instances of BHA whirl and severe acceleration and deceleration caused by stick slip.

To enhance overall bit/BHA stability, a new style 8 ½-in. PDC was implemented with innovative depth of cut control (DOC) technology and enhanced stability features. The result was a significant reduction in stick slip, lateral vibration and BHA whirl.

SPE/IADC 105906

Extreme Drilling Environment Forces Evolution of Rotary Steerable Systems and Rotary Steerable Bit Technology. B. Cox and L. Romo, BP; B. Champion and O. Maung, Schlumberger; K. Card and S. Barton, ReedHycalog.

Wells drilled in the Tuscaloosa Trend near Baton Rouge have long been recognized for the extreme nature of the HPHT operating environment and potential for well control problems. The current focal point concerns drilling the highly abrasive formations contained within the intermediate and drilling liner sections to depths of about 20,000 ft. These sections are a major cause of bit, directional tool and drill string failures. The directional complexity of the wells has increased exponentially in recent years; new drills are therefore primarily directional.

This paper focuses on the improvements which have been achieved over a 5 year period due to the implementation of Powered Rotary Steerable Systems (PRSS) coupled with Rotary Steerable Bit Technology. The step change in performance has been evidenced by a D/10K reduction from 86 to 55.

SPE/IADC 105885

Optimization of Deep Drilling Performance: Benchmark Testing Drives ROP Improvements for Bits and Drilling Fluids. A. Judzis, A.D. Black and H.A. Robertson, TerraTek; R. Bland, Baker Huges Drilling Fluids; D.A. Curry and M.J. Meiners, Hughes Christensen; T.C. Grant, US DOE.

This paper will present laboratory-measured drilling performance of full-scale bits at 10,000 psi borehole pressure, cuttings volume estimates, apparent cuttings size distributions, mud properties and the influence of bit and mud design on drilling performance, cuttings and near borehole characteristics. Findings include:

- Mudding up decreased PDC drilling efficiency and penetration rates in sandstone by 90% for both water- and oil-based systems with little sensitivity to ending mud weight or blade count.
- TCI and impregnated bit penetration rates at these pressures were an additional 70-90% slower than PDC bits.
- Cuttings from Carthage Marble and Mancos Shale appear to be compressed agglomerates of fine particles. Carthage Marble cuttings had low compressive strengths.
- Test results indicated that opportunities for improvements in bit design and smart HPHT drilling fluids are possible.

SPE/IADC 105522

Drilling Without WOB, Dream or Reality? An Effective Field Test by Total Angola. C. Simon, DrillScan; D. Goyallon and J.P. Poloce, Total; H. Sellami and L. Gerbaud, Ecole des Mines de Paris; A. Dourfaye, Varel Europe.

PDC bit modeling and single cutter analysis have enabled a new generation of cutting structure based on the optimization of a specific interactive cutting mode that generates, by the only drilling action of the cutters, an axial force oriented in the drilling direction: a negative weight on bit. This paper presents the application of this new PDC bit design and show that WOB can be strongly reduced in a large range of formations. This new bit technology has the potential to increase bit performance, specifically in operating conditions where power is available but WOB is limited due to friction, buckling or reduced vertical depth.

SPE/IADC 105898

Application of Small Vibration Logging Tool Yields Improved Dynamic Drilling Performance. D. Perez, R. Lockley, A.J. Clarke and C.M. Hanley, ReedHycalog.

The drill bit is often assigned as the cause of downhole vibration/instability and frequently bears the scars of dynamic drilling problems. Historically bit manufacturers have used a combination of dull grades and surface data to speculate on cause and effect of downhole events with insufficient attention to what may be occurring in between. This paper discusses the implementation of a vibration logging tool and its flexibility for placement of multiple tools in various locations. Specific field cases will be presented, including validation of pre-run dynamics modeling software, up to 6 distributed measurements in one drillstring, rotary steerable tools, concentric and eccentric hole opening tools, and response of different BHA configuration.

Technical Session 8: Tubulars I

SPE/IADC 105026

Catastrophic Drill String Failures Caused by Downhole Friction Heating — An Increasing Trend. L. Hehn, M. Jellison, K. Wyble and R.B. Chandler, Grant Prideco; J. Shepard, GlobalSantaFe.

