Pipe Welding Techniques: A Closer Look at PVDF Pipe for Demanding Applications

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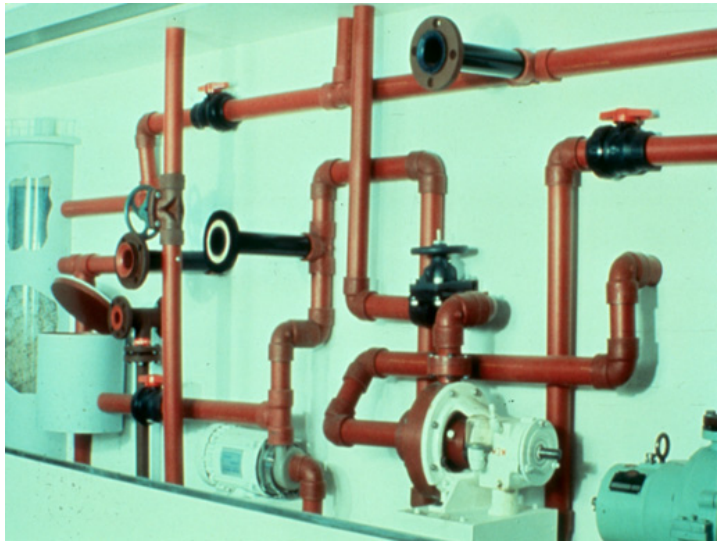
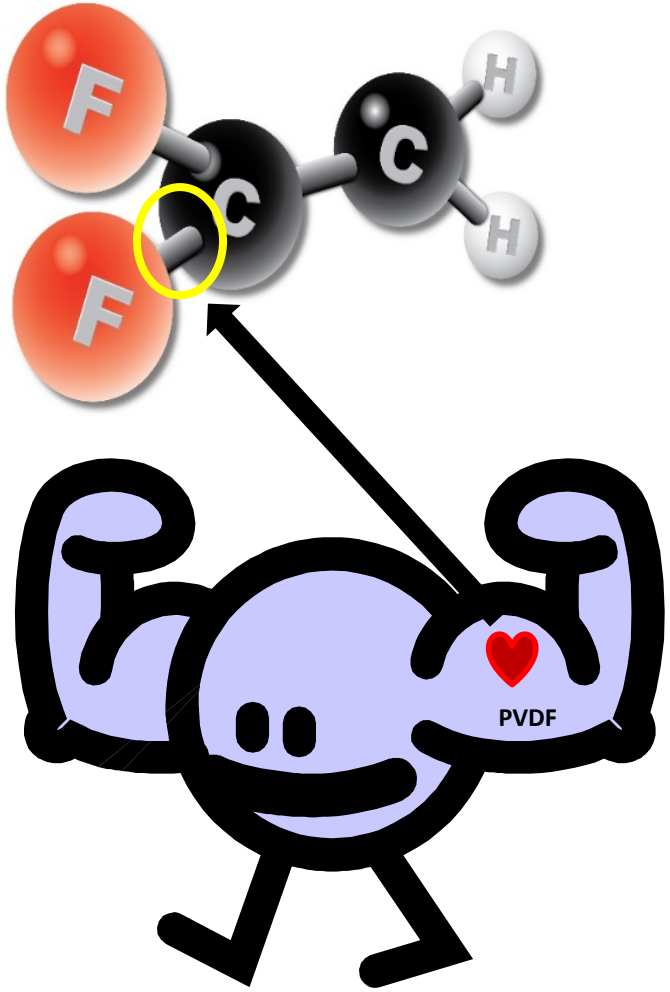
ARKEMA
INNOVATIVE CHEMISTRY

FLUOROPOLYMER CHOICES

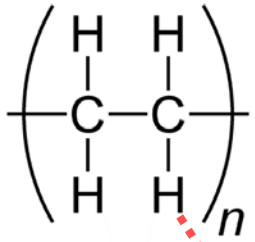
- Engineers, chemists, designers, and manufacturers have many material choices for chemical handling
- One of the most chemically resistant family of materials are the **fluoropolymers.**
- Of this family of materials, **PVDF** is the *strongest* and is one of the *least expensive*.
- **PVDF** is usually the first fluoropolymer to think about when designing chemical and water handling systems.



