

Joint Failure Prevention Guide



4 Main Causes of Failure in a Bolted Flange Joint Assembly

- ✓ **Installation**-Related Issues
- ✓ **Gasket**-Related Issues
- ✓ **Fastener**-Related Issues
- ✓ **Flange**-Related Issues

Is It Really “Gasket Failure”?

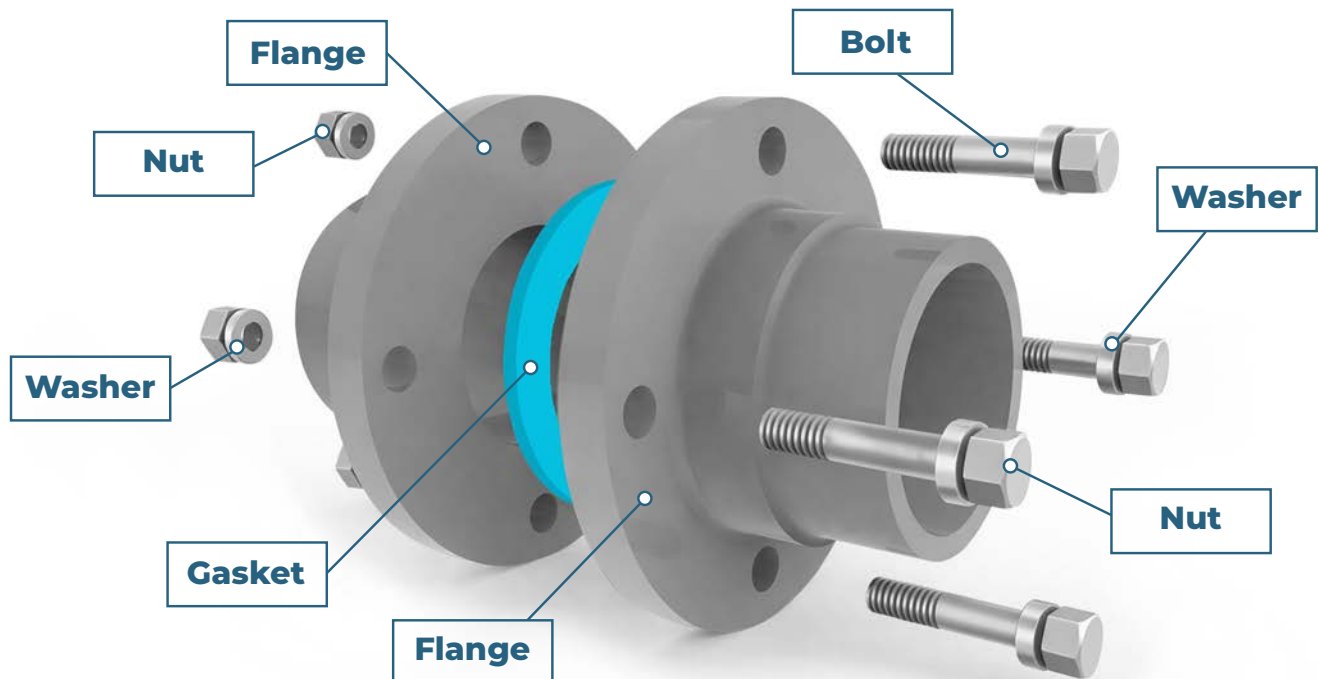
When a bolted flange joint leaks, the instinct is often to blame the gasket. However, modern research shows that leakage is usually the result of system level factors within the bolted flange joint assembly. The bolted flange joint assembly (BFJA) is a **system** made up of multiple interdependent components: the gasket, the flanges, the fasteners, lubrication, and installation practices. Calling every joint leak a “gasket failure” is looking only at the tip of the iceberg, because the performance of the joint depends on the interaction of all the components that make up the assembly.

Independent studies make this clear:

- “Failure analyses show up to 85% of all gasket failures are due to faulty user installation.”— *Pumps&Systems: Prevent Faulty Installation of Bolted Flange Connections*, Apr 2020
- Research on bolted flange assembly shows that external loads and misalignment can lead to flange separation or excessive gasket compression, both of which cause leakage. — *Cornell University: Efficient assembly of bolted joints using numerical FEM*, Nov 2024

The Bolted Flange Joint Assembly

A BFJA can fail due to any of these four reasons: gasket-related, flange-related, fastener-related, or installation-related. This guide addresses each.



