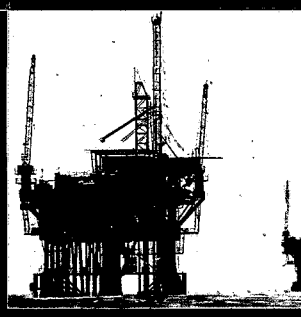
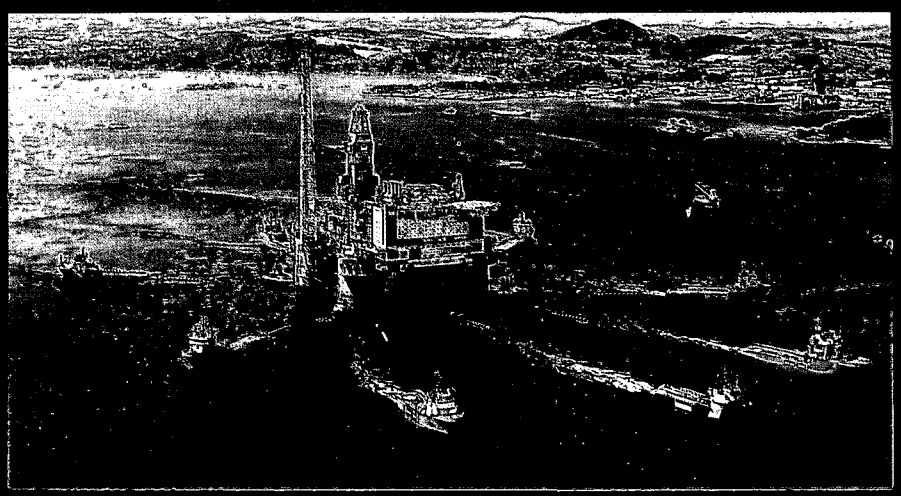


Titanium Alloys in Subsea and Offshore Production Systems



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FOREWORD

This report results from a survey, predominantly of oil companies, to assess industry's attitude to the use of titanium in offshore applications, and to identify whether research and development work is needed to address uncertainties relevant to its use in this general area.

The survey was jointly funded by The Marine Technology Directorate Limited (MTD) and the Health and Safety Executive. The work was performed under contract to MTD by Dr Carl Baxter (Carl Baxter and Associates) and Dr Roger King (Failure Control Ltd); the Project Manager at MTD was Mr Robert Barrett.

HSE's interests in the project were controlled by Mr Ken Woodward, and the work was monitored by Mr James Krol of the Marine Technology Support Unit (MaTSU).

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1. SUMMARY

Historically titanium has been considered as a material of last resort in the offshore oil and gas industry because of the perception of a high initial price and service experience limited to a few niche applications. This view is now changing due to a reduction and stabilisation in world prices over the past few years together with the increased engineering challenges of deep water production and high pressure, high temperature well flows.

It is evident from activity in the titanium industry and from the replies received from oil companies during the survey reported here that there is growing interest in titanium for many uses. It already is well established for topsides heat exchangers and companies reported no problems in using it in this application. In Norway it is also widely used for firewater and ballast systems on platforms and Conoco has installed the first titanium drilling riser on the Heidrun field. The industry recognises that there are many other parts of deep water or high pressure, high temperature systems for which the metal has potential. It is also used for coiled tubing and downhole components, and is being developed for drill pipe sections for highly deviated wells.

Various oil company studies in the past have shown a potential benefit from using titanium for drilling risers in deep water such as West of Shetlands and in Norway. The material is also being studied by several oil companies as a replacement for reinforced hose currently used for catenary production risers in conditions that preclude the use of flexible pipe (i.e. high pressure, high temperature and/or sour fluids). As a result of the survey and recent activity in the industry, it appears that the main interest in the near future will be to use titanium for catenary riser systems where it is subjected to a wide range of fluids and fatigue loading.

Unlike steel and other conventional materials, which have had many years of research and development for use in offshore oil and gas production systems, titanium is comparatively new to the field. Steel will obviously remain the primary material for structures and piping, with other materials finding niches. Titanium is expected to be one of these 'niche' materials.

1.1 Structure of the Report

This report begins with a brief history of titanium and some of the main factors to be considered when using it in offshore oil and gas systems. It then looks in more detail at applications where titanium offers advantages and presents the results of a survey amongst oil companies on their opinions of the future use of the material.

The main grades are briefly reviewed and the most promising candidates for the various applications are identified. The current state of knowledge of the material relevant to its use offshore is reviewed and future research requirements have been derived.

1.2 Research Requirements

The main areas identified for research are:

- ***Allowable Stresses:*** Structural grades of titanium, like high strength steels, have a high yield to ultimate strength ratio. Current design codes specify a smaller allowable percentage of ultimate tensile strength than yield strength (typically 50% ultimate or 67% yield whichever is the smaller). This may be overconservative when designing with high strength materials. It is proposed to look at the build up of safety factors in relation to the mode of failure and reserve strength for specific applications.