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ECITB MJI Training

Petracarbon (Thailand) Co., Ltd is a hi-tech company with their primary goal to promote advanced repair & maintenance techniologies for oil & gas, chemical, petrochemical, oil refining industries in Thailand and in neighbouring countries.

Beside the usual services, we are also an approved training provider from ECITB (Engineering Construction Industry Training Board) for delivering the Mechanical Joint Integrity (MJI) training courses, that is in line with industry standards and practices.

This ECITB MJI course which focus on skills in perfoming various techniques using range of bolting tools, which enable delegates to learn isolation, dismantling, alignment and tightening techniques on various type of flanges, as well as inspection of components as per industry requirements.

- MJI10: Hand Torque Bolted Connection
- MJI18: Hydraulically Tensioned Bolted Connections
- MJI19: Hydraulically Torqued Bolted Connection

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ASME PCC-1 Bolt Tightening Sequence/Pattern (Appendix F)

Flange joints require proper tightening to avoid the leak of the fluid from the joint. Bolt tightening sequence or torque sequence is defined in the torque tightening procedure. Most company has their flange bolt torque tightening procedure that used during construction and operation of the plant.

Flange stud torque sequence is extremely important to achieve the proper tightening of the flange joint. In this detailed article which illustrate the correct torque sequence base on ASME PCC-1 so that you can achieve the desired result without damaging the flange and studs.

Not all bolt tightening sequences are created equally. Bolt flange joint assemblers have been using the “Star Pattern” since 1938, developed by Taylor Forge. This sequence has been used for pipe flanges on both ASME B6.5 and ASME B16.47 flanges, heat exchangers and many other applications. “Star Pattern” applied to all types of gasket materials and flange types, including Raised Face (RF), Ring Type Joint (RTJ), Double-Jacketed, Spiral Wound Gaskets, as well as Kammprofile gasket. This is necessary to counter the elastic interaction (or bolt cross-talk) that occurs when tightening the bolts.

Though the “Star Pattern” is the most common sequence, it is certainly not the only nor necessarily the best bolting pattern when torqueing a bolted flange connection.

In fact, there is no one type of bolt tightening sequence ideal for torqueing every type of flange. The gasket type and arrangement of the flange connection are both critical in choosing which tightening sequence an assembler can deploy for achieving the desired final torque values with minimum bolt scatter and ensuring the gasket is not damaged in the process.

Bolt Tightening sequences in ASME PCC-1

In the 2019 edition, ASME PCC-1 Section 11 Tightening Sequence and Appendix F dedicated this “Star Pattern” (also labled the “Lagacy Pattern”) and several other options (“Alternative Pattern”). These alternative bolting sequences were included to demonstrate more efficient ways to assemble flange connection. Like the “Star Pattern” the alternative approaches could be used just about any tightening method from hydraulic to pneumatic to manual torqueing.

“Star Pattern” (Lagacy Pattern)

Once all pre-checks are completed. The assembler can go ahead with tightening the stud in the pre-define torque sequence mentioned here. Torque bolts and nuts in a “Star Pattern” sequence using a minimum of three torquing passes and the maximum bolt stress as defined.

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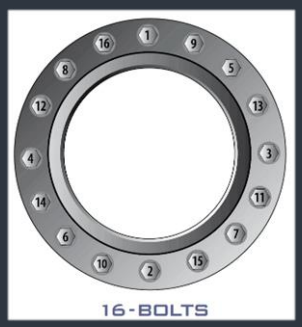
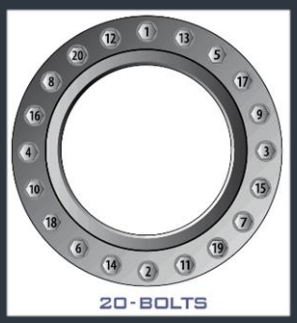
Bolt numbering pattern for single tool usage





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- PASS 1: Torque to 20 to 30% of the final torque value in accordance with the torque sequence. Check that gasket is getting compressed uniformly.
- PASS 2: Torque to a 50 to 70% of the final torque value.
- PASS 3: Torque to the final torque value (100%).

After the three basic torque passes are completed, repeat torquing the nuts using the final torque value (100%) apply in a circular passes. Typically go around the flange twice at this final torque value until no further nut movement is observed. Normally, with spiral wound gaskets or Kammprofile gaskets, this take about two circular passes, but with RTJ gaskets, probably need to perform additional passes.

The drawback to “Star Pattern” is not efficient as the alternative method and can be very time consuming when assembler is working on flanges with 20 or more bolts. But for flange size 12” or smaller, one may stick with the “Star Pattern” to avoid confusion.

Modified Star Pattern

PCC-1 refers to the Modified Star as “Alternative Assembly Pattern #1” and this bolt tightening sequence follows the same tightening pattern as the Star. The different is the preload / stress levels on the fasteners are increased more rapidly with this approach. Allowing fewer pattern passes to be performed and less overall effort. This method has been successfully applied in limited applications across the full range of gaskets and joint configurations.

