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Practical Bolting and Gasketing for the Non Standard-Flanged Joint

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Points of Discussion

- Introduction
- Joint Analysis
- Existing Flange Data
- Machining Procedure
- Bolting
- Radial Shear
- Available Gasket Styles
- Personnel Training
- New Equipment Design
- Conclusion

Introduction

- The purpose of our discussion today is to provide information to help ensure joint integrity through the use of “Gasket Selection and Practical Bolting Methods.”
- The information provided is some of the basic elements needed to obtain “leak free” operation of large diameter flanged joint connections.

Joint Analysis

- ASME PCC1 Document – scope, qualification, examination of “Working” surfaces, alignment of mating flanges, installation of gaskets, lubrication of “Working “ surfaces, installation of bolts, tightening of bolts, tightening sequence, target torque, joint leak tightness test, records, joint assembly
- Flange Analysis Software (Code Calc) – analysis software to identify complete flange data necessary for proper bolting and gasketing
- Gasket Selection Process – identify correct gasket for use in the particular joint based all data collected (is radial shear an issue?)
- Recommendations to Ensure Joint Integrity – recommend necessary pre-load, recommend final target torque, recommend torque procedure, determine need for tensioning based on the particular application or in-plant written procedures

Existing Flange Data

- Original Gasket Design
- Original Bolting Procedure
- Pressure – operating and design
- Temperature – operating and design
- Bolts – size, quantity and material grade
- Flange Type
- Gasket Surface Details (Nubbins?)

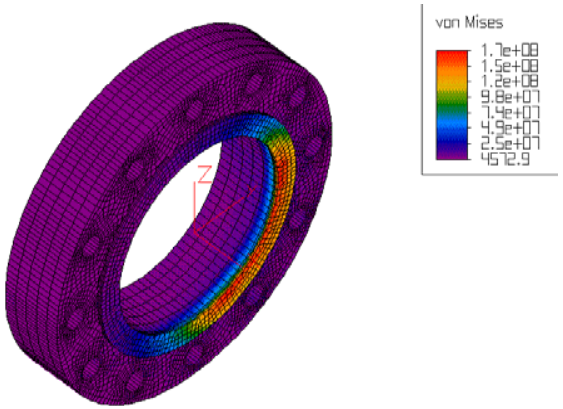
Machining Procedure and Measurement Guidelines

- It is necessary to have a machining procedure to ensure joint integrity.
- The procedure must include all of the necessary information for determining the need to machine the flanges prior to gasket installation.
- The procedure must provide for inspection for nubbins and the need to remove nubbins.
- The Procedure must include language about;
  - Flange Warpage
  - Surface Criteria
  - Surface Specifications
  - Must mandate need to machine both surfaces
  - Removal of nubbins
  - Minimum flange thickness

Bolting Data

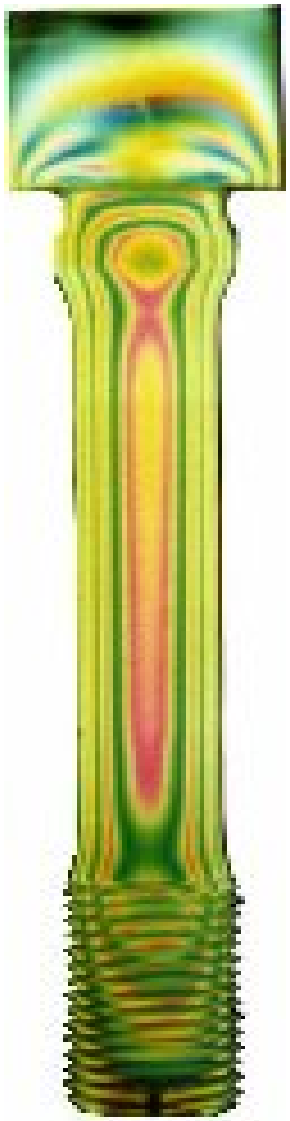
Basics

- Clean
- Inspect
- Align
- Install Gasket
- Control Friction*
- Control Tightening*
- Compensate for Relaxation*

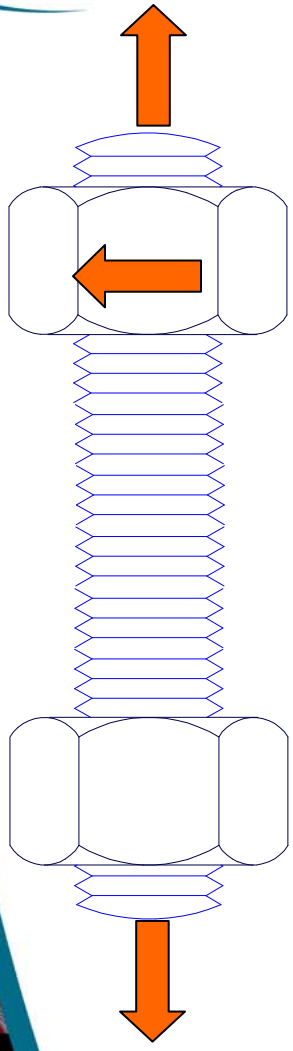


Bolt Theory

- Property of Elasticity
- Friction
- Lubrication
- Loading Scatter
- Material Relaxation

