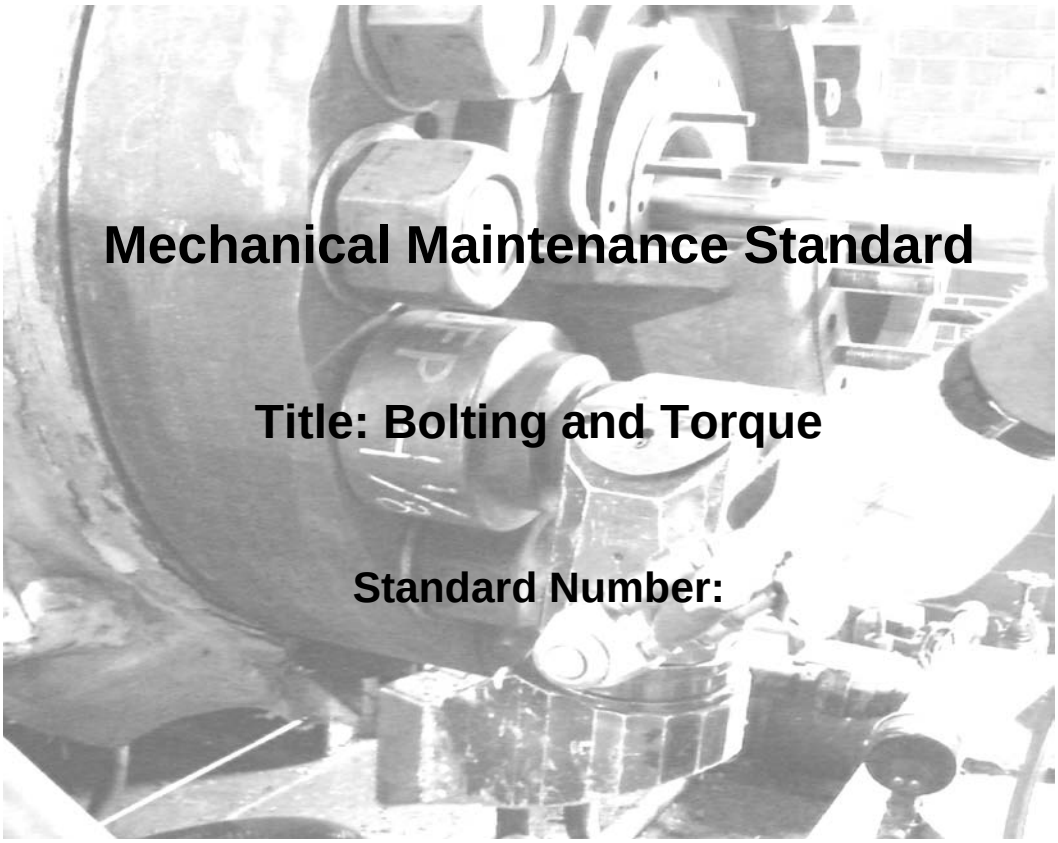

Mechanical Maintenance Standard

Title: Bolting and Torque

Standard Number:

Written By:			
	Print Name	*Signature*	*Date*
Reviewed By:			
Maintenance Supervisor			
	Print Name	*Signature*	*Date*
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Approved By:			
Maintenance Manager			
	Print Name	*Signature*	*Date*

Effective Date: _____

Next Review Date: _____

Table of Contents

1.0 PURPOSE

1.1. The purpose of this standard is to provide guidance and requirements for the tightening/preloading of fasteners and/or joint assemblies at ……

2.0 REFERENCES

2.1. Marks' Standard Handbook for Mechanical Engineers, 8th Edition

2.2. ASTM A574 90, Standard Specification for Alloy Steel Socket-Head Cap Screws

2.3. AISC S326-78, Supplement No. 1, 3-11-86; Specification for the Design, Fabrication and Erection of Structural Steel for Buildings

2.4. 5AISC Specification for Structural Joints Using ASTM A325 or A490 Bolts

2.5. Flexitallic Spiral-Wound Gaskets, General Catalog, Flexitallic Gasket Company Inc.

2.6. EPRI, Good Bolting Practices

2.7. Snap-On Torque Wrenches, Instructions

2.8. HyTorc Flanged Joint Preparation Procedure

2.9. HyTorc XLT Operational Manual

3.0 DEFINITIONS AND ACRONYMS

3.1. Definitions

3.1.1. *Snug-Tight* - tightness that exists when all plies in a joint are in firm contact. This may be attained by a few impacts of an impact wrench or the full effort of a person using an ordinary wrench.

3.1.2. *Soft Gasket* - a gasket which can be extruded under light loads, such as with strong finger pressure or low clamping loads. Examples: Gaskets made from cork and/or elastomeric compounds (rubber-like).

3.1.3. *Hard Gasket* - a gasket which will not extrude under light load, such as strong finger pressure or low clamping loads. [Examples: Gaskets made from compressed sheet materials, etc.]

3.1.4. *Spiral Wound Gasket* (i.e., Flex type) - a gasket with metal winding and graphite filler with a carbon steel outer ring.

3.1.5. *Grip Length* - the total thickness of parts to be fasten together (e.g., from underside of the head/nut to underside of the nut).

3.1.6. *Proper Closure* - the joint of interest will not slip or separate under all of the operating conditions of the equipment. If loading conditions of the joint are not known contact Maintenance Planning or Engineering.

3.1.7. *Critical Joint* - a joint that if it was to fail would affect the function or structural integrity of an important to safety component. A design torque value should be obtained from the vendor documents or as recommended by Engineering.

3.1.8. *Preload* - tension in the fastener when it is tightened against a joint.

