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Experience and Guidance in the Use of Titanium Components in Steel Catenary Riser Systems

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Abstract

Titanium alloys have been used for stress joints at the top of SCRs for approximately eight years. The impact on the riser design, hang-off structure and installation of a stress joint is discussed.

More severe loading and internal fluid conditions have also given rise to interest in using titanium in the TDZ, and several studies have shown great advantages, mainly in improved fatigue life. Practical methods of incorporating the alloy into an SCR are presented.

Many design codes do not fully address titanium alloys, and some characteristics of the material require consideration when establishing design load capacities and fatigue behavior. These are discussed and recommendations for safe design are given.

Finally, the operational requirements to ensure integrity throughout the design life are presented.

Introduction

Titanium alloys have a unique combination of properties, such as high strength, low elastic modulus and density, excellent fatigue resistance together with high chemical resistance, which make them attractive for use in offshore riser systems.

Titanium alloys are now routinely used for tapered stress joints at the upper termination of SCRs, and at the subsea wellhead of some TTRs, as listed in Table 1. In these applications, they are normally located in the highest load and fatigue zone of the riser, and those used on production SCRs are continually exposed to produced well fluids.

Recently, extension of production into deeper water and harsher environmental conditions has generated interest in extending the application of titanium alloys to the TDZ where substantial improvements in fatigue life can be achieved over steel. This increased interest has also been due to the discovery of substantial HPHT reservoirs, often associated with more corrosive and sour well flows.

This paper is aimed at the riser designer. It presents a brief guide to the selection of titanium alloys and their properties, and solutions to issues arising from integrating them into an SCR. Guidance is given on the design of tapered stress joints (TSJs), and support structures at the platform. Aspects of manufacturing of which the designer should be aware, and typical installation methods are discussed. Similar information is provided for titanium alloy riser sections at the TDZ. Finally, guidance is offered concerning the compatibility of relevant titanium alloy components with typical injected and workover well chemicals, and completion fluids.

Design Codes

A recommended practice[1] for the design of titanium risers was published by DNV in 2002. The increasing use and acceptance of titanium as a riser material is reflected in its inclusion in the new API/ISO riser design code (ISO 13628-12) currently being drafted. Other codes used for riser design could be used for titanium riser design, but the DNV recommended practice has been ratified by testing, and the results will be incorporated into the new API/ISO code.

Alloy Selection & Properties

Alloy Types

There are primarily two grades of titanium commonly used for catenary risers:

- ASTM Grade 23 Titanium: (UNS R56407)
  Nominally Ti-6%Al-4%V ELI (extra-low interstitial, 0.13% max. O)
- ASTM Grade 29 Titanium: (UNS R56404)
  Nominally Ti-6%Al-4%V-0.1%Ru ELI (extra-low interstitial, 0.13% max. O)

Grade 29 is a more corrosion-resistant alloy derived by the simple addition of 0.1 wt.% ruthenium (Ru) to the well-established Grade 23 alloy, traditionally used as a structural aerospace alloy. This ruthenium addition raises both the crevice and stress corrosion temperature limits for this alloy to over 260ºC in sweet and sour chloride brines and seawater[2,3,4]. Grade 29 alloy is also fully approved for sour service up to HRC 35 under the NACE MR0175/ISO 15156 Standard.