sugison plastics

PVDF
HIGH PURITY PIPING MATERIAL
FOR DE-IONIZED WATER
BENEFIT COST COMPARATION

PVDF HIGH PURITY PIPING _ DEIONIZED (DI) WATER

Key issues：

Years ago, high purity water was used only in limited applications. Today, deionized (DI) water has become an essential ingredient in hundreds of applications including :

Pharmaceutical, Biotechnology, Food Processing and Electronic Industries.

Many industries are seeking ways to leave behind the currently-used troublesome materials.

Stainless steel imposed constant and increasing problems : rouging, pitting, corrosion, metallic-poisoning, aggravated compliance issues, costly and environtmentally adverse cleaning protocols, and inadvertent fracture, plus costly biofilm issues.

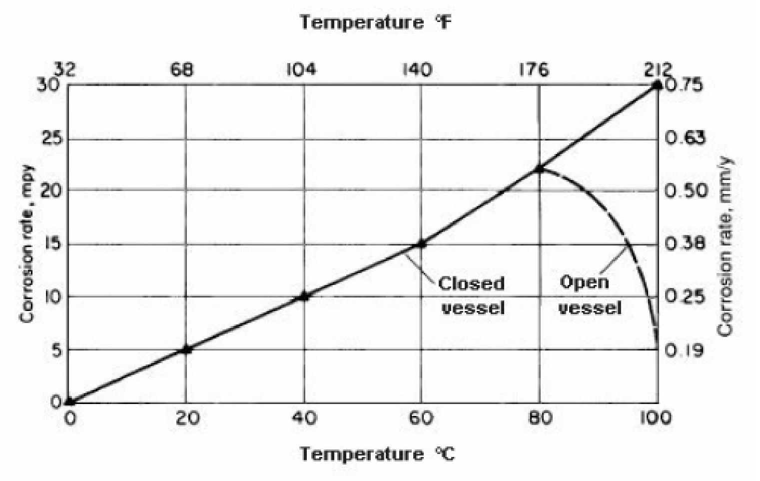
Stainless steel

has historically been adopted for containment of chemical processing because it is resistant to more chemicals than is iron or mild steel. It is an inorganic chemical combination of the essentially iron, chromium, and nickel. The chemicals resistance of stainless steel to certain chemicals can be improved, with a corresponding increase in cost. But even such chemical resistance improvement is not sufficient to overcome chemical attack or the corrosive attack of biofilm components. **Stainless steel corrode over time as the minor ingredients are lost and as electrochemical potensials arise which promote the oxidation in even the "mildest" of chemical conditions, i.e. hot steam, and the resulting rust ("rouging") contaminates and compromises the quality of the products being produced in such equipment.** Stainless steel can be further chemically treated to be made less reactive, i.e., passivated in a time consuming and expensive treatment that must be performed regularly to ensure that the iron in this material doesn't oxidize_i.e, rust.

Passivation is costly, is only temporarily durable, and must be repeated if additional weldments are incorporated in to the system. **Passivated or not stainless steel is reactive to many harsh chemical, particularly chloride and other halides**, preventing their beneficial use in pharmaceutical and biotechnologis applications.

Stainless steel are formed using various processing techniques including melting, extrusion, casting, forging, shaping, heat treating, welding, cutting, and rolling. Such processing result in microscopic irregularities in the structure. The surface irregularities of stainless steel_ranging from 180 grit to 400 grit_can be ameliorated, although with only temporary beneficial effect, to double digit microinches by ***electropolishing***. But electropolishing is also expensive, non permanent, and needs to be repeated often to maintain such a surface.

Temperature accelerates a chemical reaction rate



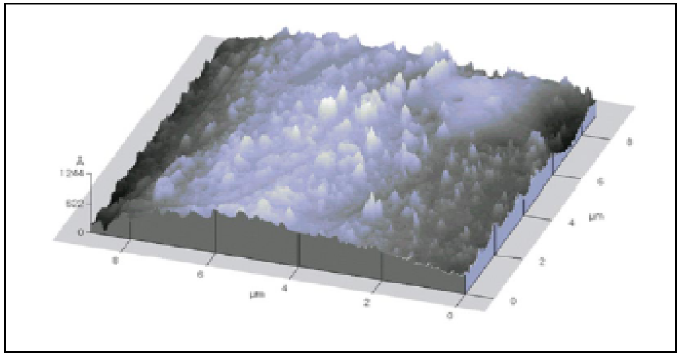
Steel Corrosion vs Temperature

sources :
Materials Engineering for the Chemical Process Industries

Higher temperature increases chemical reaction rate. And since corrosion is an electrochemical reaction, an increase in temperature will increase corrosion rate. Generally, for every 30°F increase in temperature, corrosively doubles. In an open system, where the dissolved oxygen (DO) is allowed to escape at higher temperature, corrosion peaks at about 150°F and then drops off as the DO drops. In a closed system, where the DO is trapped, corrosivity continues to increase with temperature.

