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Troubleshooting Fluid Sealing in Pump Systems for Safety and Reliability

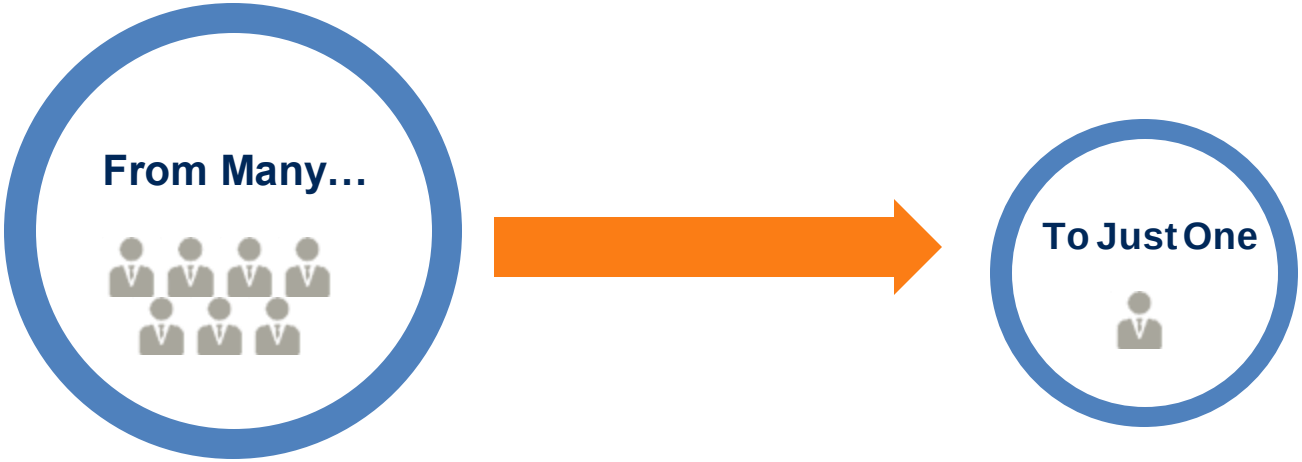
Leaders in Sealing Integrity

Introduction

- Partnering to create a cleaner and safer world
- We understand the frustrations with servicing our industry where the minimizing downtime and costs in industrial plants seem to be driving every decision.
- We have seen through our global applications engineering team that fluid sealing failures seem to one of the most frustrating experiences and wanted to share some insights we have learned.

Introduction

Reliability Engineers are now responsible for a lot more pieces of equipment or areas of the plant than in the past.



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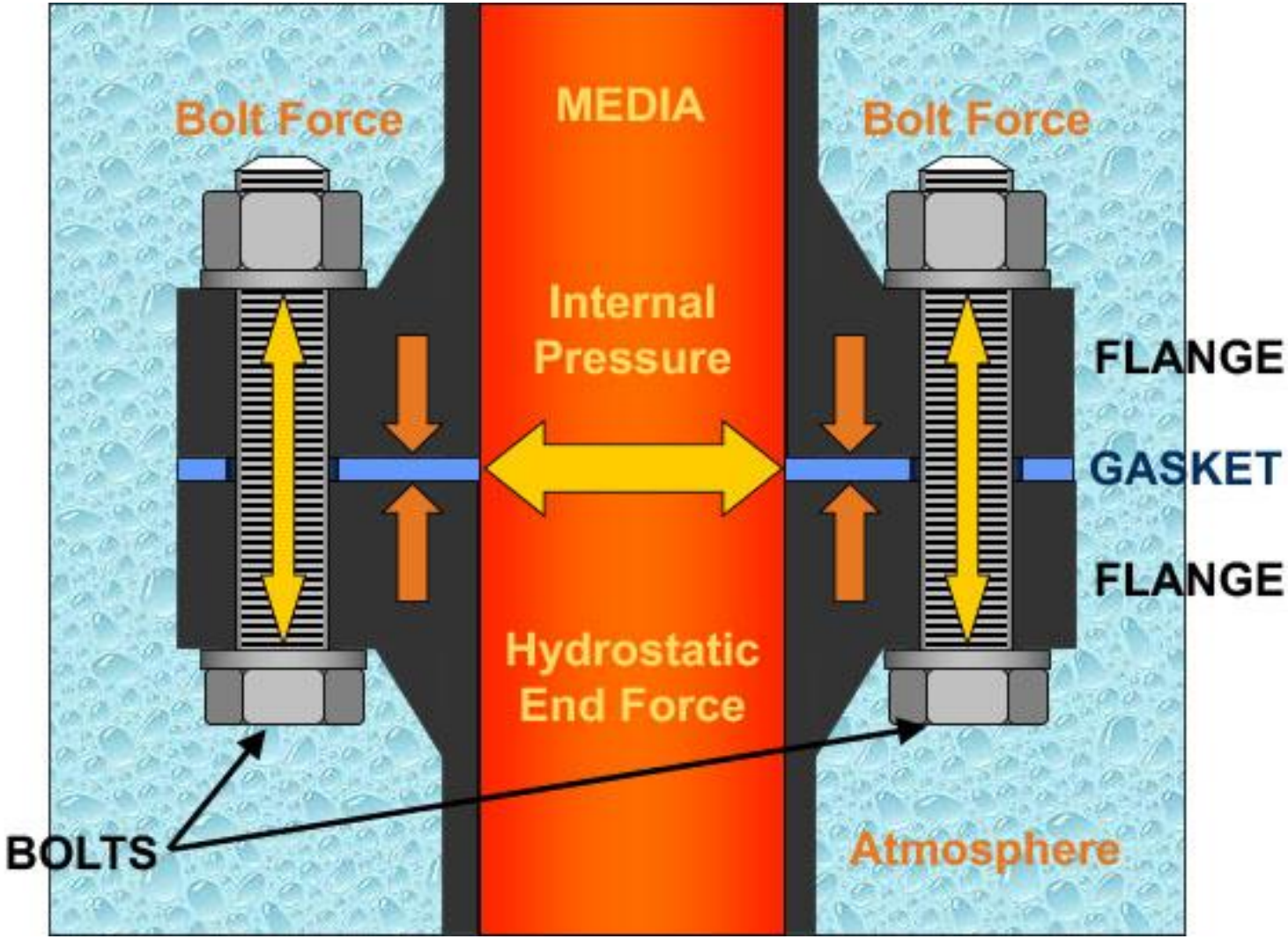
Forces Acting on a Gasketed Joint



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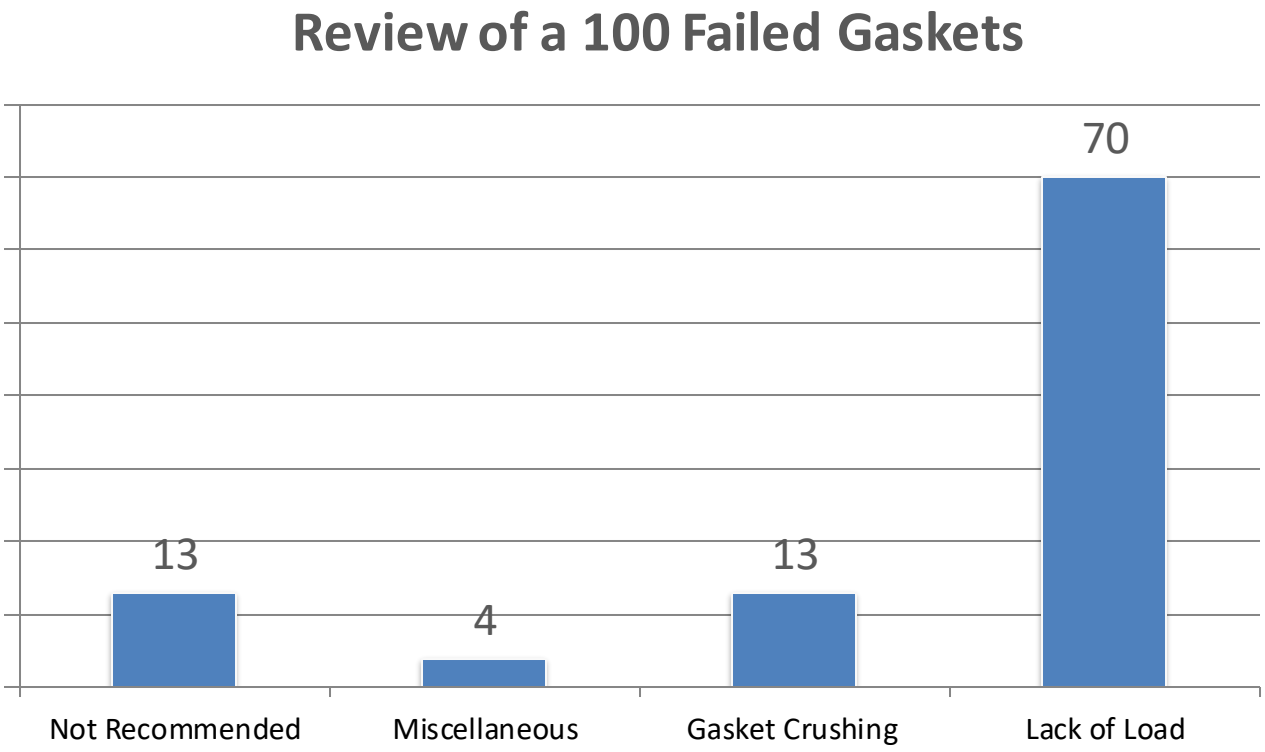
Gasket Failure Analysis