3.2. Acronyms

3.2.1. AISC - American Institute of Steel Construction

3.2.2. ASTM - American Society for Testing and Materials

3.2.3. SAE - Society of Automotive Engineers

3.2.4. ASME - American Society for Mechanical Engineers

3.2.5. UNC/F - Unified National Course/Fine

3.2.6. NC/F - National Course/Fine

3.2.7. IV - Independent Verification

3.2.8. IE – Industry Event

4.0 PRECAUTIONS AND LIMITATIONS

4.1. This standard applies only when torque values for tightening/preloading of fasteners and joint assemblies are **NOT** specified by vendor, design drawings or specifications.

4.2. This standard does **NOT** apply to the following applications:

4.2.1. Hilti Kwik-Bolts or equipment anchor bolts.

4.2.2. Valve packing adjustment.

4.3. This standard is **NOT** applicable when an approved maintenance work order or procedure directs torquing; however, the general guidelines should be used (i.e., when extensions increase effective torque wrench length).

4.4. **IF** the instructions in this standard cannot be performed as written,
THEN stop work and notify Supervision.

4.5. **IF** abnormal conditions are encountered while following this standard,
THEN stop work, inform personnel in the area that may be affected, and notify Supervision.

4.6. Incorporate the STAR self-checking technique before and immediately after performing a task:

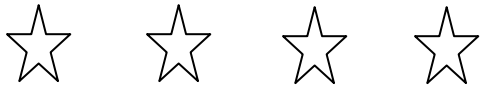
4.6.1. **STOP** - Pause before performing a task to enhance attention to detail. This is the most important step of any self-checking technique. The simple act of stopping increases the likelihood of performing the task correctly. Attempt to eliminate current or potential distractions.

4.6.2. **THINK** - Understand specifically what is to be done before working on any component. Identify the correct component, train, unit, etc., before taking any action.

4.6.3. **ACT** - Perform the intended action

4.6.4. **REVIEW** - Verify that the actual response is the expected response. If an unexpected response is obtained, take action as previously determined.

4.7. **NOTE**, **CAUTION**, **WARNING**, and **CRITICAL STEP** boxes may be used throughout this procedure to provide information that must be considered prior to the performance of a step, or series of steps.



5.0 LESSONS LEARNED FROM INDUSTRY EVENTS (IE)

5.1. Mechanical Seal Failure

5.2. Fatal Injury

6.0 GUIDELINES FOR BOLTING AND TORQUE

6.1. Bolt Tension

For components to work as the engineer intended mating pieces must be held together with a precise amount of clamping force, which is determined by the amount of "tension" created in bolts as they're tightened. Tension is a force trying to stretch the bolt, and clamping force is proportional to tension, but working in the opposite direction. Using enough properly sized bolts yields the needed clamping force without stretching bolts to their elastic limit - the point beyond which they can't return to their original length.
To make sure mating parts are securely fastened, you need to determine clamping force. One way to do that is to measure bolt tension.

6.2. Torque Application

Torquing methods use the inclined plane of a thread to convert rotary motion of the nut into axial motion of the bolt. To achieve required bolt stress, it is essential that each bolt, nut and washer is in good condition and well lubricated. Torquing may be carried out using conventional wrenches, impact wrenches or manual/hydraulic torque wrenches.

6.2.1. Hand Tightening

Hand tightening is the simplest form of torquing. It involves tightening flange bolts by conventional combination and hammer wrenches. Generally used on lower risk joints pressure, i.e. class 150 and 300 utility piping.

6.2.2. Manual Torque Wrench

The two manual torque wrenches used at the East River Station are the dial and micrometer.

a. The dial-type torque wrench employs Hooke's Law by

deflecting a torsion bar at the "square drive" (the socket-attachment point). The torsion bar's movement may then be transferred via a "floating beam" to a clock-like mechanism with a dial scale. The standard dial-type has the disadvantage of a line-of-sight scale and between-the-lines readings.

b. The most widely used torque wrench is the adjustable micrometer or "clicker." Specific designs vary, but typically, as the tool's adjustable barrel is turned to select a specific torque value, a large spring is compressed against an interface mechanism (toggle, cam or low-friction roller) that engages a deflecting beam. When the deflection of the tool is sufficient to overcome the compressive forces at the interface, the beam disengages and the wrench "clicks."
When setting/resetting the required torque value on a micrometer style torque wrench, go up the scale to set the higher value, or to reset to a lower value, go back to the lowest setting, then up the scale to the required setting.

NOTE: After a micrometer type torque wrench has been used for torquing, it should be returned to its lowest calibrated setting (10% - 20% of full range). Settings below lowest calibrated setting can cause damage to wrenches. Settings above the lowest calibrated setting can cause a set in the load spring.

6.2.3. Hydraulic Torque Wrench

Bolt torquing involves tightening flange bolts by use of manual or hydraulic torque wrenches. It is recommended to use hydraulic torque wrenches when the target torque exceeds 500 ft-lbs, i.e. for bolts exceeding 1” diameter.

6.2.4. Torque Multiplier

A torque multiplier is a device that increases the torque that can be applied by an operator. Because the power output can not exceed the power input, the number of output revolutions will be lower than the number of input revolutions (Torque x rpm = Power)

In the planetary gear system, torque is applied to the input gear or 'sun' gear. Three or four planet gears whose teeth are engaged with the sun gear therefore rotate. The outside casing of the

multiplier or 'annulus' is also engaged with the planet gear teeth, and would normally rotate in the opposite direction to the sun gear. A reaction arm prevents the annulus from rotating, and this causes the planet gears to orbit around the sun. The planet gears are held in a 'planetary' carrier which also holds the output square drive. Therefore as the planet gears orbit around the sun, the carrier and square drive turns.

