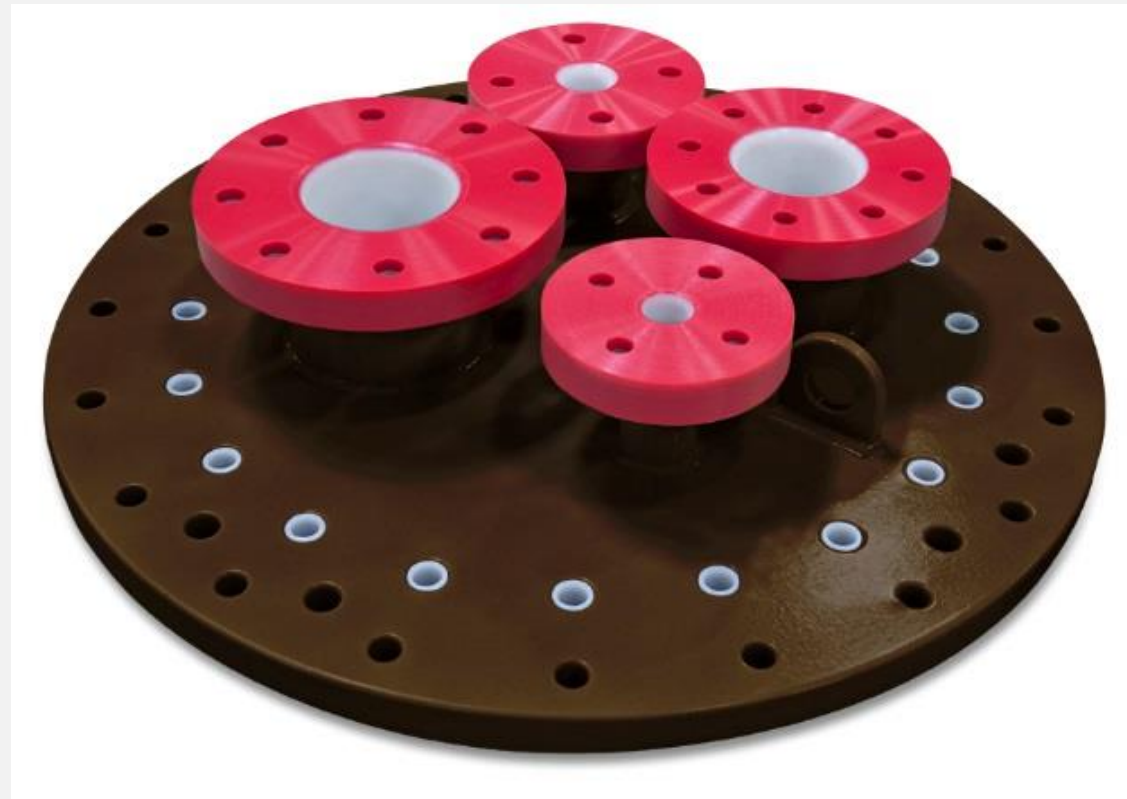


Lined Fittings Plates



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

Figure 3 • Notched impact strength of UHMWPE as a function of temperature, using sharp V-notched test bar with double 15°V-notch