83% of Failures were due to Installation Errors

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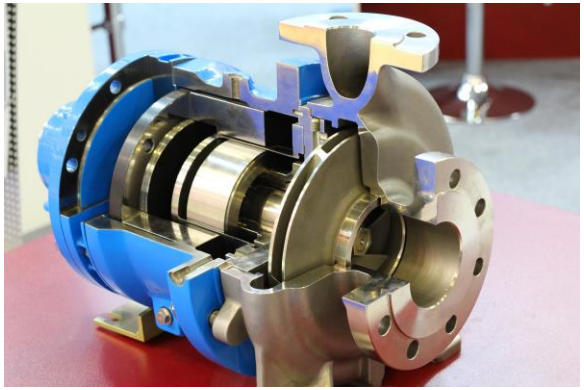
Gasket Failure Analysis

- Gaskets located either at either face of the pump inlet/outlet along with any flange to flange connection in the pump system
- Around pump flanges there are many possible failure modes
  - Gasket Blow-out
  - Chemical Attack
  - Erosion
  - Crush
  - Under compression
- Some failure modes can be hard to identify or be confused with others



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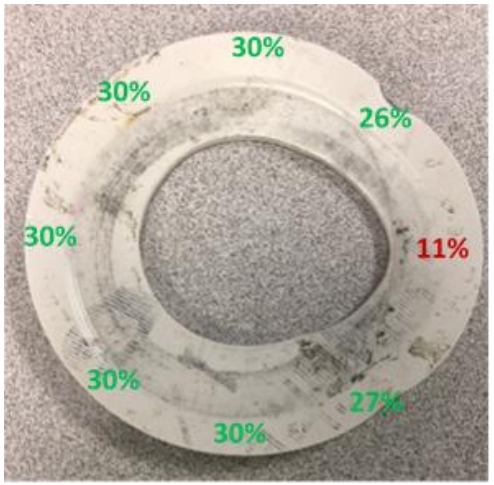
Gasket Failure Analysis – Blow-out

- Gasket blow-out is probably the most common gasket failure and has the most causes
- Identification: Usually most of the gasket remains in place and either part of the gasket is pushed out past the sealing area (egg shaped), sections missing, or split and gasket open

Gasket Failure Analysis – Blow-out

Causes & Mitigation

- Under-compression of the gasket
  - Will discuss this in later slides
- Uneven compression of the gasket/Rocking of the flange
  - Ensure proper installation procedure to bring flanges down evenly, rocking of flange more common in smaller flanges
- Pump dead heads
  - Avoid this occurring, not much can stop the gasket from blowing out if this is the cause
- Media freezes and expands
  - Pressure builds as ice expands–heat tracing to ensure solids do not build up when media is located in freezing situations
- Gasket not suitable for pressure
  - Review pressure rating for material and determine if torque/stress appropriate for pressure rating
- Pump turned on too quickly
  - Add a pressure regulator or increase pressure ramp uptime if that is possible



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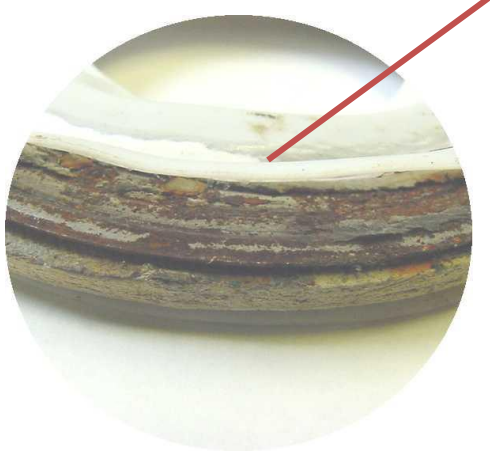
Gasket Failure Analysis – Chemical attack

Identification

- Gasket frayed or missing (jagged) at ID where gasket in contact with media
- Extremely soft or disintegrated appearance

Causes & Mitigation

- Gasket is not compatible with the media
  - Ensure that the components of the gasket are suitable for contact with media –consult chemist or chemical textbook
  - Ensure concentration or temperature does not adversely affect gasket or components of gasket



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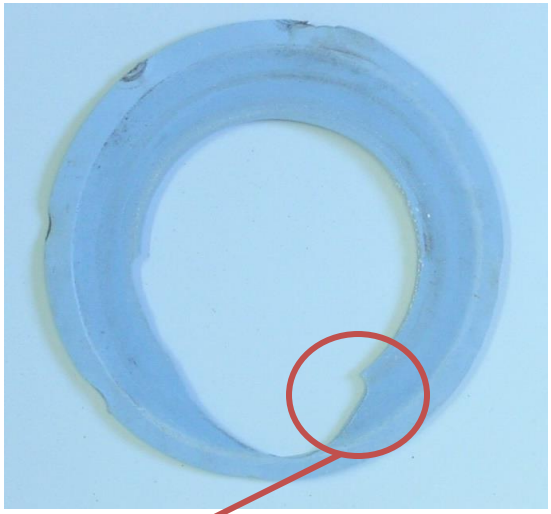
Gasket Failure Analysis – Erosion

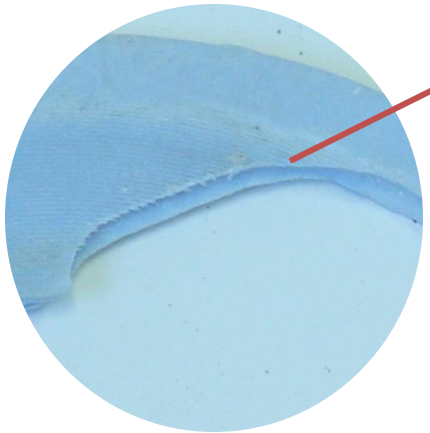
Identification

- » Gasket missing at ID (smooth cut away)

Causes & Mitigation

- » Media is highly abrasive – high solids
- » Abrasiveness is worse due to turbulent flow – near 90degree turn or outlet of pump
  - » Upgrade to a materials with better abrasion resistance – such as HNBR for rubber or PTFE for sheet materials
  - » Use thinner gasket and/or more highly compressible material – less height exposure to media and less likely to be eroded





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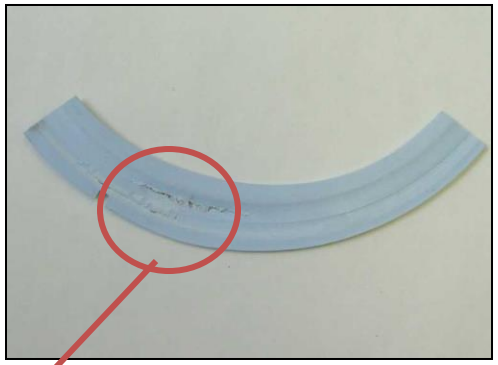
Gasket Failure Analysis – Crush