Installation-Related Failures

A gasket must be compressed adequately and uniformly to deliver long term, leak free performance. Research shows that most gaskets in service that leak are **under compressed**.

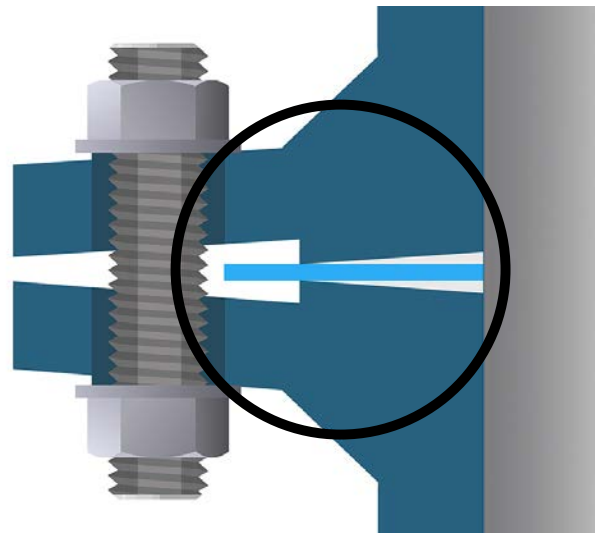
Achieving the correct level of compression is the most controllable factor in joint reliability because the compression should be neither excessive nor insufficient and should be distributed evenly.

Over-Compression

Over-compression occurs when excessive bolt load is applied, damaging the gasket and sometimes the flange itself. It arises in several scenarios:

- Using elastomeric (rubber) gaskets in raised face (RF) flanges, which have low allowable gasket stress limits.
- Rubber gaskets in HDPE RF flanges are also vulnerable to crushing.
- Using sheet/cut gaskets in pressure classes above 300#, where bolt loads exceed the gasket's compressive limit.
- Over-torquing beyond the gasket manufacturer's recommended values.
- FRP (fiberglass) flanges with overly smooth surface finishes can concentrate stress, causing concentric splitting in the gasket.
- Applying liquid surface treatments (thread lube, anti-seize, RTV, grease) directly onto the gasket reduces friction, promotes extrusion, cracking, and performance disruption.
- Spiral wound gaskets (SWGs) without an inner ring are susceptible to inward buckling when they

are over compressed. It's always recommended that spiral wound gaskets be furnished with an inner ring.



The above illustration represents an over-tightening issue that can be observed on certain Class 150 flanges due to their lightweight nature. In the industry, the term "flange rotation" is used to describe this phenomenon, wherein the outer edges of the flange are "rotated" towards each other.

Signs of Over-Compression:

- Soft gaskets: extrusion beyond the flange face, splitting, irregular shape
- Metallic gaskets (SWGs): inward buckling, imprint on the guide ring

Causes:

- Excessive compressive stress (rubber in RF flanges; cut gaskets in Class 300+ flanges)
- Flange surface finish too smooth
- Liquid surface treatments applied to gasket