Drillstring failures caused by friction heating of BHA components and drillpipe have increased dramatically over the last several years. In one failure mode, the drillpipe is heated above a critical transformation temperature accompanied by a rapid decrease in tensile strength. Subsequently, the component fails under a tension loading, well below the rated strength of the drillstring.

This paper addresses the features of a downhole heating failure, including the material attributes that can be used to identify the phenomena. Guidelines and operating practices that can be employed to minimize the occurrence of these costly and potentially dangerous failures are discussed.

SPE/IADC 105930

Special Issues in the Stress Analysis of Casing Strings in Steam Injection Wells: Mathematical Development and Design. R. Garside, TNK-BP; P.D. Pattillo and P.D. Pattillo II, BP; U.B. Sathuvalli, Blade Energy Partners.

The design and development of steam injection fields is a mature subject. Since the strings in these wells invariably experience inelastic loading, issues such as the effects of temperature on the static and cyclic material properties become important. Due to the high temperatures involved, miscellaneous issues such wellhead loading gain prominence. Data on the cyclic thermal properties of OCTG steels is rare in oil field literature.

This paper presents a comprehensive mathematical model of casing strings subjected to thermal loads in steam injection wells. The model includes the effects of temperature on material properties and the effects of wellbore curvature and pre-stress during the heating cycle. Several counter-intuitive aspects of the casing stress state during cooling /unloading are examined by an analytical model and finite element analyses. Test data and the mathematical models are used to determine the stresses in the casing at different points in the life of the well via a generic example design.

SPE/IADC 104497

C125 Casing — A Viable Solution for HPHT in Mild, Sour Service Applications. B.E. Urband, Grant Prideco; S. Morey, BP.

A considerable demand for exploring and developing deep, HPHT reservoirs has brought forth the need for high-strength tubulars with adequate sulfide stress cracking (SSC) resistance.

This paper details the results of testing to explore the possibilities of using 125 ksi specified minimum yield strength (SMYS) casing in sour or mildly sour environments. The SSC resistance of the 125 ksi material was evaluated utilizing the NACE TM0177 96 1 test Method A and test Method D. This paper also details the key manufacturing steps necessary to produce a high-strength SSC-resistant tubular product.

SPE/IADC 105717

Strain-Based Design of Tubulars for Extreme Service Wells. J. Nowinka and T. Kaiser, Noetic Engineering; B. Lepper, Shell.

This paper presents fundamental concepts for strain-based design of tubular strings in extreme temperature applications and HPHT wells. Strain-based design utilizes material capacity beyond its elastic range to overcome economic and technical hurdles. The relevant concepts are illustrated by examples from analytical and experimental investigation of casing material for thermally stimulated wells operated by Shell Canada Ltd in Western Canada.

SPE/IADC 105855

First Gas Field Developed Using Exclusively Dope-Free Casing and Tubing Connections — Statoil Snøhvit. G. Carcagno and T. Castiñeiras, Tenaris; D.J. Eiane, Statoil.

The recent development of dope-free solutions for tubing and casing premium connections provides a real and proved alternative to traditional thread compounds and proprietary environmentally free solutions. Among other advantages, the dope-free solution can solve the legal limitations to operate with standard compounds in very environmentally sensitive areas. This paper describes the concept and features of a fully dry dope-free solution, and the first extensive field experience of this solution in the Snovhit field of Statoil in the Barents Sea.

Technical Session 9: Geomechanics

SPE/IADC 105405

Assuring Stability in Extended Reach Wells — Analyses, Practices and Mitigations. S.M. Willson, S.T. Edwards, N. Last, BP; A. Crook and A. Bere, Rockfield Software; D. Moos and P. Peska, GeoMechanics International.

The paper describes state-of-the-art approaches for assuring wellbore stability in high-angle extended-reach wells. While the step-out lengths of proposed ERD wells are becoming more challenging, wellbore stability assurance technologies are developing at an equal pace. Incremental step out increases are no longer required, and it is now quite reasonable to plan 10 km ERD wells on the basis of a limited number of vertical or near vertical appraisal wells. The paper reviews the prior art of ERD wellbore stability, focusing on the Wytch Farm, Valhall and

Niakuk experiences of the 1990s. New developments in theoretical understanding and predictive capability of rock failure surrounding wells drilled at high-angle to bedding will be described.