WHAT IS PVDF AND PVDF COPOLYMER?

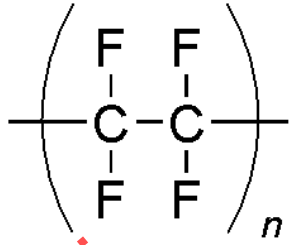


PE



- Processability
- Inertness
- Temperature
- Mechanical

PTFE



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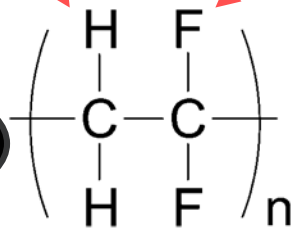
PVDF



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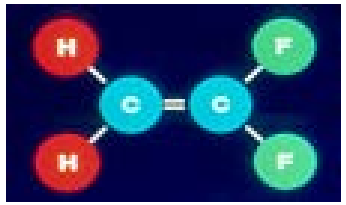
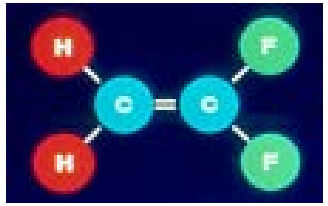
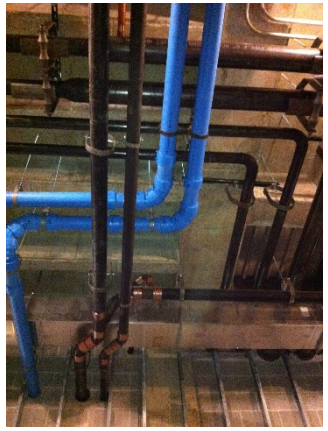
PVDF GRADE RANGES

PVDF Homopolymer



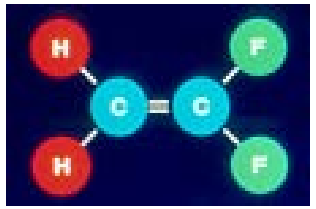


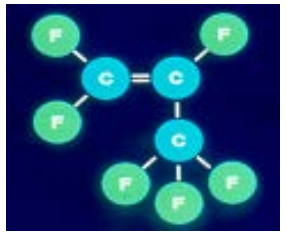
Rigid, High-Temperature



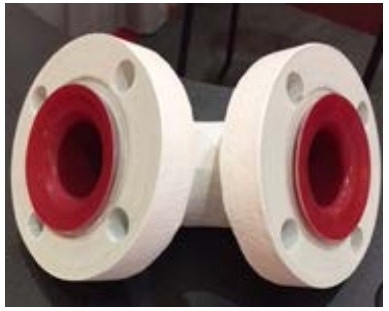
Solid Plastic piping systems made of PVDF homopolymers

