Editor's note: The following abstracts represent papers, scheduled and knowledge-sharing presentations, that were scheduled as of 6 January to be presented at the 2009 SPE/IADC Drilling Conference, 17-19 March in Amsterdam. Abstracts have been edited for space.

Technical Session: Case Histories I

SPE/IADC 119506

How Continuous Improvement Lead to the Longest Horizontal Well in the World. Kumud Sonowal, Maersk Oil Qatar; Kwong Ming Wong, K&M Technology Group; Bjarne Bennetzen, Maersk Oil Qatar; Erhan Isevcan, Schlumberger.

Maersk Oil Qatar recently completed drilling the BD-04A well offshore Qatar, setting world records for both the longest well at 40,320 ft MDRT and the longest along hole reach of 37,956 ft. The introduction of new techniques has allowed existing constraints to be successfully overcome. This was achieved through sound engineering principles and optimization during the Field Development Plan. This case study will review the history, challenges and planning, leading through to the successful drilling of the BD-04A well. Achievements and improved practices will be discussed, as will the engineering analysis of field data where key learning points have been shared for future applications.

SPE/IADC 119748

Case History: Successful Wellbore Strengthening Approach in a Depleted & Highly Unconsolidated Sand in Deepwater Gulf of Mexico. Joseph Fett, Philippe Marchina, Frederic Martin, Claude Dardeau, Joel Rignol and Saddok Benaissa, Total.

In early 2008, Total E&P USA sidetracked the MC243-A2 well on itsMatterhornTLP in deepwater Gulf of Mexico. The operations included de-completing, sidetracking and re-completing the well, which had stopped producing after extended shut-in periods during recent hurricanes. A geomechanics study identified that the mud weight/fracture pressure window had essentially disappeared, and that a strong potential existed for mud losses in the depleted and highly unconsolidated Areservoir due to the mud weight required in the caprock shales above.

The risk of losses, particularly when cementing the liner, was a concern. The well would be frac-packed, and if a competent cement column did not reach a sufficient height above the reservoir, the fracturing operation would have been compromised. To strengthen the formation and prevent differential sticking, the decision was made to drill through the reservoir using a "flat rheology" synthetic-based fluid with a high concentration and blend of particles. It allowed the reservoir to be drilled successfully and the liner to be run and cemented with full returns.

The high-quality cement bond allowed frac-pack operations to be completed successfully. Data from the frac-pack showed that the formation breakdown pressure was lower than the wellbore pressures experienced while drilling and installing the liner, suggesting that the designer fluid improved the fracture resistance of the formation. The results suggest that using a designer fluid with engineered bridging particles can have a strengthening effect on depleted/unconsolidated formations.

The paper will describe the approach taken in the laboratory for the fluid design, as well as operational practices to apply the treatment on location.

SPE/IADC 118806

Use of Liner Drilling Technology as a Solution to Hole Instability and Loss Intervals: A Case Study Offshore Indonesia. Steven Rosenberg, Weatherford; Andrias Darmawan, Liao Jianhua and Chao Zhao, CNOOC SES; I.B. Budi Utama and Keith Hillis, Weatherford.

The problematic Lower Baturaja limestone formation, known for lost circulation, occurs in the Banuwati field in southeast Sumatra, Indonesia. The operator had previously experienced severe losses with wellbore stability issues in this formation with the inability of setting the 7-in. drilling liner at planned depth. The liner had to be pulled out of the hole, leading to the eventual abandonment of the existing open-hole section. This resulted in the sidetracking of the well.

Liner-while-drilling technology was identified as the solution because it has minimized or eliminated documented lost-circulation problems, possibly due to the "smear effect" phenomenon. The liner system selected provided high torsional capability, as well as requiring both a mechanical and pressure event to release the setting tool, minimizing chances for premature release. A drill shoe with a displaceable PDC cutting structure was used to drill the 8 ½-in. hole section. The PDC cutting structure was displaced prior to cementing to allow drill-out with a conventional drill bit and BHA. The liner was successfully cemented in place.

SPE/IADC 119903

Further Developments in Drill Pipe Fatigue Management: A Case Study. Richard Zoanni and Scott Everage, T.H. Hill Associates.

Demand for the development and implementation of a practical drill pipe fatigue management system continues to grow. The result has been the development of realistic pipe section rotation schemes and implementation of effective inspection interval scheduling based on incurred fatigue damage rather than on arbitrary footage and/or hours.

The cumulative fatigue damage technique was introduced in IADC/SPE 110076. Recently the cumulative fatigue damage technique was applied in the field with promising results. The case study further illustrates the management and modeling of fatigue damage accumulated in newly deployed drill pipe over a three-well project. Developed in this case study is the pipe management strategy employed to complete the drilling program without the need for mid-program inspections. Through utilization of the cumulative fatigue damage method of fatigue monitoring, drilling was successfully completed on three wells by executing precise and timely pipe section rotations rather than pipe inspection.

SPE/IADC 118806, "Use of Liner Drilling Technology as a Solution to Hole Instability and Loss Intervals: A Case Study Offshore Indonesia."

SPE/IADC 119907

Case Histories of a New Wireline Logging Tool for Determination of Free Point in Support of Drilling and Pipe Recovery Operations. Calvin Kessler, Daniel Dorffer, Donald Crawford, Rory Dehart and Jerry Weiser, Halliburton.

A new logging tool identifies the free point in drill collars, drill pipe, tubing or casing for drilling support and well abandonment operations. Unlike previous free point methods, which used strain measurements of the pipe obtained as a series of stations with and without the application of pipe stretch or torque, this method is simply overlay of two logging passes. The first logging pass is recorded with the pipe in a neutral weight condition, and the second is recorded with tension or torque applied to the pipe. The tool utilizes a property of steel called magnetostrictive effect. When a mechanical stress is applied to steel, its magnetization is modified. When torque or tension is applied to the pipe that is free to move, their magnetization will change. If the pipe is not free to move, its magnetization will remain the same.

This tool has many advantages. First, from a rig safety standpoint, the application of pipe stretch is applied only once for a few minutes for the logging pass. Real-time operations and 24/7 satellite communications allow remote-based operator and service company pipe recovery experts to be involved. The tool is run centralized and does not require weight bars for slip engagement. This shortens the tool string and simplifies e-line rig-up procedures.

Technical Session: Extended Reach

SPE/IADC 119373

Increasing Sakhalin Extended-Reach Drilling and Completion Capability. Michael Walker, Andrew Veselka and Shane Harris, ExxonMobil.

Extended-reach drilling (ERD) and completion capability on the Chayvo field, Sakhalin Island, has evolved in well design and operational practices to increase well reach to over 10.5 km. Learnings and design changes will be discussed using a recent record well, the Chayvo Z-12, as a case study.

Implementation of the operator's drilling performance management process and Integrated Hole Quality technology have enabled continuous improvement in overall ROP and hole quality. BHA designs and operational practices have been modified to reduce vibration effects leading to poor borehole patterning and micro-doglegs, thus enabling higher ROP with a better-quality borehole. Detailed torque and drag modeling, engineering surveillance, and lubricants have also led to improved hole cleaning, lower ECDs, and reduced friction effects required to drill and complete these wells.

Chayvo completion design incorporates the use of pre-drilled liners, standalone screens, swell packers, and inflow control devices (ICDs) allowing effective zonal isolation, prevention of sand production, and flow control. Management of ICD placement and configuration provides the flexibility for early well life zonal isolation while maintaining cost-effective non-rig intervention options for the future.

SPE/IADC 119553

Development and Installation of an Extended-Reach Multilateral Junction. Erick Peterson,

Jerome Eggemeyer, Stephen McKeever and Dennis Hartwig, ConocoPhillips Alaska; David Bjork, Alex Ortiz and Bryan Pendleton, Baker Oil Tools.

A multitude of extended-reach technologies have been used in the West Sak field on Alaska's North Slope. Significant to the shallow, heavy oil development is the use of multilateral horizontal wells with a junction providing mechanical support and both through-tubing lateral isolation and re-entry capabilities. However, as ERD capabilities evolved to routinely reach departure to true vertical depth ratios in excess of five to one, multilateral junction technology did not evolve at the same pace.

A new multilateral junction was designed to match current ERD capabilities. It allows lateral liners to overcome drag limitations by rotating the liner and junction to setting depth in one trip and includes positive indicators for successful installation.

This paper discusses the evolution of multilateral wells in the West Sak development, the limitations of multilateral junctions when used in extended-reach wells, the development and testing of a new multilateral junction, and several successful field installations. Operation highlights during the completion phase of a multilateral well with a lateral departure to true vertical depth ratio in excess of six to one are included.

