



DATA SHEET No 6

The Titanium Oxide Film; Formation and Preservation

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Titanium is a highly reactive metal. Fortunately the oxide film which forms spontaneously and is always present in oxidising environments is stable and self healing if damaged. It is this film which gives titanium its outstanding resistance to corrosion in a wide range of aggressive media.

What is meant by an 'oxidising environment'? In fact the titanium oxide film is self supporting and self healing not only in oxidising environments, but also in neutral and mildly reducing conditions. For titanium 'oxidising' means conditions where a critical minimum level of oxidising agent is present in the media, under conditions where it can react with titanium preferentially to repair or inhibit further breakdown of the oxide film. This covers a very wide range of chemicals, mixtures, process conditions and products.

In practice air, moisture, moist gases, water, even heavily polluted brackish water and sea water, will support the oxide film. Deaeration of an aqueous media does not affect the corrosion resistance of titanium, because water alone supports the oxide film. Only traces (e.g. ppm) of moisture or oxygen are required to maintain passive behaviour in most environments. Notable exceptions are chlorine gas, red fuming nitric acid and methanol where specific concentrations of moisture from 1.5% up to 10% are required to support the oxide film on titanium alloys under the worst conditions of environment and temperature.

Pure reducing acids, hydrochloric, sulphuric, phosphoric etc. will attack titanium in proportion to concentration and temperature. Titanium is inhibited from attack, and its oxide film supported by the presence of limited concentrations of oxidising ions such as Fe³⁺, Cu²⁺ and others shown below. Inhibition becomes less effective as acid concentration and temperature increase. No inhibition is available to prevent breakdown of the titanium oxide film by hydrofluoric acid and acidic fluorides.

Moderate inhibition	Strong Inhibition	Very Strong Inhibition
Oxygen, Ni ²⁺ , OCl ⁻ , picric acid, nitro- nitroso-and quinone organics	ClO ³⁻ , cupric, ferric and mercuric ions, Ti ⁴⁺ , Te ⁴⁺ , Te ⁶⁺ , Se ⁴⁺ , Se ⁶⁺	Bromine, Chlorine, ClO ₄ ⁻ , Cr ⁶⁺ , Mo ⁶⁺ , Mn ⁶⁺ , V ⁵⁺ Ions of Au, Ir, Pd, Pt, Ru

The corrosion resistance of titanium and its alloys in crevices or under deposits, (strongly reducing conditions and in the absence of oxygen or oxidisers) can be enhanced by alloying with palladium, ASTM Grades 7,11,16,17,18,20,24, or ruthenium, ASTM Grades 26,27,28,29.

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