PVDF Copolymer





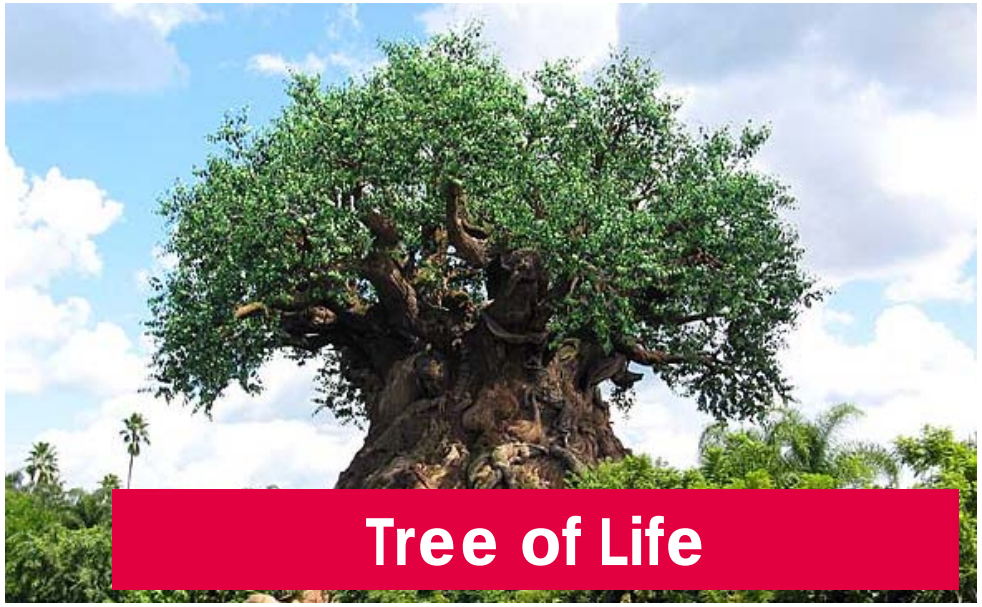
Flexible, Wider Range of Chemical Resistance



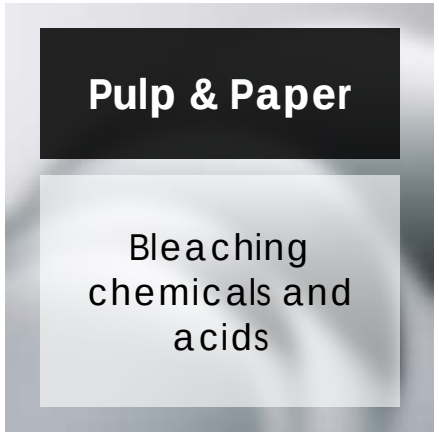
Lined Systems (metal or FRP) made of PVDF copolymers

EXCELLENT PROPERTIES OF PVDF

- **Resistant to most chemicals and solvents**
- Oxidation Resistance
- Low Surface Energy
- **Low permeability to most gases and liquids**
- High thermal stability
- Mechanical strength at elevated temperature
- Cold weather impact strength
- **High purity**
- **High abrasion resistance**
- Resistant to UV degradation
- Resistant to nuclear radiation
- **Resistant to fungus**
- Low flame and smoke characteristics