NOTE: When the torque wrench needed to complete a task is unavailable, if may be possible that a smaller torque wrench and a multiplier can be used.

For greater torque accuracy, only use a dial type wrench with a multiplier. Also, use a ratchet adaptor with a multiplier when loosening fasteners.

6.3. Determine Torque When Using Adapters

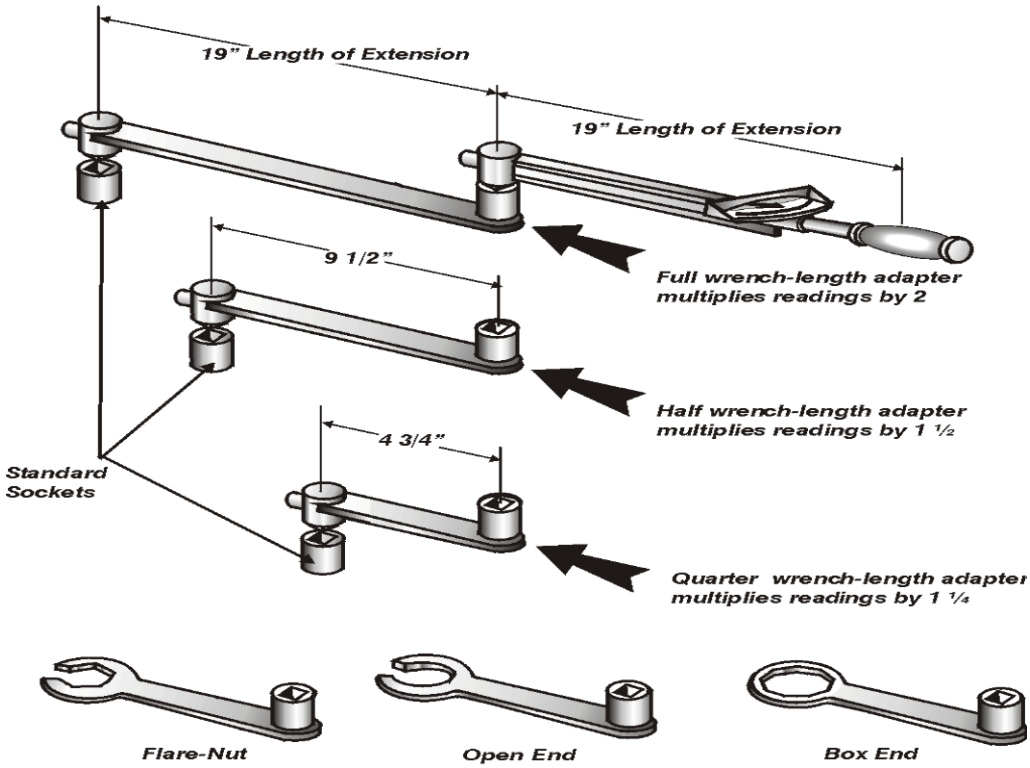
If an adaptor or extension is attached to the square drive of a dial or click-type torque wrench and this adds to its length, then the applied torque will be greater than the dial reading or the pre-set torque.

As a general rule of thumb, the applied torque can be determined by the length of the extension as follows:

- If the extension length equals 0.25 the length of the wrench, then multiply the reading by 1.25
- If the extension length equals 0.5 the length of the wrench, then multiply the reading by 1.5
- If the extension length equals the length of the wrench, then multiply the reading by 2.

NOTE 1: Any offset from the wrench's square drive to the end of the adaptor is not a factor when computing overall length. Final torque values are not affected because the overall length is the determining factor and not the offset.

NOTE 2: Use of handle extensions (cheater bars) are acceptable and does not change the required torque wrench setting.



Typical Extensions

Another way to determine the correct applied torque is to use a formula to find what the dial should read or what the pre-set torque should be.

The formula is the following:

$$\text{Dial Reading or Pre-Set Torque} = \frac{\text{Torque Wrench Length x Torque Desired}}{\text{Torque Wrench Length + Extension Length}}$$

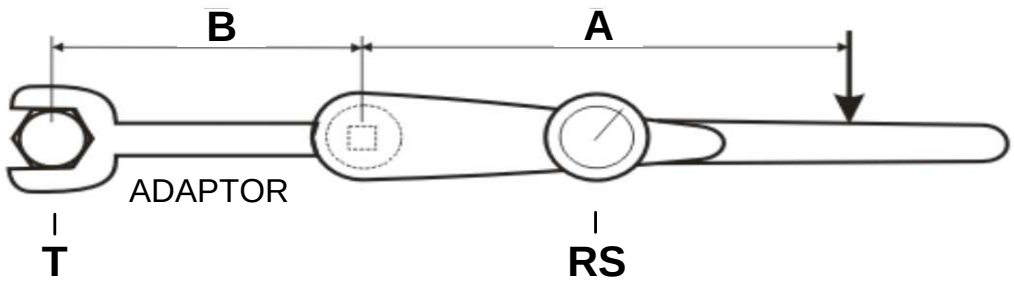
$$\text{This becomes RS} = \frac{A \times T}{A + B} \text{ when}$$

RS = Dial reading or torque setting of the torque wrench.

A = Distance from the center of the square drive of the torque wrench to the center of the handle grip.

B = Length of the adaptor from the center of the square drive to the center of the nut or bolt. Use only the length which is parallel to the handle.

T = Torque desired. This is the actual torque applied to the fastener.