SPE/IADC 118705

The Trials and Tribulations of a Long-Reach Well in the Deepwater GOM. Ron Day, BP America; Nesny Pardo, INTEQ; Louise Jacobsen Plutt and Ramsey Fisher, BP; Segun Jebutu and Hans-Christian Freitag, Baker Hughes INTEQ.

Where the water-bottom topography is irregular, subsea infrastructure can often be placed in only a few locations above a field. This can constrain access to reservoir targets, particularly when there are drilling challenges above the reservoir, like pressure ramps or layers with unstable lithologies. Given the size of this field, long step-outs are required. This paper presents the strategies implemented to successfully drill and access reservoirs in a large faulted anticline in the deepwater GOM.

The well in question faced three challenges. First, the well would be the longest step-out (~7,500 ft of lateral step out over ~10,000 ft of vertical depth) drilled to date in the field. Second, the well targeted a fault block in a portion of the field that was poorly constrained due to limited offset well control and a poor quality seismic image. Third, the well faces several wellbore integrity challenges in the form of two pressure ramps, one unstable slump zone, and one pressure regression.

Wellbore integrity management made use of realtime ECD and bulk-density to optimize drilling, measure borehole stability and limit formation damage. After drilling to TD, log, formation pressure and image log (dipmeter) data confirmed that the well had crossed an unexpected fault in the targeted reservoir section, which caused one of the target reservoirs to be absent. A sidetrack was successfully drilled.

SPE/IADC 119446

High-Angle Directional Drilling with 9 5/8-in. Casing in Offshore Qatar. Jason Talkington, Schlumberger; Michael Avery, Occidental Petroleum Qatar; TBN TBN, Qatar Petroleum.

Casing while drilling is becoming a powerful method in mitigating lost circulation and wellbore stability issues in offshore directional wells. Programs that require drilling through unstable formations at high angle before entering the productive zone for a horizontal well are becoming more common. Occidental Petroleum faced this task in drilling horizontal Shuaiba wells offshore Qatar. The unstable Nahr Umr formation lies directly above the Shuaiba payzone and is typically drilled with 12 ¼-in. bits. The Nahr Umr shale tends to slough in shortly after drilling, leading to stuck BHAs and difficulty running 9 5/8-in. casing.

This paper details the directional casing drilling developments that have been accomplished.

SPE/IADC 119459

Ultra Extended-Reach Drilling (u-ERD: Tunnel in the Earth) - A New Wellpath Design. Robello Samuel, Halliburton.

Drilling ultra-extended-reach wells and extending the reach to a greater depth requires both improved models and comprehensive analysis. Wellbore friction is an important issue, and optimizing the design of well path is an effective means to reduce torque and drag. This paper describes a new well path that will allow extending the reach to a greater depth.

Usually the trajectories are designed with constant curvature with well-defined arcs connecting the transition between the tangent sections. Even though the transition between the tangent section and build section, or tangent section and drop section, appears smooth, there will be discontinuity, which will cause stresses in the tubulars, increased torque and drag, poor hole cleaning and other failures. To avoid discontinuity, curvature bridge curves or transition curves called clothoid spiral can be used.

The paper presents a new mathematical formulation for curvature bridged well path designs. The results show that the essential elements of planning a proposed well path are to determine the shape and position of the bridge section, the characteristic parameter describing its shape, and position in the well profile. A coupled analytical criterion based on the minimum energy of the curve is proposed to measure the complexity of the well paths. This paper documents the comparison between the predicted mathematical simulation results with the actual traditional well path designs.

SPE/IADC 119768

A Study of Temperature-Dependent Friction in Wellbore Fluids. Eirik Kaarstad, Bernt Aadnoy, Tomas Fjelde, University of Stavanger.

Increased well reach is one of the most important developments in modern drilling. Wellbore friction plays a central role. However, the industry still uses the simple one-parameter Coulomb friction model.

The University of Stavanger has conducted friction research to further understand mechanical and viscous frictional effects. The paper will report extensive friction coefficents tables for many wellbore fluids from several vendors. A friction apparatus allowing both linear motion and rotational motion have been used. The test equipment also includes a heat element to study the temperature effect on friction.

The results of the paper improve the design of long-reach wells. A more correct frictional picture results, and data aid in selecting drilling fluids with best frictional properties.

Technical Session: HSE

SPE/IADC 119365

Minimize Risk and Improve Efficiency Associated with Electric Coiled-Tubing Perforating Operations. Alan Salsman, Schlumberger; Hassan Khalil, Abu Dhabi Marine Operating Co.; Feras Abu Jafar and Fardin Ali Neyaei, Schlumberger.

Perforating operations with electric coiled tubing have been considered hazardous and were avoided in the past. Following standard procedures for explosive operations, arming the gun with the explosive detonator had to be done after the electric coiled-tubing head was attached to the gun string, creating a potentially hazardous situation. Also the length of perforating gun that could run in one trip was severely limited.

New technologies make the electric coiled-tubing perforating technique more efficient and safer:

- An expendable electronic addressable switch component providing an electrical control and safety barrier to each detonator.
- A simplified radio-safe detonator incorporating safety features.
- An electric deployment bar to deploy the guns into a live well before the coiled tubing is connected.

A successful job using these technologies performed in a high-angle well offshore Abu Dhabi, a first for the UAE, will be described.

SPE/IADC 119877

Vibration Measurements – Time for Standardisation. Svein Magne Osnes, StatoilHydro; Per Amundsen, University of Stavanger; Tore Weltzin and Erik Nyrnes, StatoilHydro.

Unlike most downhole measurements, there is no industrial standard for how to sample, process and present vibration data. Measurements from different companies cannot be readily compared, and we do not know if the different tools and systems will detect the same vibration mechanisms. Additionally, vibration specifications of MWD and drilling tools from different service providers cannot be compared.

This study looks into the physics and statistics of how four LWD service providers conduct and present their vibration measurements. An analysis is conducted to establish if the companies are tuned to look for the same type of vibrations, or if different vibration modes tend to be detected with the various procedures in place. A starting point for an industry standard will be suggested.

SPE/IADC 119642

Dry Dope-free OCTG Connections: A Novel Environmentally Friendly Technology Validated Through Diverse and Severe Field Conditions. Gabriel Carcagno, Tomas Castineiras and Ernesto Gallo, Tenaris.

Dope-free alternatives for standard thread compound for the assembling of OCTG connections (tubing and casing) have been commercially available since 2003. This paper describes experiences related to the field use of a fully dry dope-free solution, the improvements and adjustments incorporated after initial experiences and operators feedback, the verification activities in laboratory and especially in experimental rigs under actual field conditions, and summarizes the advantages and the value added through the use of this type of technology.

SPE/IADC 119297

Well Design for Environmentally Friendly Drilling Systems: Using a Graduate Student Drilling Class Team Challenge to Identify Options for Reducing Impacts. Jerome Schubert and David Burnett, Texas A&M University.

A graduate petroleum engineering drilling class was challenged to develop a well plan for a rea-life drilling opportunity in a Texas coastal margin. Teams chose among five low-impact drilling scenarios to write AFEs for an independent operator. Students were permitted to choose among more than 70 ser-

vices, products, processes or equipment to create a unified design significantly lowering the impact of drilling. Each technology was judged on its ability to be assimilated into normal drilling operations, its ability to reduce the well's footprint, its cost, and its likelihood of acceptance by stakeholders.

E&P companies have hundreds of options to reduce the footprint of drilling activities, employ waste management practices, and lower emissions. Harnessing graduate student intellects successfully created a realistic design for an EFD system but also created a tool to organize and evaluate new practices.

Technical Session: Deepwater I

SPE/IADC 119519

New Riser Design and Technologies For Greater Water Depth And Deeper Drilling Operations. Emmanuel Persent, Jean Guesnon and Gerard Papon, Institut Francais du Petrole (IFP).

Deepwater exploration is challenging riser designs, with the present 15,000-psi serial rating becoming insufficient and new designs with working pressures of 20,000 psi or more being considered. The total weight of the riser, as well as the required tensioning capacity of the rig, also increase rapidly with the water depth. Static loads and fatigue become critical and may threaten the riser integrity. Further, the natural period of the riser in the disconnected mode reaches the wave energy window and may put the riser in a dangerous resonant state.