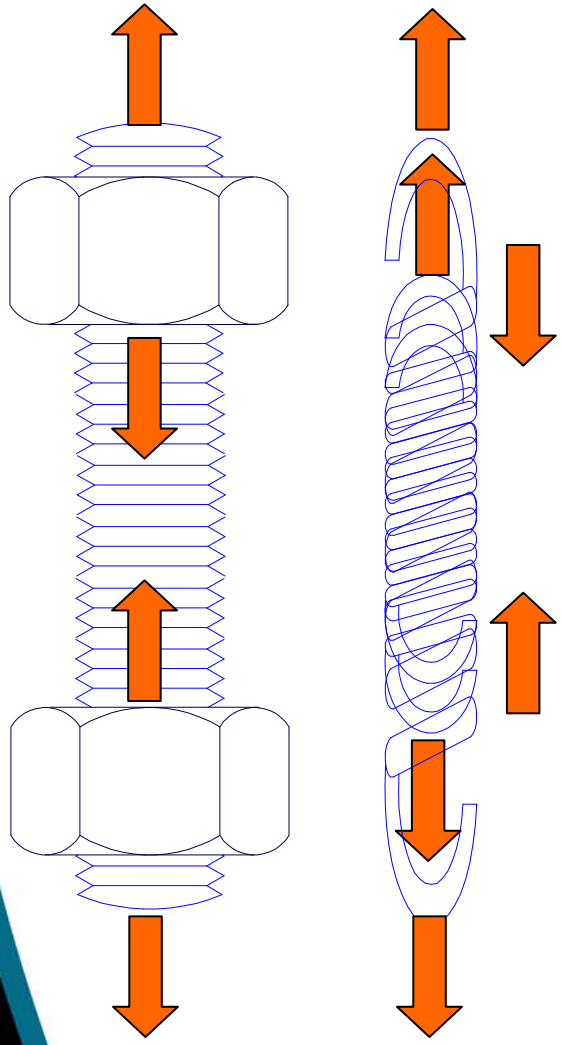


Function of A Bolt



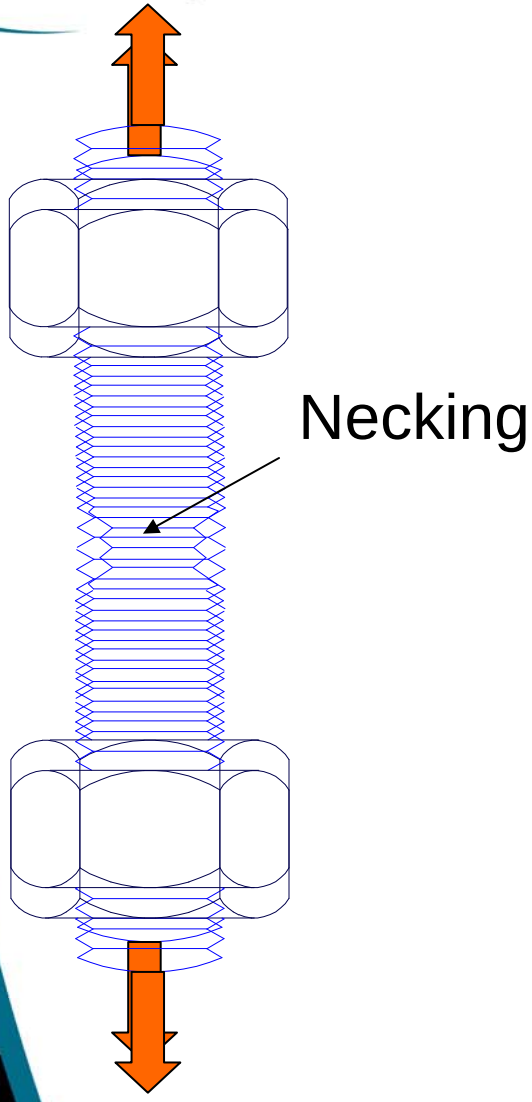
- The function of a bolt is to clamp the components of the joint together
- This clamping action compresses the gasket to creates a seal
- The bolt must be stretched to create the clamping action and this is done by turning the nut

A Bolt is like a Spring



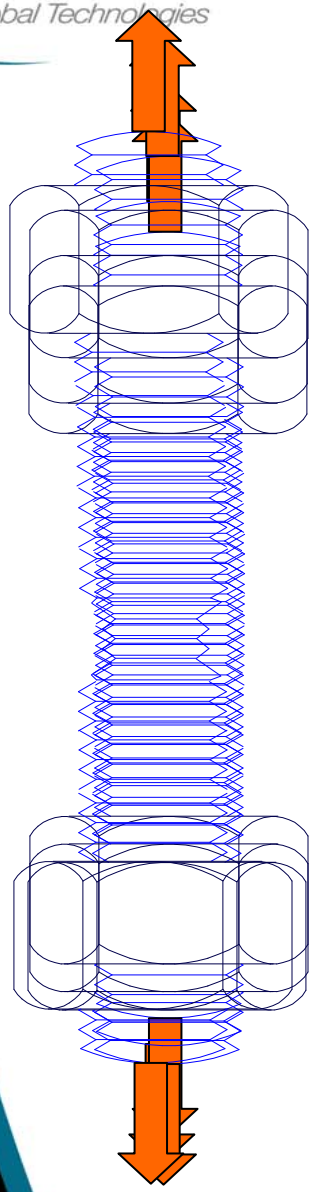
- A bolt is like a spring
- A bolt can be stretched…..
- …. but, will always try to return to its original length.
- This spring like action is what holds the bolt tight and creates the clamping force

