Bolted Connectors: Re-Torquing to Reduce Fugitive Emissions – When and When Not

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Retorque: Why or Why Not?

• Consequences of Low Operational Bolt Load
• Causes of Low Operational Bolt Load
• Overcoming Operational Bolt Load Losses
  • Gasket Selection/Optimization
  • Joint Design
  • Over-Torquing
  • Optimized Assembly
• Re-Torque
  • When
  • Dwell time after assembly
• Resources/Guidance
Definitions:

RETORQUE:

• Any Subsequent Re-Application Of Bolt Load After Initial Flange Assembly

PURPOSE:

• Re-Establish Assembly or Operating Bolt Loads and Gasket Stresses
Consequences Of Low Operational Bolt Load or Gasket Stress

1. Gasket Blow-Out
2. Visible, Gross Leakage (gasket still intact)
3. Low Operating Margin Against Failure
   - Mechanical Integrity
   - Equipment Reliability
   - Safety
   - Environmental
4. Excessive Emissions, Permeation, External Corrosion
### Excessive Emissions with Reduced Bolt Load

Comparison of PTFE Gaskets - NPS 3 x 150 flanges at 50psig using Relaxation @300°F per HOBTC Graphs

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<tr>
<td></td>
<td>Tp</td>
<td>Kg/yr</td>
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<td>18951</td>
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<td>695</td>
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Causes of Low Operational Bolt Load:

1) Bolt Load Losses From Gasket Changes:

- **Gasket Creep**
  - Example: PTFE gaskets

- **Settling/Compaction of Gaskets**
  - Example: Compressed NonAsbestos (CNA), Spiral Wound gaskets

- **Thermal/Aging Degradation of Gaskets**
  - Example: Elastomer, CNA, Flexible Graphite gaskets
Causes of Low Operational Bolt Load:

2) Bolt Load Losses Due to Piping or Joint Design and/or System Operating Losses:

- PTFE liner and HDPE Flange/Liner Creep
- Soft Joint Piping Thermal Expansion Effects from Additional Gasket Compression
- Short Effective Bolt Length
  - Tapped Bolt Holes
  - Minimal Assembly Elongation
- Rigid (stiff) Flanged Joint
  - B16.47 Series A (stiff) vs. Series B (flexible)
  - Stiff flanges more susceptible to bolt load loss
Causes of Low Operational Bolt Load:

3) Equipment with Known Low Gasket Assembly Stress / Marginally Available Bolt Load

- Limited assembly bolt load
  - Stainless steel bolts
  - Glass lined steel flanges
- Weak flanges
  - FRP
  - Lap Joint flanges
- Under-Bolted Flanges
  - Hinged Manways
  - Many Appendix 2 Designed Flanges
- Full Face Gaskets
Causes of Low Operational Bolt Load:

4) Questionable / Undocumented Assembly Practices / Torque Values

- Elastic interaction
- Questionable skills/capabilities of assembly crews
- Impact wrench assembly
- Unlubricated fasteners
- Used or damaged fasteners
- Unknown or undocumented assembly torque levels
- Unknown or undocumented assembly patterns/procedures/tools
Causes of Low Operational Bolt Load:

5) Joint Design:

- Pressure Energized Manways/Drum Doors
- Operational pressure supplies significant additional gasket compression
- Assembly bolt load is completely lost
Summary: Causes Of Low Operational Bolt Load or Gasket Stress

1. Gasket Creep (ex. PTFE), Liner Creep (ex. PTFE/PE), Flange Creep (ex. HDPE)
2. Gasket Settling/Compaction (PTFE, CNA, Flexible Graphite, Spiral Wound
3. Gasket Degradation (thickness loss) – CNA, Flexible Graphite @ T > 600°F
4. Hydrostatic Unloading of Gasket (larger diameter connections, high pressure)
5. System Pressure Energized Compression of Gasket (Drum Doors/Internal sealing Manways)
6. Piping System Thermal Expansion (Spiral Wound Gaskets)
7. Poor Assembly Practice/Guidance
8. In-Adequate Assembly Load or Gasket Stress (FRP, Glass Lined, Hinged Manways, etc.)
9. Low Assembly bolt load or bolt strain
Overcoming Operational Bolt Load Loss (without a Re-Torque)

Gasket Selection / Optimization

Joint Design

Over Shoot Torque

Optimized Assembly
Gasket Selection & Optimization

PTFE Gaskets:
- More creep-resistant material
- Thinner gasket
- Gasket design
  - Reduced area = higher stress
  - Spring inserted = live load

PVRC Project No. 96-12G – Long Duration Mechanical Performance of PTFE Based Gasket Materials

TESTING OF PTFE GASKETS AT 500°F WITH ARLA FIXTURE
Gasket Stress vs Time

Gasket Stress, psi

Initial loading
Reload
Expanded PTFE
30% drop
1st six months of continuous exposure
60% drop
2nd six months of continuous exposure
60% drop
80% drop

Skived filled PTFE

Exposure Time, hours

4/3/2018
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Figure 7 HOBT tests on VSP Loadlock 1/8 in thick for class 150 lb