To help solve these issues, technologies have been developed such as the hyperstatic integration concept allowing an axial load sharing and the hybrid choke and kill lines. A study has been performed to assess the potential of advanced drilling riser technologies. This paper presents riser technologies and describes the results of the study. Finally, it shows how such new technologies can enlarge the operating performances of risers.

SPE/IADC 119606

Surface BOP System Operational Experience Offshore Brazil in 1,900 m of Water. Brian Tarr, Shell; Tor Taklo, Shell; Eirik Sorgard, Shell; Andy Hudson, Shell; Luiz Olijnik, Cooper Cameron Corporation; Hongbo Shu, Shell; Jim Schroeder, Transocean.

This paper presents recent operational experience using a surface BOP system for both drilling and subsea completion activities offshore Brazil in the first phase of the Parque das Conchas development (block BC-10) that encompasses several reservoirs in up to 2,000 m of water. The Arctic I, a moored rig capable of operating in 1,036 m of water using a conventional 18 ¾-in. subsea BOP stack and marine riser system, was equipped with a pre-laid mooring system and surface BOP system designed for this project. A service vessel was used to pre-install the well and subsea pump system conductors, taking these activities off the critical path. Also, a subsea hammer installed the well conductors at each drill center, minimizing time required to move from well to well for batch drilling and completion operations.

The start-up performance of this rig system will be presented.

SPE/IADC 118415

Developments in Accumulator Technology: Fluid Power Options in Subsea BOP Control Systems. Paul McCurdy, Occidental Petroleum Qatar.

Conventional subsea accumulators are highly inefficient in deepwater. The constant differential accumulator (CDA) is available, but what is the cut-off depth where the CDA is more effective than the conventional accumulator? Also, the effects of gas compressibility have not been fully addressed in amendments to usable fluid volume calculations.

Research aims to improve VE calculations from the standpoint of gas compressibility and fluid power availability; determine the most effective operating depth range of both accumulators and rigid conduits; and introduce additional ranking measures of weight and space efficiencies. This should provide subsea design engineers with a set of first-glance guidelines on optimising subsea control systems.

SPE/IADC 119762

Pull Your BOP Stack – Or Not? A Systematic Method to Assist You in Making This Multi-Million Dollar Decision. Jeff Sattler, WEST Engineering Services.

Pulling your BOP stack, particularly in deepwater, is one of the singularly most costly events in the drilling of a well, if it occurs. Sometimes the stack pull could have been avoided. Avoidable occasions occur for a variety of reasons, including inadequate information or staff training, unclear understanding of regulatory or company requirements, and non-availability of experts to assist in the decision-makings. This paper will present case studies where planned stack pulls were circumvented, as well as a systematic protocol that can be developed prior to starting a well to clearly define the decision-making process for stack pulls.

SPE/IADC 119427

Development of the 18 3/4-in., 20,000-psi Subsea Wellhead System for High-Pressure and High-Temperature Applications. Bernard McCoy and Shiva Singeetham, FMC Technologies.

This paper will present the development of the first 18 ¾-in., 20,000-psi subsea wellhead system rated for 0-35°F temperature applications. The three-year development project will be detailed, including component design, material selection and processing, reliability analysis, structural and thermal analysis, and extensive prototype testing of the equipment. Results of the prototype tests will include stress and deflection data and how they compare with industry standard allowables.

Technical Session: Bits and Hole Openers

SPE/IADC 119625

Maintaining Desired Steerability While Extending Gauge Length to Manage Whirl. Fred Dupriest and Steven Sowers, ExxonMobil.

This paper discusses the use of increased bit gauge lengths to mitigate whirl. Lengths in excess of 4 in. are now standard in all operations. The modifications have resulted in reduced vibrations, significant improvement in drill rate, improved borehole quality and reduced tool damage.

Analysis of mechanical-specific energy suggested that 40% of footage drilled worldwide was affected by whirl or lateral instability. In response, an initiative was begun in 2005 to extend gauge lengths to reduce the whirl and constrain the resultant side cutting. Significant improvement was seen in rate of penetration and bit life.

Over a two-year period, it was demonstrated that steering was not affected with gauge lengths of up to 4 in. However, it was necessary to modify the profile of the gauge area to achieve this steerability. The gauge profiles used to achieve steerability included uniform undercut, full taper, and combined straight gauge with taper above. Similar results have been observed with point-the-bit and push-the-bit rotary steerable systems. Extension of the gauge length has also benefited bent motor operations, but the effects of various gauge profiles are less certain.

Gauge lengths of 4 in. or greater have been used as a standard practice for two years. This paper discusses the rationale for use of extended gauges, the modified profiles used to maintain steerability, and the field performance achieved.

SPE/IADC 118298

True Matching of Bit and Multi-diameter String Tools Delivers Optimized Drilling Performance in Gulf of Mexico Salt Applications. Steven Barton and John Clegg, ReedHycalog.

The increased use of hole-opening tools remote from the drill bit has led to a critical need to understand the interaction between the drill bit and the hole-opening tool itself. Problems that can result from improper matching include vibration, inability to open hole, mechanical damage to string tools or to the bit, and sub-optimal drilling performance.

This paper explores the theoretical relationship between bit and reamer and modeling the relative agressivity and stability of both tools, building on established indexes for predicting and comparing the performance of bits. It also considers stabilization of the hole-opening tool using both concentric and eccentric devices. It describes theoretical modeling of the vibration behavior of the assembly. It then describes field validation of the above using a unique downhole data recording device.

Finally, the paper will review case studies in the Gulf of Mexico and demonstrate a link between the theoretical analysis, the measured validation, and actual field results.

SPE/IADC 119534

Novel Concentric Expandable Stabilizer Results in Increased Penetration Rates and Drilling Efficiency with Reduced Vibration. Steven Radford and Tracy Li, Hughes Christensen; Mark Jenkins, INTEQ.

An inherent problem of drilling and reaming concurrently is that conventional fixed stabilizers run above expandable reamers can be no larger than the pass-through diameter of the restriction above it and, thus, cannot effectively stabilize the upper BHA, which often results in undesirable vibrations. Recent controlled tests have been conducted in twin wells drilled from the same casing under a full-scale drilling rig, one well with only a concentric expandable reamer and the other with both expandable stabilizer and reamer. Results showed that the stabilizer produced significant gains in performance.

BHA modeling predicted lower bending moments above the reamer when a concentric stabilizer was utilized. The well drilled with the stabilizer above the reamer resulted in higher ROP with lower downhole WOB and up to 35% reduction in drilling MSE (mechanical specific energy), compared with the well drilled without the expandable stabilizer. The stabilized well had significantly better drilling efficiency, which is attributed to reducing buckling and whirl in the drill pipe and upper BHA, and reduced frictional losses against the borehole wall. Additionally, lower levels of whirl, lateral and stick-slip vibrations were recorded with the new expandable stabilizer.

SPE/IADC 119302

Experimental Study of MSE of a Single PDC Cutter under Simulated Pressurized Conditions. Navid Rafatian, Schlumberger; Stefan Miska, Univeristy of Tulsa; Leroy Ledgerwood, Hughes

Christensen; Ramadan Ahmed and Mengjiao Yu, University of Tulsa.

It is believed that impermeable rocks experience high differential pressures due to shear dilatancy and become stronger, thus more difficult to drill. However, recent atmospheric and pressurized single-cutter experiments show that, contrary to this belief, even at low pressures (100-200 psi) and even with permeable rocks, significant increase in mechanical specific energy (MSE) is observed compared with atmospheric tests. The experiments were carried out in a single-cutter, high-pressure testing facility refurbished with high-precision sensors and data acquisition system. A 13-mm PDC cutter was used to cut Carthage marble and Indiana limestone samples with depths of cut ranging from 0.025 in. to 0.050 in. 72 tests were performed on these two rock types under confining pressures ranging from 0-1000 psig. The confining fluids were either water or mineral oil.

Unexpectedly, analysis of the MSE consistently showed that increases in the confining pressure as small as 150 psi can increase the MSE of the cutting process significantly and reduce the cutting efficiency by half. These reductions in the cutting efficiency that were even more dramatic in the permeable and saturated Indiana limestone.

Upon analysis of the results of experiments, a new theory is proposed to explain this unexpected behavior.

SPE/IADC 119423

Advanced PDC Technologies Deliver Significant Performance Improvements in the Pinedale Anticline Production Interval. Mark Freeman, Hughes Christensen; Jon Gent, Questar Exploration and Production; James Isenhour, Hard Rock Solutions.