Here is a typical problem: What should the dial read or the setting be when "A" is 12 inches, "B" is 6 inches and "T" is 30 lb.ft.?

$$RS = \frac{A \times T}{A + B} \text{ or } \frac{12 \times 30}{12 + 6} \text{ or } \frac{360}{18} \text{ or 20 foot pound}$$

Therefore, 30 foot pound of Torque will be applied at the fastener when "RS" is 20 foot pound.

NOTE: If the torque wrench reads in foot pound, then "T" should also be in foot pound. "T" and "RS" should be in the same unit of measurement and "A" and "B" should also be the same unit of measurement.

6.4. Torque Sequence and Passes

6.5. Thread Lubricants, Sealants or Adhesives

6.6. Washers

6.7. Flange Joint Classification

In order to determine the bolt tightening method and level of quality control required, the level of risk and difficulty in obtaining an adequate seal must be evaluated. Increasing levels of risk shall require increasing levels of

accuracy in bolt stress and levels of inspection. All pipe classes are categorized as either low risk, medium risk or high risk.

6.7.1. Low Risk Joints

On low risk joints, the maintenance personnel performing the assembly shall be responsible for verifying compliance of all components and to the tightening procedure.

6.7.2. Medium Risk Joints

On medium risk joints, maintenance supervision and maintenance personnel shall be responsible for verifying compliance of all components and to the tightening procedure. Maintenance supervision and maintenance personnel shall identify, on the Bolt Tightening Data Sheet (reference Appendix 8.13), the acceptance or rejection of the flange surface condition, that the material complies with that specified on the engineered drawings and that the bolt tightening was completed as required, to the correct torque or tension.

6.7.3. High Risk Joints

All high risk joints are to be inspected by engineering and maintenance supervision. The engineer shall identify, on the Bolt Tightening Data Sheet (reference Appendix 8.13), the acceptance or rejection of the flange surface condition, that the material complies with that specified on the engineered drawings and that the bolt tightening was completed as required, to the correct torque level.

Torque Process	RISK		
	LOW	**MEDIUM**	**HIGH**
	Steam Class 150# & 300#	Steam Class 600# and above	Critical Applications* (See Below)
Hand Tightening	Bolt size 1" and smaller	Engineering Approval Only	Engineering Approval Only – (bolt sizes 1" and smaller)
Torque Wrench	Bolt size over 1"		Engineering Approval Only – (target torque ≤500 ft-lbs and bolt sizes over 1")
Hydraulic Torque	Not Required	Engineering Approval Only – (target torque >500 ft-lbs and bolt sizes over 1")	

* Critical applications are those joints exposed to temperatures exceeding 900° F or cyclic stress i.e. vibration, frequent changes of pressure and/or temperature or lines subject to slugging.

6.8. Joint Preparation

Preparation of joint mating surfaces includes the following:

6.8.1. Clean the mating surfaces with a suitable solvent and wire bristle brush. Use stainless steel bristles on alloy components.

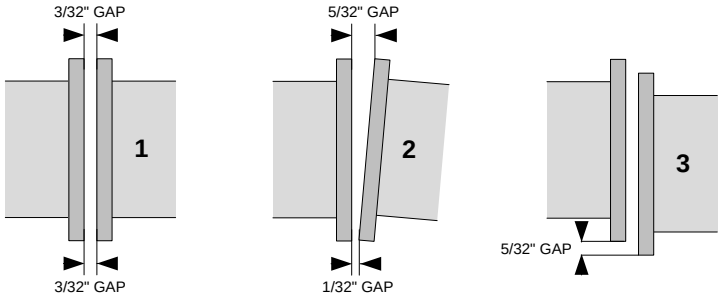
6.8.2. Inspect the seating surface for defects such as burrs and corrosion.

6.8.3. Use a straightedge to inspect the flange surface for signs of warping.

6.8.4. Inspect any flange surface with a phonographic finish for deep scratches or gouges.

CAUTION: Scrapers and putty knives used during surface cleaning can gouge into the phonographic surface and create more problems if the gouges go too deep.

6.9. Joint Alignment and Gasket Installation



6.9.1. Ensure alignment of parallelism is within tolerance.

CAUTION: Mating flanges must be aligned to each other before tightening. Tightening misaligned flanges can cause leakage or flange failure. Do not try to align flange faces by tightening bolts.

Alignment of parallelism tolerance is shown in the three sets of flanges in the diagram above. 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 is > 4/32).

6.9.2. Install enough bolts to hold the gasket in place

CAUTION: Do **NOT** reuse an old gasket unless instructed. Do **NOT** use multiple gaskets.

6.9.3. Install the gasket and ensure the gasket surface meets the flange sealing area fully.

6.9.4. Ensure gasket is properly centered.

7.0 BOLTING AND TORQUING PROCEDURE

7.1. General Fastener Requirements

7.1.1. Prior to disassembly of any bolted connection, inspect for full thread engagement.

IF	THEN NOTIFY
Less than two full thread engagement is identified,	maintenance supervision.
Thread engagement cannot be corrected during reassembly of the connection,	maintenance supervision and engineering.

Full or proper thread engagement is when the end of the bolt or stud has at least two full thread exposed beyond the face of the nut after fit up and torque (longer bolts or studs may be obtained to satisfy this condition).

NOTE: This is a minimum requirement. Other applications may require additional length or projection beyond the face of the nut.

7.1.2. Many fastening applications do not require torque values and torque wrenches or tensioning methods to attain proper closure. When values or methods are not specified by vendor, tightening using good mechanical judgment is acceptable.

7.1.3. Fasteners shall be examined to ensure that they are free of foreign matter (such as burrs, nicks, or chips) which could result in erroneous preload. Burrs of a minor nature may be filed off. Files used to remove burrs from alloy materials should not have been used previously on carbon steel materials.

