Technical Data Sheet

Zircadyne® 702/705 in Nitric Acid

(UNS R60702)

INTRODUCTION

Zirconium is produced as two major commercial alloys for nitric acid applications. Zirconium Grade 702 (UNS R60702) is considered commercially pure zirconium and is typically the material of choice for nitric acid applications. Zirconium Grade 700 (UNS R60700) is low oxygen zirconium and has the same corrosion resistance as Zircadyne® 702. Due to the lower oxygen content this alloy is used in applications where cladding or a greater degree of forming is required.

Nitric acid is one of the most widely used acids in the Chemical Processing Industry (CPI). It is a key raw material in the production of ammonium nitrate for fertilizer, and is also utilized in a variety of manufacturing processes, such as dyes, plastics, synthetic fibers, metal pickling and in nuclear reprocessing. As the demands on nitric acid process equipment have increased, material selection for selected process equipment has become crucial. Suitable structural materials need to be cost effective, reliable, durable, efficient, and non-contaminating to the product and the environment. For over 20 years, zirconium has proven to be the best solution for many nitric acid applications (Table 3).

Most nitric acid is produced by the oxidation of ammonia with air over a platinum catalyst. The resulting nitric acid is further oxidized into nitrogen oxide and then absorbed into water to form nitric acid. This process produces acid up to 70% concentration. In some cases, as shown in Table 1, even the high chromium containing stainless steels do not have sufficient corrosion resistance for this application. The superior corrosion resistance of zirconium can overcome these limitations. One example of this is the cooler condenser in monopressure nitric acid plants. At one stage of the production process the process gas is cooled and oxidized further in the cooler condenser. The conditions in this heat exchanger are exceptionally corrosive to stainless steels due to the high temperature of 204°C (390°F) and the condensing nature of the reaction. Zirconium is the preferred material of construction for this piece of equipment in many monopressure nitric acid plants.

CORROSION RESISTANCE

Zirconium's corrosion resistance in nitric acid is exceptional in acid concentrations up to 90% and at temperatures well above the boiling point. Figure 1 gives the 5-mpy iso-corrosion curve for Zirconium in nitric acid. The dotted line indicates that the upper limit line for the 5-mpy corrosion rate has not been established above about 250°C or 80% concentration.

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1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
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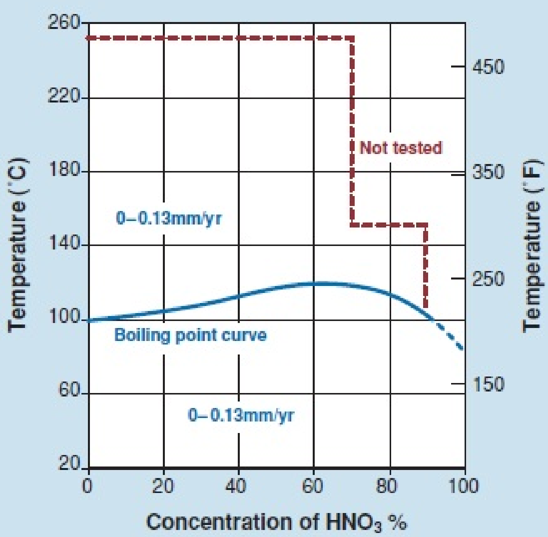
Figure 1. The 5-mpy Iso-Corrosion Diagram of Zr 702 in Nitric Acid



The corrosion resistance of titanium alloys can depend on the presence of multivalent impurities for passivation of the surface to reduce corrosion. Zirconium does not require the presence of multivalent ions for its corrosion resistance.

Table 1. Corrosion of Zircadyne® 702 vs. other alloys in 65% Nitric Acid at Elevated Temperatures

Alloy	Corrosion Rate mpy (mm/yr)		
	121°C (248°F)*	149°C (302°F)	204°C (390°F)
Duplex Stainless Steel 7-mo plus	7.9 (0.2)	---	---
Duplex Stainless Steel 7-mo plus welded	9.1 (0.23)	---	---
Stainless Steel 310	4.9 (0.12)	86 (2.18)	1064 (27)
Stainless Steel 304L	8.9 (0.22)	---	---
Stainless Steel 304L welded	7.4 (0.18)	---	---
Titanium Grade 2	10 (0.25)	---	---
Zircadyne® 702	0.0	0.0	0.0
Zircadyne® 702 welded	0.0	0.0	0.0
*Boiling Point of 68% Nitric Acid			