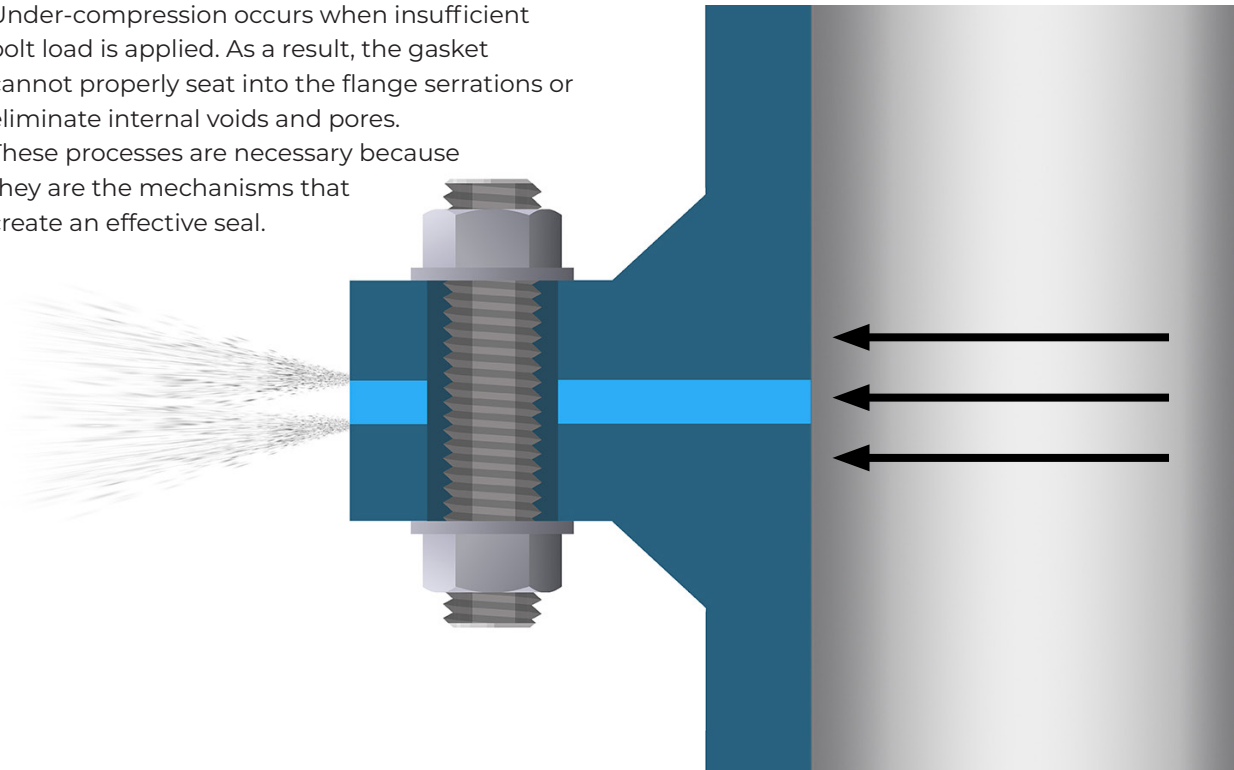
Remedies:

- Follow a plant-wide installation procedure per ASME PCC-1 (use gap tools)
- Calculate torque based on specific gasket material type
- Ensure proper surface finish: serrated face, 125–250 RMS
- Switch to semi-metallic gaskets if needed; always use inner rings with SWGs

Installation-Related Failures

Under-Compression

Under-compression occurs when insufficient bolt load is applied. As a result, the gasket cannot properly seat into the flange serrations or eliminate internal voids and pores. These processes are necessary because they are the mechanisms that create an effective seal.



Signs of Under-Compression:

- Soft gaskets: extrusion beyond the flange face, splitting, irregular shape
- Metallic gaskets (SWGs): inward buckling, imprint on the guide ring

Causes:

- Poor bolting procedures and insufficient torque
- Corroded, yielded, or weak bolting
- Lack of bolt lubrication
- Excessive pipe strain
- Flange misalignment