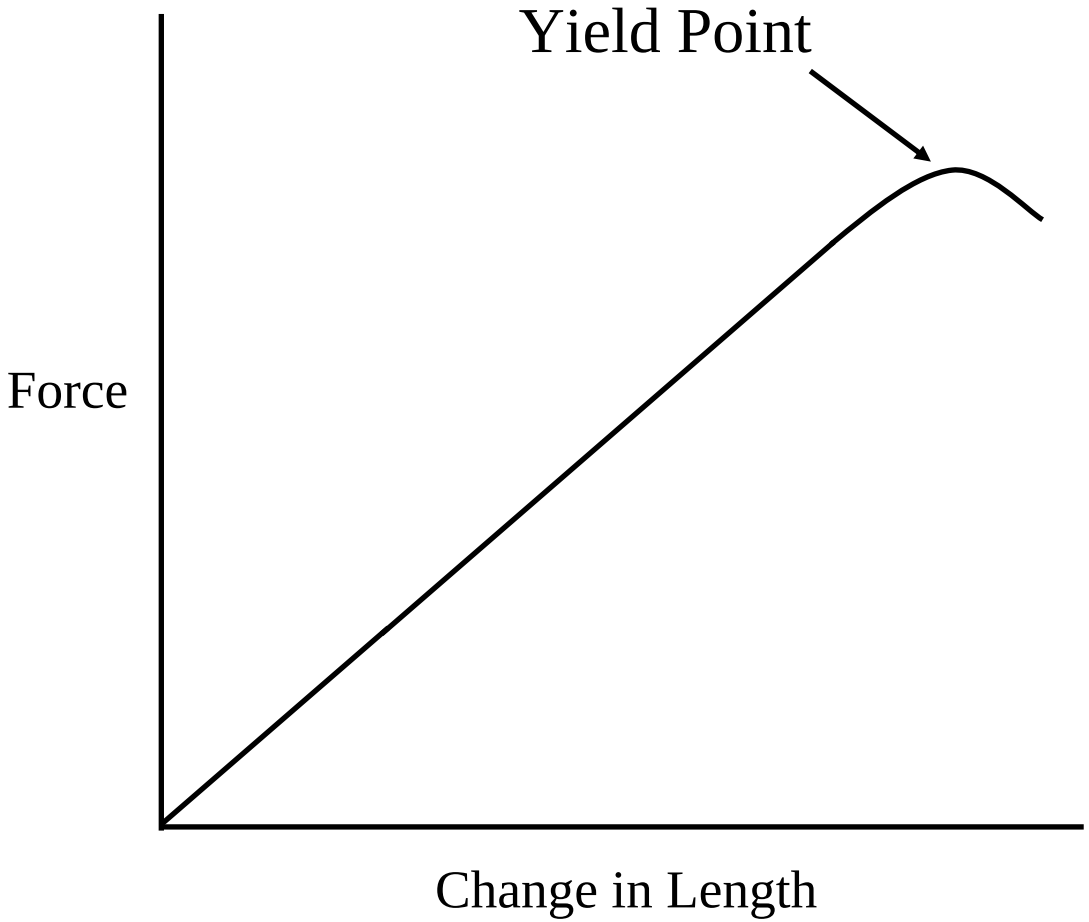
The Yield Point



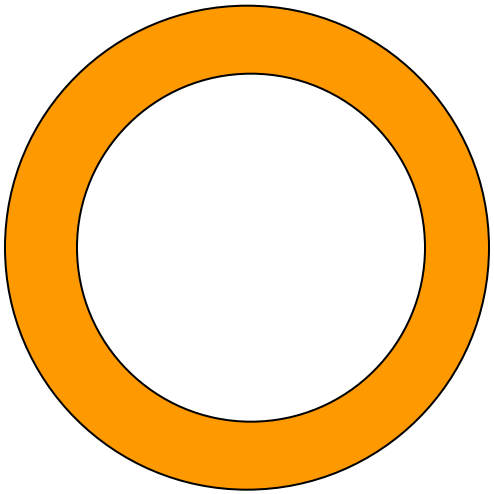
- If the bolt is stretched to far it will be permanently extended
- This is called the Yield Point of the bolt

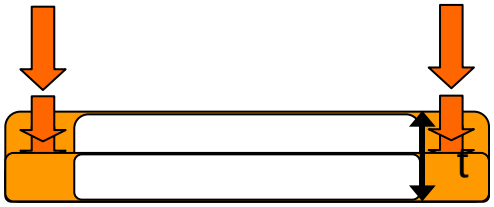
Stretching a Bolt





Compressing a Gasket

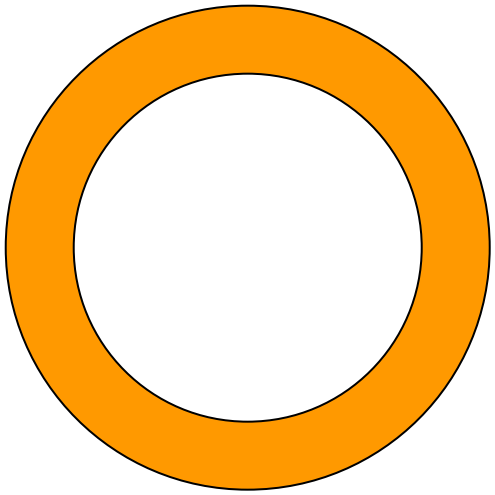


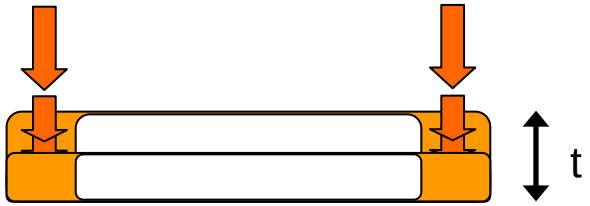


t = original thickness

- When a gaskets are compressed they fill the voids and irregularities of the mating flanges
- For this to occur, the gasket must be capable of being permanently deformed
- Unlike a bolt the gaskets only partially return to their original thickness