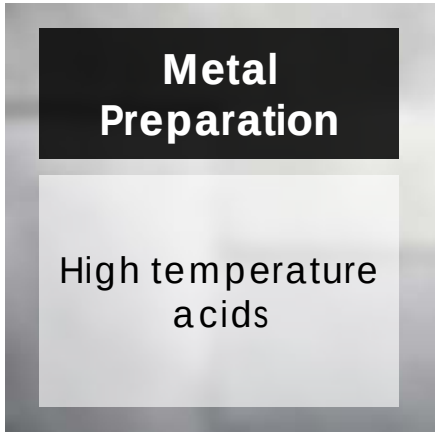


PVDF INDUSTRIES



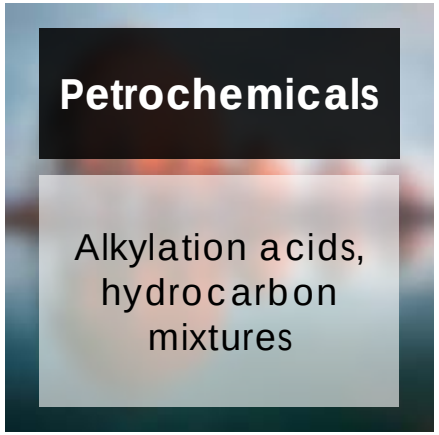
Pulp & Paper

Bleaching chemicals and acids



Metal Preparation

High temperature acids



Petrochemicals

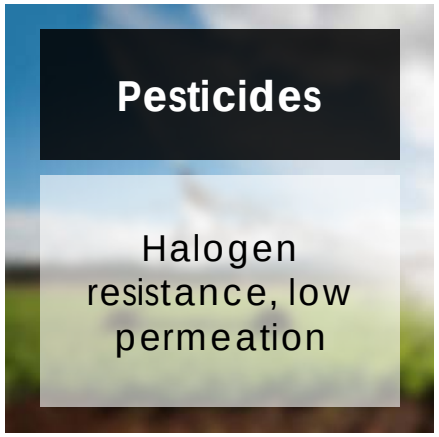
Alkylation acids, hydrocarbon mixtures

Food & Beverage

FDA listing, steam cleaning, acidic foods, aggressive cleaning agents

Waste Water

Chemical mixtures, outdoor exposure

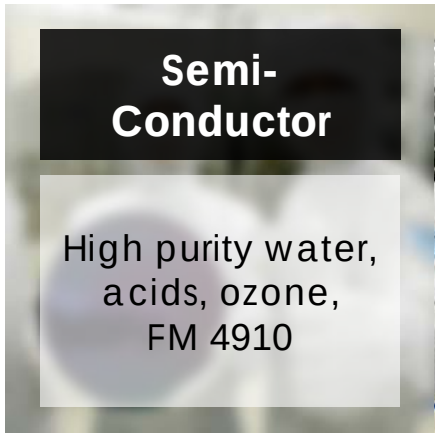


Pesticides

Halogen resistance, low permeation

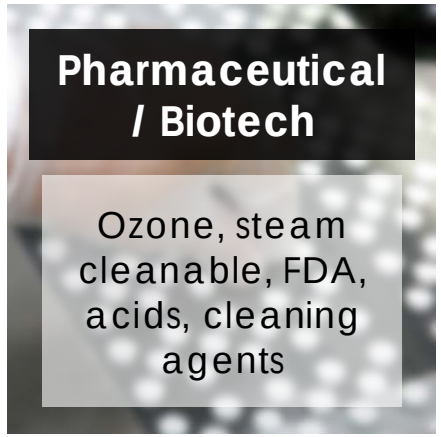
Mining

Abrasive slurries, acidic mixtures



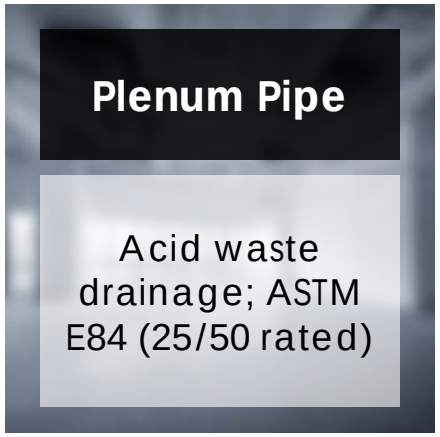
Semi-Conductor

High purity water, acids, ozone, FM 4910



Pharmaceutical / Biotech

Ozone, steam cleanable, FDA, acids, cleaning agents



Plenum Pipe

Acid waste drainage; ASTM E84 (25/50 rated)


PVDF Advantages

TOUGHNESS AND DURABILITY

Tensile Strength of Plastics

Per ASTM 638

Material	Tensile Strength
PVDF 740	6,500-8,000 psi
ECTFE	7000 psi
ETFE	6500 psi
PVC	6000-7500 psi
PVDF Copolymer 2850	4,000-7000 psi
UHMW PE	5600 psi
PP	4500-6000 psi
PFA	4000-4300 psi
PVDF Copolymer 2800	2900-5000 psi
FEP	2700-3100 psi
PTFE	2500-6000 psi
PVDF Copolymer 2500	1,700-2,800 psi
PE	1200-4550 psi

Abrasion Resistance

Taber Ring CS-10
mg/1000 cycles using a 1 kg load

Materials	Mg Loss
PVDF	5-10
Polyamide 6-10 (nylon)	5
PVC (Rigid)	12-20
Polypropylene	15-20
CPVC	20
HDPE	25
304 Stainless Steel	50
Mild Steel	100-300
PTFE	500-1000