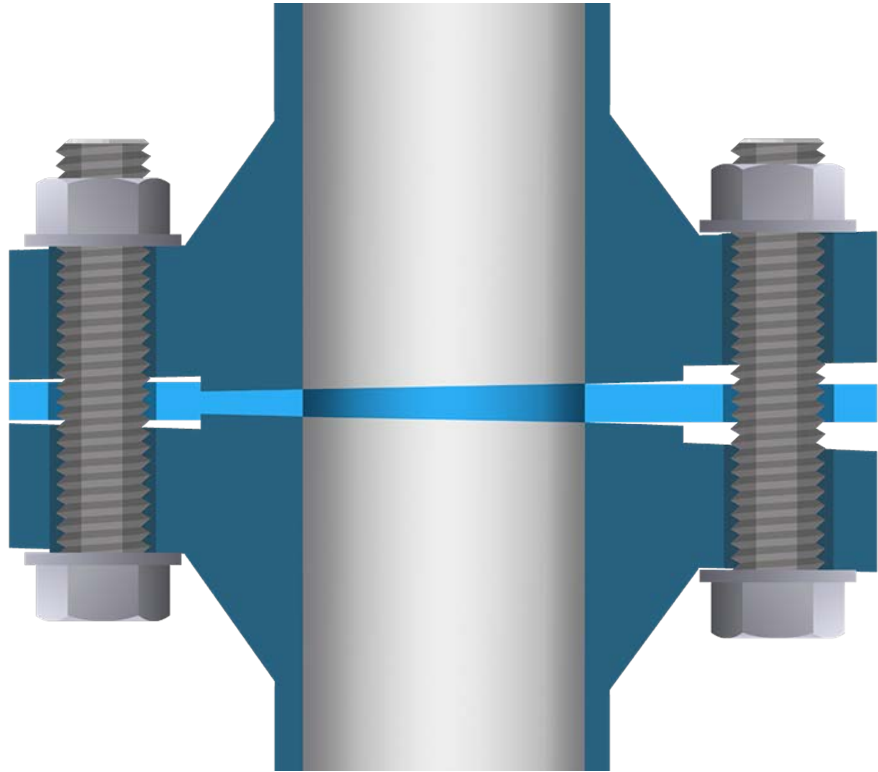
Remedies:

- Follow proper gasket installation procedure
- Use a thinner gasket to achieve adequate seating stress at available bolt load
- Inspect and verify bolt condition before installation
- Eliminate flange misalignment; add expansion joints where needed

Installation-Related Failures

Uneven Compression/Blowout

Uneven compression occurs when the bolt load is not distributed uniformly around the flange. This typically happens because the bolts were not tightened using a proper cross-pattern and staged approach. As a result, one side of the gasket may become over-compressed while the opposite side remains under-compressed. The under-compressed area then becomes the path of least resistance, and a blowout occurs from that side.



Signs of Uneven-Compression/Blowout:

- Measurable differences in gasket thickness from one side to the other
- Uneven flange serration impressions around the gasket face
- Stress cracks localized to one side of the gasket

Causes:

- Uneven bolt loading (no staged cross-pattern tightening)
- Gasket thickness too great relative to available bolt load

Remedies:

- Use a proper multi-pass gasket installation procedure
- Use gap tools during each tightening round
- Decrease gasket contact area to increase seating stress
- Use thinner gaskets
- Never reuse a gasket

Gasket-Related Failures

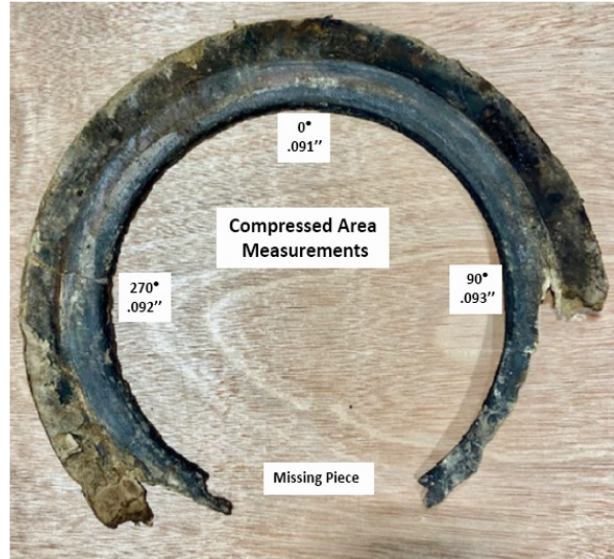
Wrong Product/Cyclic Conditions

Even with proper installation, the wrong gasket for the service will eventually fail.

Signs of Embrittlement

Compressed non-asbestos (CNA) sheet gaskets are widely used, but they are not appropriate for all services. In applications with cyclic temperature conditions, the rubber binder in CNA materials can dry out. This drying occurs not only because of the process media or sustained temperature, but also because temperature fluctuations accelerate binder degradation and lead to embrittlement.

If process piping is subject to cyclic conditions, semi-metallic style gaskets (CFG, spiral wound, Durtec, etc.) are recommended.



Smelter

- Process Gas: SO₃ (sulfur trioxide) which is incompatible with D8300. D8300 failed after 18 months of service.