Compressing a Gasket





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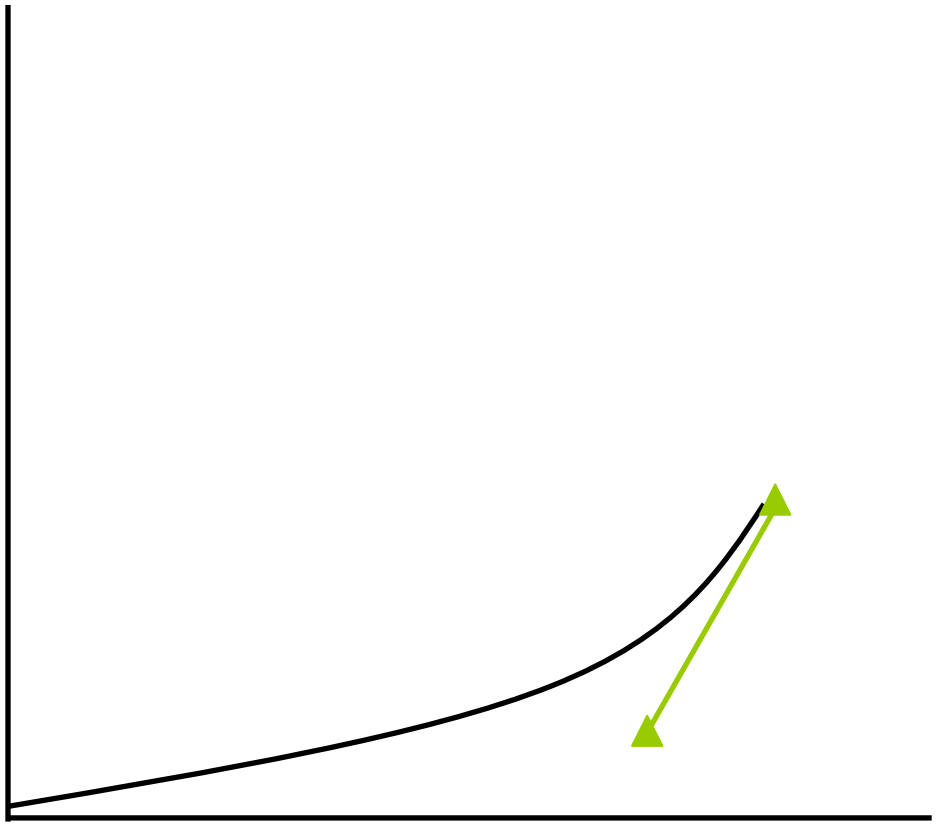
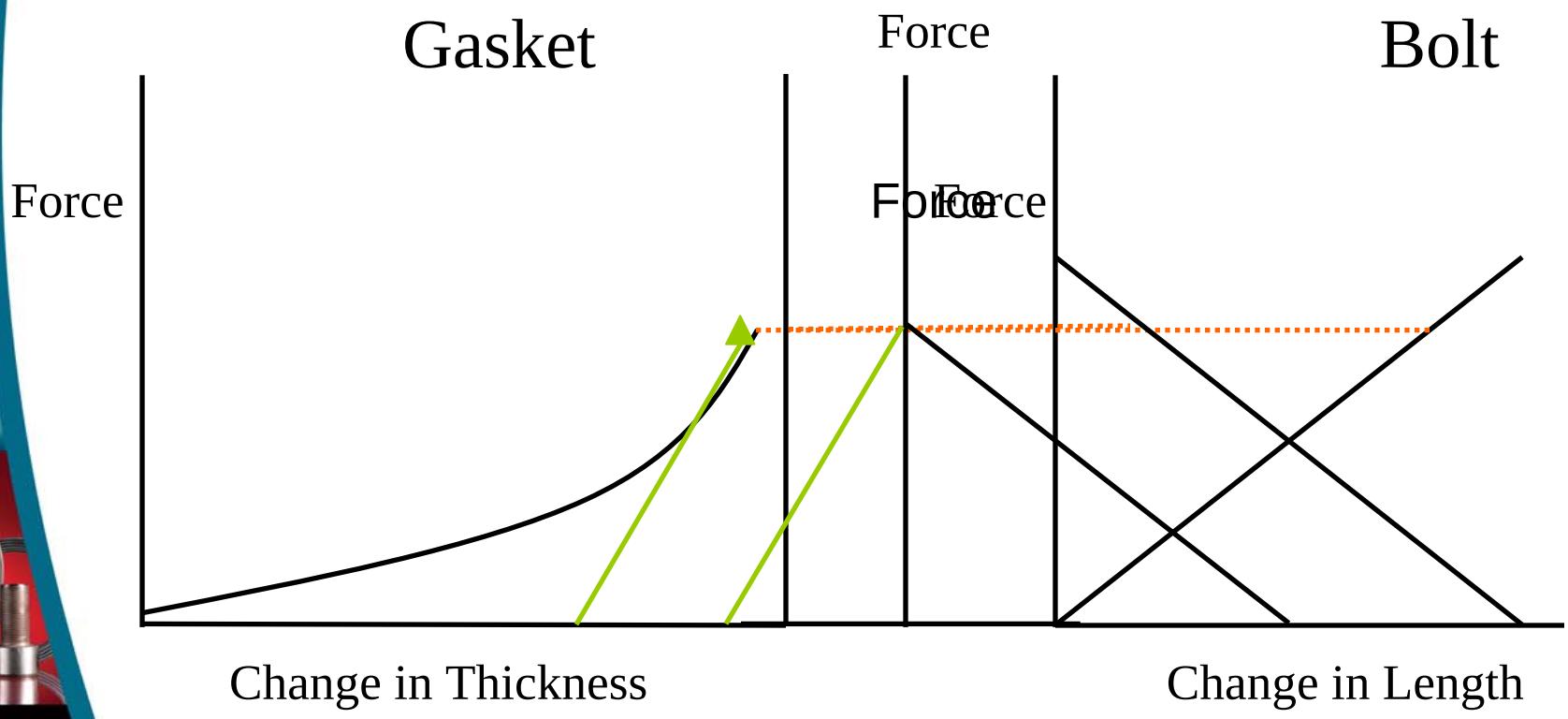