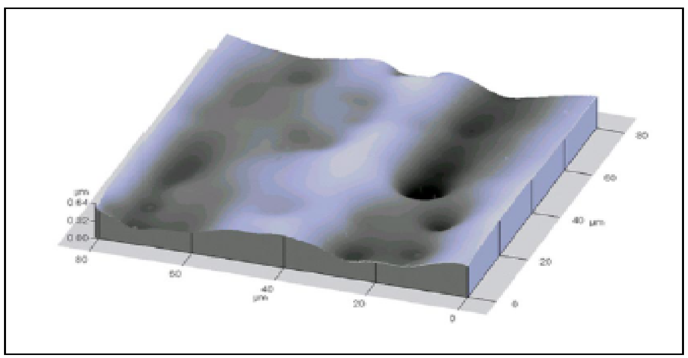
Hot water systems, if desired are compatible with thermoplastic systems and do not experience accelerated corrosion as with stainless systems.

Figure 1. AFM Photomicrograph Showing Spikes from Electropolished Asperities Ss 316L 15 Ra



even so, electro-smoothing only miniaturizes the height of the asperities in the metalurgical surface, but does little to remove the nooks and crannies surrounding the base of the asperities

Figure 2. SEM Photomicrograph Showing Pits from Electropolishing Removal of Inclusion Ss 316L 15Ra

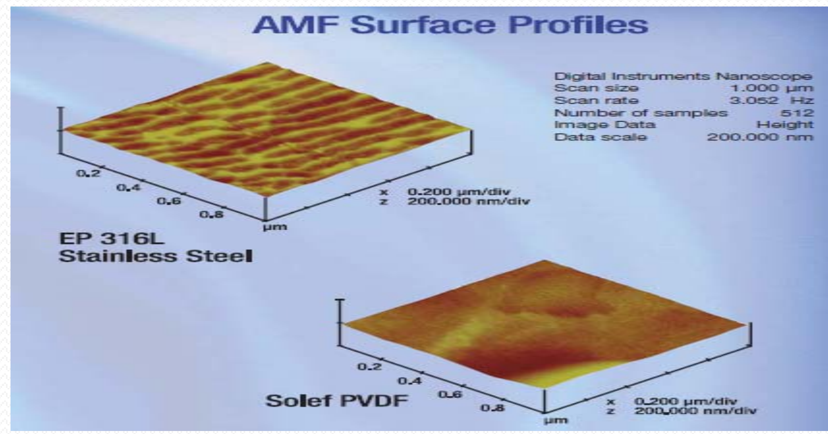


Worse still, electropolishing can remove inclusions in the metal creating pits, which in turn, can harbor microorganisms and biofilm components to perfectly shelter them from even the most vigorous cleaning (Sources : Material of Construction for Pharmaceutical and Biotechnology Processing ; Dupont Fluoroproduct . Fleming James R; et. all)

These table below, compares internal surface finish between PURAD PVDF, 316 EP (***electropolished***) and 316 MP (***mechanically polished***). It can be seen that comparable PVDF system provide a smoother surface finish as compared to stainless steel.

Material	RA Result
Purad PVDF (20mm - 90mm)	7.8 µ" max
EP 316L Stainless Steel	15-25 µ" average
MP 316L Stainless Steel	20-30 µ" average

source : www.asahi-america.com



Surface physical chemistry of stainless steel is another significant negative for its use in the Pharmaceutical and Biotechnology industries_ it is wettable by aqueous solution, a characteristic which enhances not only chemical corrosion, but also biofilm adhesion and biofilm resistance to detachment (Sources : www.solvaysolexis.com)

Plastics PVDF

Wide availability of **plastics offering lower initial cost**, **less weight, complete resistance to corrosion, good thermal insulation, elimination of the passivation process, extremely smooth interior surface** (measured in Ra = roughness average in µ)**.** have increased their application, particularly in system such as purified water distribution loops and other critical processes.

