A COLLABORATIVE APPROACH TO ACHIEVING A GAS-TIGHT SEAL USING EXPANDED POLYTETRAFLUORETHYLENE (ePTFE) GASKETS IN FIBERGLASS-REINFORCED PLASTIC (FRP) FLANGES

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Presented by John Czerwinski
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  - Filtration Felts

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  - Sealing Gaskets
  - Medical Patches

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  - Dielectric Materials
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  - Vents

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  - Microwave Cable Assemblies

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SUMMARY

• This is a case study of successful collaboration between an end user, a gasket manufacturer and a manufacturer of FRP Pipe/Flanges.

• The goal was to achieve a gas tight (T3) seal in aggressive chemical applications that require high reliability and conformance to ever stringent emissions standards.
FLANGES AND GASKETS USED TODAY

- Flat Faced FRP Flanges
  - Fragile
  - Low Recommended Bolt Loads
    - Elastomeric Gaskets Typically Recommended
      » Limited in Chemical Resistance
    - PTFE Gaskets Have Broad Chemical Resistance but Require Higher Loads to Seal
  - Ring Gaskets in Flat Faced Flanges Can Seal but Cause Bending Moments, Flange Rotation and Increased Hub Stress
FLANGES AND GASKETS USED TODAY

- These Challenges can be Addressed by Using Stub & Ring Flanges, also known as Lap Joint Flanges
  - Relatively Stronger
  - Reduces Bending Moments/Flange Rotation
  - Higher Bolt Loads
  - Reduced Sealing Surface Area Compared to Flat Faced Flanges Result in Higher Gasket Stress
  - Enables the use of GORE® Universal Pipe Gasket (Style 800), chemically inert expanded PTFE Gaskets*

*Test Gasket – GORE® UPG Gasket (made of ePTFE)
FILLED PTFE AND ePTFE GASKET

• PTFE Gaskets
  – Filled PTFE and Virgin PTFE Gasket Options
  – Typically require >2.5 times the maximum recommended load for FRP flanges to achieve a reliable seal

• Test Gasket - GORE® Universal Pipe Gasket (made of ePTFE)
  – Requires 800 psi gasket stress to achieve a T3 seal in FRP applications.
GASKET LOAD/STRESS ANALYSIS

Flat Faced Versus Stub & Ring Flange - T3 Seal Requirement

- Flange Load Required to Generate 800 psi Gasket Stress in Test Gasket
- Maximum Recommended Flange Load

<table>
<thead>
<tr>
<th>FLANGE TYPE</th>
<th>LOAD, lbf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat Faced</td>
<td>25000</td>
</tr>
<tr>
<td>Typical Stub &amp; Ring</td>
<td>10000</td>
</tr>
</tbody>
</table>

The graph shows the load required for flat faced and typical stub & ring flanges to generate 800 psi gasket stress, with the maximum recommended flange load indicated for both types.
STUB & RING FLANGE SPOOLS

• Two Class 150#, 3” Spool Pieces
• Glass Fiber with Engineered Glass to Fiber Ratio
• Concerns of Corrosion & Over Torquing Ruled Out Metal Backing Rings
• FRP Backing Rings
  – Engineered Glass-to-Fiber Ratio Resulted in High Strength
  – Superior Corrosion Resistance
  – Matching Size of Flange and Gasket Lowers Bending Moments
• ePTFE Test Gasket – GORE® Universal Pipe Gasket (Style 800)

Stub & Ring Flange w/ Test Gasket
TEST ASSEMBLY

- Two Class 150# NPS 3 Stub & Ring Flanges
- Use of Calibrated Bolts – Eliminates Use of Empirical Constants and Related Equations
- Average Bolt Stretch – 70 microns to Achieve 4493 lbf/bolt (max. load recommended by flange manufacturer)
- Bolting Procedure – Star Pattern, in 3 Increments,
  - no re-torque
EXPERIMENTS

• Flange Surface Characterization
  – Fuji Pressure paper
  – Topaq Imaging System
  – Accuracy +/- 2%

• Hydrostatic Leak Test
  – Tested Up to 225 psi Internal Pressure at Various Gasket Loads
EXPERIMENTS

• Nitrogen Leak Test
  – Tested at 100 psi (7 bar) Internal Pressure at Various Gasket Loads

• System Relaxation
  – Characterize System Relaxation Over Time With No Re-Torques
RESULTS – FLANGE SURFACE CHARACTERIZATION

- Stress Distribution on Flange Surface
  - Pressure Paper: Average Stress – 2,275 psi (15,686 Kpa)
    Min 1350 psi (higher than the 800 psi required for the test gasket)
  - Ruler Test: Observed Drawback of 0.0025” is Less than Typically Seen in Such Flanges (+/-0.030”)
RESULTS – HYDROSTATIC LEAK

• Seals at 33% of Maximum Recommended Load at 225 psi Internal Pressure
RESULTS – NITROGEN LEAK

• Test Gasket Achieved a T3 Seal at 25% of Max Recommended Load at 100 psi Nitrogen Internal Pressure
RESULTS – SYSTEM RELAXATION

• No Re-Torques Between Measurements, Ambient Conditions
• Loaded to Maximum Recommended Load of 17,793 lbf (79.95 KN)
• Maximum Relaxation – 14% over 17 hours
• Retained Load is 15,456 lbf.
RESULTS DISCUSSION & CONCLUSIONS

- Hydro test Leak Passed at 5,991 lbf (26.65 KN). This provides a design margin of 61% after accounting for system relaxation.
- Nitrogen Leak Passed at 4494 lbf (20 KN). This provides a design margin of 71% after accounting for system relaxation.
- These design margins would be higher if the bolts were re-torqued.
- Successfully demonstrated the benefits of collaborative approach between an End User, a Gasket Manufacturer and a Flange Manufacturer to develop a robust flange sealing system for use in aggressive chemical applications.
Applications

• Lap Joint Flange example with GORE® Universal Pipe Gasket (UPG)

• Test Gasket – GORE®UPG (made of ePTFE)

• New Pipe Code for “Severe Service Applications” Finalized Fall 2012
50 PSIG/FULL VACUUM DUAL LAMINATE VESSEL

- FRP Lap Joint Flanges
- UPG Gasket
  - Chemically Inert
  - Reliable Long Term Seal
End User Testimonial

• “From the positive results realized from utilizing large diameter lap joint flanges on a scrubber, and the successful lab testing, we developed a new (FRP) pipe code within DuPont, incorporating lap joint flanges and GORE® UPG Gaskets when T3 seals are required at our sites “

THIS CODE IS INTENDED FOR SEVERE SERVICE AND FUGITIVE EMISSIONS
APPLICATIONS ONLY. IT SHALL BE USED FOR PROCESS SERVICES THAT ARE
CONSIDERED CORROSIVE AND HAZARDOUS. THIS PIPE CODE IS DESIGNED FOR
A T3 LEAK TIGHTNESS CRITERIA. THIS PIPE CODE EXCLUSIVELY USES RL
INDUSTRIES STUB AND RING FLANGES, WITH GORE UPG EXPANDED TEFLOM GASKETS