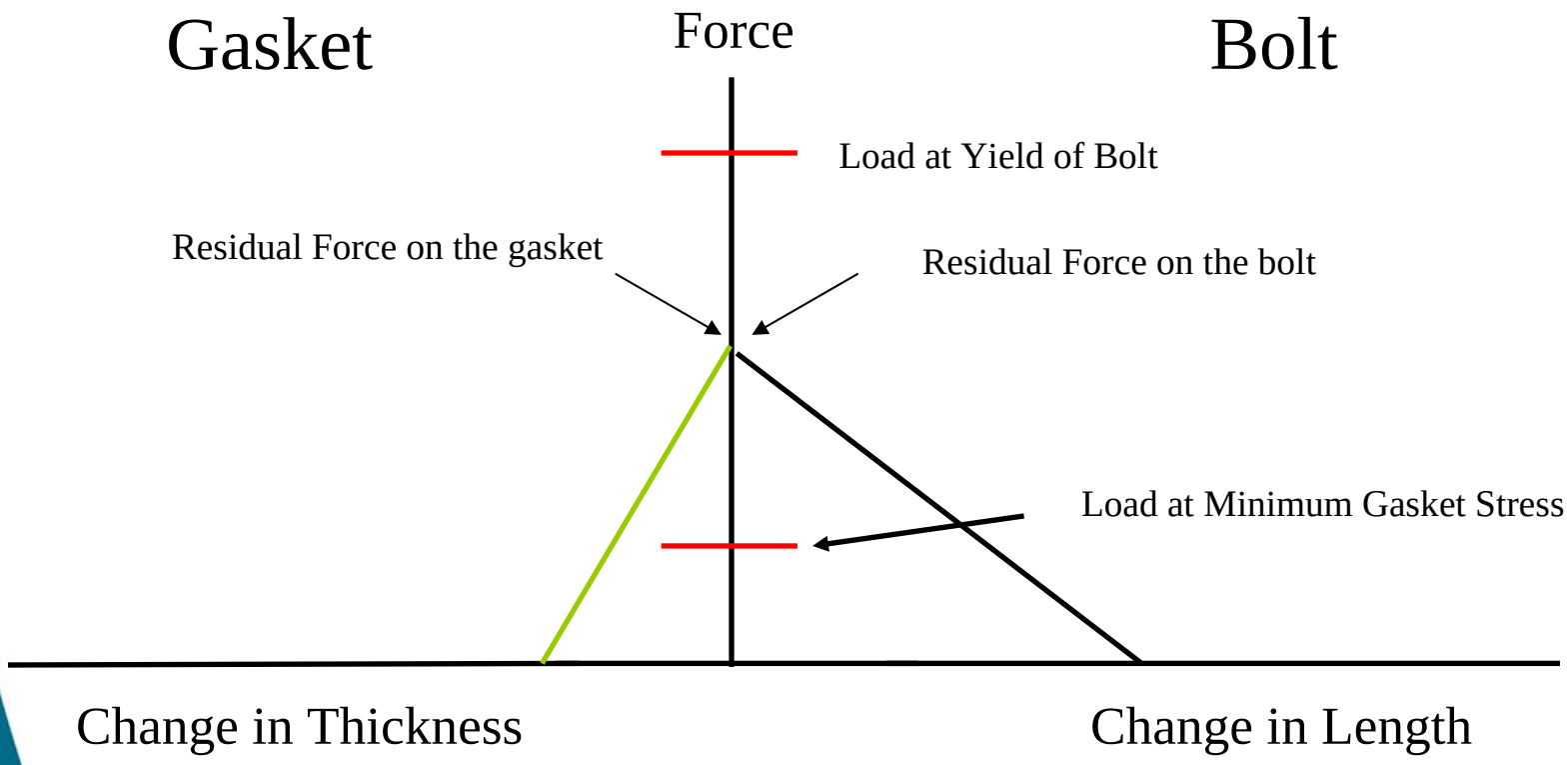
Joint Diagram

A joint diagram can be used to examine the effects the various forces that act within a joint.



Joint Diagram

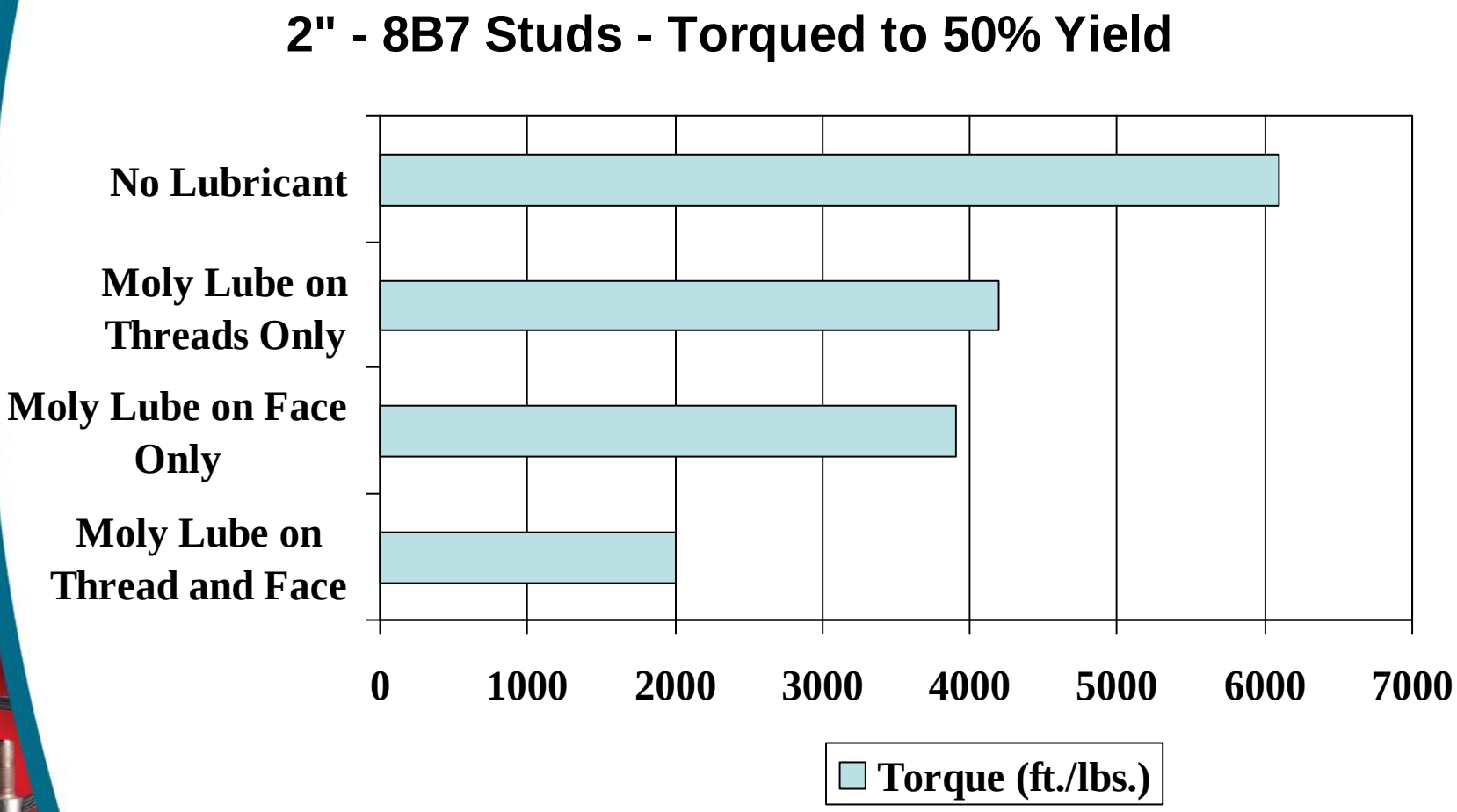
A diagram used to show the interactions between the bolting and the gasket load



Bolting

- Proper Bolt Material Selection
  - Is B16 stronger than B7 material?
  - Yes, only if above 800 F
- New studs vs. Used studs
- Bolting procedure/Assembly Procedures
  - Owner/Users should have procedure that outlines flange bolt-up requirements based on operating conditions.
  - The PCC1 addresses bolt up procedure, however, there are acceptable proven alternative bolt up procedures used through out the industry
- Hardened Washers
- Lubrication