During the last five years, the technical requirements for laboratory water have tightened to match those of the semiconductor industry. The quality of recommended water system should be **very low conductivity, low total organic carbon (TOC), and low microbial content.**

FDA requirements for **pharmaceutical piping** and equipment stipulate that materials must have **low extractables (prohibit leaching of contaminant) , tolerance for sanitizing procedures and operating temperatures, and an interior surface smooth enough to resist microbial colonization.** ***Microbial colonization can induced corrosion in steel :*** *certain microorganisms can also thrive in a deposit/crevice. This can lead to bacteria producing acid metabolites as part of their metabolism. Some bacteria produce slime which can attract deposits causing differential cell corrosion.*

Studies conducted by *G. Husted of Micro Techno Research, Inc* have compared the ***bioadhesion properties*** of high performance thermoplastics (PVDF and ECTFE) with that of high grades of EP and MP 316L stainless steel. The samples were examined and had their ***biocolonization levels*** directly counted. The results of which are shown on these table below. From these test, it is evident that PVDF and ECTFE are more resistant to bioadhesion than high grades of stainless steels.

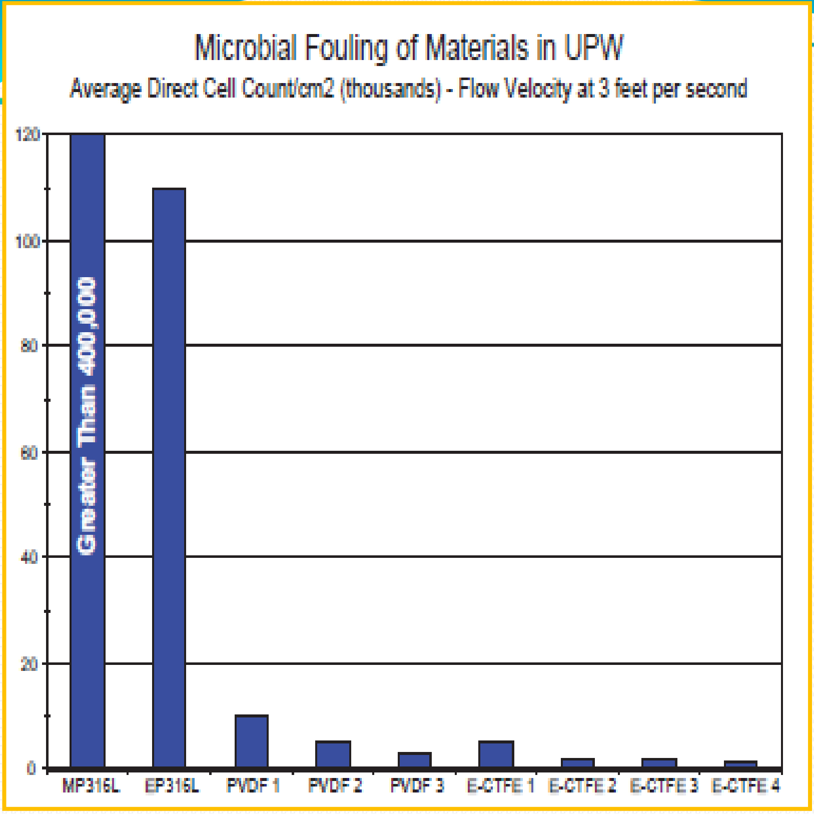


Table 2. Bio-adhesion comparison between SS MP 316 L, SS EP 316L, PVDF and ECTFE materials

Stainless steel 316L systems have been shown to be more susceptible than PVDF to excessive biofilm formation. High performance thermo-plastics do not contribute to the nutrition (ion contamination) levels of water systems.

Microbial Fouling/ biofouling is special case because the foulant, that is the microorganisms, can grow at the expense of biodegradable substances from the water phase, turning them into metabolic products and biomass. Therefore, microorganisms are particles which can multiply. They produce extracellular polymeric substances, which keep them together and glue them to the surface (bioadhesion) and also add to the fouling. Biofouling is not only a problem in technical environments but also equally in health and medical context. Contamination of drinking water frequently originates from biofilm development .

While the surface profile is an important factor in terms of reducing bioadhesion, the ***leachout*** from a pipe system is more important to a system overall purity level. While the piping cannot positively influence water quality it can have a dramatic negative effect on water quality. **It is well known; stainless steel leach higher rates of metal ions than thermoplastics systems.**

Table 3. provides a comparison of detectable ions and trace metals in high purity water systems with materials of construction of PVDF and 316L SS. Water samples were drawn from similar points and analyzed for contamination levels. As should be expected, metal ion contamination levels in the PVDF systems are dramatically lower than those of the stainless steel system.

The higher rates of contamination of stainless steel system contribute to elevated conductivity levels, high TOC levels and increased rates of microbial activity by providing bacteria a nutrition rich environment.