7.1.4. Fasteners shall be cleaned of any foreign matter, if necessary, by approved methods such as wire brushing. Use stainless steel bristles on alloy materials.

7.1.5. Any fastener suspected of having thread deformation shall be checked by running the nut down the threaded length of the bolt to ensure the suspect bolt or nut is acceptable for use.

7.1.6. Fasteners that are considered unacceptable should either be replaced with same grades or evaluated for repair.

7.1.7. The fasteners may be provided with a light lubricant, if specified in the procedure/work order package.

7.1.8. All bolts, stud bolts, and cap screws shall be engaged so that the bolts extend completely through the nuts. The minimum condition that meets this requirement is for the end of bolt to extend two threads past the face of the nut.

7.1.9. Where the bolted connections attach to a tapped and threaded hole in the mating part, the bolt length shall be sufficient to assure a proper engagement based upon mating materials. A minimum of one bolt diameter is required, unless otherwise specified.

NOTE: Bolts and nuts shall be tightened using socket type wrenches, box wrenches or wrenches with flat jaws. Pliers or pipe wrenches shall **NOT** be used.

Ratchets may be used to snug the fastener but do **NOT** use any type of handle extension (cheater).

7.1.10. Use of crows feet and extensions either together or separately will not require torque compensation providing the effective lever length does not change.

7.1.11. If a manufacturer's recommended torque is provided, or a torque is given in design documents, etc., it shall be included in the work package, and is the torque desired, unless engineering supersedes the value.

7.1.12. Where only a desired torque value is given, the acceptable tolerance is the desired torque value plus 10% of desired torque value. The torque wrench user shall exercise caution to prevent the torque reading from exceeding the desired number by more than 10%.

7.1.13. All Micrometer type adjustable torque wrenches shall be stored at 20% of torque wrenches range.

7.2. De-tensioning Flanged Joints

7.2.1. Verify system is depressurized! (isolation valve seepage may have built pressure in system)

7.2.2. Use a cross bolt un-tightening pattern. (reverse of the torque pattern may be used.)

7.2.3. Use several passes - partially loosen each fastener before further loosening any of them.

7.2.4. Gradually slacken the nuts but do **NOT** remove them.

7.2.5. Remove the nuts **ONLY** when the fasteners are sufficiently loose to verify the gasket seal is broken.

7.2.6. Once a gasket has been fully compressed by application of maximum torque, and bolt tension is removed, the gasket should be replaced. Only the following situations allow gasket reuse:

a. Reuse is specifically authorized by engineering.

b. Should a situation arise which requires prompt equipment or system restoration, the maintenance supervisor has authority to allow reuse of a gasket.

7.3. Hard Gasket Tightening – Spiral Wound Gaskets

NOTE: The use of adhesive to hold the gasket in place may be necessary to obtain proper joint assembly. Obtain guidance from supervision and/or engineering as to the type of adhesive allowed.

7.3.1. Tighten a gasket in a tongue and groove flange:

a. Reference the Raised Face Flanges torque tables (8.1, 8.2, 8.3, and 8.4) to determine the required torque values for spiral-wound gaskets.

b. Complete the applicable general fastener requirements.

c. Tighten the flange to the target value and reference this standard for the sequence and number of passes.

d. Check gap around the circumference between each of these rounds, measured at every other bolt. If the gap is not reasonably uniform around the circumference, make the

appropriate adjustments by selective bolt tightening before proceeding.

e. Reference the following table to ensure proper gasket compression.

CAUTION: Uneven gap indicates pinching of the gasket and requires joint disassembly.

Recommended Compression of Spiral Wound Gaskets*			
Gasket Thickness (in.)	Maximum Inside Dimension (in.)	Recommended Flange Width (in.)	Recommended Minimum/Maximum Compressed Thickness (in.)
0.0625	Up to 6	3/8	0.050 / 0.055
0.100	10	1/2	0.075 / 0.080
0.125	Up to 20	1	0.090 / 0.100
0.175	Up to 40	1	0.125 / 0.135
0.250	90	1	0.180 / 0.200
0.285	185	1	0.200 / 0.220

* Reference - Flexitallic

7.3.2. Tighten a gasket in a flat face flange:

NOTE: Use only a spiral-wound gasket with a compression limiting ring in this type of flange. The compression limiting ring prevents over-compression of the gasket.

a. Reference the Raised Face Flanges torque tables to determine the required torque values for spiral-wound gaskets.

b. Complete the applicable general fastener requirements.

c. Tighten the flange to the target value and reference this standard for the sequence and number of passes.

8.0 APPENDIX

8.1. 150# Flange - Raised Face Flanges – Coarse Thread

CAUTION: Joints that do **NOT** seal using the torque values given in the raised face flange tables are referred to engineering for review and disposition. The torque values listed are only to be applied to bolts and flanges at ambient temperature. If torquing must be performed when the flanges and bolts are at elevated temperatures, the torque values are to be de-rated accordingly.