A new-generation PDC technology has been applied at the Pinedale Anticline field in Sublette County, Wyoming. The development wells target interbedded fluvial sandstones and shales of the Lance Pool (Lance and Upper Mesaverde formations). Due to surface constraints, all wells are drilled directionally from centralized surface pads. To achieve uniform subsurface well-spacing, well trajectory is S-shaped, with all directional work occurring before the pay interval is encountered at approximately 8,500-ft MD. The pay interval is then drilled vertically using 6 ½-in. PDC bits to approximately 13,400-ft MD, with the final 1,000 ft frequently drilled with diamond-impregnated bits.

The sequence of interbedded fluvial sandstones and shale of the Lance Pool is characterized by moderate but erratic unconfined compressive strengths of 10-20 ksi, further complicated by high overburden pressures and increased hydrostatic pressures from mud weights reaching more than 15 lb/gal. Confining compressive strengths approaching 100 ksi (excluding formation pressures) are not uncommon.

The authors will describe the new PDC bits, reducing the time in this interval by more than 100 hrs per well, an improvement of more than 25%.

SPE/IADC 119517

Breaking Records in North Kuwait Deep Gas Fields Drilling 16-in. Hole Sections at Greater Depths. Ali Jaffar, Hughes Christensen; Anthony Brown, Baker Hughes; Maneesh Sharma, Hughes Christensen; Mohammed Al-Saeedi, Meshal Al-Khaldy and Sounderrajan Mahesh, Kuwait Oil Company.

Drilling the 16-in. hole section in north Kuwait deep gas fields is challenging due to a lithology consisting of abrasive sandstone, shale and limestone interbedded with hard siltstone stringers. The section typically spuds at depths greater than 9,000 ft and consists of three main intervals. The top interval consists of mostly abrasive sandstone and shale; the middle consists of shale; and the bottom mostly consists of limestone and thin beds of shale.

The operator attempted to efficiently drill the 16-in. top interval using both roller cone TCI and PDC technology. The TCI bits had unacceptably low ROP with short bit life. PDC technology delivered acceptable penetration rates but inconsistent run lengths.

A team was organized to seek new PDC bit technology, state-of-the-art downhole motors, and optimized drilling practices to consistently drill the top interval in one run. This paper will discuss the modeling analyses the team performed to develop the BHA/bit solution that greatly reduced lateral and torsional vibrations, in addition to the advanced bit design technology that improved bit stability. It will also discuss how the collaborative effort helped the operator to break new records in drilling the most footage ever drilled in the 16-in. top interval. The application of this new technology has thus far increased the drilled footage by 35% and the average interval ROP by 22%, resulting in a 30% reduction in drilling cost.

SPE/IADC 119422

Evolution of Drillable PDC Technology Enables Operator to Safely and Economically Drill South Texas Gas Wells with Casing. Jarod DeGeorge, Matthew Isbell, and Eric McClain, Hughes Christensen; Michael Doster, Baker Hughes; David Limbert, ConocoPhillips.

An operator in South Texas established a casing drilling program in 2002 to address drilling hazards and has since successfully drilled over 100 wells using purpose-built casing-drilling rigs. Given their success, the operator was eager to expand use of casing drilling to traditional drill pipe rigs. This was easily accomplished in the production hole but more complicated in the intermediate hole section. The purpose-built casing drilling rigs used a wireline retrievable BHA with a pilot assembly and underreamer. Weaknesses in the wireline retrievable BHAs forced the operator to seek another solution.

The solution was identified as drillable PDC casing bit technology. The existing drillable PDC casing bit was used primarily for drilling short intervals or for drilling-in liners in relatively soft formations, and was not durable enough to drill the entire interval. The authors will detail how the team developed a "heavy-duty" drillable PDC casing bit with a series of test wells in 2007 to overcome this challenge.

SPE/IADC 119461

Casing-While-Drilling 24-in. Surface Section Enables Operator to Add One Extra Slot to the Existing Drilling Template and Cut Operation Costs in Offshore Congo. Enis Aliko, Hughes Christensen – Italy; Alan Phillips, Hughes Christensen; Stefano De Luca, Eni Congo.

The Foukanda platform offshore Congo comprised a seabed drilling template with eight slots that were pre-drilled with a semisubmersible. Once the platform was installed, the wells were tied back and completed. The operator wanted to drill another well to explore another structure of the reservoir, but this was not possible because the seabed template interfered with the vertical projection of the surface well heads. The customary way of securing an extra slot was attempted but caused difficulty when re-entering the hole because of the sag of the conventional drilling assembly at the exit of the deflector.

To resolve this problem, the operator opted for casing-while-drilling (CWD), and the operation enabled the operator to secure the extra slot, to get out of the existing wells' trajectory, and to save costs associated with difficulties when re-entering a conventionally drilled hole with a casing string.

Technical Session: Drilling Fluids

SPE/IADC 119269

Drilling Fluid Design Reduces Cost by Building Integrity Continuously while Drilling in East Texas. Kenneth Vaczi and James Ryan, ExxonMobil; Shawna Linehan, University of Oklahoma; Miguel Mota, ExxonMobil.

The paper describes the application of a high-solids, high-filtration fluid with engineered particle sizes to prevent lost returns in the Trawick field in East Texas. The system is called a drill and stress fluid because fracture closure stress and integrity are built continuously while drilling. This approach is allowing the operator to routinely drill an 800-ft depleted zone with a history of severe losses without resorting to multiple discrete lost-returns treatments. Protective casing has also been eliminated.

In recent years, the variety of particulate treatment systems has been developed to build stress continuously. The drill and stress fluid differs because it is a water-based system that is relatively inexpensive, and it arrests fracture growth though the development of an immobile mass within the fracture rather than through the formation of a blockage at the fracture aperture. In the case history, the fluid worked successfully in long intervals of permeability of less than 0.1 md.

The paper will discuss the evolution of the well design to allow successful application of the drill and stress fluid, the pilot program that validated the observed increases in integrity, and the operational learnings developed during the pilot program.

SPE/IADC 119363

New Water-Based Fluid Designed for Depleted Tight Gas Sands Eliminates NPT. John Trenery, Baker Hughes Drilling Fluids; Erik Hoover, Brigham Oil & Gas; Gregory Mullen and Saddok Benaissa, INTEQ; Lawrence Richards, Baker Hughes Drilling Fluids.

Unconventional gas resources account for 43% of US gas production, with tight gas representing approximately 70% of the unconventional production. A new water-based mud system addressing depleted tight gas reservoirs has been introduced. The new High-Performance Water-Based Mud originally designed for onshore drilling in mature, depleted tight gas sands in the southern regions of the US can be used on other fields worldwide. It is applicable to any tight gas reservoir where losses or stuck pipe occur.

This paper provides a technical overview of its performance in a challenging field where massive losses, stuck pipe, twist-offs and other fluid associated NPT is common.

SPE/IADC 119378

Combining Proven Anti-Sag Technologies for HPHT North Sea Applications: Clay-Free Oil-Based Fluid and Synthetic, Sub-Micron Weight Material. David Carbajal, William Shumway, Charlotte Burress and Ying Zhang, Halliburton.

North Sea wells drilled in HPHT areas are known for presenting barite sag challenges. Fluid densities in the 17.5-18.0 ppg range require a high percentage of barite, and 400°F temperatures can adversely impact rheological properties needed for reliable suspension. Further, horizontal and ERD wells can require specific hydraulic parameters for hole-cleaning that may entail comparatively high pump rates, which can contribute to excessive equivalent circulating densities (ECD).

A non-barite manganese tetraoxide weighting agent has proven to provide equivalent anti-sag at a lower cost than micronized barite. The manganese tetraoxide weight material has been tested in a clay-free and economical paraffin/mineral oil-based fluid. This paper details the design and testing of the system, including extreme HPHT static aging and sag testing and modifications to the emulsifier package.

SPE/IADC 119567

Successful Drilling of a Deviated, Ultra-HTHP Well Using a Micronised Barite Fluid. Michel Gregoire, Total; Michael Hodder, Shuangjiu Peng and Jarrod Massam, M-I SWACO.

This paper reviews the design and application of a micronised barite (MB) fluid to drill a deviated HTHP well in the northern North Sea. The key technical challenge was to avoid sag of the weight material. On a previous well, using an API-barite-weighted fluid, sag had resulted in considerable NPT.

The MB fluid was used to drill the section from 6,354 m to 7,327 m, and the well was successfully drilled to TD. No significant sag occurred, and as a result, considerable time savings were achieved on flow checks, trips and cementing operations.

SPE/IADC 118659

Quantitative Formation Damage Evaluation Using Dynamic/Static Drill-in Fluid Filtration Tests Data. Liang Jin, Shell.

