# Tubulars: Titanium drill pipe, hole cleaning, stress release and more

## IADC/SPE 59140

### Development of Titanium Drill Pipe for Short Radius Drilling

A need exists for drill pipe that offers Improved reliability and extended life in reentry drilling programs where the radius of curvature is less than 80 ft (i.e., >95°/100 ft). Steel, aluminum, and composite drill pipe traditionally utilized in these short radius drilling operations often exhibit abbreviated lives stemming from fatigue, wear, and/or physical damage.

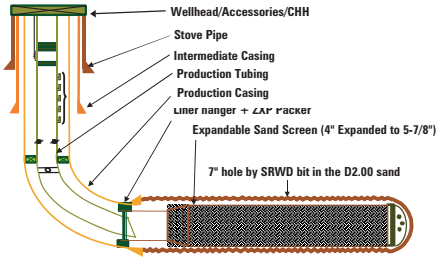
With an elastic modulus of approximately 16.5 msi, titanium pipe offers enhanced flexibility and reduced fiber stresses compared to steel pipe When rotated in holes of high curvature. Utilization of the most widely used titanium alloy, TI-6AI-4V, offers a high nominal yield strength of 130 ksi with a density 56% that of steel. Combined with good corrosion and fatigue resistance in drilling and downhole fluid environments, this titanium alloy is a lightweight, highly flexible, robust. and fatigue-resistant drill pipe material.

A practical and cost-optimized Ti drill pipe joint design consists of a seamless Ti-6AI-4V alloy pipe body, which is produced in standard API sizes and Range 2 and 3 lengths, to which steel tool joints are mechanically attached to the upset ends. The steel tool joints offer the advantages of lower tool joint costs, standard drill pip a make/break connection behavior, the option for tool joint hardbanding. and elimination of welded joints.

Successful development of titanium drill pipe assemblies for short-radius drilling primarily consisted of appropriate conditioning/treatment of OD and ID pipe body surfaces to maximize fatigue life, optimizing the pipe and upsetting procedure, establishing the tool joint-to-pipe attachment methodology, and design and testing of a high-integrity tool-joint-to-pipe connection and tool joint for optimum fatigue performance. This paper overviews these developments, and the laboratory test results used to establish critical performance behavior and requirements for 2.875-in. OD Ti-6AI-4V drill pipe for short-radius drilling. An update on recent field experience with titanium drill pipe utilization in various short radius drilling programs is provided as well.

**—J E Smith, Grant Prideco**
**—E I Bailey, Stress Engineering Svcs**

**IADC/SPE 59142: Status diagram showing ESS application**




**—R W Schutz, RTI Energy Systems**

## IADC/SPE 59141

### Optimization of Stress Relief Grooves for Rotary Shoulder Connections

Field experience and finite element studies have established the effectiveness of utilizing a stress relief groove on the pin of a threaded connection to prolong its life. Nevertheless, the exact design geometry of the stress relief groove has not been developed from sound fundamental principles and, in fact, is subject to discussion and even controversy. Moreover, the need to recut damaged threads on extant tools motivates the minimization of stress relief groove length so that subsequent machining will not be precluded.

The purpose of this paper is to present some finite element results which examine the dependency of stress on stress relief groove length. Threaded connection life is predicted by means of a failure criterion which characterizes the stress state as the sum of a linearized mean stress and an alternating stress. The alternating stress is obtained by calculating the difference between the maximum and minimum rotating bending stress developed for a specified borehole dogleg. The predictions of the finite element model agree well with the results from dynamic roll tests.

A parameterized finite element model of a 5 ½ FH threaded connection has been developed which allows the variation of the length of the stress relief groove. Stresses are computed for a variety of lengths. It is found that an optimal length does in fact exist. Lengths shorter than optimum simply introduce fur-

ther stress concentrations due to the presence of unnecessary pin threads, while longer lengths tend to load up the remaining threads excessively. It is proposed that a new industry standard be promulgated with this approach in mind. In particular, a stress relief groove can be initially cut, which will not only match the performance of a stress relief groove fabricated under the existing arbitrary design criterion, but will actually improve the stress state when a recut is necessary.