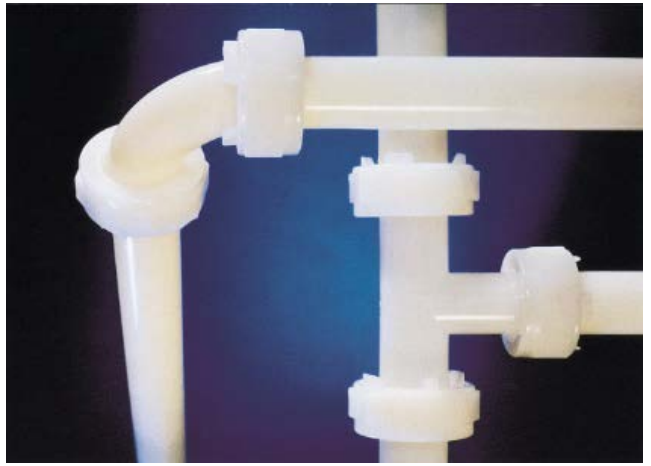
Source: Ultrapure Water® Journal

OPERATING TEMPERATURES

Deflection Temperature of Plastics (ASTM D648)			
Polymer	66 psi	264 psi	Melt Point
PVDF	147°C	113°C	172°C
CTFE	126°C	75°C	218°C
PTFE	121°C	56°C	327°C
ECTFE	116°C	77°C	240°C
PP	107°C	49°C	166°C
ETFE	104°C	74°C	270°C
PFA	73°C	48°C	310°C
FEP	70°C	51°C	290°C
UHMWPE	68°C	43 °	129°C
PVC	60°C	57°C	<141°C
LDPE	--	40°C	105°C

Chemical Resistance of PVDF

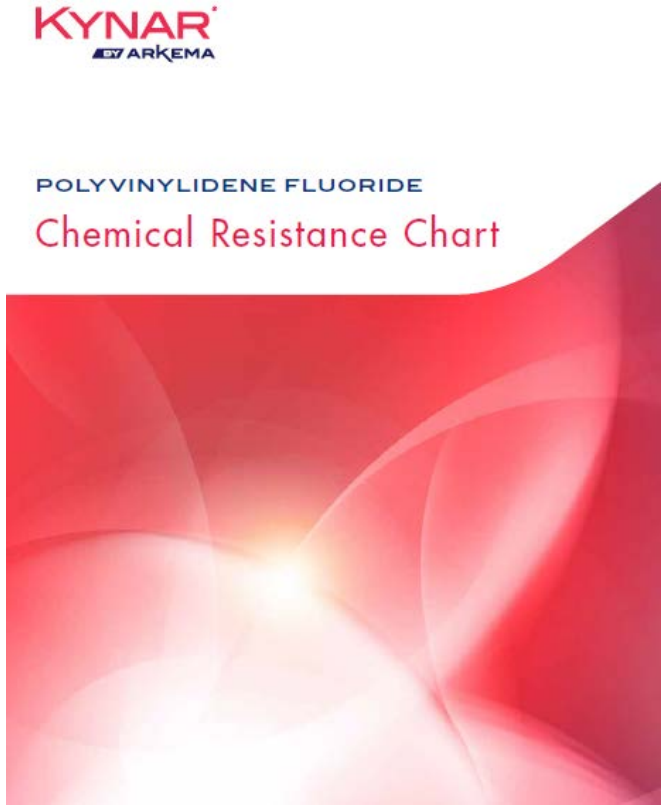
- For applications of continuous service even under stress from welding, forming, or internal pressure of a process system, Kynar® homopolymer is “generally” resistant to a pH range of <1 to 12.
- In applications with higher pH, PVDF Copolymer grades handle a wider pH range from <<1 to 13.5.