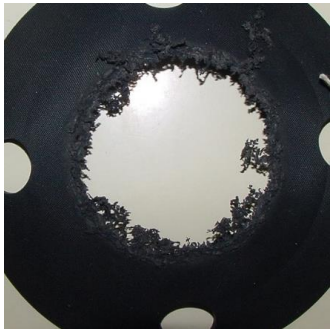
Identification

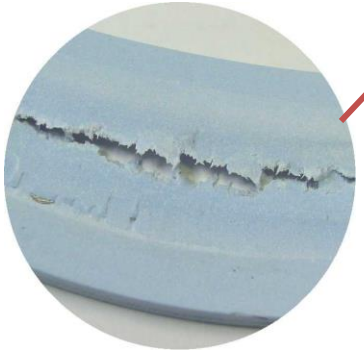
- » Gasket is cracked or split in concentric fashion
- » Rubber gaskets may be shredded at ID
- » Possibly liquid present on gasket (shiny)

Causes & Mitigation

- » Gasket is not suitable for flange facing
  - » Eg. rubber gaskets used in raised face flanges – switch to higher crush material
- » Liquid sealant or anti-stick was applied to surface of gasket
  - » Do not use liquid on gasket surface – ensure dry and oil free before installation
  - » If gasket removal a concern upgrade to more anti-stick material such as PTFE or graphite, or use dry anti-stick coating







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Gasket Failure Analysis – Under compression

Identification

- » No to little notable compression on gasket
- » possibly blown out

Causes & Mitigation

- » Bolts are not strong enough
  - » Ensure bolts are proper strength to achieve a reliable seal based on material. Harder materials and higher pressures will typically require more stress and stronger bolts
- » Lubricant/torque wrench are not used
  - » Lubricant on bolts/threads – 2x-3x efficiency of torque
  - » Using a calibrated torque wrench at a predetermined/calculated torque for material
- » Torque limited due to flange material –Brittle or Plastic
  - » Flanges such as PVC/CPVC usually require a low load gasket (options out there) or rubber. Cast iron may or may not seal fiber/ptfe if torque is limited.

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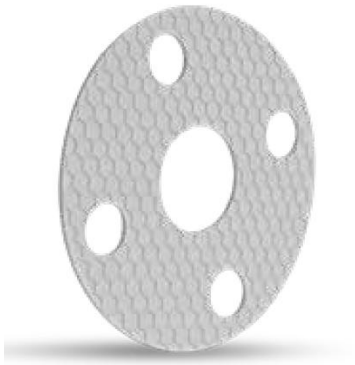
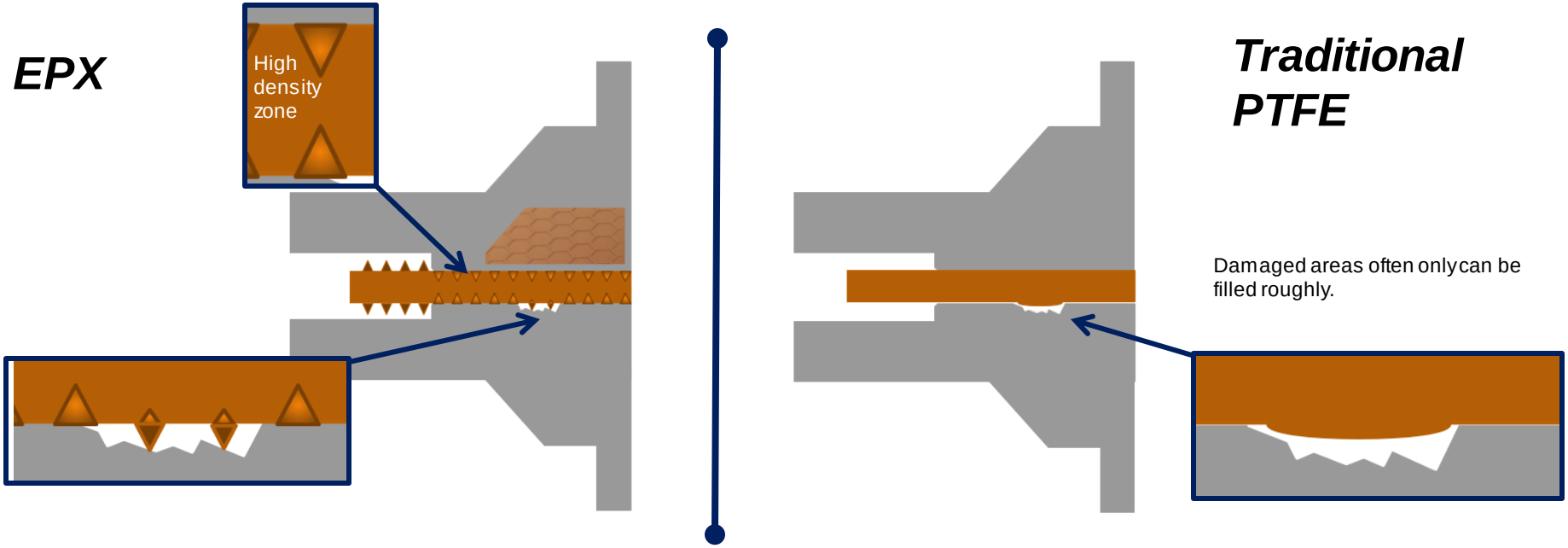
Gasket Problem Solver- 3510 EPX

- Same chemical resistance as 3510 for strong caustics
- Hex face pattern to reduce area –increase stress concentrations
- Increased compressibility over traditional PTFEs
- Better blowout resistance





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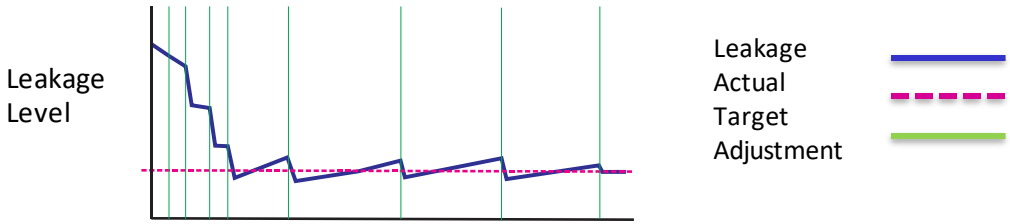
Compression Packing

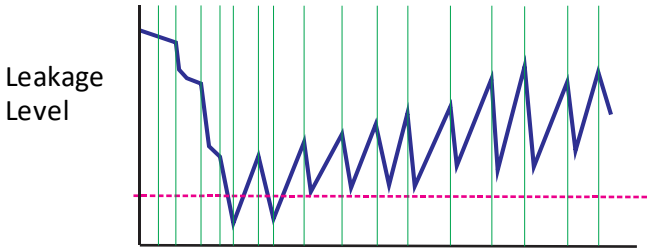
Leaders in Sealing Integrity

Troubleshooting and Failure Analysis of Pumps with Packing

Standard Procedure

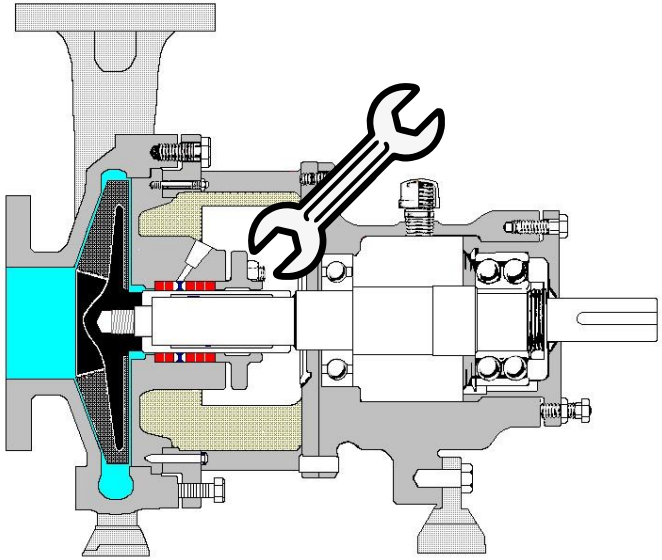
Adjusting the gland (compression packing) > desired leakage level outboard





Problem with <u>either or a combination of</u>,

the packing, the pump and the system.