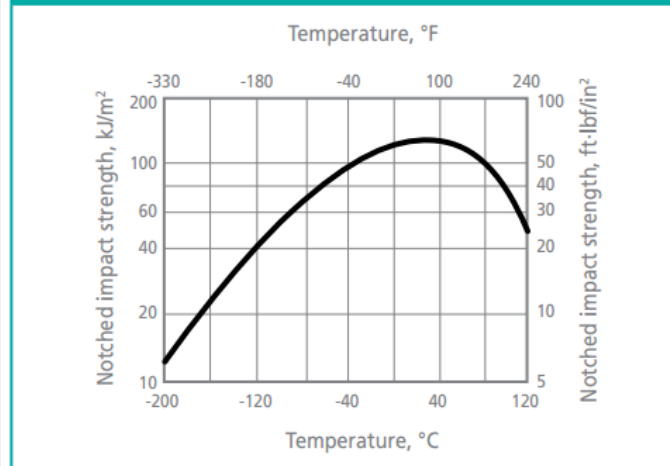
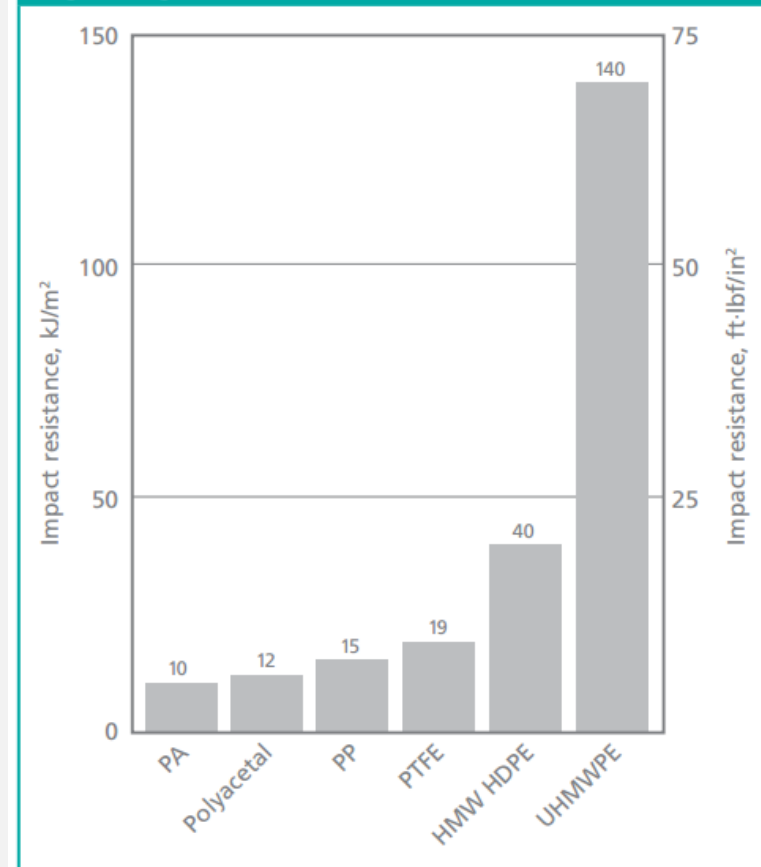


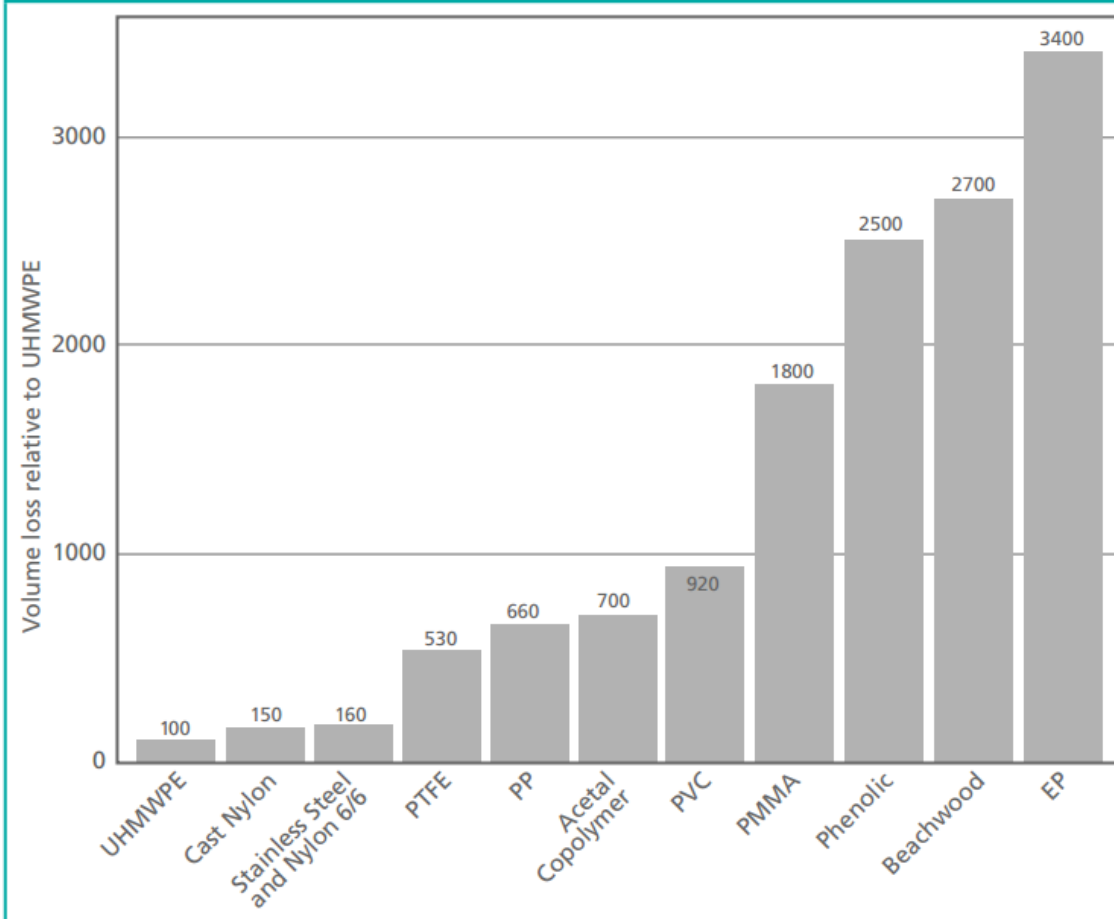
Figure 2 • Comparative impact resistance of different engineering resins



