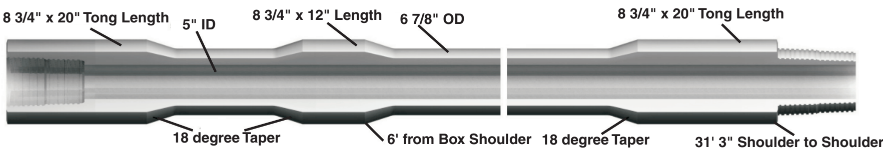
Stronger tubulars can increase drilling efficiency

LANDING STRING DEVELOPMENTS

THE AUTHORS WILL present technological developments in deepwater landing strings and handling equipment that provide the ability to extend the overall deepwater operating envelope. They will also detail the developments to overcome the current limitations associated with the use of conventional equipment at extreme loads occurring when landing very heavy casing strings in deepwater wells. All stages of evolution of this new technology including research, development and manufacturing will be detailed. Unique manufacturing challenges and solutions associated with the production of ultra-thick wall landing strings with over 2 million lb tension capacities will be presented. Laboratory qualification testing to over 5 million lbs and proof testing to 3 million lbs along with running, handling and actual case histories detailing field use will also be discussed.



Unique manufacturing challenges and solutions associated with the production of ultra-thick wall landing strings with over 2 million lb tension capacities resulted in deepwater landing strings and handling equipment that provide the ability to extend the operating envelope. IADC/SPE 87186

The new technology developments presented provide a level of overall load capacity and safety factor dramatically exceeding that of current conventional equipment. The information is applicable to all deep wells being drilled in the deepwater areas of the world, thus extending the industry's deepwater operating envelope. The main significance of the technological developments is the considerable improvements in overall load capacities and safety factors that have been achieved for deepwater landing strings and handling equipment. Field case histories that were encountered will be presented.

2,000,000 lb Landing String Developments-Novel Slipless Technology Extends the Deepwater Operating Envelope (IADC/SPE 87186) **B A Adams**, **Oil & Gas Rental Services Inc**; **B R Simpson**, **Mike Payne**, **BP**; **M J Jellison**, **Grant-Prideco**.

LINER FLOATATION

The Ringhorne platform in the Norwegian North Sea is a challenging extended reach development with 24 wells planned within an 8 km radius of the platform surface location. The platform is designed to drill to seven accumulations with target TVD ranging from 1,750 m to 2,000 m. The longest well planned is 8,400 m MD with a TVD of approximately 1,780 m. The 9 ⅝-in. liner is required to keep the ECD below the estimated fracture gradient when drilling 8 ½-in. sections with the 9 ⅝-in. shoe depth ranging from 5,000 m to 8,000 m.

The well geometry limits available weight to conventionally install the 9 ⅝-in. liner. Mud over air floatation was identified early in the planning phase as the essential means of managing the drag while running liner. While casing/liner floatation has been done before elsewhere in both onshore and offshore fields, typically the 9 ⅝-in. liner has been floated in with a so-called floatation collar in the casing string to separate the mud and air. Usually the liner job has used the same casing or a similar casing string as the landing string. The casing running string was subsequently replaced with a larger ID string to improve ECD while drilling deeper.

The authors will describe the planning, testing and execution of a novel approach to liner floatation job performed in a record-setting Ringhorne well. A standard and field proven 9 ⅝-in. liner hanger system was modified, tested and used as the mud-over-air isolation mechanism. This system was used to run 4,560 m long 9 ⅝-in. liner to a depth of 5,961 m using 6 ⅝-in. drill pipe as the landing string.

Many firsts were achieved, including:

• The longest 12 ¼-in. Rotary Steerable System run at 4,288 m. The total 12 ¼-in. section is 4,441 m;

• The longest 12 ¼-in. x 13 ½-in. ream-while-drilling at 4,441 m using one assembly;

• Record 12 ¼-in. PDC bit run.

The record-setting drilling of the 12 ¼-in. section and the successful implementation of the liner floatation technology have the potential to extend the current standard well designs to reach further by eliminating a casing string from the extended reach well designs.

A Novel Approach to Liner Floatation Extends the Standard Well Reach in a North Sea Field Development (IADC/SPE 87187) **Z Wang**, **N N Musaeus**, **ExxonMobil Development Company**; **S E Froland**, **Baker Oil Tools**.

DRILL STRING FATIGUE

Fatigue and corrosion fatigue account for roughly 80% of all drill string failures. The complexity of fatigue and the inability to account for cumulative damage has hindered the drill string designer's ability to effectively manage fatigue.