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Troubleshooting – Compression Packing

People : What do they know?

» Operator
» Installer
» Maintenance personnel
» Process engineer

Running equipment and system Anomalies:

Observations that can only be done when up and running:

» Vibrations
» Grinding
» Fluctuations
» Smell
» Smoke

Failure Definition:

» Excessive leakage?
» Overheating?
» High rate of flush water consumption?
» Excessive friction load?
» Blowout?
» Chronic seal failures in this application ?
» OR, was this an unexpected event?
» Were there any changes to the seal material, the equipment, or the overall process that preceded the failure?
» Were there any system upsets or cleaning cycles that preceded the failure?
» Can you describe the installation procedure?

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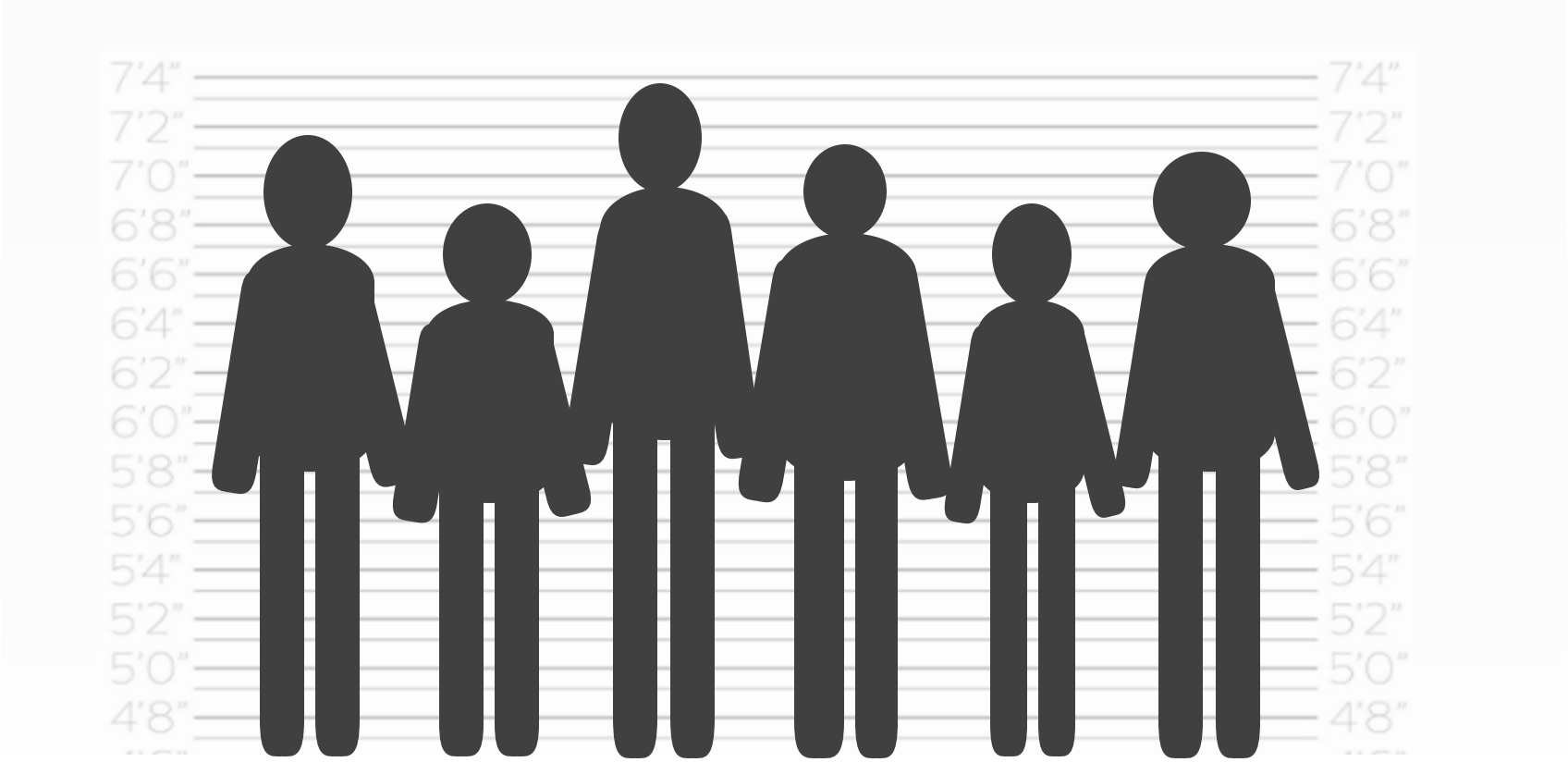
Troubleshooting – Compression Packing

The usual suspects



Over Tightening | **Excessive Speed** | **Abrasive Wear** | **Excessive Heat** | **Chemical Attack** | **Improper Installation**

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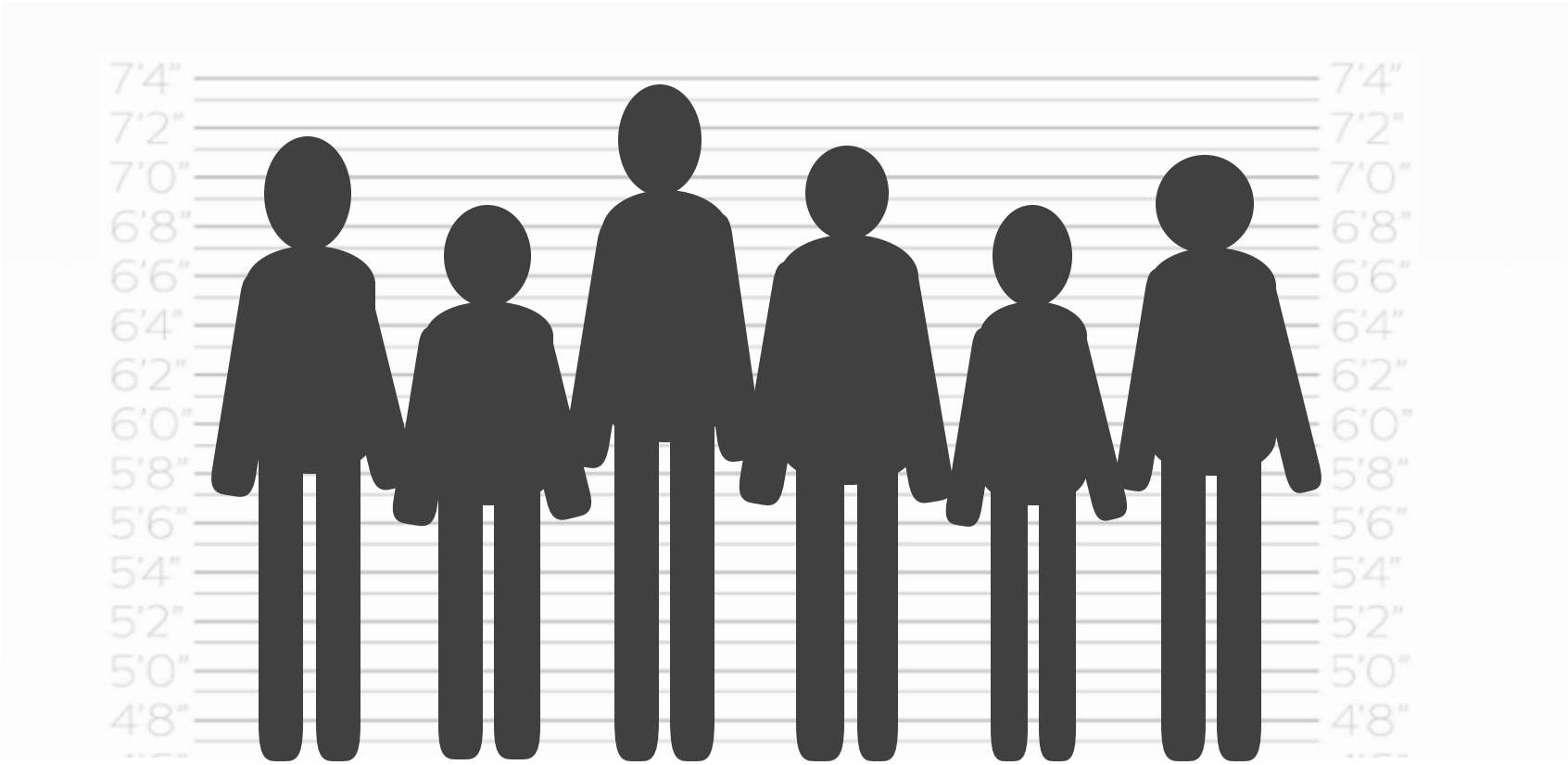
Troubleshooting – Compression Packing



