such thing as perfect, or 100% leak free joint. Even the “zero leakage” criteria we attempt to achieve only implies that we are within the limits we consider acceptable – on a molecular basis, there will always be some amount of leakage at a gasket joint! Success in controlling leaks comes only from fully recognizing the capability of each option, choosing the best combination, then - and most important – assembling the joint in a manner that enables each of the chosen options to do its job effectively. The criteria for success will be when leakage is within acceptable limits. All too often, a premium price is paid for a sophisticated gasket, then the benefits lost due to improper installation.

This then, is the purpose of this handbook, to give you, the plant builder, owner, operator, or maintenance mechanic a better understanding of what makes a good piping or pressure vessel flange joint succeed or fail, and to provide your step-by-step Guidelines for assembling flange joints.

2. General Safety Notes:

The following notes apply to general safe joint assembly and bolting practices. They can only be considered as guidelines, since it is still essential that the operator remain alert for potential hazards and conduct the field operations in a manner that will prevent injury of personnel, or damage to equipment. Where specific precautions are advised with the relation to individual items of equipment, such safety notes are included in the text:

- A. Proper Eye protection must be worn when operating hydraulic or pneumatic bolting equipment.
- B. It is recommended that gloves be worn when operating or handling hydraulic equipment. Special precautions must be taken to avoid placing hands or fingers in pinch points, especially around the torque arms of the wrenches and its reaction points.
- C. Before operating any hydraulic bolting equipment, verify the maximum operating pressure for each equipment item and do not exceed the specified maximum levels in operation. Typical max. pressures are:

Torque Wrenches	10,000 PSIG
Tensioners	21,750 PSIG
- D. Do not handle hydraulic tools by their hoses or hydraulic Connections.
- E. Always remain alert to the positions and avoid standing in the line of any component that would become a projectile if a part were to break.
- F. Avoid kinking or running equipment over hoses to prevent damage. Inspect spray shields regularly and insure they are in place and in good condition before operating equipment.
- G. Tensioning: Do not exceed the maximum allowable stroke of the Hydraulic rams. Always insure that the rams are fully returned to the retracted position prior to pressurizing. Observe ram position often while pressurizing.
- H. Verify that all quick connect coupling are connected and fully engaged before pressurizing.

3. Gasket Placement:

Regardless of gasket type, it is essential that the sealing or mating surface of the gasket and flange have full contact throughout the installation process, that the gasket is not wrinkled, warped, or cut as it is being compressed, and that in the case of spiral-wound or fabricated gaskets, the integrity of the structure is maintained. (IE: windings are intact, filler is properly positioned, etc.) To assure these conditions, the following steps should be taken:

Check that the gasket has been stored in a manner that prevents creases or excessive warp. Large spiral-wound or fabricated gaskets often require a support frame to insure against damage to the windings.

- A. Check that during both storage and handling, the sealing surfaces of the gasket are not damaged and are free of debris or surface contamination.
Note: Handling a gasket with sweaty hands can leave chloride deposits on the sealing surfaces, sufficient to cause damage in a system that is susceptible to stress-corrosion cracking.

Verify that the gasket materials are as specified. Gaskets are Often color-coded for identification of materials. A description of the codes is available from the manufacturer. Check gasket dimensions to insure they conform to the flange configuration.

Holding the gasket in place during the flanges joint assembly Can be a tricky problem. On flanges that are in a horizontal plane, the job is simplified since the gasket will normally stay in place once it has been properly positioned on the lower of the two flanges. Again it is essential that the gasket lay flat and free of wrinkles, warps, cuts, etc.

