Zirconium Alloy Data Sheet

Description

Zirconium is used in services too severe for stainless steels, nickel alloys, and titanium or where a significant improvement in service life can be achieved by choosing zirconium instead of less expensive metals or plastics.

When zirconium is chosen for an application, the high cost and expected serviceability require the chemical composition, mechanical properties, and overall casting quality be precisely controlled. Our past record shows that Flowserve meets these criteria so the full benefits of using zirconium can be realized.

Specifications

Flowserve produces two grades of zirconium castings that conform to ASTM Specification B752, Grades 702C and 705C.

Composition

Element	702C %	705C %
Carbon	0.1 max.	0.1 max.
Hafnium	4.5 max.	4.5 max.
Hydrogen	0.005 max.	0.005 max.
Iron	0.3 max.	0.3 max.
Nitrogen	0.03 max.	0.03 max.
Oxygen	0.25 max.	0.3 max.
Phosphorous	0.01 max.	0.01 max.
Niobium	–	2.0 - 3.0
Other elements (total)	0.40 max.	0.40 max.
Zirconium	Balance	Balance

Mechanical and Physical Properties

	702C	705C
Yield Strength, psi (MPa)	40,000 (276)	50,000 (345)
Tensile Strength, psi (MPa)	55,000 (379)	70,000 (483)
Elongation, percent in 1 inch	12	12
Brinell Hardness, 3000 kg max.	210	235
Modulus of Elasticity, psi x 10^6	14.4 x 10^6	14.0 x 10^6
Coefficient of thermal expansion per °C (25°C)	5.89 x 10^{-6}	6.3 x 10^{-6}
Thermal conductivity Btu-ft/hr-ft^2-°F	13	10
Density, lb/in^3/(g/cc)	0.235 (6.51)	0.240 (6.64)
Melting point, °F (°C)	3365 (1852)	3344 (1840)

Zirconium Alloy Data Sheet (continued)

Corrosion Resistance

No metal or alloy is resistant to corrosive attack in all chemical environments. Zirconium is no exception, but it does have excellent resistance to a wide variety of chemicals. Zirconium has outstanding resistance to hydrochloric acid, sulfuric acid, organic acids, and alkaline media such as sodium hydroxide. Its resistance to nitric acid is equalled only by the noble metals such as tantalum.

The most common application areas for cast zirconium equipment are in hydrochloric acid, sulfuric acid, and hot organic acids. Zirconium shows excellent corrosion resistance to all concentrations of hydrochloric acid even at temperatures exceeding the normal boiling point. However, zirconium is not resistant to hydrochloric acid containing oxidizing species such as cupric chloride, ferric chloride, or wet chlorine. Zr 702C is resistant to sulfuric acid concentrations up to 70 percent and Zr 705C is resistant to concentrations up to 55 percent to the normal boiling point of sulfuric acid. Poor resistance is obtained with higher concentrations, even at room temperature.

Zirconium is superior to stainless steels, nickel alloys, and titanium in organic acids. This alloy is considered for these applications at high temperatures where its marked superiority results in a distinct economic advantage. Zirconium has poor resistance to concentrated sulfuric acid, hydrofluoric acid, concentrated phosphoric acid, ferric chloride, cupric chloride, wet chlorine, and other oxidizing chloride environments.

Casting Quality

Flowserve zirconium castings are routinely tested and inspected to ensure that optimum casting quality is maintained. Chemical analysis is performed on each melt to verify conformance to published alloy composition.

Weldability and Heat Treatment

Weld repair is performed but must be done in an inert gas atmosphere to prevent oxidation of the weld and heat affected zone. All welds are closely examined for evidence of serious contamination. Insufficient shielding can be readily detected by blue to purple or gray to white colors in the weld whereas silver-bright or straw-yellow colors are indicative of proper shielding during welding. Zirconium castings are not normally heat treated but Zr 702C castings are stress relieved after major weld repair and Zr 705C castings are stress relieved within 14 days of all welds.

Machinability

Zirconium machines to an excellent surface quality and requires low power input compared to steels. However, care must be taken to minimize very fine chips since they are pyrophoric (i.e., may spontaneously ignite in the presence of air). Zirconium does show a tendency to gall and work harden which requires tool clearance angles higher than normal.

Costs

Zirconium is one of the higher priced alloys which find application in the chemical process industry. It is therefore used only where service conditions necessitate its selection. Initial cost of zirconium equipment should be compared to less expensive alternatives only after considering many factors such as the following:

- Zirconium often has far superior corrosion resistance relative to less expensive alternates resulting in greater expected service life.
- Mechanical reliability is often far greater for an alloy such as zirconium as compared to some nonmetallic equipment designs.
- The high cost of production downtime for routine maintenance and equipment failure may require the use of a more reliable, corrosion resistant alloy such as zirconium.

Mechanical Properties

Although Zr 702C possesses good tensile properties, it does have relatively low impact strength compared to most corrosion resistant alloys. However, with proper care zirconium equipment can provide excellent service. Zr 705C offers the user a higher impact strength and, more importantly, a higher pressure temperature limit which could eliminate the need for higher pressure class products. For further information refer to the IOMs (Installation and Operation Manuals) or contact Flowserve's Materials Engineering Department at (937) 226-4000.

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