www.tricormetals.com

www.astrolite.com

www.tricoralloys.com

Titanium Grades Used in the CPI

Author

Marc Cook – Technical consultant / Materials Specialist

Tricor Metals – Wooster OH

Titanium can seem confusing at first. There are 40 grades of titanium and it's not clear why you'd use one over another. Fortunately, there are only a handful (seven) that are the most important to get a handle on for the chemical process industry, and understanding where they all fit relative to each other is actually pretty simple. The purpose of this document is to talk about those 7 grades, what applications they are used for in general terms, and the reasons they are different. ASTM B348 is the applicable ASTM specification that covers these grades if you'd like to follow along.

The grade used most often in the CPI is grade 2/2H, so that's our benchmark. If you ask for a titanium vessel, a fabricator is going to assume you are asking for grade 2 to start. Grade 2 is commercially pure titanium, as is grade 1, which we'll talk about next.

Grade 1 is just like grade 2, but it has lower strength and higher ductility. This reduction in strength and increase in ductility is due to slightly lower Oxygen and Iron content in the alloy. The reason grade 1 is used is for applications that require greater ductility because there is a high degree of forming involved in making the part, and strength is not as important. One easy to understand example is the plates on plate and frame heat exchangers. There is lots of forming involved in making these, but the strength requirements are minimal. A second example is the corrosion resistant alloy (CRA) cladding layer on explosion-bonded equipment. In the act of explosion cladding, the thin CRA layer undergoes severe deformation as it gets bonded to the substrate. Good ductility is required to avoid cracking or damage of the CRA layer. However, strength is not needed since the strength is provided by the backing substrate.

The next grade to talk about is grade 7. Grade 7 is just like grade 2, except it has better corrosion resistance and much higher cost because it has 0.12 – 0.25% Palladium added to it. That little bit of Palladium makes a big difference in both cost and corrosion resistance. Check out the latest Alloy Cost Comparison Chart on Tricor's website for the latest data (Alloy Cost Comparisons), but usually grade 7 is around 5 times the cost of grade 2. To see the difference in corrosion resistance, look at these 5 mpy iscorrosion curves for grade 2 and grade 7 in Hydrochloric acid in Figure 1.

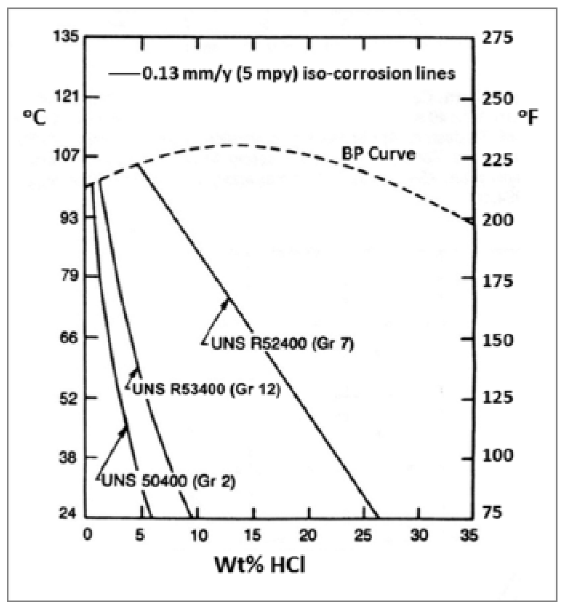

Figure 1 Isocorrosion curves for titanium alloys in Hydrochloric Acid

Grade 11 is the low strength equivalent of grade 7. It has the same Palladium content so it has the same corrosion resistance, but has the same strength as grade 1. So it's a fit for those same applications we discussed for grade 1, but when the corrosion resistance equivalent to grade 7 is required.

