PENFLEX

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Alloy Selection for Sulfur and Sulfuric Acid Applications

Sulfur (S) is one of the most abundant elements on Earth, and references to its antimicrobial and antifungal properties date back to ancient times.

While there are mentions of its use in topical ointments and as a fumigant, sulfur's yellow mass, the bright blue flame it emits when burned, along with that acrid smell, led to one more ominous association. It is to burning sulfur that the Bible refers with each mention of "brimstone" and eternal damnation was the theme of many a "fire-and-brimstone" sermon.

The element's association with the fiery depths of Hell faded as the critical role it plays in plant and human health became better understood.

SULFUR AND SULFURIC ACID USES

Historically extracted from areas surrounding volcanoes and hot springs, sulfur is, today, most often produced as a byproduct of natural gas and petroleum refining. Sulfur-containing contaminants are removed and converted to sulfur in various forms, namely sulfuric acid. It is then used across a wide range of industries.

Agriculture and food and beverage markets rely on sulfur to support growth, stave off pests, bacteria and fungi, and prolong shelf life. A primary application is fertilizer production. Other applications include crop dusting, food processing and winemaking.

Typically introduced in the form of sulfur dioxide, sulfur works as a preservative when added to items such as dried fruit. Its chemical compounds are used in sugar refining to strip brown sugar of its color. And, while sulfites naturally occur during fermentation, some winemakers add more during this stage of production to further protect and preserve their vintages.

The paper making industry also relies on sulfur's "bleaching" power. Other applications span cellophane and rayon manufacturing, water treatment, and renewable energy. More energy dense than lithium-ion batteries, lithium-sulfur batteries are promising to push the limits of rechargeable battery technology.

When sulfur burns and comes into contact with oxygen, as happens when sulfur-containing fuels such as coal or diesel are burned, the reaction produces sulfur dioxide (SO_2), a commonly cited air pollutant. While legislation to curb emissions has initiated a shift away from coal-fired plants and created a market for low sulfur marine fuels, the need to extract sulfur from energy production processes remains, and thus a need for chemically compatible piping systems remains as well.

ALLOY SELECTION

To produce, transfer, and administer sulfur in its various forms, flexible piping components are needed, and materials of construction may differ based on what is moving through the hose, and in what concentration, pressure, temperature, and environmental factors.

While 316 stainless is a suitable option for most sulfur applications—and the 300 series stainless with the widest corrosion resistance to sulfur and sulfur compounds—there are some notable exceptions. For alum, sulfur acid in 5% - 10% concentrations, and saturated sulfurous acid, 316 SS is “partially resistant” meaning we would not recommend it for continuous use.

When it comes to the following solutions, we would not recommend 316 SS in any use case.

- Sodium hydrogen carbonate (aka sodium bisulfate), saturated
- Sulfur chloride, dry
- Sulfuric acid, 50%
- Sulfuric acid concentrated, boiling

Sulfuric acid is most commonly found in concentrated solutions and it, along with the others listed above, require special alloys with higher percentages of nickel and chromium due to their aggressive oxidizing nature. Alloy options for such application would include Inconel™ 625 and Hastelloy™ C276.

For concentrated sulfuric acid, the relative order of corrosion-resistance, in descending order, would be:

- Hastelloy™ C276
- Incoloy™ 825
- Inconel™ 625

Oftentimes solutions contain chlorides, necessitating further consideration so far as alloy selection goes. Beyond media composition, high flow velocity can speed corrosion rates, and come into play as well when selecting an alloy. In these cases especially, it’s clear that wall thickness also plays a role in corrosion resistance and must also figure into engineering design.

For a more complete listing of alloy compatibility with sulfur and sulfuric acid media, have a look at our corrosion resistance chart. For further questions, please contact us.