The iron content of austenitic stainless steels increases during the **orbital welding process. This is turn disturbs the chromium/ iron balance at the product surface. Systems become more susceptible to corrosion when this balance is disturbed**. Passivation is required to restore the corrosion resistance properties of austenitic stainless steels.

Dynamic Leachout Comparison of HP PVDF vs 316L SS

Dynamic Leachout Comaprison of HP PVDF vs 316L SS

Element	PVDF-1	PVDF-2	316L-1	316L-2
Al	< DL	0.006	< DL	0.007
Ba	< DL	< DL	< DL	0.14
B	< DL	< DL	5.6	1.7
Ca	< DL	< DL	< DL	1.1
Cr	< DL	0.004	0.03	0.023
Co	< DL	< DL	0.03	0.033
Cu	< DL	< DL	0.007	0.011
Fe	< DL	< DL	< DL	0.02
Mg	< DL	< DL	0.002	0.36
Mn	< DL	< DL	0.019	0.041
Mo	< DL	< DL	< DL	0.022
Ni	< DL	< DL	0.44	0.24
K	< DL	< DL	< DL	0.5
Si	< DL	< DL	22	< DL
Na	0.015	0.04	0.16	5.4
Sr	< DL	< DL	< DL	0.038
W	< DL	< DL	0.24	0.15
Zn	< DL	< DL	0.023	< DL

DL = Detection Limit

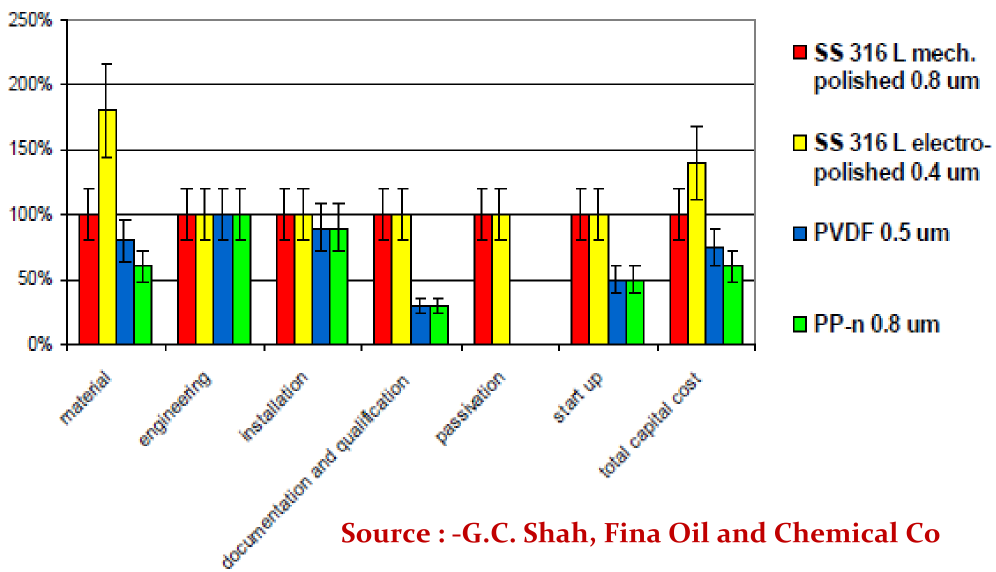
Table 3. Actual purity comparison of four sample points in system with piping material in HP PVDF and 316L SS. Measurement type is ion Chromatography

System Application and Material Usage

The de-ionization of water removes mineral ions from water to limit its ability to transfer electricity. **De-ionized (DI) water is used in : Electrically sensitive applications such as the production of semiconductors, capacitors**, and **high purity acid and chemical compound; Pharmaceutical, Biotechnology, and Food Processing.**PVDF pipe has the special ability to maintain the purity and DI quality of water. Other plastic piping materials can experience a shearing action from the water flowing against the inside of the pipe. This can lead to high concentration of particulates in the piping system. **The ultra-smooth surface of PVDF pipe reduces this effect substantially, making it essential for many high-tech applications that require contamination-free piping**.

PVDF-lined steel piping systems are also available, combining the purity and chemical resistance of PVDF with the structural support of steel. These systems are very resistant to distortion from pressure and temperature.

Benefit of Material to Systems Application_Total Cost Comparation



Source : -G.C. Shah, Fina Oil and Chemical Co

1. PVDF is easier to install and less expensive than metals suitable for high purity systems.
2. PVDF does not rust or rouge over time and doesn't need passivation, It maintains its purity over the entire length of the installation.
2. PVDF is tolerance for sanitizing procedures and high operating temperatures
4. Less expensive for environtmentally adverse cleaning protocols, doesn't costly biofilm issues.

THANK YOU

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