The next two grades we want to cover are grades 16 and 17. These grades are similar to grades 7 and 11 in that they have Palladium added for enhanced corrosion resistance. But instead of 0.12-0.25% Palladium, they have 0.04-0.08% Palladium. As you've probably guessed, this reduced amount of Palladium results in less of a price increase and less improvement in corrosion resistance as compared to grades 7 and 11. Grade 16 is the grade 2 and 7 equivalent with respect to strength. Grade 16 is roughly double the cost of grade2. From a corrosion resistance standpoint, grades 16 and 17 are reportedly "nearly equivalent" to grades 7 and 11, although the author has found published corrosion data hard to come by. If you have time for corrosion testing, it could certainly be a good investment to do some testing and determine if grade 16 or 17 will work for your application.

The 6 grades we've talked about so far fit pretty neatly into a matrix:

		Palladium Content, min (weight percent)		
		0	0.04	0.12
Tensile Strength, min (ksi/MPa)	35/240	Grade 1	Grade 17	Grade 11
	58/400	Grade 2H	Grade 16H	Grade 7H

The last grade to talk about doesn't fit as neatly into the above matrix, grade 12. Grade 12 is titanium with 0.6-0.9 % Nickel and 0.2-0.4% Molybdenum added in. These small amount of Nickel and Moly result in some interesting and important changes. First off, this alloy has high strength relative to the others already mentioned. The minimum tensile strength is 70 ksi (483 MPa), 20% higher than the grade 2H/7H/16H family. From a corrosion resistance standpoint it generally outperforms grade 2 but does not equal grade 7. For a cost perspective it is comparable to grade 2, 20% higher at the time of this writing. When the higher strength is considered, grade 12 can end up being cheaper than grade2 sometimes for process equipment, with the additional benefit of superior corrosion resistance. This MTI article Titanium Grade 12 - Alternative Alloy for Cost Reduction & Corrosion Resistance gets into much more detail on this topic.

This blog post references H grades for grades 2, 7 and 16. ASTM lists both standard and H grades for these alloys. These three grades had an original tensile strength listed of 50 ksi (345 MPa). As processing improvements occurred, the material coming out of the mills easily exceeded this minimum strength requirement. The H grades were developed to recognize this strength upgrade and most materials produced in these grades are dual certified.

There are many other interesting titanium grades, but being versed on these seven will equip you with sufficient knowledge to understand most titanium applications in the chemical processing industry. Titanium is a versatile material that is a standout performer for certain chemical applications like bleach, hypochlorites, wet chlorine gas, Chlor-alkali cells and other. Give Tricor a call if you think titanium might be a good fit for your application. We'd be happy to share any data or experience we have, and provide a competitive quote for your equipment if appropriate.

References:

Corrosion Resistance of Titanium, Titanium Metals Corporation, 1997.

ASTM B348/348M-21, Standard Specification for Titanium and Titanium Alloy Bars and Billets.

MS-3 Materials Selector Series for Hydrochloric Acid, Hydrogen Chloride and Chlorine Dioxide, 2nd ed., Materials Technology Institute, 2016.

www.tricormetals.com

www.astrolite.com

www.tricoralloys.com

TRICOR

METALS

ISO9001 ASME VIII Div. 1 & 2 PED, AS9100

FABRICATED PRODUCTS
- Shell & Tube Heat Exchangers
- Plate Heat Exchangers
- Pressure Vessels, Tanks, Columns
- Anodes & Cathodes
- Pipe Spools
- Heating Coils
- Fans & Impellers
- Titanium Forgings & Billet

FIELD SERVICE & REPAIR DIVISION
- Reactive Metal Welding
- Autoclave Repairs
- Plate Heat Exchanger Refurbishing
- Equipment Modifications

TITANIUM SERVICE CENTER
- Plate
- Sheet
- Expanded Metal
- Titanium Forgings
- Bar & Billet
- Pipe
- Tubing
- Fittings and Flanges
- Fasteners
- Weld Wire

ASTROLITE® ALLOYS
- Astrolite® UltraGrade™ Welding Wire
- Turbine Engine Welding Wires