- B. Insure that the gasket is adequately supported during placement, to avoid twists or bends that will crease the surface or break the gasket structure. On large spiral-wound gaskets this may require a special framework that is placed under the gasket, then removed once the gasket is in position.
- G. Provide some means of holding the gasket in-place during the positioning of the flanges. This task has undoubtedly generated more creative gimmicks than any other facet of pipefitting; however, some are better than others. The real trick is to avoid anything that works against the sealing mechanisms of the gasket so:
 - (1) Do not tape the gasket in place in such a way that the tape runs across the sealing surface. This leaves potential leak paths across the gasket face.
 - (2) Do not glue or stick the gasket in place with a material that will contaminate the sealing surfaces once the gasket is put into operation.
 - (3) Do not assume that the gasket, put in place before the flange is positioned, will automatically stay in position.

H. No single approach will serve all applications in this area; However, there are a few techniques you might consider – keeping in mind the precautions already cited:

- (1) Secure the gasket in-place by a series of strings taped across the gasket face with masking tape holding the ends of the strings inside and outside the gasket (IE: no tape is applied to the gasket itself). Once the flanges are brought into position, but not yet tightened down, the strings can be pulled out, leaving the tape behind but not across the flange sealing surfaces.

Note: Since part of the tape is left in contact with the process, it is essential that you consider whether this potential contamination is a problem or not!!

- (2) Wooden shim or wedges withdrawn gradually as the flanges come together are often effective.

- (3) If greases or adhesives are attempted it is important that they be chosen such that:

- a. The material will completely vaporize or “coke-off” at Operating temperature.
- b. The residue left behind is not deleterious to either The process or the joint flange and gasket materials.

Note: Materials that completely coke are often a good choice since the carbon residue can be an effective seal material.

- (4) Sufficient bolting load must be applied to insure that the material volatilized does not leave gaps and that any residue behind is sufficiently contained in the gasket structure.

4. Positioning the Flanges:

The most important principle to remember in this step is to assure that:

- A. Contact of the flange and gasket surfaces is controlled to avoid damage to the gasket.

The faces of the flanges are brought together evenly, to allow for uniform distribution of load on the gasket compression loads are applied.

- B. Extraneous loads on the flanges—due to piping misalignment or improper adjustment of hangers and supports – have been eliminated.

- C. To help reduce the effect of the above, the following steps should be taken:

- (1) Use alignment or drift pins in at least two bolt holes to insure proper alignment and concentricity of the flanges as they are being drawn together.

- (2) Use a mechanical or hydraulic draw-down device to gradually pull the flanges together in a controlled manner. Ramming flanges – a practice often used in assembling heat exchanger bundles – is a common cause of damage to the gaskets. Hydraulic flange pullers allow for the flanges to be gradually drawn together, but with sufficient force to handle tube bundle insertion, etc. These devices are available for sale or rent in industrial areas.
- (3) For ring reinforced, spiral wound or fabricated gaskets, and for metal o-ring type joints, the position of the gasket must be observed as the flanges come together to insure the gaskets are properly seated and concentric with the flanges. If the gasket slips out of position with these types, severe cutting of the gasket and misalignment of the flanges can occur, leading to almost certain leakage.
- (4) Once the flanges are within approximately 1/8" of contact check the space between the flanges at 90 degrees quadrant points to insure the gap is uniform. Continue monitoring this gap and adjust any misalignment until the bolt loading procedure is complete.
- (5) For spiral-wound gaskets supplied by the major manufacturers, the solid metal reinforcing ring (either I.D. or O.D.) also serves as a compression stop gauge ring, limiting the compression of the windings to the amount necessary to sufficiently retain the gasket and compensate for external loads. Any gap left between the flange faces and the gauge ring may gradually be considered as an indication of the sealing component of the gasket.

5. Bolt Preloading:

Two principles are to be followed during the bolt tightening

Procedure:

- A. Load is to be applied gradually and evenly across the flange to insure even-down and uniform compression of the gasket.

- B. Sufficient residual preload is to be left in the bolts at the completion of the bolting procedure, to satisfy the seating stress and retention force requirements of the gasket, with enough extra load to compensate for changes in the temperature, pressure and other external loads to which the joint will be subjected.