Characteristics

- High abrasion resistance

Figure 1 • Comparative abrasion resistance of different engineering resins. PTFE, polytetrafluoroethylene; PVC, polyvinyl chloride; PMMA, polymethyl methacrylate; EP, epoxy



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

Compatibility Chart

Salco Polyethylene

	70	122	170
Caustic Soda	1	1	1
Ferric Nitrate	1	*	*
Ferric Sulfate	1	*	*
Ferrous Chloride	1	*	*
Ferrous Sulfate	1	*	*
Hydrochloric Acid (>20%)	1	1	Boiling NR
Hydrochloric Acid (50%)	1	1	Boiling NR
Hydrochloric Acid (>40%)	1	2	*
Hydrofluosilicic Acid	1	*	*
Hydrofluorisilicic Acid	1	*	*
Hypochlorous Acid	*	*	*
Sulfuric Acid (10%)	1	1	*
Sulfuric Acid (30%)	1	1	*
Sulfuric Acid (60%)	1	1	*
Sulfuric Acid (80%)	1	3	*
Sulfuric Acid (100%)	1	NR	*

- 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.

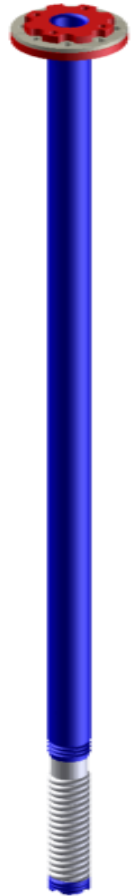
Manufacturing Process

- Starts as powder
 - Ram Extrusion
 - Compression Molding
- Additives
 - UV
 - Color