150# Flange - Raised Face Flanges – Coarse Thread SA-193 GR.B7 or SA-564 GR.630 Fasteners – Spiral Wound Type CG Gasket

Nominal Pipe Size (in.)	Raised Face Inside Diameter (in.)	Raised Face Outside Diameter (in.)	No. of Bolts	Size of Bolts (in.)	Torque (ft-lb.)
1/2	0.84	1.38	4	0.50	50
3/4	1.06	1.69	4	0.50	50
1	1.31	2.00	4	0.50	55
1-1/4	1.66	2.50	4	0.50	55
1-1/2	1.91	2.88	4	0.50	60
2	2.38	3.62	4	0.63	100
2-1/2	2.88	4.12	4	0.63	115
3	3.50	5.00	4	0.63	150
3-1/2	4.00	5.50	8	0.63	95
4	4.50	6.19	8	0.63	120
5	5.56	7.31	8	0.75	175
6	6.62	8.50	8	0.75	250
8	8.62	10.62	8	0.75	260
10	10.75	12.75	12	0.88	335
12	12.75	15.00	12	0.88	440
14	14.00	16.25	12	1.00	570
16	16.00	18.50	16	1.00	575
18	18.00	21.00	16	1.13	930
20	20.00	23.00	20	1.13	820
24	24.00	27.25	20	1.25	1180

Manufacturer recommended gasket stress: minimum 7,000 psi - maximum 20,000 psi

8.2. 300# Flange - Raised Face Flanges - Coarse Thread

300# Flange - Raised Face Flanges – Coarse Thread SA-193 GR.B7 or SA-564 GR.630 Fasteners – Spiral Wound Type CG Gasket					
Nominal Pipe Size (in.)	Raised Face Inside Diameter (in.)	Raised Face Outside Diameter (in.)	No. of Bolts	Size of Bolts (in.)	Torque (ft-lb.)
1/2	0.84	1.38	4	0.50	50
3/4	1.06	1.69	4	0.50	80
1	1.31	2.00	4	0.50	85
1-1/4	1.66	2.50	4	0.50	85
1-1/2	1.91	2.88	4	0.50	140
2	2.38	3.62	4	0.63	80
2-1/2	2.88	4.12	4	0.63	140
3	3.50	5.00	4	0.63	140
3-1/2	4.00	5.50	8	0.63	160
4	4.50	6.19	8	0.63	185
5	5.56	7.31	8	0.75	210
6	6.62	8.50	8	0.75	210
8	8.62	10.62	8	0.75	340
10	10.75	12.75	12	0.88	380
12	12.75	15.00	12	0.88	560
14	14.00	16.25	12	1.00	500
16	16.00	18.50	16	1.00	785
18	18.00	21.00	16	1.13	875
20	20.00	23.00	20	1.13	960
24	24.00	27.25	20	1.25	1565

Manufacturer recommended gasket stress: minimum 12,000 psi - maximum 23,000 psi

8.3. 600# Flange - Raised Face Flanges - Coarse Thread

600# Flange - Raised Face Flanges – Coarse Thread SA-193 GR.B7 or SA-564 GR.630 Fasteners – Spiral Wound Type CG Gasket					
Nominal Pipe Size (in.)	Raised Face Inside Diameter (in.)	Raised Face Outside Diameter (in.)	No. of Bolts	Size of Bolts (in.)	Torque (ft-lb.)
1/2	0.84	1.38	4	0.50	50
3/4	1.06	1.69	4	0.63	80
1	1.31	2.00	4	0.63	85
1-1/4	1.66	2.50	4	0.63	85
1-1/2	1.91	2.88	4	0.75	140
2	2.38	3.62	8	0.63	80
2-1/2	2.88	4.12	8	0.75	140
3	3.50	5.00	8	0.75	160
3-1/2	4.00	5.50	8	0.88	310
4	4.50	6.19	8	0.88	340
5	5.56	7.31	8	1.00	465
6	6.62	8.50	12	1.00	465
8	8.62	10.62	12	1.13	685
10	10.75	12.75	16	1.25	790
12	12.75	15.00	16	1.25	875
14	14.00	16.25	20	1.38	950
16	16.00	18.50	20	1.50	1400
18	18.00	21.00	24	1.63	1810
20	20.00	23.00	24	1.63	1620
24	24.00	27.25	24	1.88	2535

Manufacturer recommended gasket stress: minimum 15,000 psi - maximum 27,000 psi

8.4. 900# Flange - Raised Face Flanges - Coarse Thread

900# Flange - Raised Face Flanges – Coarse Thread SA-193 GR.B7 or SA-564 GR.630 Fasteners – Spiral Wound Type CG Gasket					
Nominal Pipe Size (in.)	Raised Face Inside Diameter (in.)	Raised Face Outside Diameter (in.)	No. of Bolts	Size of Bolts (in.)	Torque (ft-lb.)
1/2	0.84	1.38	4	0.50	140
3/4	1.06	1.69	4	0.63	140
1	1.31	2.00	4	0.63	225
1-1/4	1.66	2.50	4	0.63	225
1-1/2	1.91	2.88	4	0.75	335
2	2.38	3.62	8	0.63	225
2-1/2	2.88	4.12	8	0.75	335
3	3.50	5.00	8	0.75	280
3-1/2	4.00	5.50	8	0.88	315
4	4.50	6.19	8	0.88	500
5	5.56	7.31	8	1.00	700
6	6.62	8.50	12	1.00	560
8	8.62	10.62	12	1.13	950
10	10.75	12.75	16	1.25	950
12	12.75	15.00	16	1.25	1065
14	14.00	16.25	20	1.38	1250
16	16.00	18.50	20	1.50	1615
18	18.00	21.00	24	1.63	2535
20	20.00	23.00	24	1.63	3100
24	24.00	27.25	24	1.88	6220