SPE/IADC 105808

Wellbore Stress Indicators While Drilling: A Comparison of Induced Features from Wireline and LWD High-Resolution Electrical Images. G. Lindsay, S. Morris and J. Lofts, INTEQ; S. Ong, Baker Atlas.

Using recent examples from vertical and deviated wells, the differences between LWD and WL image logs for determining wellbore stress are explored. Wellbore stability analysis using wireline image data is well established. High resolution LWD images offer real time and time lapse image data until recently unavailable. Comparison of post drilling images with detailed wellbore images acquired at time of drilling shows that different features are observed. Extended reach, high pressure and geometrically complex well designs require increasingly sophisticated wellbore stability management. A method for incorporating the use of high resolution images in real time to supplement traditional analysis is discussed.

SPE/IADC 105193

Improving Formation Strength Tests and Their Interpretation. E. van Oort, Shell; R. Vargo, Halliburton.

Verifying pressure integrity of a casing string and the adjacent formation is an important requirement during drilling of a well. Crucial decisions on mud weight, kick tolerance, interval total depth and casing setting depth are based on the outcome of formation strength (FS) tests such as leak off tests (LOT) or formation integrity tests (FIT). Yet the majority of FS tests and their interpretation currently carried out in the field are inadequate. In this paper, we will highlight many of the problems underlying current FS tests and their interpretation, illustrating them with actual field examples. We will show how test artifacts can be overcome to correctly assess formation strength parameters.

SPE/IADC 105763

Pre-Drill Estimation of Subsalt Fracture Gradient: Analysis of the Spa Prospect to Validate Nonlinear Finite Element Stress Analyses. J.T. Fredrich, BP; B.P. Engler and J.A. Smith, Sandia National Laboratories; E.C. Onyia and D.N. Tolman, ConocoPhillips.

In 2002, Conoco drilled the Spa prospect, Walker Ridge 285 #1, in the Gulf of Mexico to a depth of 29,452 ft MD / 29,434 ft TVD, penetrating a nearly 10,000-ft salt section. While the potential for reduced fracture gradient below salt was recognized in well planning, pre-drill pore pressure and fracture gradient estimates were based on seismic velocities in the adjacent abyssal basin. The subsalt section was difficult to drill, and several formation integrity tests were performed. We developed basin scale finite element models to represent the geometry of the salt diapir and performed non-linear geomechanical simulations to analyze the stress changes in and around the diapir. The simulations predict stress perturbations that vary spatially in accord with the complex and irregular salt geometry.

The study provides validation of non-linear finite element stress modeling techniques that can be applied when drilling through salt diapirs. It also demonstrates the potential for stress distortions associated with topography along the top of salt.

SPE/IADC 104947

Fractured Wellbore Stree Analysis: Sealing Cracks to Strengthen a Wellbore. H. Wang and M. Soliman, Halliburton; B.F. Towler, U of Wyoming.

Wellbore instability during drilling is usually treated by casing and cementing the wellbore using several casing strings. If a formation is strengthened with fewer casing strings, it would save significant money and time. With wellbore strengthening, a wellbore can be stable under higher pressure without failing under tension. One way to strengthen a wellbore is to seal the fractures and/or microcracks penetrating the wellbore by adding sealing materials in drilling fluids. But without a fundamental understanding, selecting materials is a challenge This paper will report results from a fundamental study aimed at revealing the basic physics that controls the success of treatments strengthening wellbores.

SPE/IADC 104606

Novel Approach for Estimating Pore Fluid Pressures Ahead of the Drill Bit. J. Jones, Marathon Oil; M.D. Matthews and W. Standifird, Knowledge Systems.

The use of forward basin models in pore pressure prediction to enable real-time updates of pore pressure estimation ahead of the bit represent a significant improvement in modeling. The real-time application of pressure purposed basin modeling technology has been investigated in 10 wells in which this technique was applied. Overall, approximately 80% of these 10 wells were within 0.5ppg for the first 2,000 ft after update, 90% were within 1.0ppg.