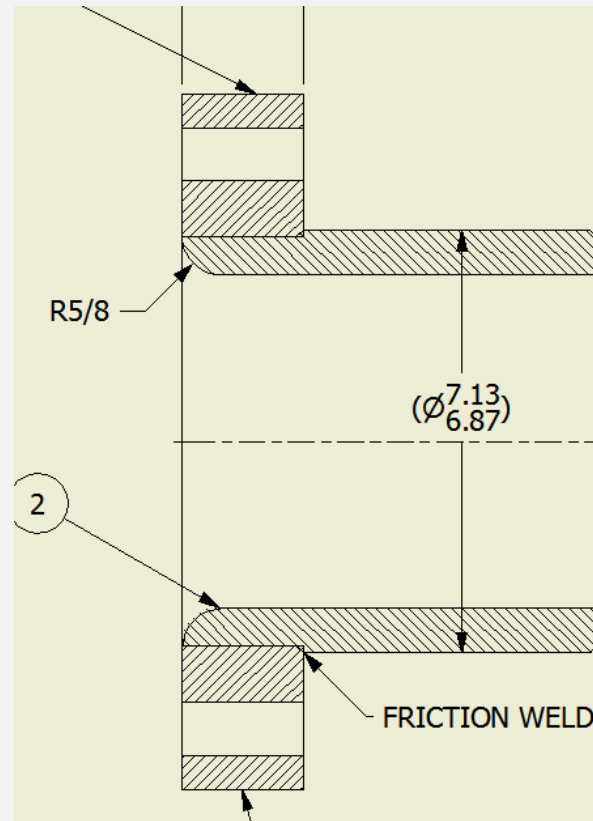
UHMWPE Manufacturing

- 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



Lined Fittings Plate



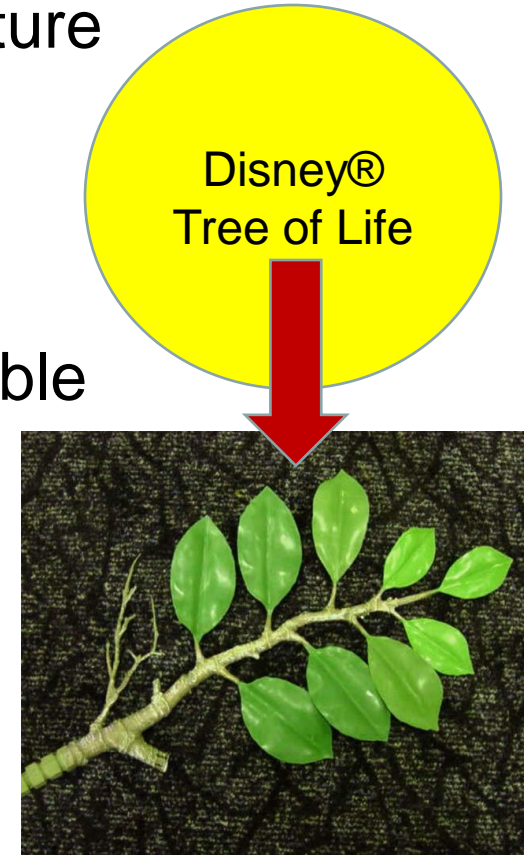
- U.H.M.W. allows for a higher compression/torque vs. rubber lining.
- Kynar™ coating can be repaired in the field for small areas.



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

KYNAR® vs PE, PP & CPVC & PVC

- *Higher operating temperature*
- *Greater chemical resistance*