Quantifying near-wellbore formation damage by drilling and completion fluids at dynamic and static conditions is important for a field development drilling and completion concept selection. This paper presents an evaluation methodology that combines results from dynamic/static filtration tests, returned permeability tests, and SEM tests on real cores with actual exposure time to fluids during drilling and completion into a well performance model to establish an invasion profile along the open-hole section to quantify the impact on the production of the well..

SPE/IADC 119212

Improve Drilling Performance by Controlling Risk and Reducing Non-Productive Time in a Challenging High-Temperature, High-Pressure Well. Ole Iacob Prebensen, Gunvald Nesheim and Svennung Vidvei, M-I SWACO; Reagan James and Trygve Anda, ConocoPhillips Norge.

One requirement on a challenging HPHT well in the North Sea was to drill the well without replacing the existing drill pipe on location. As the hydraulic window was narrow, maintaining the configuration of the drill pipe limited the ECD. At the same time, the temperature regime was high. An oil-based drilling fluid (OBM) with treated micronized barite (TMB) was chosen as the solution. Simulation software also enabled real-time hydraulic values to be displayed during the operation.

SPE/IADC 119445

Formation Damage Induced by Formate Drilling Fluids in Gas-Bearing Reservoirs: Lab and Field Studies. Hamoud Al-Anazi and Mohammed Bataweel, Saudi Aramco.

Formate-based drill-in fluid was used for the first time to drill gas wells in Saudi Arabia. Gas wells were completed in sandstone reservoirs where temperature range between 280-310°F. Na/K formate mud was used to drill these wells with required mud weight ranges between 90-102 pcf. Studies were conducted to optimize mud formulation to meet drilling operation requirements and to explore possible induced formation damage. Compatibility tests were performed, and corrosivity of formate brine was studied on tubing alloys.

Studies showed that Na/K formate system resulted in less damage compared with conventional mud systems. The formate fluids gave a high return permeability, up to 70%, after circulating the corresponding washing fluid. Two damaging mechanisms were identified: external filter cake and potassium chloride precipitation. Compatibility tests indicated that precipitate formed due to mixing of filtrate with formation brine that contains large amount of chloride. Lab tests imply that formate brine had low corrosion rate when the pH of the solution was maintained above 9. On the other hand, the corrosivity of K-formate brine increases in the presence of CO_2 due to the formation of formic acid. The results of this study were implemented on several gas wells.

SPE/IADC 119973

Advances in API/ISO Standard Grade Purified Poly-Anionic Cellulose (PAC) and Drilling Grade Xanthan Gum (XG) Test Procedure and Specifications Definition. Andrea Balestrini, Lamberti USA; Antonius Maas, Kelco Oil Field Group; Keith Morton, Chevron; Mac Seheult, Kelco Oil Field Group.

This paper will describe the technical work performed to develop reliable and reproducible testing procedures for standard purified Polyanionic Cellulose Polymers (PAC) and Drilling Grade Xanthan Gum Polymers (XG), leading to new specifications limits in API 13 A/ISO 13500. The new specs include the following:

- For PAC, moisture content, fluid loss and viscosity.
- For XG, moisture content, particle size analysis and viscosity.

The final procedures and specifications for both PAC and XG will be published with the new revision of the API 13 A/ISO 13500 in January 2009.

Technical Session: Complex Wells

SPE/IADC 119440

Significant Step Taken to Eliminate Sustained 'B' Annulus Pressure in Major North Sea HPHT Development. Liz Hunter and Bill Kinnaird, Halliburton; Michel Gregoire, Total.

Long-term isolation of the gas-bearing Hod has been an issue in Central Graben HPHT, leading to costly management and maintenance of sustained "B" annuli pressure. Six clear steps were taken to achieve life-of well isolation:

1. Analyses to predict failure mechanisms across all well events were carried out. Results were similar, identifying risk areas, the main being cement-formation debonding at the change to lightweight completion fluid.

2. Effect on risks were investigated by altering well parameters. Most effective reductions were made by altering mechanical properties of the cement.

3. Extensive lab analysis was used to develop the best solution. A cement slurry was designed providing optimum mechanical properties.

4. A full-scale yard trial qualified the design for the field.

5. The large volume job was carried out with the rig cement unit.

6. Since placement, the annulus pressure has been recorded. No abnormal pressure has occurred in 24 months since completion.

SPE/IADC 119819

Drilling and Completing the First US Offshore Gas Storage Wells in Mobile Bay, Alabama. Robert Fulks, Weatherford; Douglas Cagle, MoBay Storage Hub.

The paper discusses the technical challenges in drilling and completing the first offshore gas storage reservoir in the United States. A depleted gas field in the environmentally sensitive shallow water of Mobile Bay, Ala., known as the Dauphin Island field was determined capable of serving as a storage facility after a two year geomechanical analysis. The paper describes the drilling and completion of 26 wells in the severely depleted Dauphin sands.

In order to inject and withdraw gas for connection to various interstate natural gas transmission pipelines, MoBay Storage Hub, together with Weatherford and Schlumberger, engineered 21 horizontal gas injector/withdrawal wells in the unconsolidated Dauphin sands with porosity above 30% and permeability as high as 4500 mD. The reservoir had been continuously drilled since the early 1990s and was exhibiting pore pressure of less than 50 psi as the project commenced. The poor rock strength required the use of expanable sand screens in the shallow completions to allow subsequent injection/drawdown activity.

The program is documented in the paper, along with lessons learned.

SPE/IADC 119942

Kicks In Offshore UK Wells - Where Are They Happening, And Why? James Dobson, Health & Safety Executive.

The proposed paper will review the frequency of kicks on the UK Continental Shelf over the last 10 years, looking at trends in relation to the level of rig activity. It will look at frequency of kicks in the different sedimentary basins and the types of operations in which they happen. There will be a more detailed review of incidents over the last three years. It will look at the factors, both geological and operational, that contributed to their frequency. It will attempt to identify possible steps reduce that frequency.

The paper will identify where potentially hazardous incidents are still occurring in what is now a mature province, and why.

SPE/IADC 118961

The Use of a Novel Rigid Setting Fluid for Well Isolation and to Cure High Rate Losses, Pumped Through Drilling BHAs in the Southern North Sea. Chris Couper, Halliburton; Donald Macarthur and Dougie Scott, RWE Dea UK.

Several lost-circulation materials (LCMs) are available to help minimize down time while combating lost circulation. In general, fine- to medium-sized particulate-based materials mixed into the mud system are the first line of defence. When this fails, the common response is coarser LCM, which often cannot be pumped through downhole tools. This paper discusses a practical, field-proven solution using a right-angled, temperature-activated fluid that, once set, exhibits similar characteristics to Portland cement.

The cases discussed in this paper are located in the 43/19a Cavendish field in the Southern North Sea, whilst drilling through Platten Dolomite. This is a thin, complexly folded and rafted dolomite that is found within the Zechstein halites. This formation presents significant well control challenges with the potential for high overpressures coupled with high rate dynamic losses,. The novel fluid was used to cure dynamic losses of up to 400 bbl/hr.

SPE/IADC 119909

HPHT Drilling – New frontiers for Well Safety. Rubens Junior and Otto Santos, Petrobras; Paulo Ribeiro, Universidade Estadual de Campinas.

In a scenario of huge investments in the quest for new oil and natural gas discoveries, the oil industry has reached a consensus: no easy fields to be developed remain undiscovered, especially in offshore environments. New and old challenges on well drilling such as drilled extensions over 6000 m, sub-salt drilling, very narrow operational windows, operational problems like lost of circulation, stuck pipe, and kicks are aggravated when drilling in high pressure and high temperature (HPHT) environments.

In the world's exploratory context, the occurrence of HPHT areas is an increasing trend. It is the materialization of the worst case scenario for well drilling and safety, formed by great challenges and operational, environmental, and economic risks. Field experience has shown that the economical risks have been overshadowed by the great premium target: increments on reserves. However, if the well safety aspect is dealt with the conventional approach, the oil industry is at risk of losing its investments, causing great impacts to the environment and also to the company's image. Since HPHT well construction costs are so much higher than those of traditional wells, the scope of knowledge and science on well safety, once limited to kick prevention and well control contingencies, are now an integral part of the technical and economic feasibility of well construction.

Within this context, this work surveys the best HPHT techniques and procedures practiced by the oil industry, presents the new researches and trends and shares some valuable lessons learned on Petrobras' operations in Brazil and throughout the world.

