

Galvanic Series In Flowing Sea Water

Material	Steady State Electrode Potential, Volts (Saturated Calumel Half-Cell)
Graphite	+0.25
Platinum	+0.15
Zirconium	-0.04
Type 316 Stainless Steel (Passive)	-0.05
Type 304 Stainless Steel (Passive)	-0.08
Monel 400	-0.08
Hastelloy C	-0.08
Titanium	-0.1
Silver	-0.13
Type 410 Stainless Steel (Passive)	-0.15
Type 316 Stainless Steel (Active)	-0.18
Nickel	-0.2
Type 430 Stainless Steel (Passive)	-0.22
Copper Alloy 715 (70-30 Cupro-Nickel)	-0.25
Copper Alloy 706 (90-10 Cupro-Nickel)	-0.28
Copper Alloy 443 (Admiralty Brass)	-0.29
G Bronze	-0.31
Copper Alloy 687 (Aluminum Brass)	-0.32
Copper	-0.36
Alloy 464 (Naval Rolled Brass)	-0.4
Type 410 Stainless Steel (Active)	-0.52
Type 304 Stainless Steel (Active)	-0.53
Type 430 Stainless Steel (Active)	-0.57
Carbon Steel	-0.61
Cast Iron	-0.61
Aluminum 3003-H	-0.79
Zinc	-1.03

Data from ASM Handbook, Vol. 13, Corrosion of Titanium and Titanium Alloys, p. 675.

As long as titanium remains passive, it will be galvanically protected by any material below it (less noble) in the galvanic series. The farther apart in the series, the greater the rate of attack on the less noble metal. While the sea water series is a good guide, behavior in other environments may be different, so care should be exercised when dissimilar couples are to be utilized. A smaller relative area of the corroding (less noble) metal will result in accelerated metal loss because the smaller area must provide a higher corrosion current density to protect the larger area. Under galvanic conditions, hydrogen evolves at the titanium (cathode) surface and may be galvanically charged in to the titanium where the potential difference is 0.75 volts or greater, if temperatures are above 80 °C (176 °F), pH is low (>3), and the titanium surface is breached (by iron) or damaged by abrasion. If titanium becomes active, for example in a reducing acidic environment, the protective surface oxide may be destroyed, titanium's galvanic behavior more like aluminum, and titanium may suffer loss of metal. In couples with stainless steel, there is a strong possibility that the stainless steel will become active.