- *Greater mechanical strength*
- *Greater resistance to fire*
- *No swelling in hydrocarbons*

KYNAR® vs ECTFE, ETFE, FEP & PFA

- *Greater mechanical strength*
- *More listed components*
- *Lower cost*
- *Lower processing temperature*
- *Improved permeation resistance*



*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

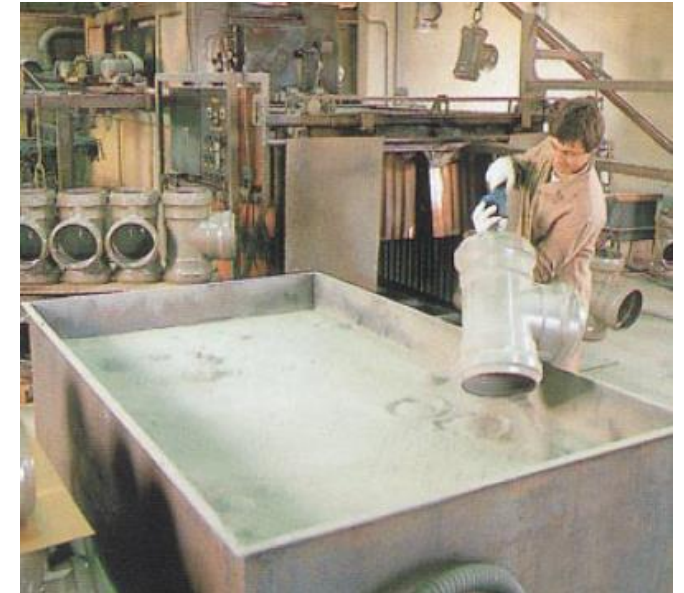
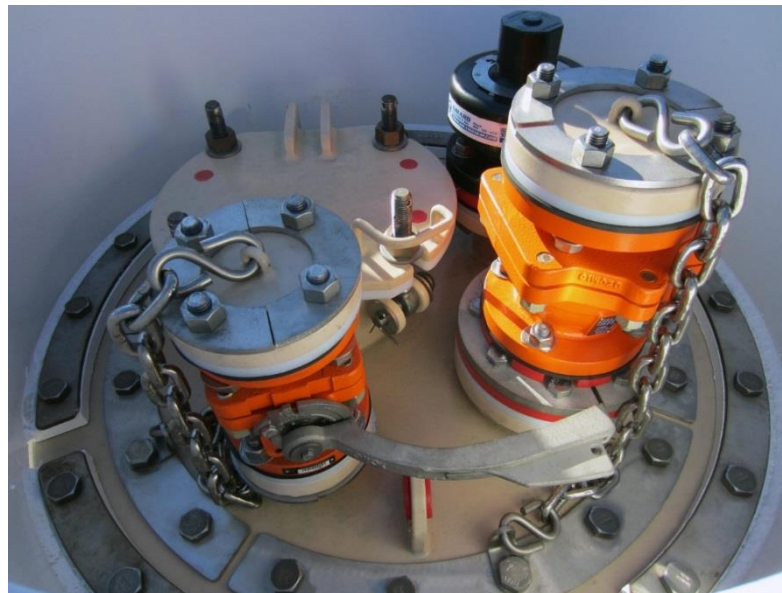
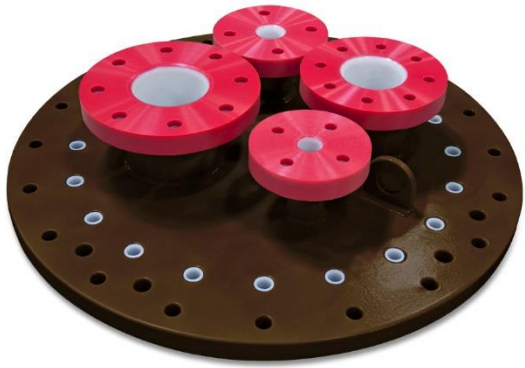