SPE/IADC 119458

The Impact of Multilateral Drilling Technology in Meeting the Field Development Objectives for the Castilla Field in Columbia – A Case History in Improving the Drainage Efficiency of the Guadalupe Reservoir. Orlando Mercado, Ecopetrol SA; Steven Fipke, Halliburton; Ricardo Rojas Moreno, Sandra Rodriguez and Alberto Florez Anaya, Ecopetrol SA; Jorge Velez, Halliburton.

The Castilla field, located 250 km southeast of Bogota, Colombia, was discovered in 1969 and originally was developed with vertical wells. It produces heavy oil from the Guadalupe reservoir (Upper Cretaceous), which has strong bottom aquifer water drive. Ecopetrol completed the first horizontal well there in February 2001. In 2005, a 7-well cluster design was used to increase reservoir exposure and delay aquifer water influx effect. In 2006, the feasibility of advanced well architecture was evaluated with the objective of increasing oil sweep efficiency, avoiding bypassed oil in the K2 reservoir due to coning and minimizing water production.

It was recommended that several TAML Level 4 multilateral wells be drilled to replace the nine directional wells originally planned. The result has been increased exposure in K1 and K2 reservoirs; reduced drawdown pressure to produce K2; reduction in water production; and higher estimated final oil recovery per well. Lessons learned are presented.

Technical Session: Cementing

SPE/IADC 119267

Improving Wellbore Seal Integrity in CO_2 Injection Wells. Glen Benge, ExxonMobil.

Work on carbon sequestration in subterranean formations has renewed interest in investigating the long-term effects of CO_2 on Portland cements, which will react with the injected CO_2. Work is ongoing to improve the long-term effectiveness of the wellbore sealant. Efforts have focused on enhancing the properties of Portland cement by reducing the permeability of the set cement, lowering the concentration of materials in the cement that react with CO_2, or replacing the conventional Portland with specialty cements. Additional work has been done in evaluation of the long-term stress environment of the well. This work goes beyond the simple drilling and completion of the well to include input from long range reservoir and wellbore stress modeling through the full life cycle of the well.

This paper discusses various solutions to the selection of a proper wellbore sealant for a CO_2 injection well. Additionally, the paper reviews the available sealant technologies, their application, and includes a discussion of stress modeling for these wells.

SPE/IADC 119415

Innovative Computer Model Increases Success Rate When Placing Deep Kick-off Plugs in Southern Mexico. Lenin Diaz, Mathieu Pasteris, Juan Flores, Willie Dakduk, Wilfredo Espinoza, Frederico Justus and Nicolas Flamant, Schlumberger.

Wells in Southern Mexico usually go deeper than 5,000 m. Over the years, service companies have had to place consecutive cement plugs to successfully kick off, particularly in wells deeper than 3,500 m. Several plug failures made it clear that the success rate must be raised. A study was performed with a simulation allowing for engineered optimization of the plug placement design and that shows how a 100% success rate in plug cementing can be achieved in wells as deep as 6,614 m, with hard formations and an OBM environment.

The new software value resides in a live analysis and display of the fluid interfaces, mixing both while traveling down the drill pipe and up the annulus and resulting in the output of an estimated top of uncontaminated cement after pulling the pipe out of hole. This workflow displays the effect of each variable affecting the amount of contamination of the cement slurry downhole, giving the engineer the possibility to optimize the plug placement design before job execution.

SPE/IADC 119386

New Lab Tests and Models Improve Planning for Complex Cementing Jobs Offshore New Zealand. Iain Parr, Shell; Sarah Farnworth, Stuart Lee and Ronald Sweatman, Halliburton.

Recent investigations into cementing highly deviated offshore liners in New Zealand employed laboratory tests and numerical models to determine the best way to prepare the hole and complete the cement job. Newly developed testing included: mud film testing using mud, spacer and cement; ultra-low shear rheology (ULSR) testing under downhole conditions to determine mud and cement static gel strength development, as well as erodibility of the mud by spacer and cement; dynamic high-angle sag testing (DHAST) for mud and spacer; dewatering and filter cake build-up testing of mud, spacer and cement using the FannB.

This paper will highlight the testing and provide results, which have greatly aided the understanding of the cement, mud and spacer interactions with the formation.

SPE/IADC 119960

Flexible Cement Improves Wellbore Integrity in SAGD Wells. Gunnar DeBruijn, Schlumberger; Carlos Siso, ConocoPhillips Canada; Don Reinheimer, Schlumberger.

Zonal isolation and cement sheath integrity are key requirements for heavy oil development and production. Current commercial production techniques use steam to provide heat to mobilize oil and allow production – like steam-assisted gravity drainage (SAGD). Maintaining cement sheath integrity prevents unwanted fluid migration, especially oil, gas and/or steam. Flexible cement systems can be designed and installed so that the cement sheath can withstand the expected stresses in the well. Installation practices are critical to providing a high-quality cement sheath. Challenges that are prevalent in SAGD wells are centralization in the soft formations, assessment of the cement bond between the cement and formation, and assessment of the cement bond after steaming.

This case history will compare two cement systems with flexible properties installed in seven SAGD well pairs (14 wells) in Alberta. Zonal isolation and wellbore integrity are examined with the use of cement bond logs and ultrasonic cement evaluation tools. These logs provide evidence that zonal isolation is achieved and is improved with the use of industry best practices for cement placement.

SPE/IADC 119535

Guidelines for Appropriate Application of Non-Foamed Ultralightweight Cement Slurries. James Curtis and Mohamad Dajani, BJ Services Co.

Well cementing advances have enabled the use of ultra-light weight (ULW) cement slurries with densities as low as 7.5 ppg without foaming. These slurries often achieve significant compressive strengths, even at moderate or low curing temperatures. However, there are opportunities for disaster when conventional cement slurry design criteria, laboratory testing procedures and field practices are inappropriately applied to ULW cementing applications.

This paper will discuss the relevant issues that must be taken into account when planning a successful ULW cement operation, including materials selection, liquid volume fraction, surface and downhole densities and rheologies, compressive strength testing procedures, quality control measures, blending and bulk handling, operating error margins and on-the-fly mixing control systems.

SPE/IADC 119296

Zonal Isolation Achieved in Kashagan Field Through Integrated Approach. Krishna Ravi, Halliburton; Nevio Moroni, ENI; Carmen Repetto, Agip KCO; N Dettori, ENI.

The primary purpose of the production liner in the Kashagan field is zonal isolation, but the challenges are magnified due to the presence of corrosive fluids (CO_2 and H_2S), rock properties and high pore pressures. The cement sheath was designed for structural integrity, lower permeability and chemical stability. The structural integrity helped prevent the formation of micro-annulus and cracks during well operations. The cement sheath was also designed to withstand completion and subsequent operations over the well life. The cement system was formulated to withstand well operations by improving the elasticity. The potential for carbonation was decreased by lowering permeability and reducing the components in the cement sheath that could react with CO_2.

The cement system has been successfully deployed in four wells. The cement bond logs verified the successful cement slurry placement on all jobs, and subsequent successful well operations confirmed the zonal isolation. The same cement system is being deployed in additional wells.

Technical Session: Tubulars

SPE/IADC 119357

Analysis of Complex Wellhead Load Events for Conductor and Surface Casing Strings. Albert McSpadden and Simon Glover, Altus Well Experts.

The analysis of thermal-induced wellhead growth and resultant loads can be critical for tubular stress design and failure analysis of platform wells. But standard simulation tools don't account for some common complex wellhead loading events. Analysis of wellhead growth and loads from first principles is used to investigate these complex load events. Particular attention is given to conductor and surface casings, and some non-intuitive conclusions are discussed. Case studies are presented to illustrate a range of field applications.

SPE/IADC 119552

Evaluating the Expandability and Collapse Resistance of Expandable Tubulars. Jun Agata, Eiji Tsuru, Mitsuru Sawamura, Hitoshi Asahi and Hidefumi Tsugihara, Nippon Steel Corp.

This paper summarizes the results of a study to assess the mechanical integrity of expandable tubulars in monobore wells, and understanding the tubular material behavior as it is being expanded. Described herein is an experimental setup that simulates the expansion process, and the development of a finite element model.

Test results show that the variation of wall thickness around the circumference of the pipe is amplified when the axial load in increased, which results from the restraint condition in the wellbore. For both the experimental and the numerical simulations, a strong correlation was observed between pre- and post-expansion pipe wall thickness variations, and it was also concluded that the magnitude of the wall thickness variations of the expanded pipes is dependent on the work hardening rate of the original non-expanded pipe. In addition, the collapse resistance of the expanded pipe was found to have degraded when the restraint condition was applied.