Importance of Lubrication



Controlling Friction

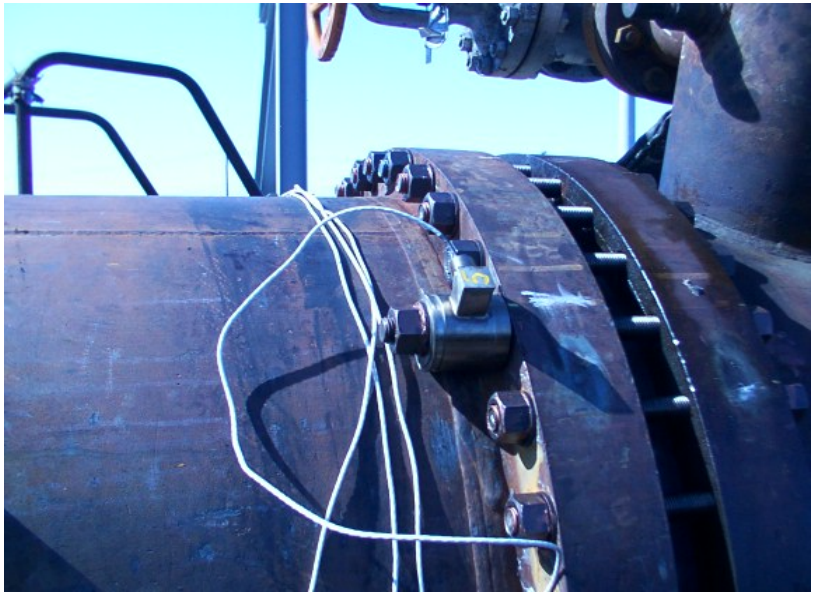
- We want to control friction for two reasons:
  - To achieve as closely as possible the desired load on the bolts
  - To achieve the same load on all of the bolts in the flange
- Good Practices to help control friction
  - Remove burrs and flat spots from threads
  - Nuts run freely past anticipated point of travel by hand
  - Replace worn, corroded, damaged or over torqued bolts
    - When replacing bolts, place them in the flange so that they are evenly spaced from each other.
  - If force is necessary to install bolts, inspect the threads for damage after installing
  - Bolts should pass through the flanges at right angles
  - Use hardened steel washers
  - Apply the correct lubricant
  - Avoid getting trash on the lubricated bolt

Bolt Load Scatter

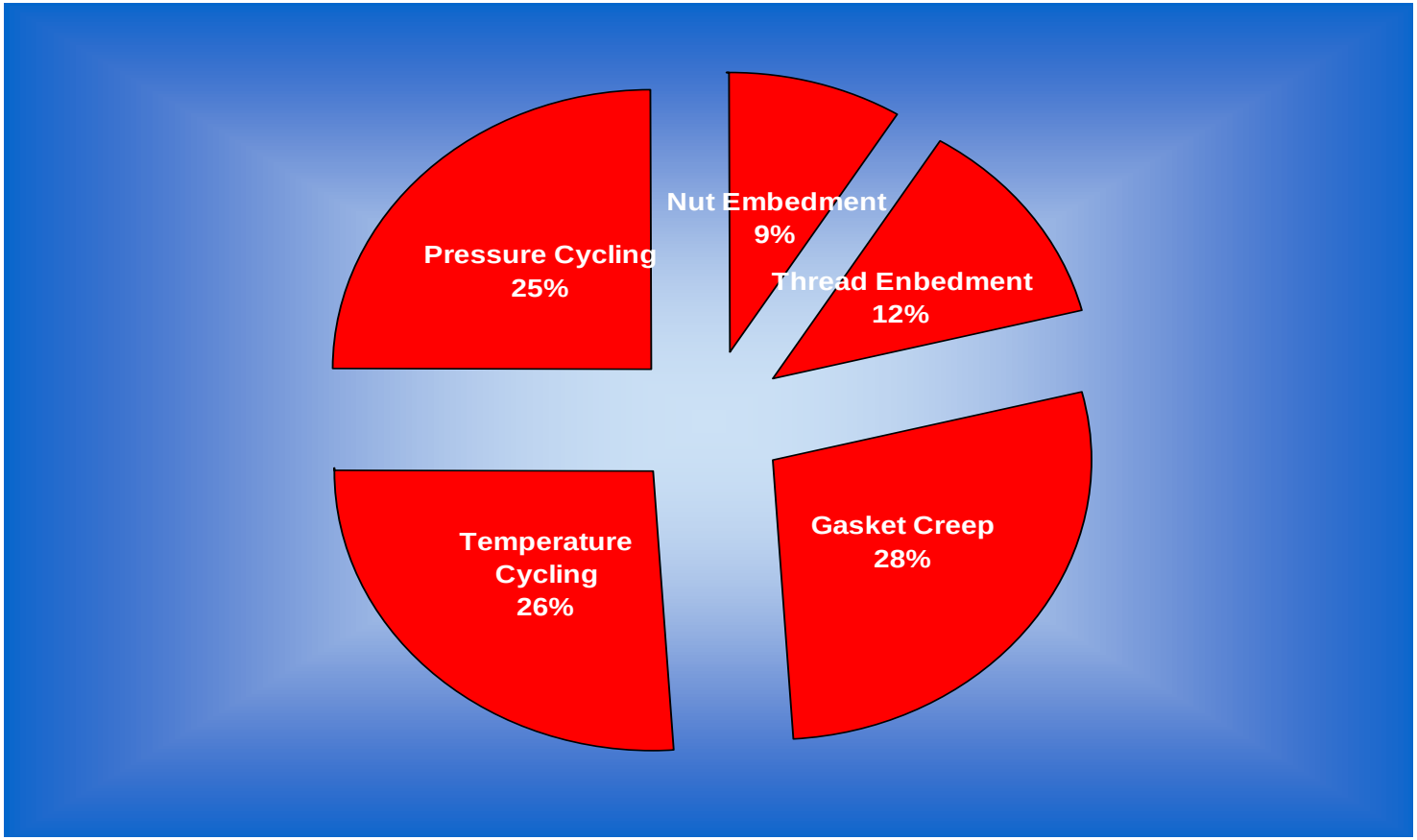
- Definition: Amount of load retained from bolt to bolt across the entire flange
- Little scatter equates to sealing
  - This is true even if you miss the ideal load on the bolts slightly
  - The reverse is not true
- Scatter Reduction
  - Control friction
  - Apply torque evenly
  - Control cross talk by using a cross-bolting pattern
- Cross talk: Premise that the area of the flange that one bolts effects overlaps the effected area of the adjacent bolts
  - Bolts 180 degrees from each other will both tighten when you tighten one.