***Some families of chemicals in high concentration, or at high temperature, can cause swelling or dissolving.

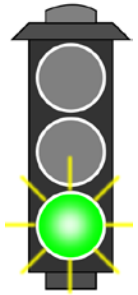
COMMON CHEMICALS HANDLED BY KYNAR®

- **Chlorine**
- Chlorine Dioxide
- Methyl Chloroform
- **Hydrochloric Acid**
- Salt Water
- Chlorobenzene
- **Sodium Hypochlorite**
- **Sulfuric Acid <98%**
- Chlorinated Salts
- Phosphoric Acid
- **Hydrofluoric Acid**
- Metallic Chlorides
- Acid mixtures (concentrations)
- **Bromine (Gaseous)**
- Bromine Water
- Hydrobromic Acid
- Bromobenzene
- Brominated Salts
- Iodine
- Salicylic Acid
- <50% Acetic Acid
- Methyl Alcohol
- Chromic Acid
- **Nitric Acid**
- Peracetic Acid
- **Deionized Water (DI)**
- Biodiesel & other fuel mixtures



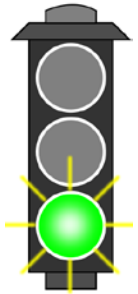
Mixtures of chemicals can create aggressive by-products

PRESSURE for PVDF Piping Systems



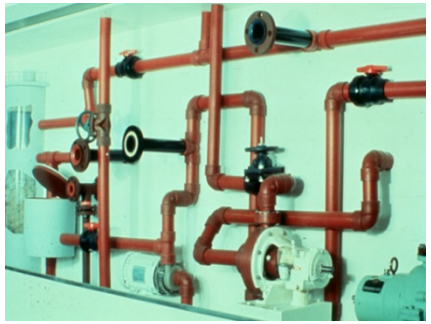
<10 PSI → Drain Systems

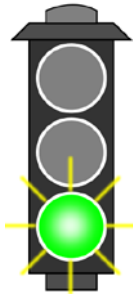
- Short Term Chemical Exposures



10 – 150 PSI → standard pipe systems

- Solid and supported systems



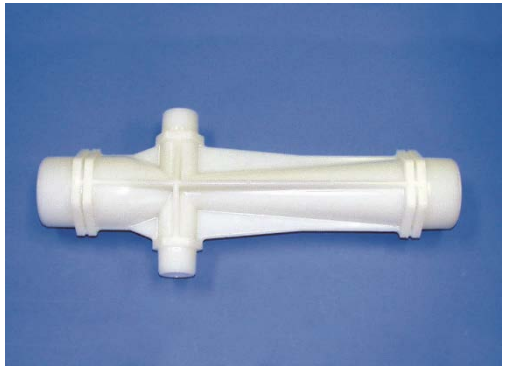


>150 PSI → Supported systems or thick schedule

- Support adds safety factor

COMMON PVDF COMPONENTS

- **Plastic Lined Steel** – Better permeation resistance than PTFE
- **Lined Vessels** – Lined metal, coated metal, dual-laminate FRP
- **Solid Plastic Piping & Fittings** – Natural or pigmented, Sch. 80, Sch. 40, SDR 11 or 32, sanitary, socket fused, butt fused, flanged, mechanical drainage systems available.
- **FRP Wrapped Piping**
- **Flexible Tubing** – less expensive than PFA, FEP
- **Valves and Instrumentation**
- **Braided Hose**
- **Pumps**
- **Filtration Components** (membranes, molded filter housings)
- **Tower Packing**
- **Injection Nozzles**
- **Stock shapes** (rod & sheet)
- **Woven Fabrics**

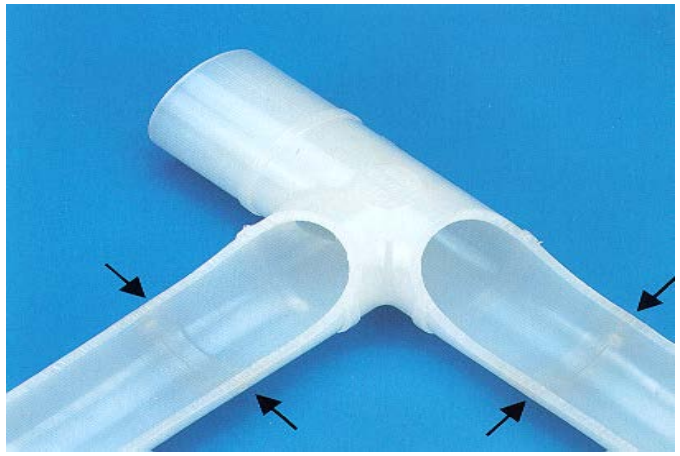


JOINING METHODS OF PVDF PIPE

Electrofusion

- Reliable and consistent fusion
- Effective for parts where butt fusion is not practical such as a joint or tee
- Requires proper set up for an effective weld