SPE/IADC 119468

New Standard for Evaluating Casing Connections for Thermal Well Applications. Jaroslaw Nowinka and Daniel Dall'Acqua, Noetic Engineering.

Casing connections in thermal well applications such as SAGD and CSS (cyclic steam stimulation) experience extreme loads due to exposure to high temperatures 200°C-350°C, stresses exceeding the elastic limit, and cyclic plastic deformation. To date, no standard procedure has been adopted by the industry to qualify casing connections for such conditions. This paper introduces a new connection evaluation protocol, designed specifically for thermal well applications. It employs analytical and experimental procedures to assess performance of a candidate connection under conditions typical of service in thermally stimulated wells.

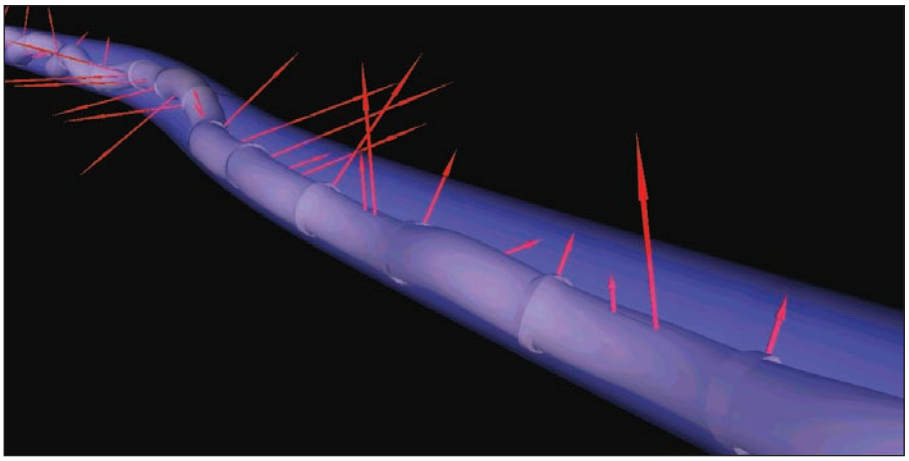
The ISO has opened a work item to consider adopting it as an international standard.

SPE/IADC 119888

Latest enhancements in High-Strength Sour Service Tubulars. Frederic Bernard, Vallourec and Mannesman; Bruce Urband, GrantPrideco; Garth Lynn, Bruce Bradley and Cedric Linne, Vallourec & Mannesman; Frederic Legay, Vallourec & Mannesmann.

More and more deepwater, HPHT wells are being drilled and completed in the presence of H_2S, requiring high-strength sour service-rated tubulars. Suppliers overcame critical metallurgy challenges to widen technical options, including heavy wall casings and high collapse manufactures; dedicated products such as 110 ksi for mild sour use, or thick DST strings used in extreme HPHT wells. These improvements paved the way for 125 ksi mild sour service C125 grades.

This paper will discuss various high-strength sour service tubulars, their relative applicability, basic manufacturing techniques to optimize tubular, as well as NACE testing to characterize sulfide stress cracking resistance."



SPE/IADC 119861, "Axial Force Transfer of Buckled Drill Pipe in Deviated Wells."

SPE/IADC 119861

Axial Force Transfer of Buckled Drill Pipe in Deviated Wells. Stephane Menand, Hedi Sellami and Ahmed Bouguecha, Paris School of Mines; Patrick Isambourg, Total; Christophe Simon, Drillscan.

Axial force transfer is an issue in deviated wells where friction and buckling phenomenon take place. The general perception is that once drill pipe exceeds conventional buckling criteria, axial force cannot be transferred downhole anymore. This paper shows that, even though buckling criteria are exceeded, axial force transfer could be still good if drill pipe is in rotation. Results from a drill string mechanics model show will show how axial force is transferred downhole in many simulated field conditions: sliding, rotating, with or without dog legs.

This paper should contribute to reduce unpredictable lock-up situations and improve axial load transfer performance.

SPE/IADC 119954

Fluid Momentum Balance Defines the Effective Force. Robert Mitchell, Halliburton.

Effective force is a concept developed for including the effects of the surrounding fluids on the pipe. The paper that defined our current understanding of pipe-fluid interaction was written by Klinkenberg, with essential discussions by Arthur Lubinski and Henry Woods. However, there's been a shift in point of view from the pipe to the fluid. What information can we obtain from a simple balance of momentum of the fluid in bulk? For example, for flow inside a pipe, we can determine exactly the load exerted on the pipe by the flowing fluid in terms of only the fluid density, pressure and momentum.

This paper also will address fluid dynamics. Most papers about effective force have dealt with static fluids. How are these static effects modified for a flowing fluid? General equations for the balance of fluid momentum will be combined with the equilibrium equation for the pipe. The effective force then emerges as a natural combination of pipe force and fluid force terms. Numerical examples will be calculated.

Technical Session: Deepwater II

SPE/IADC 119651

Improvements in Efficiency for Subsea Operations in Deepwater Angola. Jason Zook, ExxonMobil; Arran Keith, Coremax.

Esso Exploration Angola (EEAL) has substantial improved the efficiency of subsea operations in the deepwater environment of Angola Block 15 (AB15), dedicating a work vessel solely to subsea activities. EEAL also evaluated improving efficiencies during simultaneous operations. This paper will present case histories of the various operations such as close tolerance well positioning, suction embedded plate anchor handling and horizontal christmas tree installation, both on and off line.

SPE/IADC 105578

Achieving Improved Performance Through Drilling Optimization and Vibration Management Process at a GoM Development Project. Louise Jacobsen Plutt, BP; Nesny Pardo, INTEQ; Allen Pere, BP; Edgar Rodriguez, INTEQ.

Challenges at the GOM Atlantis field include directional control, drilling efficiency, wellbore integrity and vibration management. Expandable reamers are used to drill thin bedded alternating sands and shales. This drilling configuration can result in high levels of vibration. Over the past two years, a continuous improvement cycle has been established, based on comprehensive pre-well planning, downhole data acquisition with real-time diagnostics and thorough post-well analysis. This provided an accelerated learning curve from each well.

Especially in the intermediate interval, this has proven particularly critical. In offset wells, no well in this interval had been successfully drilled in one run. By monitoring downhole environment in real time so personnel could react immediately to damaging vibrations, this section was drilled in one run in the five consecutive wells drilled, and all formation evaluation data acquisition and directional objectives were met with low hole tortuosity, facilitating casing placement.

SPE/IADC 119523

The Structure of Currents in the Deepwater Gulf of Mexico. Steven Anderson, Matthew Cadwallader,

Horizon Marine; Sergei Frolov, Accurate Environmental Forecasting; James Feeney, Horizon Marine.

Three phenomena dominate the mesoscale ocean variability in the Gulf of Mexico: loop current, anticyclonic (warm core) eddies, and cyclonic (cold core) eddies. In the early years of GOM deepwater exploration, it became apparent that the loop current regularly shed anticyclonic eddies that drifted west across the Gulf. Original analysis and models assumed that these eddies have simple elliptical shapes and that they could be sufficiently described with a few geometric parameters.

However, observations have proven that this is not the case. Each eddy varies in shape, structure, duration, movement and intensity. Cyclonic eddies, which were generally ignored early on, have been found to play a significant role in the changing dynamics of the loop and eddies. Oceanographers are now incorporating these features in their dynamical models.

Acoustic doppler current profilers (ADCPs) mounted on workboats are now commonly used for ocean current surveying to supplement data from drifting buoys, satellite remote sensing, and rig-mounted current meters. Real-time monitoring of both near-surface and mid-water currents is critical. Strategically planned survey patterns are followed to best observe and forecast the encroachment of oceanographic features into areas of sensitive operations. The data can be used operationally and to initialize a forecast model.

SPE/IADC 118901

Implementation of Novel Tar Casing Drilling Tool in Deepwater Gulf of Mexico. John Connor, Arifun Djamil, Chevron; Charles Newhouse, Hess Corp; Tommie Graham, Dril-Quip.

In late 2007, while drilling Chevron's Big Foot #3 appraisal well in the deepwater GOM, an extremely mobile tar zone was encountered subsalt at 20,800 ft. Unsuccessful attempts were made to conventionally drill through the tar to deepen the well. It was determined that the tar had to be cased off in order to continue drilling. Further, due to the extreme tar mobility, the liner must be drilled through the tar.