Currently, the use of Bending Strength Ratio (BSR), Stiffness Ratio (SR), Stress Relief Features (SRF), and API corrosion coupons are the primary means available to mitigate corrosion fatigue in drill strings. While these methods offer some benefit, an innovative design approach offers new techniques that combine drill stem and trajectory design improvements with real-time corrosion monitoring to dramatically increase the designer's ability to manage fatigue.

Calculating the absolute number of cycles that a component can undergo before failure is not a realistic approach. Important variables, including load history, material properties, environment, stress concentrators and many other factors, can dramatically affect fatigue life but are often unknown to the designer. On the other hand, the designer will know component dimensions, yield strength, weight, planned and actual hole curvature, and tension with high confidence. If fatigue lives are calculated for many commonly used components, holding unknown variables constant and changing only known variables, a meaningful, quantitative comparison can be made between design alternatives. Various options can be compared to determine which is best from a fatigue standpoint.

Three new comparative fatigue design indices have been developed that focus on normal weight drill pipe (NWDP), heavy weight drill pipe (HWDP), and the bottom hole assembly (BHA). One example is Curvature Index (CI). Drill pipe fatigue is generally the result of rotating the pipe across a dogleg while it's under tension. CI combines build/drop rate, inclination, mud weight, tension, adjusted pipe weight, pipe grade and pipe size to compare two or more design alternatives. Two other new design indices, Diameter Ratio (DR) and Stability Index (SI) will be presented by the authors. Portable real-time corrosion monitoring devices were tested in drilling fluids to evaluate their ability to monitor general corrosion rates in real time. The general corrosion rates reported by three meters closely matched the actual corrosion measured using the API corrosion coupons.

Each meter also displayed appropriate responses to the addition of chemical treatment to the fluids. Use of meters such as these in the field would allow real time monitoring of mud corrosivity and real time evaluation of the impact of inhibitors and scavengers.

An Innovative Design Approach to Reduce Drill String Fatigue (IADC/SPE 87188) **T H Hill**, **S Ellis**, **N Reynolds**, **K Lee**, **M Zheng**, **T H Hill Associates Inc**.

ROTARY SHOULDERED CONNECTION

The author will detail the assessment of rotary shouldered connection mechanical performance by comparing the widely used Goodman diagram assessment of fatigue life to a more advanced and accurate plastic strain life evaluation. The technical approach defined by the author challenges the general use of the Goodman diagram and the concept of an endurance limit for API rotary shouldered connections. Likewise, the approach confronts the general assumption that the make-up torque values defined in API RP7G are set in stone. These make-up torque values do, however, have a consistent basis. Understanding this basis, the state of stress in the connection and how a rotary shouldered connection functions allows use of the connection's mechanics to the industry's advantage.

Such an assessment recently led to a justification for increasing the make-up torque on an API NC50 connection for a major operator while drilling a challenging directional well in the Gulf of Mexico. A concerted effort to understand and evaluate the connection performance allowed reaching TD without having to lay down drill pipe and incur the cost associated with switching to a high-torque rental string. Any operator or service provider can utilize the evaluation techniques presented in this paper to assess the impact a controlled increase in make-up torque may have on a rotary shouldered type connection.

Application of Increased MUT on API Rotary Shouldered Connection - Goodman Diagram vs Strain Life Method (IADC/SPE 87190) **S D Everage**, **S E Ellis**, **K Lee**, **T H Hill Associates Inc**.

ROTATED BHA CONNECTIONS

When designing bottom hole assemblies, both the types of connections and the use and size of stress relief features must be defined. These design choices are especially critical when the components will experience stress cycles when rotated while buckled or under bending loads, as fatigue accumulates. The author will detail the methods and results of a two-fold analysis on the relative fatigue life of API rotary shouldered connections. Pin stress relief grooves (SRGs) of various widths were studied to determine the width that yields the longest fatigue life.

Additionally, the relative fatigue life of NC56 and 6 5/8 REG API connections were studied to determine the advantage, if any, of one connection type over the other. The relative magnitude of improvement in fatigue life was quantified using finite element analysis (FEA) and either the Forman crack growth model, or the Morrow approach strain-life model.

Use NC56 Connections on 8-in. Drill Collars and Cut 1-in. of ¾-in. Pin Stress Relief Grooves on Rotated BHA Connections NC38 and Larger (IADC/SPE 87191 – Alternate) **S E Ellis**, **N M Reynolds**, **K Lee**, **T H Hill Associates Inc**. ■