Bead and Crevice Free



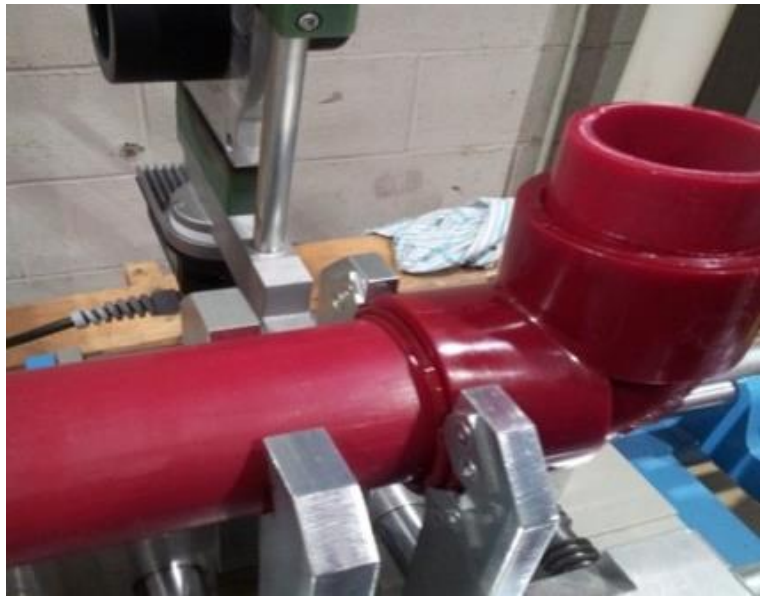
- Weld integrity equivalent to injection molded or extruded part
- Smooth continuous system
- Advanced joining method

Infrared

- No outside contact of heater plate
- Consistent and controlled weld bead
- Relatively quick welding time
- Current industry standard for semiconductor

