Lined Fittings Plates
Topics to Cover

• New style plates
  – UHMW lined and Kynar coated
    • UHMW information
      – Background
      – Strength characteristics
      – Manufacturing processes
    • Kynar
      – Basic Properties and Strengths
      – Chemical compatibility
      – Application Process

  – Lined Plate Field Review
    • Plate condition
    • General Findings
    • Changes and improvements
History

• Lined Fittings Plates have been in service for over 6 years
• By the end of the year we will have about 700 in service
• Multiple plate configurations have been manufactured
• Other UHMW products have been in service for over 17 years
UHMW Background

- Ultra High Molecular Weight Polyethylene (UHMW)
- Commercialized in 1950’s
- Thermoplastic
- Molecular weight 2-6 million
- Strength through long chains
- Lightweight
- USDA/FDA Approved
Characteristics

- **Impact Strength**
  - No break (standard ASTM D256 Izod)
  - Modified test (Two 15° notches)
  - Highest notched impact of any plastic
Characteristics

• High abrasion resistance
Corrosion Resistance

- Excellent Corrosion Resistance to harsh chemicals
  - 5 year review of the fittings plate showed no degradation to material constantly in vapor space
  - Individually we’ve had a dip tube in service for 17 years with no issues

### Chemical Compatibility

<table>
<thead>
<tr>
<th>Compatibility Chart</th>
<th>Salco Polyethylene 70</th>
<th>Salco Polyethylene 122</th>
<th>Salco Polyethylene 170</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caustic Soda</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Ferric Nitrate</td>
<td>1</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Ferric Sulfate</td>
<td>1</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Ferrous Chloride</td>
<td>1</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Ferrous Sulfate</td>
<td>1</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Hydrochloric Acid (&gt;20%)</td>
<td>1</td>
<td>1</td>
<td>Boiling NR</td>
</tr>
<tr>
<td>Hydrochloric Acid (50%)</td>
<td>1</td>
<td>1</td>
<td>Boiling NR</td>
</tr>
<tr>
<td>Hydrochloric Acid (&gt;40%)</td>
<td>1</td>
<td>2</td>
<td>*</td>
</tr>
<tr>
<td>Hydrofluosilic Acid</td>
<td>1</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Hydrofluosilic Acid</td>
<td>1</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Hypochlorous Acid</td>
<td>1</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Sulfuric Acid (10%)</td>
<td>1</td>
<td>1</td>
<td>*</td>
</tr>
<tr>
<td>Sulfuric Acid (30%)</td>
<td>1</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Sulfuric Acid (60%)</td>
<td>1</td>
<td>1</td>
<td>*</td>
</tr>
<tr>
<td>Sulfuric Acid (80%)</td>
<td>1</td>
<td>3</td>
<td>*</td>
</tr>
<tr>
<td>Sulfuric Acid (100%)</td>
<td>1</td>
<td>NR</td>
<td>*</td>
</tr>
</tbody>
</table>

1. <15% loss in property values. Little or no chemical attack.
2. 15-30% loss in property values. Minor chemical attack.
3. 30-50% loss in property values. Moderate chemical attack.
NR. Not recommended. > 50% loss in property values.
* No data available.
Manufacturing Process

• Starts as powder
  – Ram Extrusion
  – Compression Molding

• Additives
  – UV
  – Color
UHMWPE Manufacturing

- Engineering
- Bar, Sheet, & Tube (Meets ASTM D2040)
- CNC Mill
- CNC Lathe
- CNC Router
- Friction Welding
- Compression Molding
- Lining
- Quality Control
Friction Welding

- All welds performed in set vertical fixtures
- Interference fit
  - Feed rate
  - Spin rate
  - Interference
- Optimize crystallization
  - 24 hr post weld dwell time
- No additives or adhesives used
- Third part testing, 91-93% weld strength
Kynar® PVDF for Chemical Applications
Excellent Properties of Kynar® PVDF

- Resistant to most chemicals and solvents
- Low permeability to most gases and liquids
- High thermal stability
- Mechanical strength at elevated temperature
- Cold weather impact strength
- High purity
- High abrasion resistance
- Readily processible, formable, and weldable
- Resistant to sunlight degradation
- Resistant to nuclear radiation
- Resistant to fungus
- Low flame and smoke characteristics
Testing in Acid Environments

• Handles most acids to elevated temperature without significant change in physical properties.

• Common acids handled by PVDF in industrial applications are: Hydrochloric (0-37%); Nitric Acid (0-71%); Sulfuric (0-97%); Hydrofluoric (0-70%); Acetic (0-50%); Hydrobromic; Phosphoric, Citric, Salicylic, Methane Sulfonic; Chromic.

• In extraction testing, exhibits purity to Semiconductor Grade acids equal to PFA.
## Compared with Other Polymers

<table>
<thead>
<tr>
<th>KYNAR® vs PE, PP &amp; CPVC &amp; PVC</th>
<th>KYNAR® vs ECTFE, ETFE, FEP &amp; PFA</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Higher operating temperature</td>
<td>• Greater mechanical strength</td>
</tr>
<tr>
<td>• Greater chemical resistance</td>
<td>• More listed components</td>
</tr>
<tr>
<td>• Greater mechanical strength</td>
<td>• Lower cost</td>
</tr>
<tr>
<td>• Greater resistance to fire</td>
<td>• Lower processing temperature</td>
</tr>
<tr>
<td>• No swelling in hydrocarbons</td>
<td>• Improved permeation resistance</td>
</tr>
</tbody>
</table>

*KYNAR® PVDF is the hardest and most abrasion resistant high purity polymer*

**It has passed many flame and smoke tests, including Factory Mutual 4910 and ASTM E84**

***Offers flexible range of products that are compatible/weldable***
PVDF Power Coating Fabrication

- Three application methods
  - Spray
  - Liquid
  - Dip
- Thickness can be tailored
  - 10 mils to 100 mils

Photo Courtesy of Salco
PVDF Coating Case Study

- PVDF Coatings applied to manways in railcars
- PVDF powder spray - applied to strong HCl environment for 5+ years
  - Entire metal substrate is coated
- System creates a chemically resistant cover plate
  - Resists corrosion
  - Resists mechanical damage from product and metal to metal connection
- Methods used for testing: FTIR, GPC, DSC

<table>
<thead>
<tr>
<th>Condition</th>
<th>Melting Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unexposed</td>
<td>155-160°C</td>
</tr>
<tr>
<td>5 year HCl</td>
<td>158.4°C</td>
</tr>
</tbody>
</table>

Thermal analysis testing confirms no change in MP

CONCLUSION

PVDF COATINGS GOOD IN HCl SERVICE FOR 10+ YEARS
Continuous Improvement
2016 Five Year Fittings Plate Inspection
Just Removed
Before Cleaning
Fittings Plate
Base of the plate
Plug Hole Damage
After Cleaning
After Cleaning
Underside After Cleaning
After Cleaning
After Cleaning
Blind Flange Development

Design improvements from left to right
2017 Five Year Plates
Plug Hole Damage – Old vs New

2016 Plate

2017 Plate
Overall Condition
Lined Fittings Plates