Over Tightening | Excessive Speed | Abrasive Wear | Excessive Heat | Chemical Attack | Improper Installation

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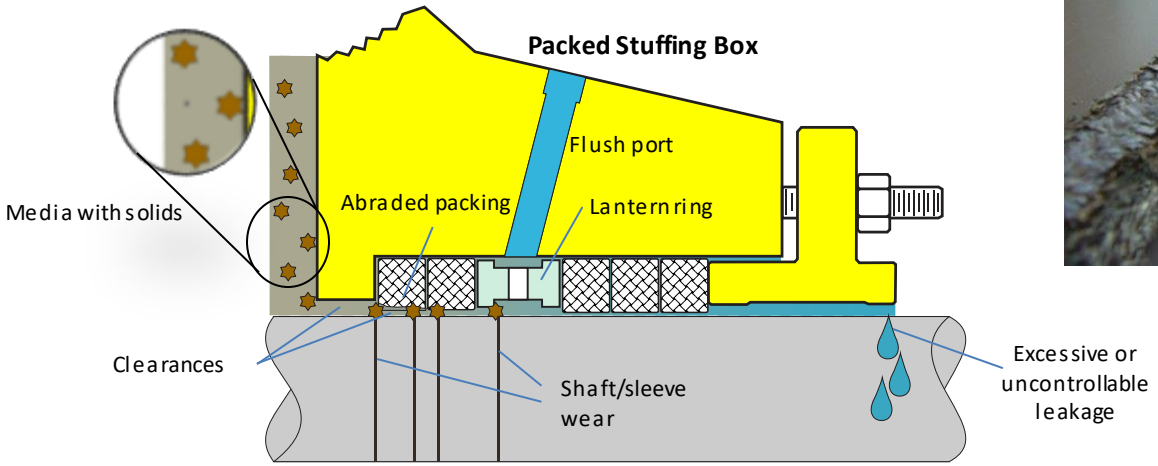
Abrasive Wear

Occurrence:

» Abrasives in media enter the stuffing box getting inside the packing, in between the shaft sleeve and the packing

  » Generating wear on both packing and sleeve, thus increasing the clearance and leakage.



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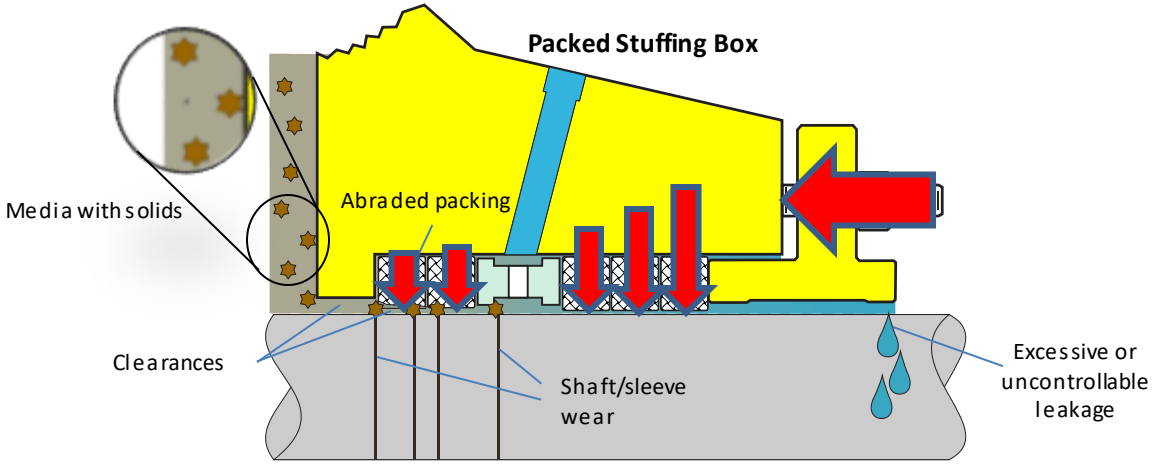
Abrasive Wear

Occurrence:

- Abrasives in media enter the stuffing box getting inside the packing, in between the shaft sleeve and the packing
  - Generating wear on both packing and sleeve, thus increasing the clearance and leakage.
  - Re-tightening the gland to reduce the leakage might make things worse.



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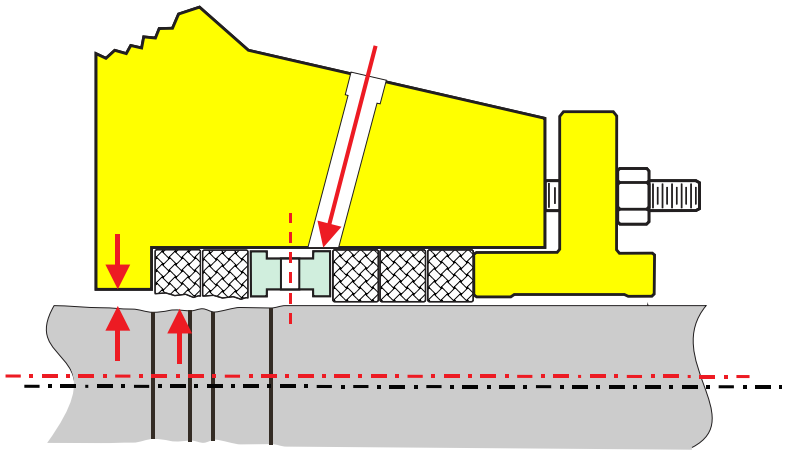
Abrasive Wear

Troubleshooting:

- » Equipment condition
  - » Replace worn parts
  - » Clearances
  - » Alignment
  - » Flush working properly
    - » Fluid
    - » Pressure



Abraded packing

Damaged sleeve

Excessive leakage

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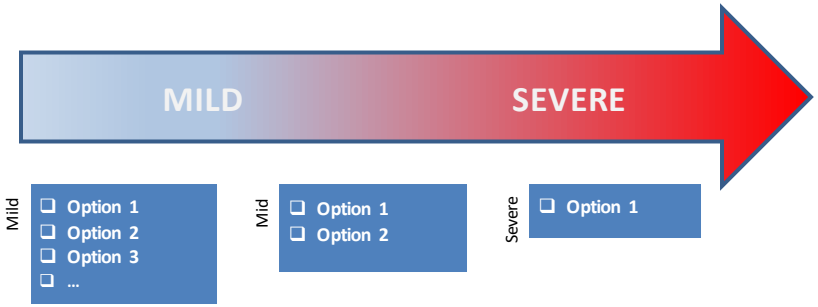
Abrasive Wear

» Media Abrasiveness & Chemical Compatibility



» Packing Selection

» Abrasive Resistance

	Flexible Graphite	PTFE (virgin)	P-Aramid	Carbon fiber
Abrasive	0	2	9	7
Heat	9	1	3	8
Speed	9	2	4	8
Creep	4	1	9	9
Sealing ability	9	7	4	7
Note	Clean media only In some cases, flush might not be required	Last resort only for Chemical resistance	Need hardened sleeve to match	Not all created equal - Fit