The Standard Pressure Vessel and Piping Codes specify the requisite methods for calculating the required preload of flange bolts. Tightening to the “Minimum Allowable Design Stress” is seldom sufficient. It is essential that the characteristics of the gasket be taken into account, as specified in the Code, and that allowance for hydro testing and operating conditions be made as addressed in appendix “S” of the Code.

Before beginning the tightening process, the following preliminary steps will avoid future problems:

- (1) Visually inspect all bolts and nuts for damaged or corroded threads. Replace or repair bolts or nuts as necessary.
- (2) Verify the specified bolt load according to the control method being used. (torque, elongation, stress measurement, etc.)
- (3) Number the bolt holes in sequence, starting from the top (or plant north on horizontal flanges) and progressing in order clockwise around the flange.
- (4) Lubricate the threads of the bolt or stud, and the surface of the nut face adjacent to the flange or washer.
- (5) Hardened washers are recommended in most applications. They provide a landing or bearing surface for the nut, which is relatively resistant to gouging or galling, thus compensating for bending or misalignment of the bolt. They also spread the load of the nut. Where uneven flange surfaces are unavoidable, or when significant bending of the bolts is anticipated, the use of spherical washers is recommended.
- (6) Adjust the position of the nuts to insure that a full portion of the threads is visible above the top of the nut:
 - a. 2-3 threads if torque methods are used
 - b. One full diameter of threads if tensioning
- (7) Establish a star pattern or cross bolting pattern that will alternate sides of the flange as load is applied. Follow the sequence of numbers according to the pattern chosen.

Torque Procedure For Piping Flanges

SCOPE

This document defines general requirements for assembly of flanged joints in piping systems where controlled tightening of stud bolts using torque measurement is mandated.

PROCEDURE

1. Flange faces must be parallel within 1/16" per foot of diameter, and flange bolt holes must be aligned to within 1/8" maximum offset. (NOTE: These limits of misalignment apply to properly supported, unconstrained piping. Pulling flanges into temporary alignment for the purpose of assembly, by use of com-a-longs, etc., is not permitted)
2. Flange faces shall be clean and free of defects (burrs, pits, dents, etc.). Gaskets shall be in new, undamaged condition. ONLY SPIRAL WOUND GASKETS are to be used.
3. Before installation, stud bolts and nuts shall be clean and free of defects (burrs, worn or damaged threads, bends, etc.). Inspect nut seating area for gouging, etc.
4. Information on number and size of stud bolts, torque values, and suitable thread/nut lubricant is to be obtained from the applicable Flange Torque Table by flange rating class and stud bolt material.
5. Stud Bolt threads (over complete length of bolt) and nut bearing faces shall be coated liberally with the specified lubricant compound. (See Flange Torque Table)
6. Two bolts shall be installed diametrically opposite each other, and one bolt halfway between the previously installed bolts (on the underside in horizontal lines) for retaining the gasket. The nuts shall then be engaged.
7. The gasket shall be inserted and centered between the flanges. Nuts shall be hand-tightened to hold the gasket in place.
8. The remaining bolts and nuts shall be installed and hand-tightened with the flange faces parallel. Care shall be taken to assure proper seating and centering of the gasket. Nuts shall be positioned on the stud bolts such that all nut threads are fully engaged when assembly is complete.

Torque Procedure For Piping Flanges

9. The bolts (or the flange) shall be numbered with the cross bolting pattern sequence to be used.
10. The bolts shall then be tightened (torqued) to the First Torque Table, using the cross-bolting sequence marked on the flange or Bolts. This sequence shall be repeated as necessary at this torque level until all the nuts cease to move when the torque is applied.
11. The bolts shall then be tightened to the Second Torque Level, using the same cross-bolting sequence. The sequence shall be repeated until the nuts cease to move when the torque is applied.
12. The bolts 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 the torque is applied.
13. 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.
14. Full torque shall then be applied to all the nuts in reverse rotational order. This shall be continued until all the nuts cease to move when the torque is applied.