Manufacturer recommended gasket stress: minimum 17,000 psi - maximum 29,000 psi

8.5. 150# Flange - Raised Face Flanges – Coarse Thread – Sheet Gaskets

150# Flange - Raised Face Flanges – Coarse Thread – Sheet Gaskets						
Nominal Pipe Size (in.)	Raised Face Inside Diameter (in.)	Raised Face Outside Diameter (in.)	No. of Bolts	Size of Bolts (in.)	Non-Rubber Sheet Gasket Torque (ft-lb.)	Rubber Sheet Gasket Torque (ft-lb.)
1/2	0.84	1.38	4	0.50	23	1
3/4	1.06	1.69	4	0.50	34	2
1	1.31	2.00	4	0.50	38	2
1-1/4	1.66	2.50	4	0.50	50	3
1-1/2	1.91	2.88	4	0.50	50	5
2	2.38	3.62	4	0.625	99	9
2-1/2	2.88	4.12	4	0.625	99	11
3	3.50	5.00	4	0.625	99	16
4	4.50	6.19	8	0.625	99	11
5	5.56	7.31	8	0.75	175	17
6	6.62	8.50	8	0.75	175	21
8	8.62	10.62	8	0.75	175	28
10	10.75	12.75	12	0.875	282	27
12	12.75	15.00	12	0.875	282	36
14	14.00	16.25	12	1.00	424	44
16	16.00	18.50	16	1.00	424	43
18	18.00	21.00	16	1.125	622	65
20	20.00	23.00	20	1.125	622	57
24	24.00	27.25	20	1.250	874	82

8.6. 300# Flange - Raised Face Flanges – Coarse Thread – Sheet Gaskets

300# Flange - Raised Face Flanges – Coarse Thread – Sheet Gaskets					
Nominal Pipe Size (in.)	Raised Face Inside Diameter (in.)	Raised Face Outside Diameter (in.)	No. of Bolts	Size of Bolts (in.)	Non-Rubber Sheet Gasket Torque (ft-lb.)
1/2	0.84	1.38	4	0.50	23
3/4	1.06	1.69	4	0.50	43
1	1.31	2.00	4	0.50	56
1-1/4	1.66	2.50	4	0.50	86
1-1/2	1.91	2.88	4	0.50	137
2	2.38	3.62	4	0.625	91
2-1/2	2.88	4.12	4	0.625	128
3	3.50	5.00	4	0.625	175
4	4.50	6.19	8	0.625	175
5	5.56	7.31	8	0.75	175
6	6.62	8.50	8	0.75	175
8	8.62	10.62	8	0.75	282
10	10.75	12.75	12	0.875	424
12	12.75	15.00	12	0.875	622
14	14.00	16.25	12	1.00	601
16	16.00	18.50	16	1.00	847
18	18.00	21.00	16	1.125	847
20	20.00	23.00	20	1.125	847
24	24.00	27.25	20	1.250	1192

8.7. Recommended Torque Values* for Coarse Thread Bolts

		Screw, Stud, or Bolt Shank Diameter (inches)													
I.D.	**Grade/Type**	**1/4**	**5/16**	**3/8**	**7/16**	**1/2**	**9/16**	**5/8**	**3/4**	**7/8**	**1**	**1-1/8**	**1-1/4**	**1-3/8**	**1-1/2**
		Torque Values (ft-lb)													
	SAE Grade 2	4	8	15	24	35	55	75	130	***125***	***190***	***270***	***380***	***490***	***650***
	SAE Grade 5	6	13	23	35	55	80	110	200	320	480	600	840	1100	1460
	SAE Grade 5.2														
	SA/A-325 Type 1														
	SA/A-325 Type 2														
	SA/A-325 Type 3														
	SA/A-449														
	SAE Grade 7	8	16	30	45	70	100	140	240	400	600	840	1100	1560	2080
	SA/A-354 Grade BC														
	SA/A-193 Grade B7														
	SAE Grade 8	9	18	35	55	80	110	170	280	460	680	960	1360	1780	2360
	SAE Grade 8.2														
	SA/A-354 Grade BD														
	A490														
	SA/A-540														

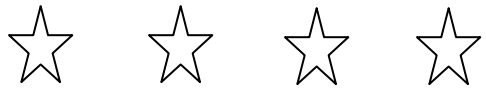
* Values given in above table are **NOT** intended for gasketed joints.

Value based upon low minimum yield strength of bolts over ¾" for Grade 2 only

8.8. Recommended Torque Values for Fasteners of Different Materials

Screw/Bolt Size	Aluminum 2024-T1	Brass	Monel	Silicon Bronze	Steel Low-Carbon	Steel 18-8 Stainless (304)	Steel 316 Stainless
Maximum Torque (in-lb)							
2-56	1.4	2.0	2.5	2.3	2.2	2.5	2.6
2-61	1.7	2.5	3.1	2.8	2.7	3.0	3.2
3-48	2.1	3.2	4.0	3.6	3.5	3.9	4.0
3-56	2.4	3.6	4.5	4.1	4.0	4.0	4.6
4-40	2.9	4.3	5.3	4.8	4.7	5.2	5.5
4-48	3.6	5.4	6.7	6.1	5.9	6.6	6.9
5-40	4.2	6.3	7.8	7.1	6.9	7.7	8.1
5-44	5.1	7.7	9.6	8.7	8.5	9.4	9.8
6-32	5.3	7.9	9.8	8.9	8.7	9.6	10.1
6-40	6.6	9.9	12.3	11.2	10.9	12.1	12.7
8-32	10.8	16.2	20.2	18.4	17.8	19.8	20.7
8-36	12.0	18.0	22.4	20.4	19.8	22.0	23.0
10-24	13.8	18.6	25.9	21.2	20.8	22.8	23.8
10-32	19.2	25.9	34.9	29.3	29.7	31.7	33.1
1/4”-20	45.6	61.5	85.3	68.8	65	75.2	78.8
1/4”-28	57.0	77.0	106	87	90	94	99
5/16”-18	80	107	149	123	129	132	133
5/16”-24	86	116	160	131	139	142	147
3/8”-16	143	192	266	219	212	236	247
3/8”-24	157	212	294	240	232	259	271
7/16”-14	228	317	427	349	338	376	393
7/16”-20	242	327	451	371	361	400	418
1/2”-13	313	422	584	480	465	517	542
1/2”-20	328	443	613	502	487	541	565
9/16”-12	413	558	774	632	613	682	713
9/16”-18	456	615	855	697	668	752	787
5/8”-11	715	907	1330	1030	1000	1110	1160
5/8”-18	7598	1016	1484	1154	1040	1244	1301
3/4”-10	980	1249	1832	1416	1259	1530	1582
3/4”-16	958	1220	1790	1382	1230	1490	1558
7/8”-09	1495	1905	2775	2140	1919	2328	2430
7/8”-14	1490	1895	2755	2130	1911	2318	2420
1”-08	2205	2815	4130	3185	2832	3440	3595
1”-14	1995	2545	3730	2885	2562	3110	3250
Maximum Torque (ft-lb)							
1-1/8”-07	265	337	499	383	340	413	432
1-1/8”-12	251	318	470	361	322	390	408
1-1/4”-07	336	428	627	485	432	523	546
1-1/4”-12	308	394	575	447	396	480	504
1-1/2”-06	570	727	1064	822	732	888	930
1-1/2”-12	450	575	840	651	579	703	732

