



# DATA SHEET No 5

## Connecting Titanium to other Metals

*(Revision 1 October 1997)*

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1. 'Galvanic' corrosion may occur when dissimilar metals are coupled together and requires:

- one metal to be substantially less corrosion resistant than the other
- a good electrical contact between the metals
- an electrolytic path (water, sea water, acid, alkali or salt solution) between the metals

If one or other of these requirements is absent galvanic corrosion will not occur.

2. The galvanic corrosion rate of the less resistant (less noble) metal in the couple will vary according to the active or exposed surface areas of the two coupled metals, the anode (corroding)/ cathode ratio.

The greatest corrosion on the less noble anodic metal occurs when the cathode is large in relation to the anode. Little or no damage may be caused when the anode is large in relation to the cathode.

3. Titanium is highly corrosion resistant, and will usually cause more rapid damage to a less resistant active material to which it is coupled. Titanium will usually be the more noble metal and the cathode in the galvanic cell.

4. Titanium should not be coupled directly to less noble metals, such as magnesium, zinc, and aluminium. These are likely to experience accelerated corrosion and, in the process, titanium may pick up hydrogen which is generated as the cathodic product of the corrosion reaction.

5. Titanium may be coupled to copper based alloys and carbon steel. Effective protection against galvanic attack must be provided for these less noble metals.

6. Titanium may safely be coupled directly in neutral, slightly reducing and oxidising environments to corrosion resistant metals and alloys of similar potential in the galvanic series, such as super duplex stainless steels, 6Mo austenitic steel, 22% chromium duplex steel, 625, C-276 and the like. Care must be taken to check compatibility for the intended working environment. For example 22% chromium duplex steel may be coupled to titanium in mildly sour oil and gas brines, but not in sea water, unless cathodic protection is provided to overcome the susceptibility of the steel to crevice corrosion.

7. Metals and materials such as graphite and carbon fibre composites which are even more corrosion resistant than titanium and which raise the corrosion potential into the passive region for titanium, may be coupled to it, and will maintain the resistance of titanium in reducing as well as neutral and oxidising environments. This effect is the basis of the protection of titanium by palladium and other platinum group metals in reducing acid chloride environments and crevices. This protection may not be provided in the few cases where in very strong reducing acid conditions (e.g. in concentrated sulphuric and hydrochloric acids and hydrofluoric acid) the oxide film on titanium is attacked and cannot be maintained or restored.

8. Titanium may also be connected directly with metals and alloys such as stainless steels which are galvanically compatible when in their passive condition in a specific environment. These alloys may become activated, for example by local alloys may become activated by local corrosion or pitting but the added effect of coupling to titanium is small. The primary consideration must be to ensure that the alloy selected is appropriate for the service environment.

9. Galvanic corrosion should be avoided by selection of materials in design, and by protection of adjoining less noble metals in the system. Techniques include, coating the titanium in the neighbourhood of the joint to reduce the effective cathode/anode ratio; electrical isolation of the titanium components through the use of non conducting gaskets and sleeved bolts; installation of short easily replaced heavy wall sections of the less noble metal; chemical corrosion inhibition of the active metal.

10. Impressed potential cathodic protection of the base metal, should deliver no more than -0.85v SCE in sea water or near neutral brines. Similarly, sacrificial anodes must be selected to produce negative potentials of less than -0.85v SCE when the adjacent titanium components are thin walled (such as heat exchanger tubing) or are heavily stressed critical parts. Aluminium and zinc sacrificial anodes may however be used when the adjoining titanium parts are under low levels of stress and are of heavier section. e.g. 6mm wall thickness or more. Magnesium anodes must not be used, their potentials are too negative. A review of the cathodic protection system is essential when a significant area of titanium replaces steel in a corrosive environment.

**DO NOT galvanically couple titanium alloys to less noble active metals and alloys such as carbon steel, aluminium, zinc or active stainless steels at temperatures above 75oC in sour sulphide containing aqueous environments. The titanium will absorb hydrogen and this may lead ultimately to failure by embrittlement. (See Data sheet 3 – Titanium and Hydrogen).**

**TAKE CARE when coupling titanium to a less noble metal if only that metal is coated. Any coating defects, damage or breakdown in localised areas will immediately cause rapid attack of the less resistant metal unless cathodic or chemical protection is available or unless the adjoining titanium structure is also coated.**

#### FOR FURTHER INFORMATION CONTACT

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