PPS Outshines Stainless Steel
in Chemically-Hostile Valve Applications

What is PPS?

Polyphenylene Sulfide (PPS), is a high performance, fiber reinforced, advanced composite, linear thermoplastic polymer.

For over a decade, PPS has replaced conventional materials, such as stainless steel, for industrial applications that require superior corrosion resistance, non-sticking and high temperature performance. PPS offers high strength-to-weight ratio, ease of machining, and cost savings through molded production. Some of the most recognized applications for PPS include blower and pump housings, impellers, flow meters, sensors, conveyor components, downhole oil production parts, and use as a protective coating.

About Chemically Hostile Environments

These environments can be defined as ones where there is deterioration of a metal or other material due to chemical or electrochemical reaction with its environment.

Why PPS is Superior to Stainless Steel in Corrosive Applications

PPS has higher resistance to corrosion than stainless steel, increasing operational life and sealing characteristics. This enables these valves to operate reliably and maintain tight sealing characteristics that meet or exceed the highest industry standards of 1 scfh @ 90% set pressure per valve.

PPS is a linear poly (phenylene sulfide) polymer, produced by a polycondensation reaction of p-dichlorobenzene and sodium sulfide. The chemistry of PPS gives it the edge in hostile territory. The reaction yields a PPS polymer with floating intermittent benzene double bonds with the structure (C6H4S)n .

These repeating benzene rings are connected by sulfur. Benzene rings are an extremely stable molecule and don't readily react with other molecules or compounds. The weak link in repeating molecules (polymers) like benzene rings is just that - the compound that links the molecules together. PPS utilizes a carbon-sulfur bond that is extremely stable because the sulfur is a small compound; therefore, it is extremely difficult for other compounds to squeeze in between the benzene rings to replace the sulfur.

PPS consists of stable repeating molecules with extremely stable bonds between the repeating molecules and an extremely stable and small compound that link them together, producing truly superior chemical resistance at ambient and elevated temperatures.

There is no known solvent, organic or inorganic, that dissolves PPS at temperatures below 200°C (392°F).

Stainless steel, on the other hand, is more susceptible to corrosion because it deals with corrosion on a macroscopic level (porous granular steel alloy solution). PPS deals with corrosion on a microscopic level (tight repeating molecular crystalline structure).

Stainless steels are basically low carbon alloy steel solutions containing at least 11.50% chromium. The addition of nickel as the second major alloying element produces austenitic stainless steel of the 200 and 300 series. Austenite is defined as a solid solution of one or more elements in face-center cubic iron. The austenitic types provide the best corrosion resistance of all the stainless steels, particularly when they have been annealed to dissolve chromium carbides and then rapidly quenched to retain the carbon in solution. This is the type of stainless steel most common in pressure vacuum relief valves. See 316 stainless steel composition below:

CF-8M 316 Stainless Steel:

Element	% of Composition
Cr	18 to 21
Ni	9 to 12
C	0.08 max
Mn	1.50 max
Si	1.50 max
Mo	2 to 3
P	0.04 max
S	0.04 max
Fe	Remaining

The chromium addition provides resistance to corrosion and to scaling at elevated temperatures. All stainless steels owe their "stainlessness" to the chromium addition.

Corrosion resistance, called "passivity," results from the chromium contributing to the formation of thin films of oxide called "passive films." Under favorable conditions, usually oxidizing, such films are protective; unfavorable conditions destroy the film and leave the surface in the "active" state, causing its corrosive resistant characteristics to be only slightly greater than that of ordinary iron or steel.

Stainless steel is susceptible to several types of corrosion and specialized types of attack which may occur as a result of equipment design or because of the peculiar action of the corrosive medium. These corrosion phenomena are known as intergranular, transgranular, stress cracking, imbrittlement, pitting and localized corrosion.

Corrosion occurring preferentially at grain boundaries is called ***intergranular corrosion***, and in this state the steel is said to be in a sensitized condition. Exposure to acids and other aggressive chemicals results in the chromium depleted areas being selectively attacked causing potential disintegration of the steel. To optimize its corrosive resistant characteristics, stainless steel has to be quench annealed. If this process is omitted or is not performed properly, complex chromium carbides may form preferentially at grain boundaries. These carbides are attacked selectively in oxidizing solutions and will in time lead to failure by ***intergranular corrosion***.

Exposure to aggressive chemicals combined with an applied load can cause material failure by intergranular and/or transgranular cracking under combined action of corrosion and stress and is known as ***stress corrosion cracking***.

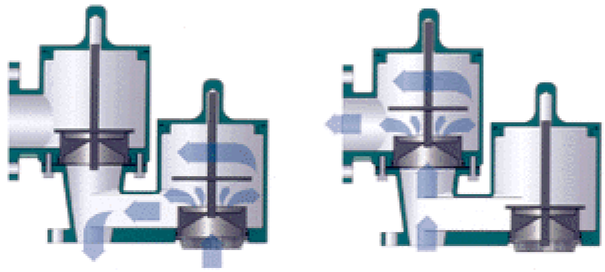
The severe loss of ductility of a metal resulting from corrosive attack, usually intergranular, is defined as ***corrosion embrittlement***.

Localized corrosion under circumstances that prevent restoration of passivity may cause rapid penetration at the point of initiation. This is because an active-passive electrolytic cell is formed between the large cathodic (passive) area and the small anodic area under attack; the surrounding oxygen serves as a depolarizer, and pitting proceeds. This type of attack is defined as ***pitting or localized corrosion***.

PPS is not susceptible to these types of corrosion, and therefore has more predictable and stable properties when exposed to chemically aggressive products, thus giving PPS superior operational life when compared to stainless steel.

