DATA SHEET No 13
Titanium Alloys for Sour Service

(Issue 1 September 2001)

The combination of stress corrosion resistance, low density, low modulus and non-magnetic properties possessed by titanium alloys makes many of them suitable for service in sour conditions. Titanium has been successfully used in a variety of sour service applications in the drilling, logging and production phases of the oilfield industry.

Sour service environments are defined by NACE International specification MR0175 as "fluids containing water and hydrogen sulphide (H_2S) that is at a total pressure of 0.4MPa (65psia) or greater, and if the partial pressure of hydrogen sulphide in the gas is greater than 0.0003MPa (0.05psia)". The acidity of the environment is below pH 3.5, and carbon dioxide, and chlorides are also normally present.

Titanium alloys are available in a range of strength levels, and this permits selection for a wide variety of oilfield and geothermal applications including pipework, manifolds, valves and pumps, chokes, kill and booster lines, instrument casings and drill strings. The lower strength alloys such as Grades 2 and 12 are currently used in sour water piping systems, for low pressure lines and for wellhead seal rings. Medium strength alloys (Grades 25, 28 and 29) are used for offshore sour service taper stress joints providing maximum flexibility in highly stressed dynamic production riser systems. Current applications for the highest strength grades (Beta-C, Ti-6-2-4-6), most corrosion resistant because of their high molybdenum content, include packers, safety valves, springs and formation test components.

The current revision (2001) of MR0175, lists the above seven titanium alloys, (see table), have been tested and found acceptable for direct exposure to sour environments. Conditions for supply, including heat treatments, are detailed in the specification as well as the maximum hardness allowed for each alloy.

Name/ASTM Ref	Composition	UNS Ref
Commercially Pure Gr. 2	Ti – 99%	R50400
Grade 12	Ti-0.8Ni-0.3Mo	R53400
6-2-4-6	Ti-6Al-2Sn-4Zr-6Mo	R56260
Grade 28	Ti-3Al-2.5V-0.1Ru	R56323
Grade 25	Ti-6Al-4V-0.5Ni –0.05Pd	R56403
Grade 29	Ti-6Al-4V-0.1Ru	R56404
Beta-C, Grade 19	Ti-3Al-8V-6Cr-4Zr-4Mo	R58640

The widely available 'workhorse' titanium alloy, Ti-6Al-4V, (ASTM Grade 5) is not currently listed, but is nonetheless used as a standard material for drilling and non magnetic instrument housing applications in sour down hole environments. The relatively short exposure times of measuring and logging while drilling operations, (MWD and LWD), are a factor in the success of such applications.

Other titanium alloys, including ASTM Grades 7,9,18,21,23,24 and Ti-4Al-4Mo-2Sn (Ti-550) similarly not listed in the MR0175 list may also be expected to perform satisfactorily to specific levels of exposure in sour conditions. Any alloy may be release tested as satisfactory for operation under the proposed service conditions, pH, H_2S, CO_2, chlorides etc., at an appropriate temperature, for example in accordance with the guidelines for the selection and

testing of corrosion resistant alloys for sour service, in the European Federation of Corrosion Handbook EFC 17.

CAUTION: Special attention is required when certain down hole treatments are applied where titanium equipment is in use.

ACIDISING: Hydrofluoric acid (HF) and Hydrochloric acid (HCl) are commonly used for sour service production. All titanium alloys are rapidly attacked by HF, even in very dilute concentrations and in fluoride containing solutions below pH7. Titanium should not be specified or used if regular HF acidising is anticipated. If in exceptional circumstances titanium equipment is accidentally subjected to exposure for very short periods to hydrofluoric acid or active fluorides, limited general corrosion may be expected. Once the HF is removed or has been reduced to insignificant levels, (less than 20ppm), corrosion will not continue. The protective titanium oxide film will reform spontaneously, restoring the original level of corrosion resistance. Similar considerations apply to titanium when uninhibited hydrochloric acid, (HCl), or HCl/HF mixtures are used. Inhibited hydrochloric acid, may be used with titanium in accordance with supplier instructions. Alternative acidising solutions, including a selection of organic acids, to which titanium alloys are resistant should also be considered.

Ask for a copy of TIG Design Guide *TITANIUM OFFSHORE*

METHANOL : Methanol is one of the few specialised environments which may cause stress corrosion cracking (SCC) in titanium alloys. SCC failures have occurred in dry methanol, methanol/acid and methanol/halide mixtures. Water is an effective inhibitor and will maintain the passivity of titanium alloys in oilfield environments if present in the weight % concentrations identified in the following table:

Titanium Alloy Grade	%water–Intermittent exposure[1]	% water – Sustained exposure[2]
1,2,7,11,16,17	1.5	2.0
9, 12	2.0	2.0
28	2.5	3.0
5,23	3.0	3.0
19, 29, 6-2-4-6	5.0	10.0

1 = short term non continuous 2 = long term continuous

Ask for a copy of TIG Data Sheet No 5 *TITANIUM and METHANOL*

MERCURY: Susceptibility of some titanium alloys to SCC in mercury has been demonstrated under clean conditions in the laboratory. In the field there are no reported cases of liquid metal embrittlement of titanium by mercury. Titanium alloys are highly resistant to solutions of mercury salts over the pH range 3 – 11,at metal temperatures well in excess of the boiling point of the solution.

Ask for a copy of TIG Data Sheet No 9 *TITANIUM and MERCURY*

Copies of the MR0175-2001 specification can be obtained from NACE International in the USA, fax +1 281 228 6200.

Copies of The European Federation of Corrosion (EFC) guide – EFC17 - can be obtained from EFC in the UK, fax +44 (0) 1782 202 421.

FOR FURTHER INFORMATION CONTACT

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