Stress Loss at 300F
Bolted Connectors: Re-Torquing to Reduce Fugitive Emissions – When and When Not
Gasket Selection & Optimization:

Compressed Non-Asbestos (CNA) Fiber Gaskets:

- Thinner seals better
- 250°F Maximum Temperature

Thermal Degradation Of The Rubber Binder Creates Porosity and Stress Relaxation

**Example:**

“High Temp” CNA

Steam Pressure Aging @ 320 °C

40 Days Exposure:

Gasket Stress
44 MPa – 31 MPa = 30% Loss

Steam Pressure
180 Bar – 15 Bar
Flexible Graphite (FG) and Corrugated Metal Graphite-faced Gaskets:

- 600°F Maximum temperature
- Specify Oxidation Inhibited FG
- Failure Mode is Oxidation @ T >600°F (for a 5yr life)
**Flanged Joint Arrangements / Design:**

Hard Joint = Metal to Metal contact

Soft Joint = No metal to metal contact (soft gasket between)

**Hard Joints are Less Susceptible to Load Loss**

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**Soft Joints with Sheet Gaskets:**
- Subject to creep, degradation, bolt load loss
- Belleville washers for more flexibility

**Hard Joints w/SW with Inner and Outer Rings:**
- IF Fully Compressed During Assembly, otherwise can further compress
- Cammprofile
Deliberate Overshoot Torque:

Knowing there will be Bolt Load Loss from Gasket Creep, Settling/Compaction, and Operational Lossess….

- Compensate for Expected Losses by Increasing Initial Assembly Load
- Within the Flange and Bolting Allowable Stresses at Operating Conditions
- FEA/Flange Analysis is Often Required
  - Gasket Maximum Stress
  - Flange Maximum Stress
  - Bolting Maximum Stress
Consider PTFE Relaxation with Temperature:

- Blow-Out, Increased Leakage: If Residual Stress Too Low
- Higher Assembly Bolt Loads Shifts The Relaxation Curve Up
- Cycles To Ambient
Optimize Assembly:

• Overcome Flange Bolt Interactions (“Cross Talk”)
• Achieves Target Assembly Bolt Load
• Use Slower Assembly
  • 5 (or more) passes instead of 3
  • Multiple final rotational passes
• Recoup Gasket Creep Losses During Assembly Process
  • (Retorque During Assembly)
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Bolt Load Distribution During Assembly

NPS 4 Class 900, Weld-Neck Flange

100% Bolt Load Not Achieved Until 3 Final Circular Passes

Load after 3 Star Pattern Passes

Load after 6 Passes (3 Star + 3 Rotational)

*Bolt #4 data not included due to strain gauge malfunction
Glass Column Body Joint
PTFE Envelope Gasket
300 °F Operation, 6 Month Torque Check
Star-Pattern Assembly, (1) Final Rotational Pass

Assembly Torque = 370 Ft-Lb
Average Residual Torque = 288 Ft-Lb

Retorque Necessary

Note: Initial Torque 370 Ft-Lbs

Bolt Number
Ft - Lbs Torque
Bolt Torque
287.6 Average Torque
Glass Column Body Joint
Expanded PTFE Envelope Gasket
300 °F Operation, 6 Month Torque Check
Star-Pattern Assembly, Multiple Final Rotational Passes

320 Ft-Lb Assembly Torque

Assembly Torque = 320 Ft-Lb
Average Residual Torque = 316 Ft-Lb

Retorque Not Necessary
If Component, Design or Assembly Improvements Are Not Possible:

THEN Re-Torque – Timing Options:

• Ambient Temperature Re-Torque Prior To Start-Up
  • Re-Torque 2 – 24 Hours After Assembly, But Before Start-Up
  • Dwell-time based primarily on GASKET creep properties

• Ambient Temperature Re-Torque After Operation/Process Cycle
  • Re-Torque After Operation/Cycle, While Vessel Is At Ambient Temperature & Pressure

• Start-Up Hot Torque
  • Re-Torque While Vessel Is Coming Up To Temperature
  • Not recommended for PTFE based gaskets

• On-Line Re-Torque (Hot Re-Torque)
  • Re-Torque After Operation, While Vessel Is At Temperature, Preferably At Low or Ambient Pressure
Guidance & Resources:

ASME Post Construction Committee

• PCC-1-2013
  • Section 10.4 Start-Up Re-Torque
  • Appendix B Definitions & Guidance on Hot Bolting, Half Bolting, and Live Tightening

• PCC-2-2015
  • Article 3.10 Hot Bolting (still under development)
  • Note: Hot bolting can also be used to check residual bolt stress after a period of operation or to retighten loose bolts. Hot bolting for these purposes is beyond the scope of PCC-2.

Plastics Pipe Institute

• TN-38 - July 2011 – Bolt torques for Polyethylene flanged joints

Gasket Manufacturer, 3rd Party Test Data

• HOBTC (Hot Blowout with Thermal Cycles) test

BFC Engineering & Component Suppliers