The Effects of Corrosion on Valves

An excellent application for PPS is a pressure vacuum relief valve. Such valves are used to protect systems against positive and/or vacuum overpressure, prevention of air intake, evaporative losses of product, blanketing product losses, and containment of odorous and potentially explosive vapors. When applying one valve for multiple industries, i.e. exploration and production, pharmaceutical and chemical processing, refining, etc., the valve can be exposed to many types of corrosive chemicals, such as weak and strong acids, oxidizing acids, alcohols, aldehydes, ketones, amines, bases, chlorinated organics, esters, ethers, hydrocarbons, inorganics, nitro compounds, phenols, salt spray, organic solvents, oxygenated fuels, auto-oxidizing fuels and other aggressive fuels. These chemicals can attack and corrode the critical operational components of the valve causing pitting and cracking. This degradation of the valve can break down its sealing integrity causing excessive leakage; possibly hinder its relieving capacity; and sometimes cause mechanical failure. PPS can be selected in place of conventional corrosion resistant metals to reduce or eliminate these possibilities.

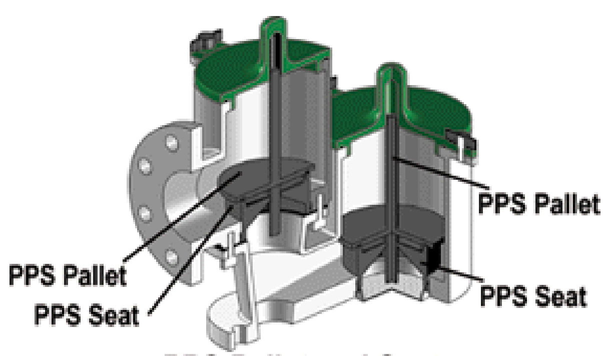


Vacuum Relief   Positive Pressure Relief

PPS was used by Enardo (an Emerson Electric Company) beginning in 1980 for the seat and pallet of its pressure vacuum vent valves due to the superior performance demonstrated in high content $H_2$2S applications. These pressure relief valves provide protection against excess positive or vacuum pressure; prevent air intake, evaporative or blanketing product losses; and help contain odorous, hazardous and potentially explosive vapors.

Application trials utilizing the valve components in other corrosive atmospheres were similarly successful, bringing unanimous acceptance of PPS components even in hydrochloric acid vapor containment. The success and wide acceptance of this material in almost every application led Enardo to utilize PPS in its premium pressure vacuum relief valve line. This ranked as a major improvement over existing product designs that had not changed in more than 50 years.

PPS is used for the seat ring and pallet, which are the critical operational components of the safety valve. The pallet and seat are responsible for maintaining a vapor tight seal during normal tank storage or other process system operations. When tank breathing or process system interruptions cause positive or negative pressure buildup, the pallet and seat function together to relieve the pressure. It is critical that the valve components provide a tight seal until relief and open reliably.



PPS Pallet and Seat

About “Sticking”

Sticking may be defined as: To attach by or as if by causing to adhere to a surface; to halt the movement or action of; to hold to something firmly by adhesion.

The Effects of Sticking on Valves

Valves are used in numerous industries that expose them to various types of chemicals that in many cases are very sticky. In addition, the valve may be exposed to harsh environmental conditions, especially severe cold.

The valve's internal components (pallet assembly and seat) must be allowed to move relative to each other in order for the valve to function properly. When the valve is operating, the internal components are exposed to the process stream that may consist of entrained particles or droplets of chemicals and/or water. These particles can build up on the sealing surface of the pallet or on the valve seat ring. This causes the seat and pallet to gum up, glue or freeze together. This is known as valve freeze or sticking. If the valve is unable to open and relieve the excess pressure in the tank or process system, it creates a potential for damage or failure to system equipment that the valve is supposed to protect.

Why PPS is Superior to Stainless Steel in Sticky Applications

The same characteristics that give PPS its superior corrosive resistance to chemical attack are also responsible for its superior nonsticking capability. PPS is a tight crystalline structure of extremely stable repeating benzene rings held together with a small stable element. Because PPS is so stable, it does not readily react with other molecular compounds (ice, chemicals, etc.) which prevent particles from bonding or adhering to it. PPS is so resistant to sticking, it is even used for nonstick cookware.

Stainless steel is prone to react with other molecular compounds that allow chemical adhesion and ice buildup because its structure does not have as dense crystalline formation; its molecules are not as stable; and it is more porous than PPS.

PPS is better suited for sticky processes and severe cold conditions, and is superior to stainless steel in resisting chemical attack which can adversely affect the valve's operation and sealing characteristics.

Physical Properties, Certifications and Ratings

PPS has an excellent continuous usage temperature range, from -50 to 428°F, and has a UL 746 flame rating. It has inherent flame retardant characteristics without the use of fillers or additives (UL 94 V0 & 5Vagrades, CSA A00 & V0). PPS has approvals under military specifications M-24519 and M-46174 (ASTM D4067). Its high strength-to- weight ratio makes it strong and durable. PPS has excellent properties for machining, dimensional stability and precision tolerance, all of which are important for use in pressure vacuum relief valve applications.

Conclusion

When subjected to chemically hostile environments PPS outshines stainless steel.

Material selection for the operational components of the valve is crucial to maintain performance and reliability. Many applications subject the valve to stored or processed vapors, which can be chemically hostile, corrosive and sticky, as well as to harsh environmental conditions like extreme cold and heat. These conditions are the prime causes of deterioration, pitting, sticking and freezing, which cause leakage and possible valve failure. When used for valve seat ring and trim, PPS material provides greater resistance to these destructive factors compared to conventional metal materials such as aluminum, ductile iron, carbon steel and stainless steel.