Photo Courtesy of Salco

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



Thermal analysis testing confirms no change in MP

	Melting Point
Unexposed	155-160°C
5 year HCl	158.4°C

CONCLUSION

PVDF COATINGS GOOD IN HCl SERVICE FOR 10+ YEARS

Continuous Improvement

2016 Five Year Fittings Plate Inspection



Just Removed
Before Cleaning



Fittings Plate



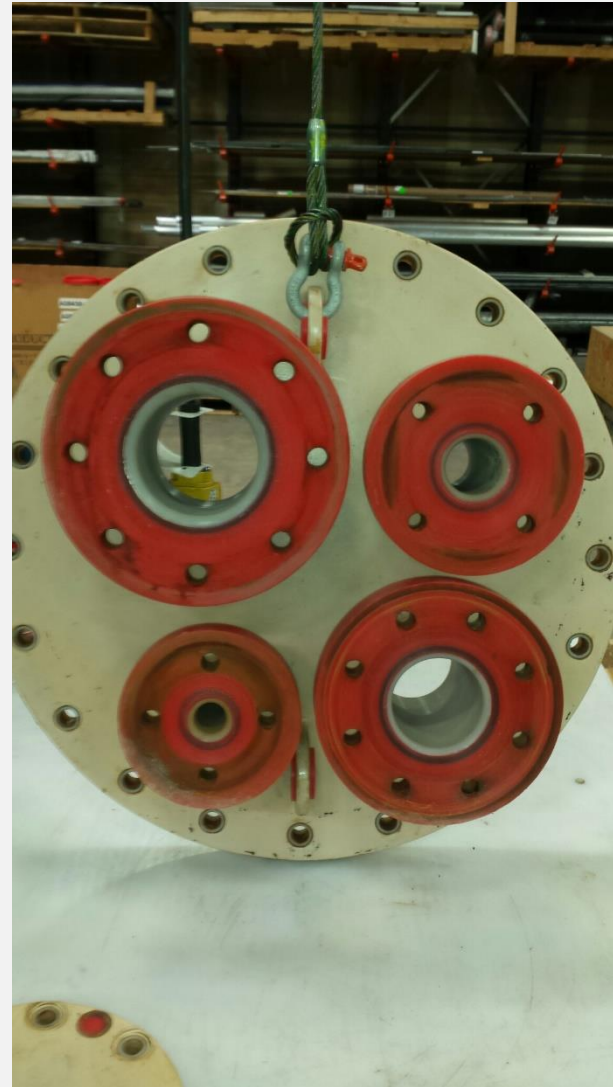
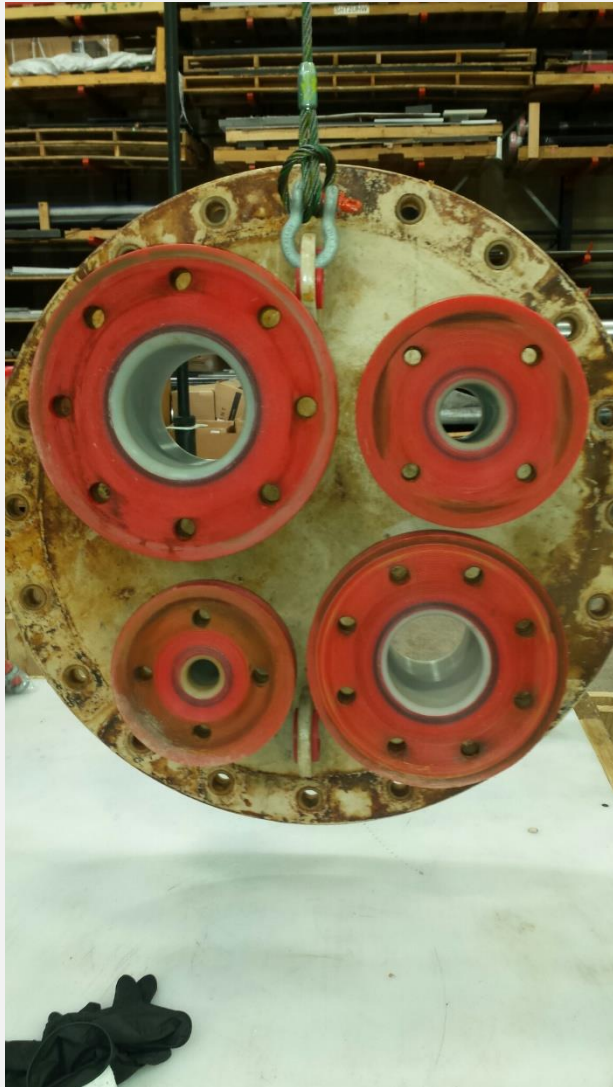
Base of the plate