These values should develop bolt tension to slightly less than yield point.
Specify 80% - 100% of these values.



8.9. Recommended Torque Values for Coarse Threaded Socket-Head Cap Screws

Size Dia. (in.)	Threads per inch	Stress Area sq. in.	Proof Load (psi)	Torque*
0.125	40	0.00796	1110	15 (in-lbs)
0.138	32	0.00909	1270	19 (in-lbs)
0.164	32	0.0140	1960	36 (in-lbs)
0.190	24	0.0175	2450	52 (in-lbs)
0.250	20	0.0318	4450	10 (ft-lbs)
0.3125	18	0.0524	7340	22 (ft-lbs)
0.375	16	0.0775	10800	38 (ft-lbs)
0.4375	14	0.1063	14900	61 (ft-lbs)
0.500	13	0.1419	19900	93 (ft-lbs)
0.625	11	0.226	30500	179 (ft-lbs)
0.750	10	0.334	45100	317 (ft-lbs)
0.875	9	0.462	62400	512 (ft-lbs)
1.000	8	0.606	81800	767 (ft-lbs)
1.125	7	0.763	103000	1086 (ft-lbs)
1.250	7	0.969	131000	1380 (ft-lbs)
1.375	6	1.155	156000	2010 (ft-lbs)
1.500	6	1.405	190000	2667 (ft-lbs)
1.750	5	1.90	256000	4208 (ft-lbs)
2.000	4 1/2	2.50	338000	6328 (ft-lbs)
2.250	4 1/2	3.25	439000	9255 (ft-lbs)
2.500	4	4.00	540000	12656 (ft-lbs)
2.750	4	4.93	666000	17159 (ft-lbs)
3.000	4	5.97	806000	22667 (ft-lbs)
3.250	4	7.10	958000	29204 (ft-lbs)
3.500	4	8.33	1120000	36899 (ft-lbs)
3.750	4	9.66	1300000	45847 (ft-lbs)
4.000	4	11.08	1500000	56092 (ft-lbs)

*Values based on 140 ksi for 0.500 and smaller and 135 ksi for 0.625 and larger

8.10. Recommended Torque Values for Fine Threaded Socket-Head Cap Screws

Size Dia. (in.)	Threads per inch	Stress Area sq. in.	Proof Load (psi)	Torque*
0.125	44	0.00830	1160	16 (in-lbs)
0.138	40	0.01015	1420	22 (in-lbs)
0.164	36	0.01474	2060	38 (in-lbs)
0.190	32	0.0200	2800	59 (in-lbs)
0.250	28	0.0364	5100	12 (ft-lbs)
0.3125	24	0.0580	8120	24 (ft-lbs)
0.375	24	0.0878	12300	43 (ft-lbs)
0.4375	20	0,1187	16600	68 (ft-lbs)
0.500	20	0.1599	22400	105 (ft-lbs)
0.625	18	0.256	34600	203 (ft-lbs)
0.750	16	0.373	50400	354 (ft-lbs)
0.875	14	0.509	68700	564 (ft-lbs)
1.000	12	0.663	89500	839 (ft-lbs)
1.125	12	0.856	116000	1219 (ft-lbs)
1.250	12	1.073	145000	1698 (ft-lbs)
1.375	12	1.315	178000	2288 (ft-lbs)
1.500	12	1.581	213000	3001 (ft-lbs)

*Values based on 140 ksi for 0.500 and smaller and 135 ksi for 0.625 and larger

8.11. Recommended Torque Values for Set Screws

Nominal Set Screw Size	Seating Torque
No. 0	0.5 (in-lbs)
No. 1	1.5 (in-lbs)
No. 2	1.5 (in-lbs)
No. 3	5 (in-lbs)
No. 4	5 (in-lbs)
No. 5	9 (in-lbs)
No. 6	9 (in-lbs)
No. 8	20 (in-lbs)
No. 10	33 (in-lbs)
1/4 in.	87 (in-lbs)
5/16 in.	14 (ft-lbs)
3/8 in.	24 (ft-lbs)
7/16 in.	36 (ft-lbs)
1/2 in.	52 (ft-lbs)
9/16 in.	52 (ft-lbs)
5/8 in.	102 (ft-lbs)
3/4 in.	177 (ft-lbs)
7/8 in.	417 (ft-lbs)
1 in.	583 (ft-lbs)

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8.12. Torque Pattern and Sequence