Most mixtures of nitric acid and other mineral acids do not pose a problem for zirconium. The corrosion resistance of zirconium in Nitric acid with various impurities is given in table 2. Zirconium can tolerate a wide range of acid mixtures containing both nitric acid and sulfuric acid. Mixtures of nitric and hydrochloric acid can be tolerated by zirconium as long as the nitric acid to hydrochloric acid ratio does not approach that of aqua regia (1:3 Molar ratio hydrochloric acid-nitric acid). For mixtures of nitric acid and phosphoric acid the possibility of fluoride content of the phosphoric acid must be considered. Fluoride is a common contaminant of non-food grade phosphoric acid.

Table 2: Zircadyne® 702 in Nitric Acid with Impurities (Boiling Point)

	Corrosion Rate mpy (mm/yr)

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		Liquid Phase		Vapor Phase	
Nitric Acid %	Impurity	Non-welded	welded	Non-welded	welded
30/50/70	1% Ferric Chloride	<2.5 (0.064)	<2.5 (0.064)	<2.5 (0.064)	<2.5 (0.064)
30/50/70	1% Sea Water	<2.5 (0.064)	<2.5 (0.064)	<2.5 (0.064)	<2.5 (0.064)
30	1% Sodium Chloride	<2.5 (0.064)	<2.5 (0.064)	<2.5 (0.064)	<2.5 (0.064)
50	1% Sodium Chloride	<2.5 (0.064)	<2.5 (0.064)	12.7 (0.32)*	35.6 (0.9)*
70	1% Sodium Chloride	<2.5 (0.064)	<2.5 (0.064)	<2.5 (0.064)	<2.5 (0.064)*
30/50/70	1% Iron	<2.5 (0.064)	<2.5 (0.064)	<2.5 (0.064)	<2.5 (0.064)*
30/50/70	1.45% dissolved 304SS	<2.5 (0.064)	<2.5 (0.064)	<2.5 (0.064)	<2.5 (0.064)*
0%	Saturated Chlorine	<2.5 (0.064)	102 (2.59)	<2.5 (0.064)	91.4 (2.3)*
30/50/70	Saturated Chlorine	<2.5 (0.064)	<2.5 (0.064)	<2.5 (0.064)	<2.5 (0.064)*
*Pitting					

SUITABLE PROCESSES

Table 3: Major Nitric Acid Processes Suitable For Use Of Zircadyne®
Synthesis of Nitric Acid
Synthesis of Adipic Acid (without an oxidizing catalyst)
Nitration of Organics
Reprocessing of Spent Nuclear Fuels
Production of Ammonium Nitrate and other Nitrate Salts

LIMITATIONS

Despite the superiority of its corrosion resistance in HNO3, zirconium is not suited for all nitric acid containing environments. Stress corrosion cracking becomes a concern in concentrated HNO3 but can be controlled with proper equipment design and heat treatment. Zirconium may also suffer pitting in the vapor phase of nitric acid and chloride mixtures as a result of the evolution of chlorine gas. A good surface finish and proper equipment design can prevent this problem. Finally, the presence of fluoride ions can significantly decrease the corrosion resistance of zirconium. Adding an inhibitor to convert fluoride ions into non-corrosive fluoride complexes can control this problem. Several compounds, including zirconium sponge and zirconium nitrate, can be used as inhibitors.

SUMMARY/CONCLUSION

Zircadyne® 702 and Zircadyne® 700 can be the material of choice for many applications involving the use of Nitric Acid. Longer equipment life, reduced maintenance downtime, and higher quality product streams are all possible with the proper application of Zircadyne® Zirconium. This can make Zircadyne® Zirconium the most cost-effective option when compared with other alloys.

Although zirconium has proven its outstanding corrosion resistance in a wide variety of Nitric Acid containing environments, one way to determine zirconium's suitability for a particular environment is to perform an in-plant corrosion test. Corrosion test samples for both alloys are available from ATI for testing in your process equipment. In consultation with ATI, the most suitable combination of metal chemistry, surface condition and heat treatment can be provided at no charge. These tests can show how zirconium will perform under your actual process conditions. ATI also has a fully capable corrosion laboratory and analytical facilities for complete testing and detailed analysis for specific nitric acid applications.

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Adherence to proper temperature and acid concentration limits in conjunction with an effective heat treatment will give the best corrosion resistance for Zircadyne® 702, and Zircadyne® 700 in Nitric Acid service.

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