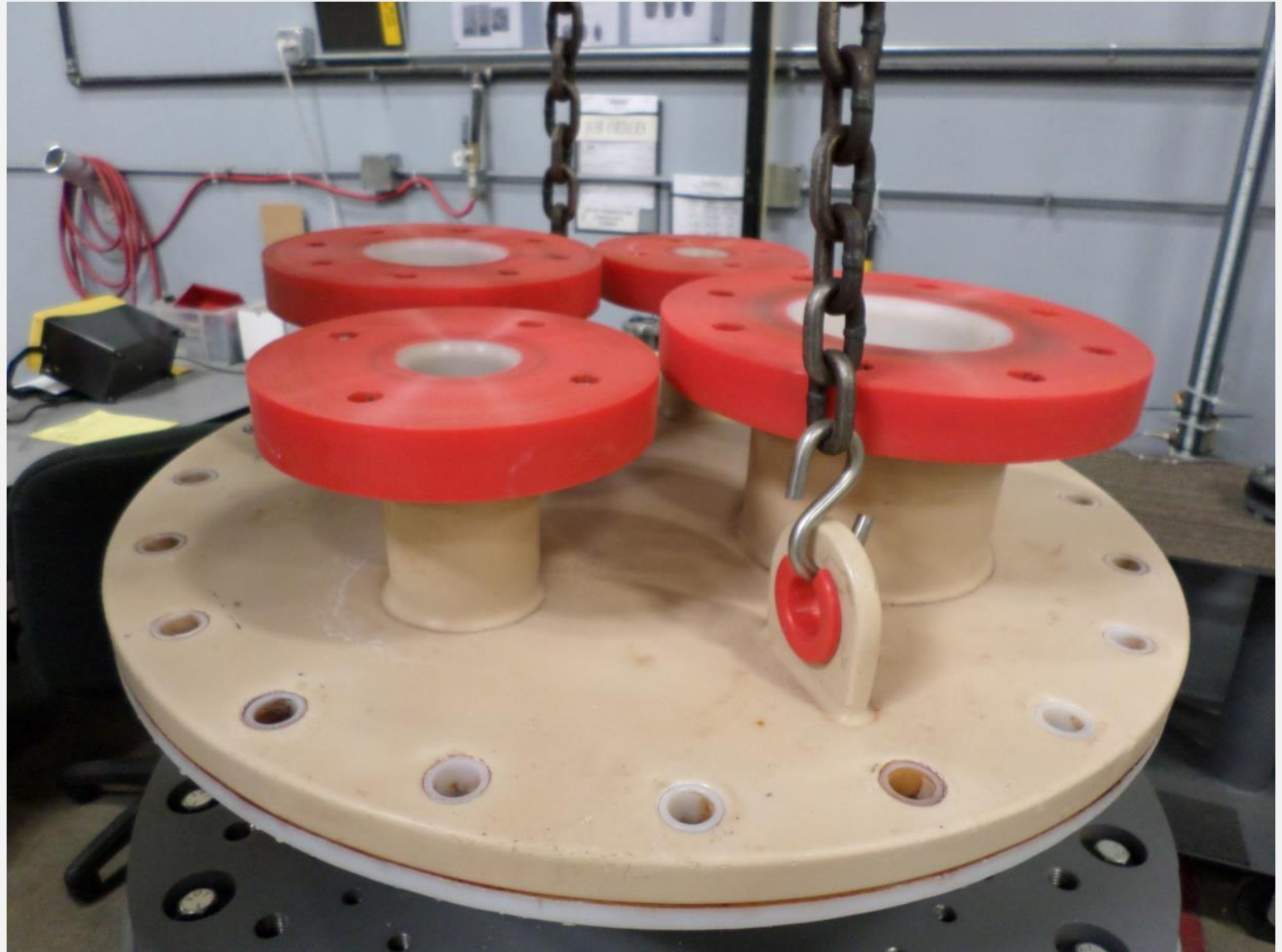
Plug Hole Damage



After Cleaning



After Cleaning



Underside After Cleaning



After Cleaning

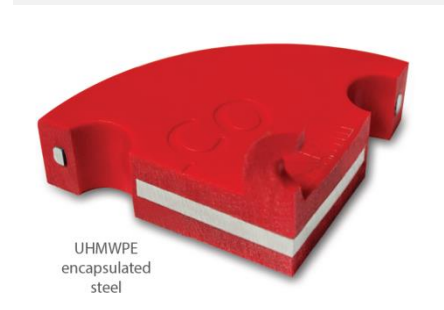
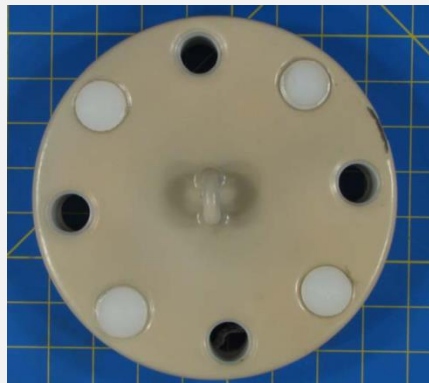