Controlling Joint Relaxation

- Joint relaxation: joint members begin to lose load due to the applied forces continuing to effect movement in the joint
- Contributors to joint relaxation
  - Embedment of the nut threads with the bolt threads
  - Embedment of the nut to the flange
  - Bolt Misalignment
  - Gasket Creep
  - Gasket type and material
  - Metal Creep
  - Temperature
  - Pressure
  - Hydrostatic testing
  - Vibration Loosening



Joint Relaxation



Relaxation Reduction

- Recognizing that it is present and to what degree
- Adding passes to your procedure at later times that allows for the relaxation to take place. These passes require no increase in torque
- Increasing your torque to higher values within allowable limits and anticipating the relaxation of the joint
- Some combination of the above

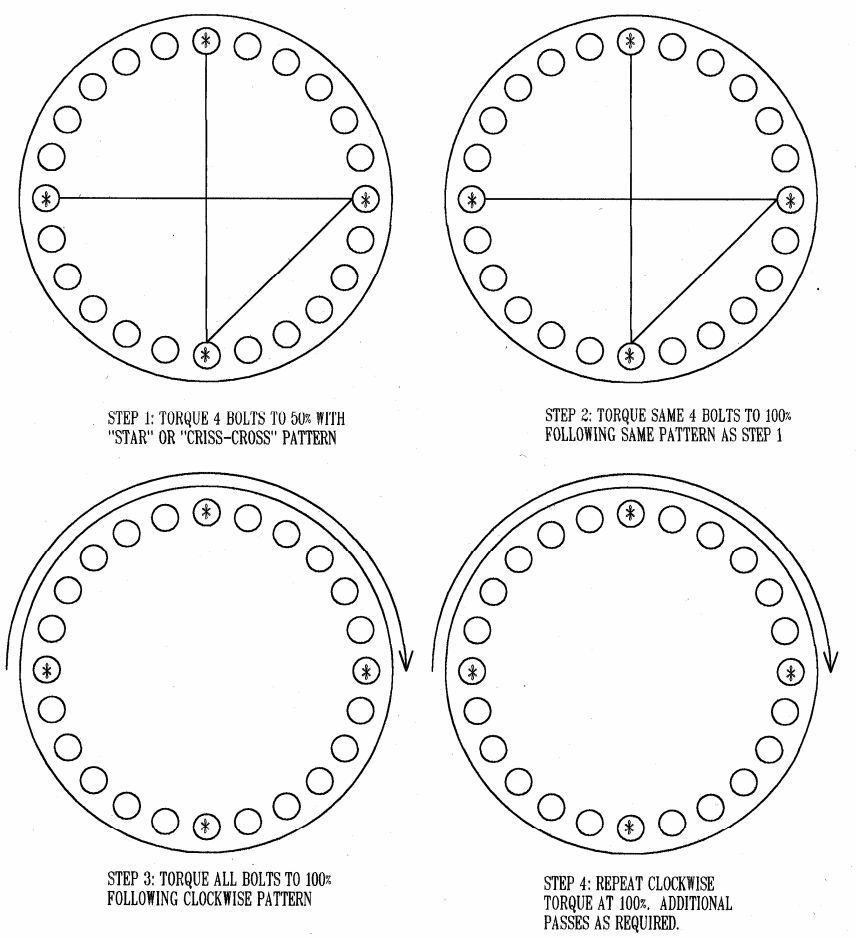
Bolting Procedures and Methods

Procedures and Methods

Methods

Controlled Bolt Torquing (Flanges with 16-30 bolts)

- Apply the torque wrench set at initial value in the “criss-cross” pattern to four (4) equally spaced bolts as follows:
- Round 1: 50% of target torque value
- Round 2: 100% of target torque value
- Round 3: 2 complete clockwise passes at 100% of target torque value for all flange bolts.
- Verify that the flange gap is uniform after each pass.

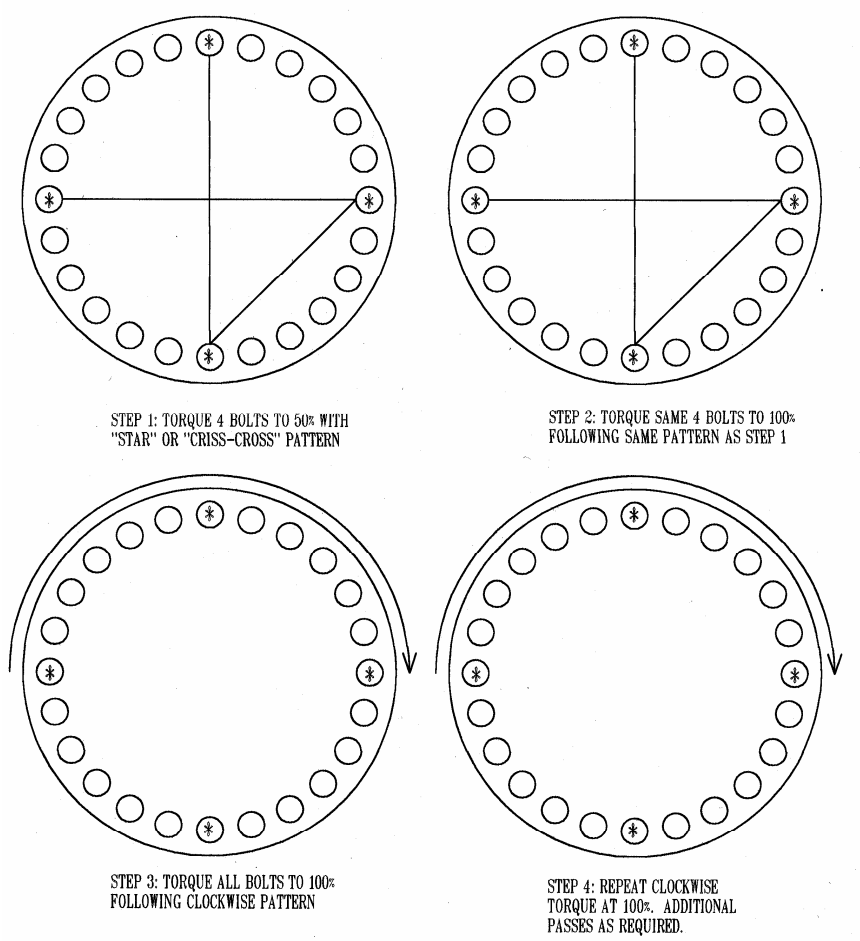


Procedures and Methods

Methods

Controlled Bolt Torquing (Flanges with 32+ bolts)

- Apply the torque wrench set at initial value in the “criss-cross” pattern to eight (8) equally spaced bolts as follows:
- Round 1: 50% of target torque value
- Round 2: 100% of target torque value
- Round 3: 2 complete clockwise passes at 100% of target torque value for all flange bolts.
- Verify that the flange gap is uniform after each pass.



Procedures and Methods

Methods

Controlled Bolt Torquing (30/70/100 Method/Star Pattern) – acceptable alternative.