- Process Temperature: ~220 °C
- Gasket Purpose: Manway sealing

Gasket-Related Failures

Chemical Attack

Chemical compatibility is not simply a binary pass or fail check based only on the primary gasket material. Compatibility must be verified for every component of the gasket, including binders, fillers, and facing materials, against each constituent of the process media. In addition, the rate of chemical reactions increases as temperature rises, meaning that a material that may be marginally

acceptable at ambient conditions can fail quickly when exposed to elevated process temperatures.

Chemical compatibility of each gasket material is affected by:

- Process temperature
- Fluid composition
- Fluid concentration



- Storage Tank Gasket
- 14 Years in Service
- 2" 150#
- Sulfuric Acid 96%

Signs of Chemical Attack:

- Gasket cracking or becoming brittle
- Softening of material
- Tearing
- Missing material or erosion
- Uneven discoloration of gasket face

Causes:

- Wrong gasket material selected for the service

Remedies:

- Verify full chemical compatibility using the Durlon Gasket Manual (all components, not just primary material)
- Use visual aids in the storeroom to identify the correct gasket for each service
- Consider gasket consolidation to reduce selection errors
- Eliminate flange imperfections per ASME PCC-1

Fastener-Related Failures

Fasteners are often overlooked in joint failure analysis, yet they are the primary load-generating element in the system. Problems with threaded fasteners arise from:

- Insufficient preload - bolts not tensioned adequately during installation
- Self-loosening - vibration in service causes bolt load relaxation over time
- Tensile overload - bolts stretched beyond yield during installation
- Fatigue - cyclic loading causing progressive bolt failure
- Galling - thread damage during assembly, especially in stainless fasteners
- Thread stripping - damaged threads unable to sustain load
- Service temperature incompatibility - using bolt grades not rated for the operating temperature causes a major drop in yield strength and in-service bolt load loss



- Improper bolt storage - corrosion and hydrogen embrittlement from poor storage conditions
- Mixed bolt grades on a single flange - uneven elastic behavior creates uneven gasket load
- Wrong bolt size for the bolt hole - oversized or undersized bolts relative to the flange hole compromise load path and alignment
- Most notably - human error



Flange-Related Failures

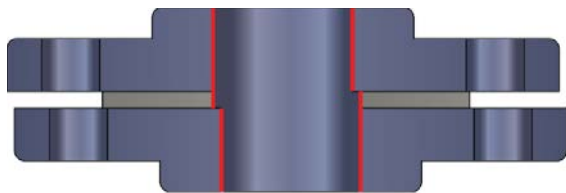
Flange Surface Issues

The flange face must be in the right condition to allow the gasket to seat properly. Common flange-related problems include:

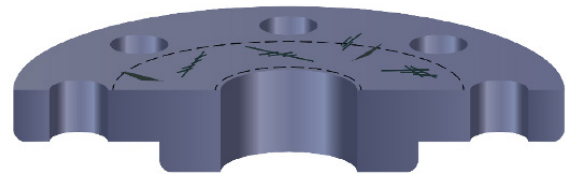
- Surface imperfections - pitting, gouges, or radial scratches that create leak paths across the gasket face
- Surface waviness - a non-flat flange face that prevents uniform gasket contact
- Flange flatness deviation - global out-of-flatness across the flange face, concentrating gasket

- stress in some areas and leaving others unseated
- Misaligned flanges - angular or lateral offset creates a non-parallel gap, making uniform bolt loading and gasket compression impossible

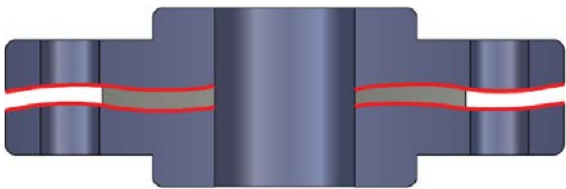
Remedy approach: Inspect, clean, and measure flange faces before installation. Follow ASME PCC-1 acceptance criteria for surface condition and flatness.