After Cleaning



Blind Flange Development

Design improvements from left to right



2017 Five Year Plates

Plug Hole Damage – Old vs New

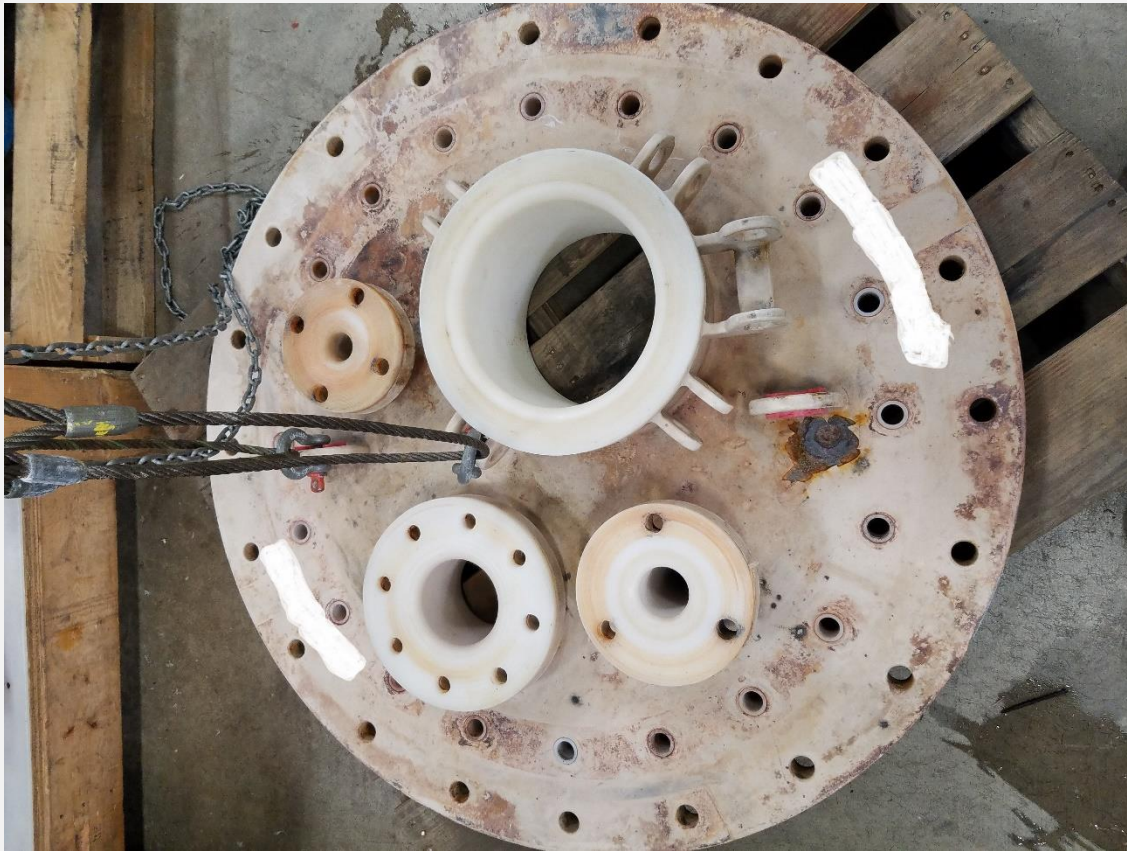
2016 Plate

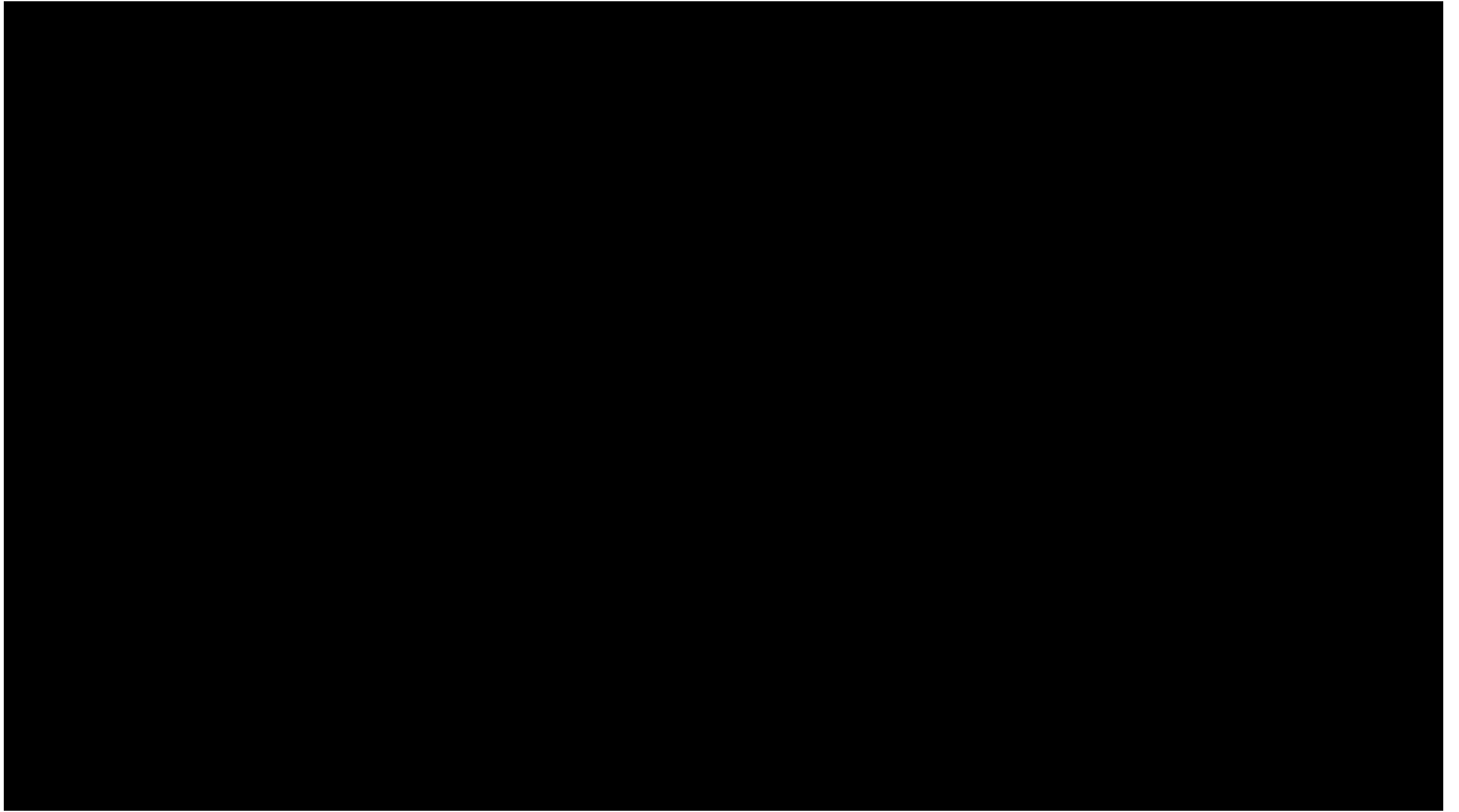


2017 Plate



Overall Condition





Lined Fittings Plates