•Apply the torque wrench set at initial value in the “criss-cross” pattern as follows:

•Round 1: 30% of target torque value

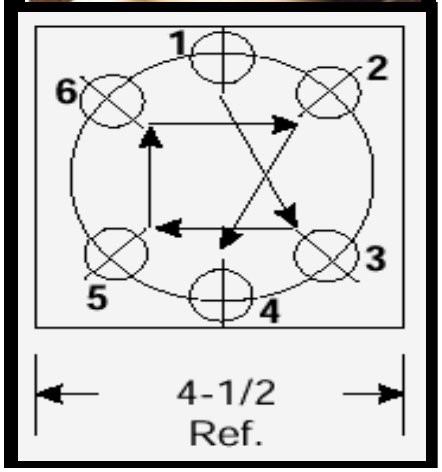
•Round 2: 70% of target torque value

•Round 3: 100% of target torque value

•Verify that the flange gap is uniform after each pass.

•Complete a minimum of 2 more passes rotationally around the flange until 100% of the torque value has been achieved on each bolt.

•This method is acceptable, but much more time consuming than the method detailed earlier in presentation.



Procedures and Methods

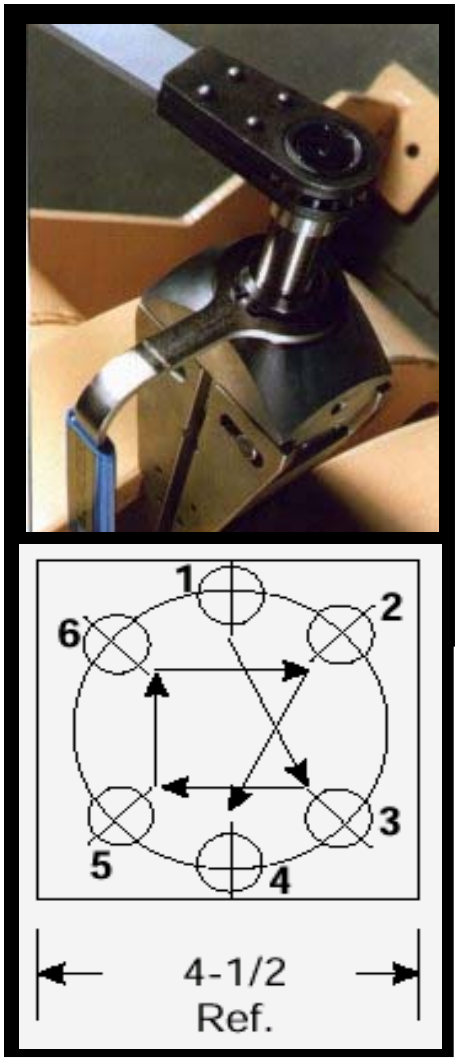
Methods

Controlled Bolt Torquing

•Consideration should be given to verifying the bolt loading 24 hours after the initial joint make-up to compensate for relaxation. Final “hot” torquing or cold re-torquing may also be specified for equipment operating at high temperatures or in cyclic services.

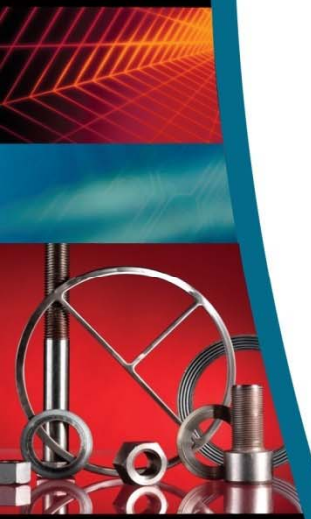
•If this is the case, it should be noted in the job notes and supplied to the field crew.

•This is specially required for bolted joints using sheet gaskets.



Things to Avoid

- Make the gasket wider to increase sealing area
  - Leak Potential Increases due to reduced seating stress
- Wrap graphite tape around the gasket
  - Graphite can improve sealing if applied radially
- Use tape to hold gasket in place
  - adds leak points
- Add nubbins
  - industry experience shows that there is no benefit (actually reduces performance in many cases)
- Gasket materials with high hardness
  - May damage sealing surface or gasket may not compress
- Re-use Gaskets (“Save $$”)
  - Gaskets are cheap, Leaks are expensive



Radial Shear

- Mating flanges on heat exchanger joints most often operate at dissimilar temperatures, particularly in tubesheet joints.
- Differences in radial expansion occur between the mated flange faces.
- This causes a condition where the gasket is forced into a radial shear loading pattern by the flange faces.
- This form of gasket loading can lead to failure in certain gasket types.
- Because of this loading pattern it is necessary to consider the potential effects of radial shear when selecting the gasket style to be used for large diameter heat exchangers

This is a major concern in cyclic services

Available Gasket Styles

- **Dynagraph Corrugated Metal with Flexible Graphite Face**
  - Cost effective with widest application range
  - Only corrugated gasket that uses 1/16” metal core for 1/8” THK gaskets
  - **Only design proven to accommodate cyclic radial shear**
  - Can be difficult to handle
  - Widths of 3/8” and greater currently available
  - Only gasket with corrugated rib design
- **Cam Profile (LeaderCam; Kammprofile; Kamm)**
  - Solid metal core with machined grooves
  - High integrity seal (**not recommended for cyclic applications**)
  - Often selected for HRVOC
  - Easier to handle than corrugated design.
  - Can be reconditioned/reused (be careful...)

Available Gasket Styles

- Spiral Wound
  - High temperature applications
  - Difficult to handle.
  - Requires high sealing stress.

- Solid Metal
  - Common in exchanger floating heads and where narrow gasket width is required.
  - Requires highest sealing stresses

Available Gasket Styles

- Sheet
  - Flex-Graphite, Non-Asbestos, mica, etc.
  - Many do not meet fire safe criteria.
  - Unforgiving in cycling services
  - Not recommended for hazardous/hydrocarbon services

Personnel Training

- Proper Bolting Techniques
- Proper Measuring Techniques
- Proper Gasket Selection
- Pre-turnaround Contractor Training
- In-plant Contractor Training
- Plant Engineering and Inspector Training
- In-plant Maintenance Employee Training
- Gasketing 101

Conclusion

- Leaking equipment is no longer an acceptable part of plant operations, and there are effective methods to achieve leak free operation without replacing older equipment.
- Review of existing gasket and flange data, gasket selection and bolting procedures should be considered the first alternative.
- There is no “silver bullet” solution, but leak free operation is more likely easier than you think.