- PASS 1A: Torque to 20 to 30% of the final torque value for first four bolts in star pattern.
- PASS 1B: Torque to 50 to 70% of the final torque value for next four bolts in star pattern.
- PASS 1C and PASS 2: Tighten the rest of the bolts in star pattern at final torque value (100%).
- PASS 3: Tighten in circular passes until the nuts no longer turn.

ASME PCC-1 states that soft gaskets, a minimum of two pattern Passes are required. For hard gaskets, a minimum of one Pattern Pass is required. This mean that spiral wound and double jacketed gaskets must have a full star pattern completed. However, Kammprofile gaskets do not need PASS 2. The final series of passes are rotational passes, where it need to tighten around the flange in circular direction at final torque value until there is no nut movement. Normally, with spiral wound gaskets and Kammprofile gaskets, it takes two circular passes. RTJ gaskets may require additional passes.

Thus, this modified star pattern is much more time efficient than the convention method and is good for all ASME B16.5 and B16.47A/B and heat exchanger flanges where bolt quantity is more than 20 and cover all flange face and gasket types. It can be helpful on some 16-bolts flanges, especially if they involve large size stud, say 1” diameter or greater.

Petracarbon is an ECITB MJI approved training provider for courses on tightening techniques in specialist critical bolting applications.

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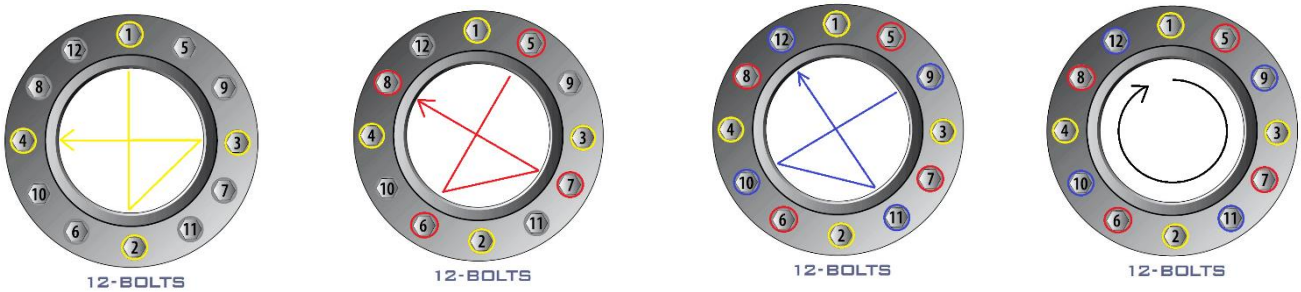
Modified Star Pattern for 12-Bolt Flange



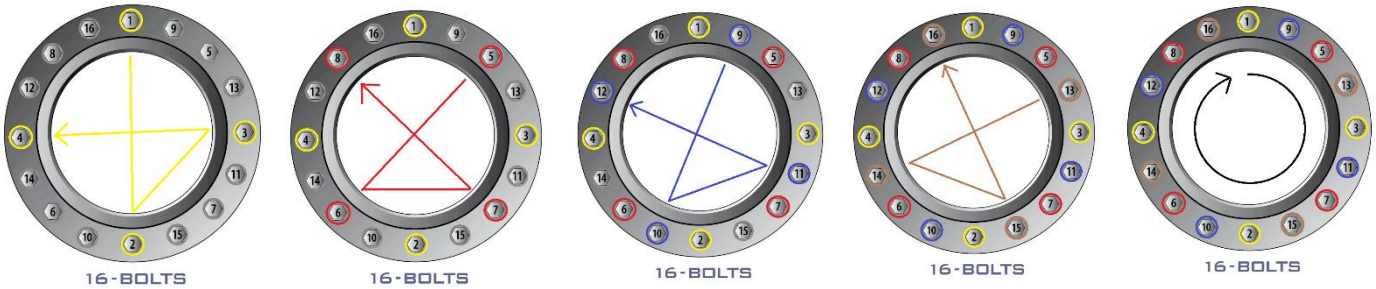
- Bolt 1 to Bolt 4 (Star Pattern)
- Torque value = 20 to 30% of final torque

