

Engineering Procedure

SAEP-351

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Bolted Flange Joints Assembly

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1 Scope

- 1.1 This procedure defines minimum requirements to assemble pressure containing bolted flanged joints including bolt tightening. It is applicable for both new and existing facilities.
- 1.2 This procedure is applicable to all pressure piping systems in conjunction with piping systems defined per [SAES-L-100](#).

2 References

2.1 Saudi Aramco References

Saudi Aramco Engineering Standards

SAES-L-100	<i>Applicable Codes & Standards for Pressure Piping Systems</i>
SAES-L-109	<i>Selection of Pipe Flanges, Bolts and Gaskets</i>
SAES-L-350	<i>Construction of Plant Piping</i>

2.2 Industry Codes and Standards

American Petroleum Institute

API BULL 5A2

*Bulletin on Thread Compounds for Casing,
Tubing, and Line Pipe*

American Society of Mechanical Engineers

ASME B16.5

*Pipe Flanges and Flanged Fittings NPS ½
Through NPS 24*

ASME B16.47

*Large Diameter Steel Flanges NPS 26 Through
NPS 60*

ASME B31.3

Process Piping

ASME PCC-1

*Guidelines for Pressure Boundary Bolted Flange
Joint Assembly*

3 Responsibilities

- 3.1 For existing facilities the following shall apply:
 - 3.1.1 It is the responsibility of Operations Superintendent to ensure that this procedure is adhered to during the maintenance activities within the facilities under his jurisdiction.
 - 3.1.2 The maintenance personnel executing the flange assembly activities must be aware of this procedure and have the proper training to conduct the work.
- 3.2 For new capital program projects the following shall apply:
 - 3.2.1 The Project Manager is responsible for ensuring that the Construction Contractor is following this procedure or a pre-approved procedure as outlined in [SAES-L-350](#).
 - 3.2.2 The contractor personnel executing the flange assembly shall be aware of the importance of adhering to proper flange assembly. They shall have proper training and skills to conduct the job.
- 3.3 ASME PCC-1 has been referenced to be used as a document for more guidance.

4 Pre-Assembly Inspection

- 4.1 The gasket shall be verified for correct type, rating, dimension and compatibility with the flange facing. Also, it shall be free from any damage particularly in the seating element. Ensure that spiral wound gaskets are stored flat especially for large sizes, 24 inches and larger.

4.2 Bolts, nuts and washers shall be visually checked for proper size, grade, dimension and for any physical damage to shanks or threads which would affect the bolt assembly or performance. Also, check the suitability of the stud bolts and nuts material for the service temperature and the compatibility with the flange material.

4.3 The flange facing, particularly the seating area, shall be visually examined for cleanliness and ensure that no damage, such as scratches exist.

For ring joint type flanges, the ring and the ring groove shall be free of damage and dirt.

4.4 Verify that proper lubricant is used. Lubricant for bolts and nuts shall be Jet-Lube SS-30 or other acceptable lubricants listed in Table-SAEP-351-01.

4.5 Tightening tools shall be checked for adequacy, performance and calibration, if required.

4.6 Verify that lubricant is not used on the gasket seating area.

4.7 Verify that flange shielding is installed if required.

Commentary Note:

Flange shielding is normally used for personnel protection against possible liquid splash or high temperature.

5 Torquing

5.1 Torque values vary according to flange rating, bolt size, type of gasket, and friction factor of the thread lubricant.

5.2 The torque values are specified in Table-SAEP-351-02 and Table-SAEP-351-03.

5.3 Table-SAEP-351-02 applies to all gaskets listed in [SAES-L-109](#), except for insulating gaskets, based on a friction factor of 0.12, using graphite and oil.

5.4 Table-SAEP-351-03 applies to isolating gaskets (e.g., PIKOTEK), based on a friction factor of 0.125.

6 Torquing Tools

6.1 There are various types of tools available to achieve the proper torque value. Selection of the proper tool depends on the stud bolt size, physical location of the flanged joint, and criticality of the flange. Identifying the proper tools shall be resolved between Contractor, SAPMT, Proponent and Inspection prior to commencing the erection of the piping.

- 6.2 The manufacturer's instructions shall be followed for the operation, limitation and maintenance of all torque wrenches used to perform flange bolts tightening.
- 6.3 Torque wrench calibration shall be performed in accordance with manufacturer's recommendations, or as required by the inspector after consultation with Piping Specialist in Consulting Services Department.

7 Stud Bolt Tightening Procedure

- Step 1 Align flanges and gasket. Forced tightening is not allowed to overcome non acceptable alignment tolerances. Clamp securely in place.
- Step 2 Apply lubricant to stud threads over length and nut engagement and to face of nut which contacts flange. Ensure that the nuts run freely down the thread of the studs.
- Step 3 Install all studs and nuts hand tight, ensure that studs pass freely through the flange holes. Position the nut on one end of the stud such that only the crown of the stud projects beyond the face of the nut. The excess stud length should project beyond the nut on the other side.

Commentary Note:

By doing this, the nut that is installed nearly flush with the end of the stud can be easily removed since the threads are not coated, and normally have not been subjected to corrosion. The side of the stud with the flush nut should be chosen by taking into consideration factors such as whether one side has better access for maintenance personnel and/or tightening tools, e.g., torque wrench or impact wrench, etc.