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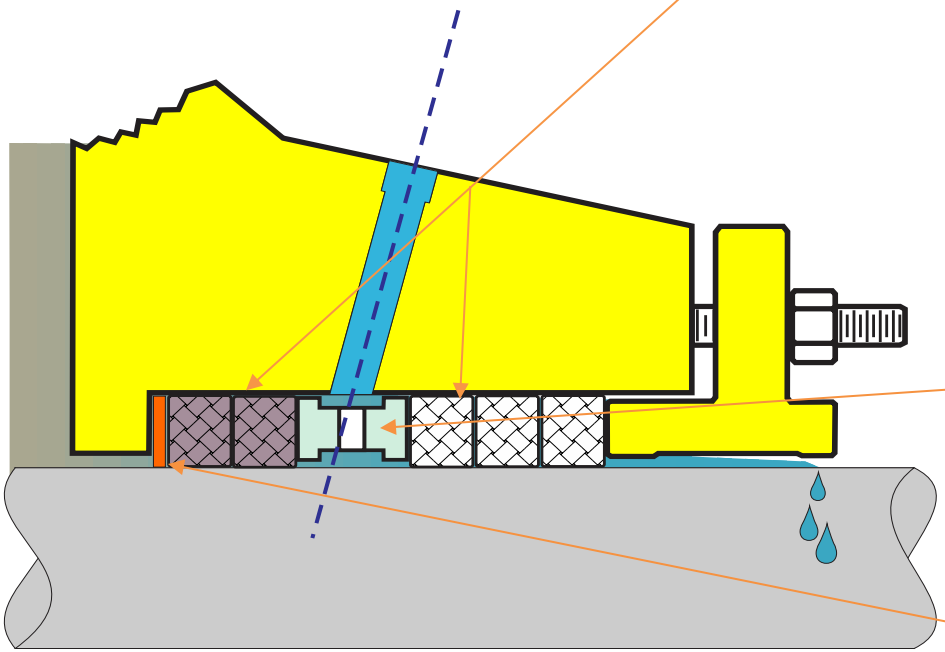
Abrasive Wear

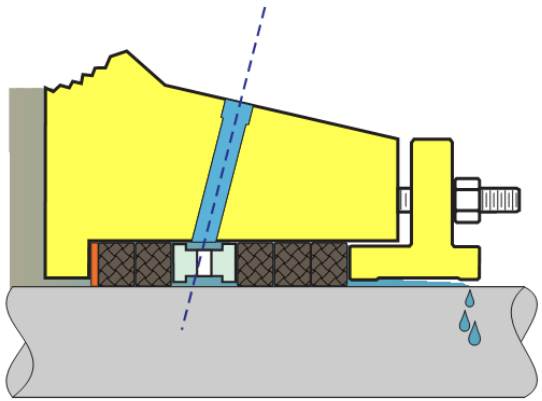


Packing
Style selection
  Fit
  Design

Lantern ring – Flush alignment

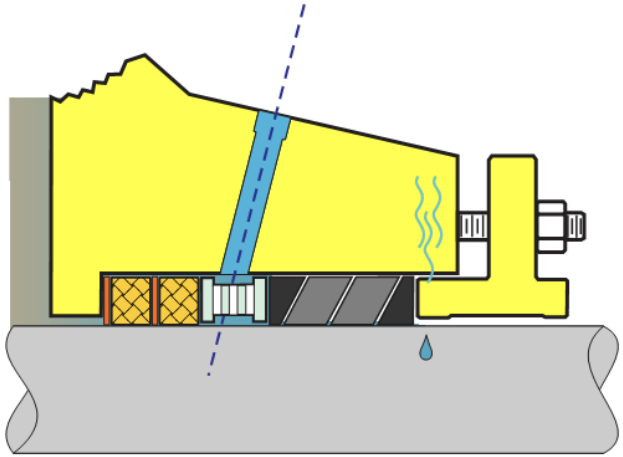
Excluder ring

Abrasive Wear



High Solid and Abrasives
Option =
Wear control
Caustic resistance

Style 98/GYLON 3510 Ring Set



Low Solid Option
= **Water conservation**
Leakage control

8091 – Hydra-Just Set

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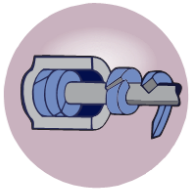
Abrasive wear

Packing Installation Basics

Design, dimensions, components

- » Stuffing box
  - » Clean (old packing all removed)
  - » Good condition – Flat bottom
- » Clearances
- » Flush - Flow and pressure

- » Install and sit each component individually and in the correct order, staggering the seam
- » Lantern ring – alignment
- » Apply gland load evenly – gland nut finger tight



Start-up:

1. Flush
2. System

Gland Adjustments

- » Proportionate to leakage
- » Leakage stable before re-adjusting

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Expansion Joints

Leaders in Sealing Integrity

Standard Design

Tube

- » Protects body from media
- » Critically important to be compatible with pipe media

Body

- » Fabric - Provides strength and flexibility for pressure
- » Metal - Provides strength for vacuum

Cover

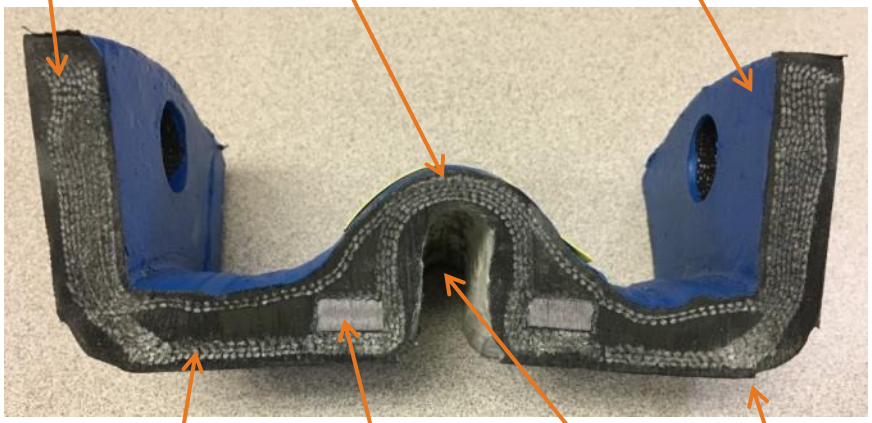
- » Protects body from mechanical and environmental damage

Arch

- » Allows for movement; can be filled to prevent solids entrapment

Flange

- » Provides sealing surface without use of a gasket



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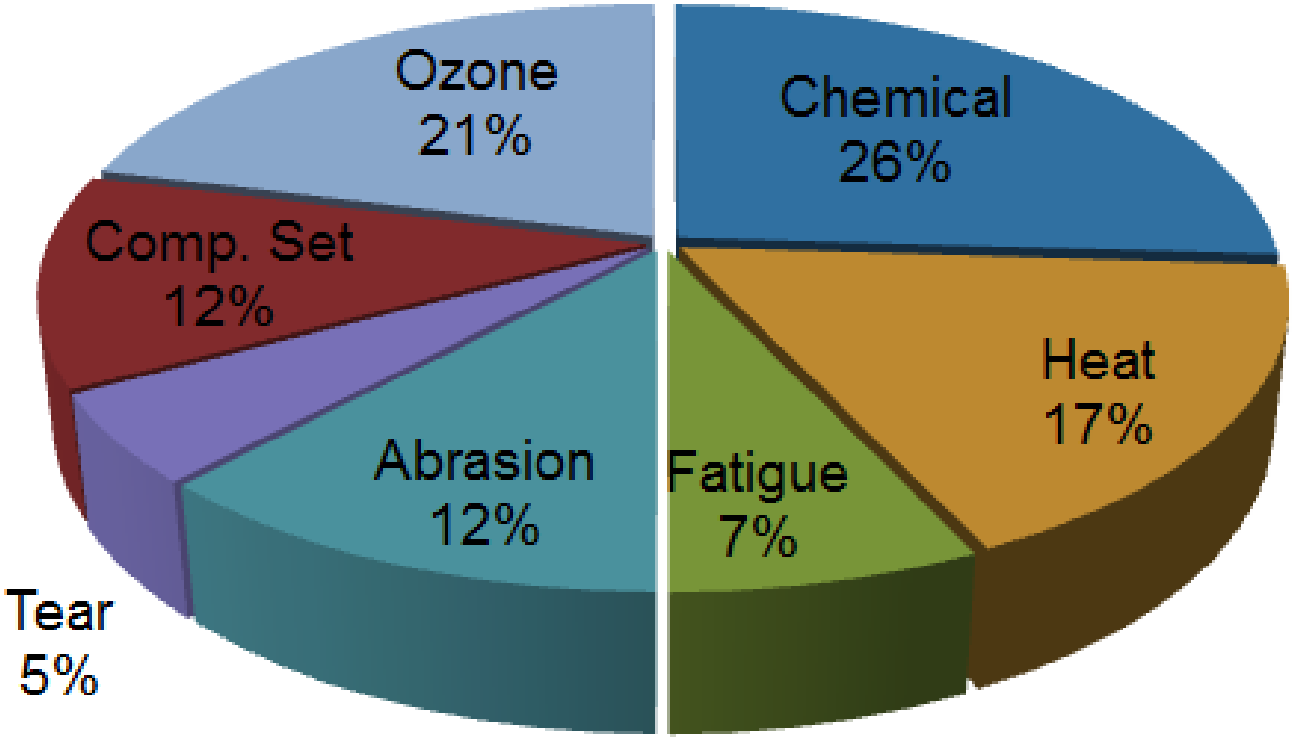
Reasons for Failure