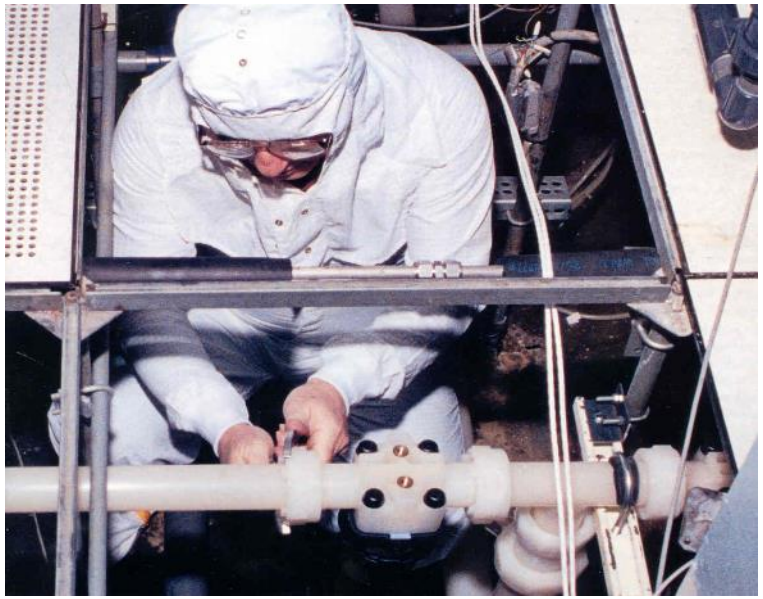
JOINING METHODS OF PVDF PIPE

Socket Fusion



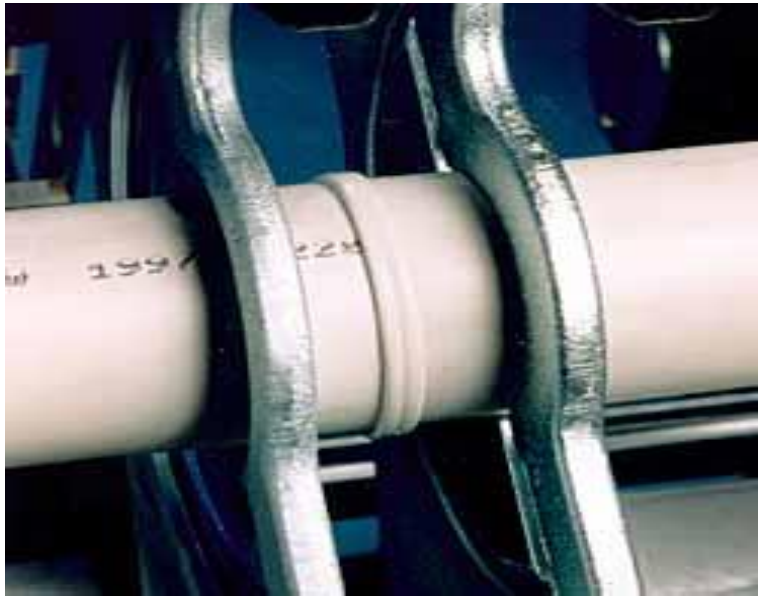
- Strongest Weld
- Kynar® PVDF service life exceeding 20 years
- Br_2, H_2SO_4, HCl, $HBrO_3$, and HF
- Popular in nuclear, chemical, pulp & paper, metals preparation, petrochemical
- Larger bead weld

Mechanical



- Includes threaded, flange, and interface fit
- Reduced welding beads
- Can join dissimilar materials
- Limited in diameter size
- Remains popular in laboratories due to its versatility

Butt Fusion



- Simple Process
- Visibility to joint geometry
- Weld bead created

Special Considerations

Joining

- Socket fusion is preferred due to lap joint providing a protective mechanism
- Threading is simple but never recommended over 2 inches
- Lined steel and FRP wrapped may cost more but gives an added structural support that may be desirable even at higher cost
- Mechanical used low pressure systems only
- **PVDF and PVDF Copolymers easily weld together!**

Sunlight

- If piping system is handling chlorine in direct sunlight, recommend pigmenting, covering, or encasing

Case History – Drainage Pipe

- Chicago Field Museum of Natural History*
  - Research labs handled corrosive and volatile fluids
    - Sulfuric acid, bromic acid, acetic acid, chromic acid, etc.
- Pipes underground and encased in concrete
  - Engineers had to ensure material would last 25+ years
  - Eliminated metals due to corrosion and rust concerns
- Solution: PVDF homopolymer double containment system
  - 1.5” schedule 80 PVDF encased by 3” schedule 40 PVDF
    - Primary joined by socket fusion, outer joined by mechanical fittings

* Published in *Processing* magazine, October 2004

Case History – Socket Fusion Pipe

- US Steel in Gary, IN
  - Stainless steel (2”-6”) pipes transferring acidic fluids for surface finishing
  - Failing within 2 years of service
- Solution: PVDF homopolymer piping system
  - Engineers needed chemical resistance to highly corrosive acids
    - Sulfuric acid and hydrochloric acid
  - Abrasion resistance was key attribute
  - 2”-6” installation of pipe
  - Socket fusion preferred, as the fusion joint is stronger

ABILITY TO ADAPT IN ANY APPLICATION

PVDF is the strongest and stiffest fluoropolymer

PVDF copolymers can be the most flexible of all commercial melt processable fluoropolymers

Choosing the best grade of PVDF or PVDF Copolymers can lead to continuous performance

There are many different ways to make and/or join PVDF piping/tubing/hose systems

Pipes, flex tubing, fittings, valves, pumps, and more are all available in Kynar® PVDF

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