**—M Hommel, Schlumberger Oilfield Services**

## IADC/SPE 59142

### Optimisation of Well Economics by Application of Expandable Tubular Technology

The paper presents the deployment of Expandable Tubular Technology (ETT) as an Expandable Completion Liner/ Sand Screen (ESS) in an application that impacts positively on well economics. It addresses numerous drilling, completion and productivity challenges to deliver the optimum drain hole (increased productivity) from a slimmer well (reduced well construction costs) with downhole equipment that needs minimal reentries and remedies, (reduced operating expenditure).

To improve **Shell Petroleum Development Co's** production by 60% in the short term and by over 200% (to 2.5 MM bbl/day) by the year 2010, most new wells are completed horizontally with minimum potentials of 3,000 bbl/day. The application of ESS in these types of wells is a novel challenge with a history to date of only four installations in wells up to about 60º deviation and maximum deployed length of about 240 ft.

The paper introduces the business case and economic justification for the application of ESS in well SMTQ-5. It highlights the planning, project management and the critical engineering considerations applied to the execution phases. It also describes the QRA approach applied to assess the technical feasibility of deploying an Expandable Sand Screen in a horizontal well that indicated a 94% chance of success and only a 1.6% chance of losing the well.

**—D O Owoeye, Shell Petroleum Development Company, (SPDC), Nigeria**

## IADC/SPE 59143

### Improved Hole Cleaning & Reduced Rotary Torque By New External Profile on Drilling

This paper will describe the application and effects of a completely new design of machined profiles that have been incorporated into Drill String Equipment to improve hole cleaning and reduce rotary friction. The paper will report on a series of qualification programs which have been implemented to supplement successful field operations to date.

One of the new profiles generates local changes in mud flow by combining an archimedian screw and scoop effect to prevent cutting sedimentation and enhance cuttings transportation.

The other profile creates a continuous tangential film of drilling fluid that is designed to reduce downhole rotary friction. By using both of these profiles it is possible to improve overall drilling performance and extend current operational limits

**—J Boulet, SMF International, *et al***

## IADC/SPE 59144

### Development and Testing of Insulated Drill Pipe

The paper describes the theoretical background, laboratory testing, and field testing of insulated drillpipe (IDP). Structural and thermal laboratory testing procedures and results are described. Results are given for a field test in a geothermal well, in which circulating temperatures in IDP are compared with those in conventional drill pipe (CDP) at different flow rates. A brief description of the software used to model wellbore temperature and to calculate sensitivity to IDP design differences is included, along with a comparison of calculated and measured wellbore temperatures in the field test.

**—J Finger and R D Jacobson, Sandia National Laboratories**
**—A T Champness, Drill Cool Systems Inc**

## IADC/SPE 59146

### Lateral Buckling of Pipe with Connectors in Horizontal Wells

Laterally buckled pipe with connectors is analyzed for the first time in this paper. It presents an analytic solution of the beam-column equations in 3 dimensions in a horizontal wellbore with pipe weight. Pipe deflections, contact loads, and bending stresses are determined with explicit formulas. Sag between connectors is calculated so that pipe body contact with the wellbore between connectors can be determined. Critical loads for buckling initiation are determined. Conditions for positive contact forces are determined and compared to previous buckling criteria, such as Paslay-Dawson.

Applications include the analysis of bottom hole assemblies, drill pipe, casing, and tubing. The solutions are simple formulas that are suitable for hand calculations

**—R F Mitchell, Landmark Drilling and Well Services**

## IADC/SPE 59147 (ALTERNATE)

### Development of OCTG Connection for Automated Drilling Rigs

This paper describes research data for a newly developed tapered connection design. The design is capable of being assembled quickly and easily with the characteristics of simple easy stabbing and high gall resistance. The development incorporates a unique thread profile that is distinctly different from current thread forms on OCTG. The new thread form may be applied to other connection that use the API Buttress thread form.

**—K Maruyama, *et al*, Nippon Steel Corp**