Common Service Related Causes of Failure



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Insufficient Torque on Installation

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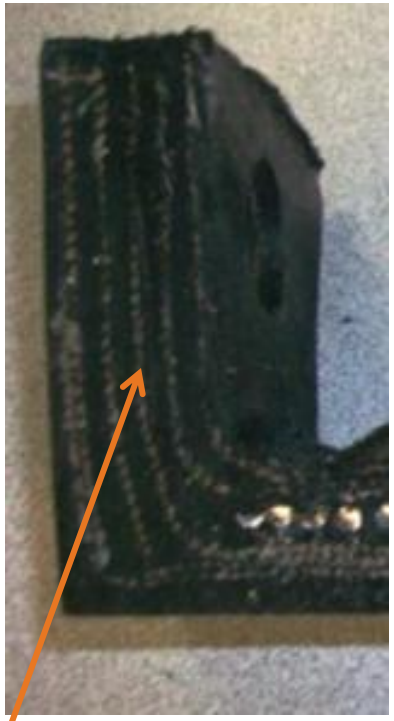
Design Considerations



Multiple Plies in Flange

- » Increase Sealability
- » Reduce Bolt Load Creep

Very Little Fabric

- » Poor Sealability
- » Rubber Creeps and Bolts Loosen

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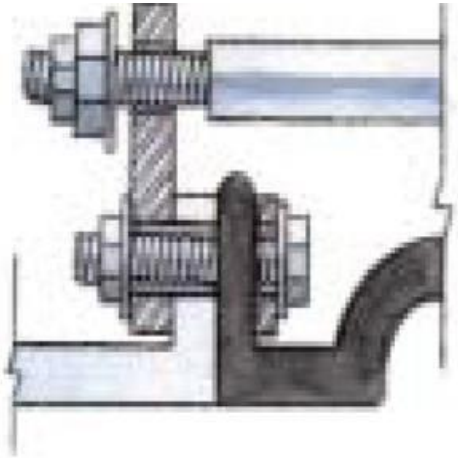
Installation

Step 1 – Insert bolts with washers through retaining rings on the arched side of the expansion joint and then through to the mating flanges in a cross pattern. (Where there is not enough room for a bolt, **fully threaded rod** can be used with nut on each end. All thread past the nut on arched side should be kept to a minimum.)

Step 2 – Attach and tighten nuts (with washers) until hand tight.

Step 3 – Torque each bolt to full torque with the cross-bolt pattern until the outside edge of the expansion joint flange bulges slightly. Recommended torque specifications are available at Garlock.com.

NOTE: Check bolt tightness within 1-2 weeks after installation and periodically thereafter to ensure the seal is maintained.



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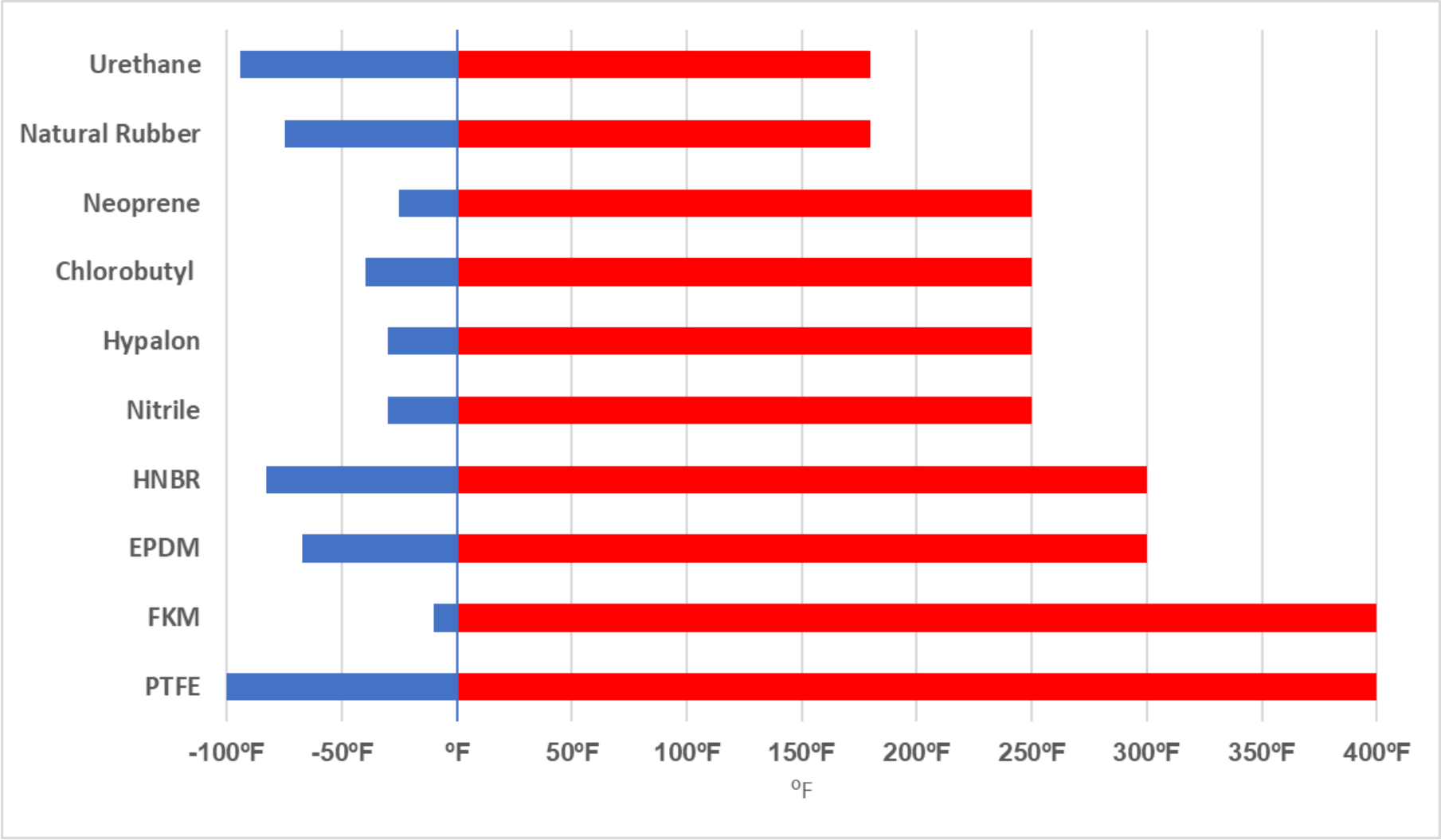
Excess Temperature

Common Temperature Ranges of Rubber



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Safety Considerations

- The closer the material is to the temperature limit, the faster it degrades
- Temperature ratings are subjective
- No industry standard to set temperature limits
- Vary from manufacturers and between different compounds
  - Cure systems, polymer grades, and formulations all effect actual performance

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How to Specify

- Minimum - ASTM D2000 Call Out:
  - Typical properties of elastomers from Fluid Sealing Association: FSA-PSJ-703-19

M2BA 607 A13 Z1 Z2

Grade 2 Material + Heat resistance, Test Method D573, 70 h at 70°C: = Max change in hardness, ±15 points
Max change in tensile strength, ±30%
Max change in ultimate elongation, -50%

- Preferred
  - ASTM D573 - 04(2019) - Standard Test Method for Rubber—Deterioration in an Air Oven
    - Create specifications for actual values, not change in value
    - Use longer time spans than 70 h