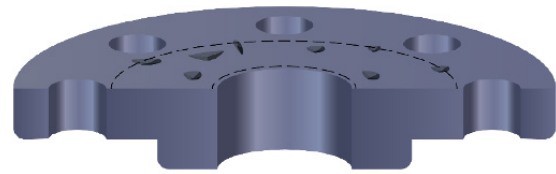
Misaligned Flanges



Flange Surface Imperfections



Flange Surface Waviness



Flange Surface Imperfections

Gasket-Flange Incompatibility

Not every gasket type is appropriate for every flange type. A common and damaging mismatch is using spiral wound gaskets (SWGs) in slip-on flanges.

On slip-on (SO) flanges, the raised face contact area is reduced by the thickness of the pipe wall. The inner edge of the raised face is encroached upon by the pipe bore. As a result, the spiral wound gasket's windings and or inner rings can extend beyond the sealing face and protrude into

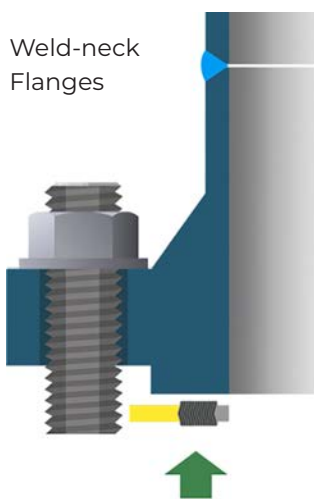
the flow stream, which can cause issues such as gasket damage, turbulence in the flow, or reduced sealing performance.:

- Loss of inner ring support and gasket integrity
- Cupped or deformed inner diameter on the SWG
- Flow disruption and potential process contamination

This is covered under ASME B16.20, which specifies acceptable flange and gasket combinations.

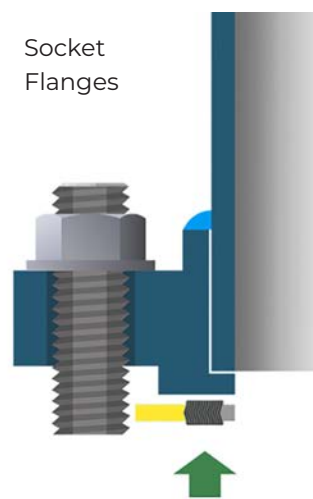
Flange-Related Failures

Gasket-Flange Incompatibility



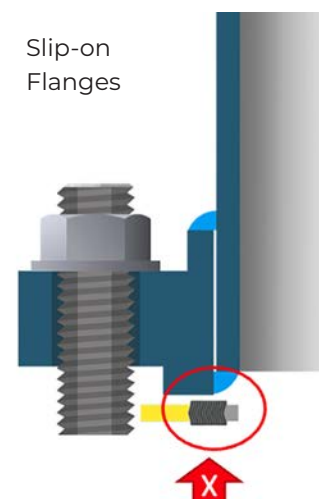
Weld-neck
Flanges

Full raised face flange
contact area



Socket
Flanges

Full raised face flange
contact area



Slip-on
Flanges

Raised face flange contact area is
reduced by the pipe wall thickness

Signs of Flange-Related Failures:

- Cupped ID visible on removed SWG

Causes:

- Wrong gasket type selected for the flange style

Remedies:

- Verify flange type before specifying gasket
- Consult ASME B16.20 for acceptable flange-gasket combinations
- For slip-on and socket-weld flanges, consider cut gaskets or semi-metallic alternatives (Durtec, Kammprofile, CFG)



Joint Failure Prevention Guide

Most BFJA failures are preventable. By focusing on proper installation, correct gasket material selection, correct size and proper storage of fasteners, and flange surface awareness, you can significantly improve reliability and reduce downtime.

Quick Prevention Checklist

- ✓ Select correct gasket material (media, temperature, pressure, cyclic conditions)
- ✓ Fully verify chemical compatibility for all gasket components and all media elements
- ✓ Verify flange surface finish, flatness, and alignment before installation
- ✓ Confirm correct gasket type for the specific flange style
- ✓ Verify fasteners are inspected, correctly sized, graded for service temperature, and properly stored
- ✓ Confirm proper torque is applied in staged, cross-pattern sequence using calibrated tools
- ✓ Follow ASME PCC-1 installation guidelines
- ✓ Never reuse gaskets

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