- Bolt 5 to Bolt 8 (Star Pattern)
- Torque value = 50 to 70% of final torque

- Bolt 9 to Bolt 12 (Star Pattern)
- Torque value = 100% of final torque

- Bolt 1 to 12 (Circular Pattern) X 2
- Torque value = 100% of final torque

Modified Star Pattern for 16-Bolt Flange



- Bolt 1 to Bolt 4 (Star Pattern)
- Torque value = 20 to 30% of final torque

- Bolt 5 to Bolt 8 (Star Pattern)
- Torque value = 50 to 70% of final torque

- Bolt 9 to Bolt 12 (Star Pattern)
- Torque value = 100% of final torque

- Bolt 13 to Bolt 16 (Star Pattern)
- Torque value = 100% of final torque

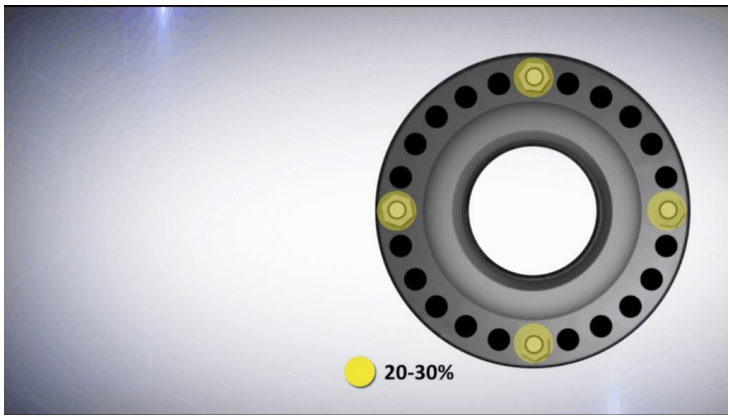
- Bolt 1 to 16 (Circular Pattern) X 2
- Torque value = 100% of final torque

Quadrant Pattern

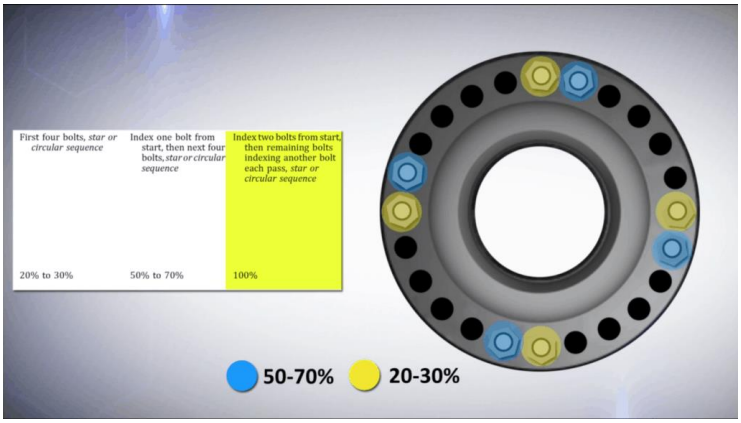
PCC-1 refers to the as "Alternative Assembly Pattern #2" or Quadrant Pattern. It is more efficient than both the Star Pattern and Modified Star Pattern. With the Quadrant Pattern, fastener preload levels increase rapidly within the first tightening sequence.

Assembler don't have to "criss-cross" the flange as much, which saves even more time. An added bonus is that experienced assemblers won't need to number the flange when they are applying this pattern — so long as they were trained well. This method has been successfully applied in limited applications across the full range of gaskets and joint configurations commonly found in the refining industry.

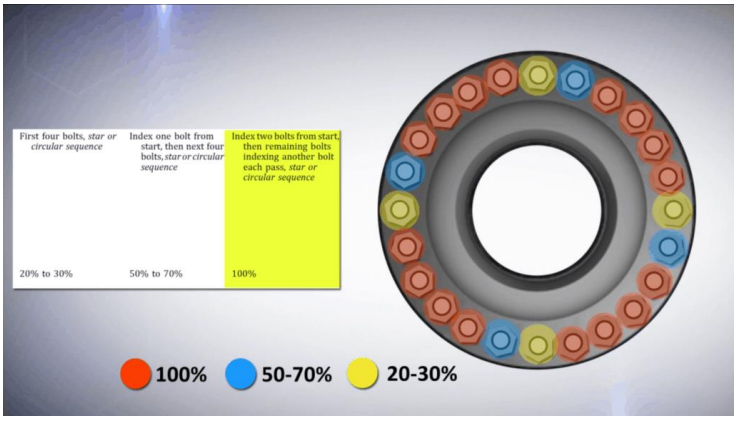
The diagram below shows how the torque wrench moves only one bolt over after the assembler have made the first "Star or Circular sequence." The assembler also increase the bolt load settings after tightening the first four bolts. Then continue to index to the next bolt from the start. And continue the next indexing. Finally, perform a circular sequence until no further nut movement.



- First four bolts (Star or Circular Pattern)
- Torque value = 20 to 30% of final torque



- Index one bolt from the start and next 4 bolts (Star or Circular Pattern)
- Torque value = 50 to 70% of final torque



- Index two bolts from the start and then remaining bolts indexing another both each pass (Star or Circular Pattern)
- Torque value = 100% of final torque

- All bolts (Star or Circular Pattern) X 2
- Torque value = 100% of final torque