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Weathering/Aging

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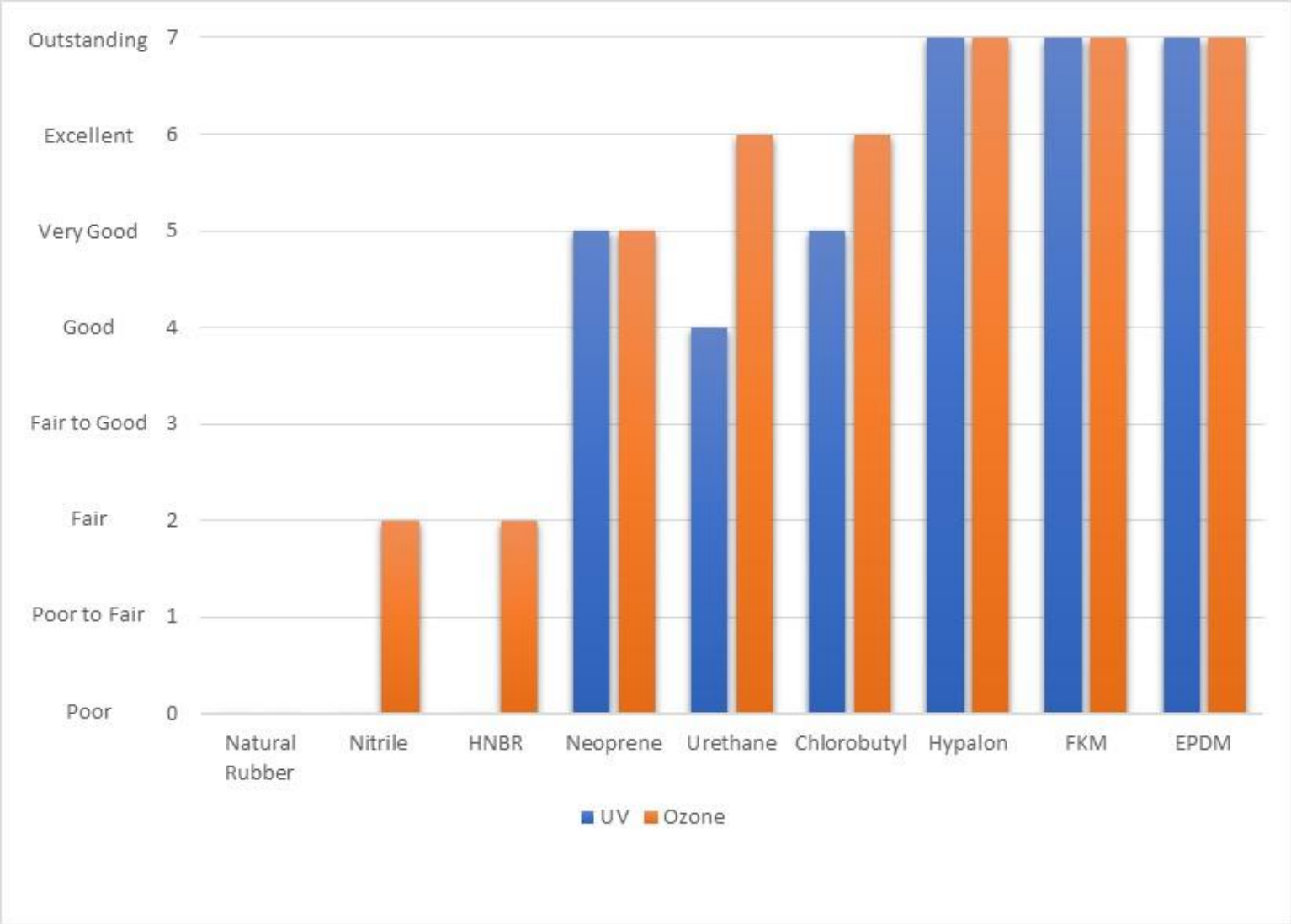
Common Resistance to UV & Ozone



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How to Specify

- Typical properties of elastomers from Fluid Sealing Association: FSA-PSJ-703-19
  - **DOES NOT INCLUDE OZONE STANDARDS**

- Preferred
  - ASTM D1171-18, Standard Test Method for Rubber Deterioration—Surface Ozone Cracking Outdoors
    - Exposure Method B
    - Result: Pass

  - Summary: Rubber is exposed for 70hr at 40+/- 1°C (104 +/- 2°F) at an ozone level of 50 +/- 5 mPa partial ozone. Rubber is viewed under 2x magnification and no cracks shall be permitted

Insufficient Vacuum Support

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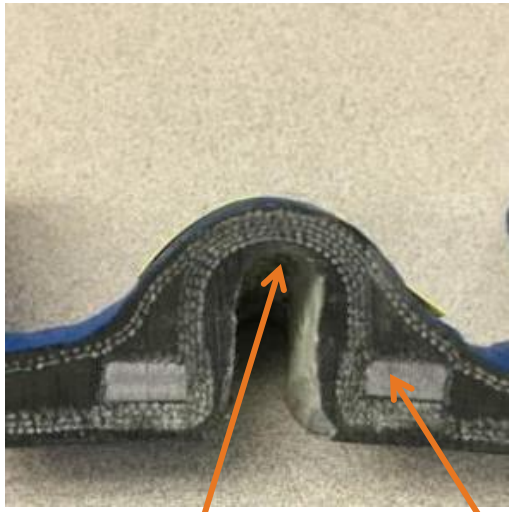
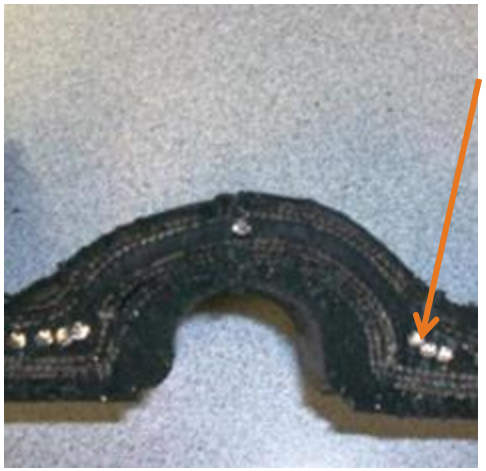
Design Considerations





Wire Reinforcement

- » Lower Strength than Body Rings
- » Higher chance of vacuum inversion

Metal Body Rings

- » Improve strength
- » Reduce chance of vacuum inversion
- » Tied into arch to prevent migration

Multiple Plies in Arch

- » Improve strength
- » Reduce chance of vacuum inversion

Joint Type

- » Wide arches are more geometrically susceptible to collapse due to vacuum forces

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Preventative Maintenance & Reliability Service

Garlock Expansion Joints

Expansion Joint Inspections

- All expansion joint manufacturers recommend a periodic inspection of rubber expansion joints as part of an effective reliability and preventative maintenance program.
- Average frequency is annually but can be less or more based on severity of service.
- Unlike most system components, rubber expansion joints exhibit obvious outward signs of deterioration.
- While these characteristics may be obvious during visual inspection, it can be difficult for untrained personnel to judge the severity of the deterioration.

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Proven Success

PMR Service

Pulp and Paper Mill - Southeastern US

Size: 1.5” - 48” ID
Temperature: 70°F - 250°F
Application: Various throughout mill
Media: Water, pulp, black/white liquor, bleach, and CLO2
Pressure: Vacuum to 200psi

OBSERVATION:
After the inspection, 3 expansion joints failed, and all were marked in Garlock’s inspection as “Replace” but were not replaced during the next outage. The last joint that failed resulted in a flooded administration building floor with 4 feet of pulp.

SOLUTION AND BENEFITS
A sense of urgency is now in place and a reliability engineer has asked Garlock to write the spec for all rubber expansion joint. Now, all rubber expansion joints for this mill are spec'd Garlock. Replacement recommendations are now accepted with high priority.

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PMR Service Benefits

Inspect

Garlock can help FREE OF CHARGE

Plan

When replacements are planned, the correct expansion joint can be ordered for the application.

Optimize

With proper fit and materials, expansion joints last longer.

Don’t pull the black one off the shelf

Operate Failure Free

Garlock

We're Here to Help

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Thank you!

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