- Step 4 Number each stud according to its position in the flange as shown on Figure 1: Stud Bolt Tightening Sequence.
- Step 5 Tighten studs per the Stud Bolt Tightening Sequence per Figure SAEP-351-01 with an appropriate tool such as an air impact wrench or equal.
- Step 6 For joints containing RTJ or Spiral Wound Gaskets, repeat step 5.
- Step 7 Tighten the stud bolts in stages to obtain the final required torque from the appropriate torque Table-SAEP-351. The first stage should not be more than 30% of the final torque. The final torque shall be within $\pm 5\%$ of the required torque value.

Apply the torque evenly to each stud following the stud bolt tightening sequence. The final torque must be within $\pm 5\%$ of the required values per Section 5 above.

8 Stud Bolt Additional Tightening Procedure where Leaks Occur During Pressure Testing

- Step 1 Depressurize the piping system and re-torque stud bolts to maximum torque value shown on Table-SAEP-351.
- Step 2 If leak does not stop after re-torquing has been performed, disassemble the flange joint and inspect as follows:
- a. Inspect stud bolts and nuts for defects or damage to threads or improper cleaning of threads.
 - b. Inspect flange faces for damage, misalignment.
 - c. Inspect gasket for damage or defects.
- Step 3 After all defective and damaged items have been repaired or replaced, reassemble the flange joint using a new gasket and tighten the bolts using the maximum torque values.

30 April, 2003 **Summary Revision**
New Saudi Aramco Engineering Procedure.

Table-SAEP-351-01 – Friction Factors for Different Lubricants

Lubricants	Friction Factors	Torque Correction Factor
Moly Graphite	.06	0.67
Tool Joint Compound	.08	0.8
Graphite and Oil (used as the base line for torque values in Table-SAEP-351-02)	.10	1.0
Aerocote #4	.11	1.1
KOPR-KOTE	.11	1.1
EL-PRO C5A	.11	1.1
FEL-PRO C100	.11	1.1
FEL-PRO C102 (commonly called Anti-Seize)	.11	1.1
Jet Lube SS-30	.12	1.2
API BULL 5A2 Thread Compound	.125	1.3
Light Machine Oil as shipped	.15	1.5
Dry Bolts	.2	2

**Table-SAEP-351-02 – Torque Value for A193 B7
and B7M Stud Bolts with A194 2H and 2HM Nuts**

Stud Bolt Size inch	Torque Minimum Ft-Lb	Torque Maximum Ft-Lb
1/2	30	34
9/16	43	49
5/8	60	68
3/4	107	120
7/8	170	190
1	256	287
1-1/8	374	420
1-1/4	524	590
1-3/8	709	798
1-1/2	934	1051
1-5/8	1201	1351
1-3/4	1515	1704
1-7/8	1879	2113
2	2296	2583
2-1/4	3311	3724
2-1/2	4151	5155
2-3/4	6150	6918
3	8033	9037
3-1/4	10,253	11,545
3-1/2	12,872	14,481
3-3/4	15,901	17,888
4	19,356	21,775

Notes:

- 1) Torque values based on 0.10 Average Friction Factor and 30,000 psi prestress on stud bolts. A combination of various elements such as the conditions of the threads, the condition of the flange to the nut bearing surface and the type of lubricant used, makes up the friction factor which can vary from .04 to .20 or as much as 500%.
- 2) Torque values for stainless steel or other alloy stud bolts can be obtained by multiplying the ratio of the specified minimum yield strength (SMYS) of stainless steel stud bolts to A193 B7 stud bolts, to the torque values in the Table-SAEP-351. The SMYS values for all bolting materials are listed in Table-SAEP-351-02 of ASME B31.3 code (Note: SMYS depends on grade, class and size).

**Table-SAEP-351-03 – Torque Values for Isolating Gaskets (PIKOTEK)
on ASME B16.5 and ASME B16.47 Series A & B,
Class 150 through Class 2500 Flanges**

Stud Bolt Size inch	Torque Minimum Ft-Lb
1/2	30
5/8	60
3/4	100
7/8	160
1	245
1-1/8	355
1-1/4	500
1-3/8	680
1-1/2	800
1-5/8	1100
1-3/4	1500
1-7/8	2000
2	2200
2-1/4	3180
2-1/2	4400

Note: Torque values based on 30,000 psi tension load and 0.125 Friction Factor from API BULL 5A2 thread compound. See Table-SAEP-351-02 Note (1) for other factors.

Commentary Notes:

- a) *For ASME Class 900 through Class 2500, API-6B and API-6BX Class 2000 through Class 15000, and RTJ Flanges, the maximum compressive stresses induced during installation should not exceed 25,000 psi. Design to 12,500 psi when possible.*
- b) *Calculations for compressive stresses applied during torque-up procedures must account for ring joint grooves, gasket seal grooves, raised face diameters, and gasket inside diameter. (See PIKOTEK Gasket User's manual).*
- c) *Bolt tensioning equipment such as HYDRATIGHT may be used for class 900 and above resulting in a minimum residual bolt stress of 30000 psi and a maximum of 50,000 psi. Refer to PIKOTEK Gasket User's manual for specific bolting instructions.*

Figure SAEP-351-01 – Stud Bolt Tightening Sequence