A service provider had recently developed a tar liner drilling tool that allowed the concurrent running of a 11 $^{7}/_{8}$-in. liner while drilling oversized hole below the liner shoe utilizing a bit, motor and concentric reamer, with returns taken up the inside of the casing. This paper will discuss the implementation of the tool on three succesive attempts before finally successfully casing off the tar zone 55 days after encountering it.

SPE/IADC 119818

A Seasonal Solution for Offshore Drilling in an Ice Environment. Bruce Keener and Rod Allan, Transocean.

Offshore drilling in the Arctic environment is becoming more feasible, though obstacles are formidable:

- Leases may only be ice-clear a few months a year.
- Fall and early winter months expose severe weather analogous to a North Sea wind and wave environment.
- Winterization measures must consider potential of severe icing.
- The vessel hull and exposed machinery must tolerate temperatures of -40°C.
- The ice management strategy must anticipate operations in one-year ice.
- Logistic lines are long and tedious.
- Water depths range from 50 m to extreme depth.
- Heavy ice and formidable ridges compel an exodus mid-winter through mid-summer.

Against these challenges, a fit-for-purpose vessel has been optimized for extended-season operations in the Arctic and off-season performance in a more hospitable environment.

SPE/IADC 119287

Probabilistic Well Time Estimation Revisited. Adrian Adams, Colin Gibson and Bob Smith, Nexen Petroleum.

Probabilistic estimation of well duration has been common practice for over a decade, yet several essential aspects of both data characterisation and probabilistic analysis have been overlooked. A database of over 100 central North Sea wells was independently re-analysed for NPT. Extreme NPT events (over 2.5 days) were only 4% by number but contributed 51% of NPT by duration. It is shown that mechanical parent NPT, mechanical extreme NPT, open water WOW, and riser-connected WOW are all statistically distinct, with different occurrence frequencies and probability density functions.

The statistical data apply to central North Sea wells only. The method itself may be used to develop data and time estimates for any drilling location, given a sufficiently large well database.

SPE/IADC 119437

Application of Active Heave Compensated Cranes For Mobile Offshore Drilling Units. Tonnes Seierstad and Jeremy Ogg, National Oil Well Varco.

Nearly all subsea operations require crane support at the seabed. Since the 1990s, various field support and offshore construction vessels with high-capacity active heave compensated (AHC) subsea cranes have provided a cost-effective alternative to using semis.

A modern drillship or semisubmersible is normally equipped with large knuckle boom pedestal offshore cranes for handling provisions and personnel. Handling pipe, casing and risers are either done by the same cranes or dedicated special cranes, and subsea support work is generally conducted with the derrick and motion compensator. New crane technology is being implemented in semi and drillship designs that introduces crane types capable of acting as the traditional knuckle boom pedestal cranes, with or without pipe-handling functions. With additional systems and functions, these cranes can also perform AHC subsea lifting operations.

This paper will discuss some of these new crane types and their functions and areas of application.

Technical Session: Drilling Automation

SPE/IADC 119570

Step Change Improvements with Drill String Telemetry at Occidental of Elk Hills, Inc (OEHI). Chris McCartney, Scott Allen, Oxy Oil and Gas; Mike Reeves, IntelliServ; Maximo Hernandez, GrantPrideco; Danial MacFarlane and Azaad Baksh, Baker Hughes INTEQ.

Breakthroughs in MWD, LWD and drillstring telemetry systems are allowing informed decisions to be made in real-time based on insight that had previously been available only with memory-quality formation evaluation measurement data. This paper will describe the rationale behind the deployment of two telemetry drill strings (4-in. and 5-in. strings) into underbalanced and horizontal drilling applications in California. The completed document, supported by data from actual well examples, will detail the benefits gained from the combined technology of a high-speed drillstring telemetry network interfaced with complex downhole bottomhole assemblies.

Of particular focus will be a discussion of the value added by the real-time transmission of downhole annular pressure for ECD management, stick-slip measurements for vibration management, instantaneous downlink commands to rotary steerable systems and memory-quality formation evaluation measurements to improve geosteering and wellbore placement.

SPE/IADC 119965

Multi-Parameter Autodrilling Capabilities Provide Drilling, Economic Benefits. Fred Florence, Ryan Fox, Mike Porche and Randall Thomas, NOV.

Computers and programmable logic controllers (PLCs) have significantly increased the capabilities of automated drilling devices. An electronic auto-drilling system was developed to provide steady-state weight at the drill bit and/or differential pressure across the motors. Recent field tests demonstrated that the system improved WOB and ROP and provided favorable attributes like controlled reaming, smooth kick-offs, protection against surge pressures and a soft landing for bits. The system, when combined with computing and data acquisition technology, can optimize drilling by controlling the rig braking system while simultaneously examining multiple drilling parameters.

SPE/IADC 119884

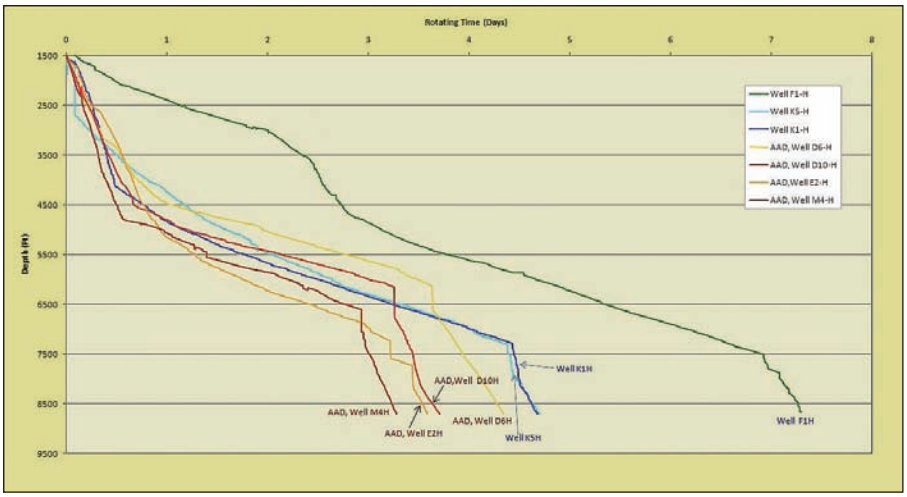
Drilling Automation: Technologies, Terminology and Parallels with Other Industries. John Thorogood, Drilling Global Consultant; Walt Aldred, Schlumberger; Fred Florence, NOV M/D Totco; Fionn Iversen, International Research Institute of Stavanger.

Drilling automation is a rapidly developing area of technology where associated jargon is fast-evolving and different terms are used by different groups to refer to similar concepts, with the potential for confusion and misunderstanding. This paper will describe concepts already in operation and under development and to classify them into of key categories. The more significant interface requirements will be identified, and key safety concerns will be highlighted. Parallels will be drawn with other industries to demonstrate analogues and suggest directions for further developments.

SPE/IADC 119761

Remote Automated Directional Drilling Through Rotary Steerable Systems. Hernan Melgares Escalera, Will Grace, Claudio Alric, Dennys Moreira, Arturo Romo, Luis Gonzalez, Leonardo Toco, Goke Akinniranye and Julio Palacio, Schlumberger.

The evolution of rotary steerable systems (RSS) has been rapid in the past several years. However, the increase in directional drilling activity is challenging the deployment of sufficient experienced directional drillers (DD). This paper describes an automated method for drilling directional wells remotely with RSS, which has been successfully deployed in Mexico. The DD is located at the operation support center with the ability to remotely control the mud pumps. An automatic trajectory program compares the current well trajectory with that planned and



SPE/IADC 119965, "Multi-Parameter Autodrilling Capabilities Provide Drilling, Economic Benefits."

proposes the best steering command for the RSS. Once the command is accepted by the DD, the system remotely controls the rig pumps to execute the downlink sequence and change the downhole settings of the RSS. This system allows a few experienced DDs to control multiple operations.

SPE/IADC 118769

Pattern Recognition-Based Remaining Useful Life Estimation of Bottom Hole Assembly Tools. Dustin Garvey, Joerg Baumann and Joerg Lehr, Baker Hughes INTEQ; J. Hines, University of Tennessee.

This paper will describe a new pattern recognition-based system for estimating the remaining useful life of BHA tools. Industry is shifting towards simple condition-based maintenance approaches, which use design guidelines and rough operational thresholds to assess individual tool health. In that approach, a large amount of tool performance and environmental data are not effectively incorporated into the health assessment process. Using real data collected from a rotating steering system tool, the prognosis system is shown to be able to predict the remaining useful life of individual tools with an accuracy ranging from 0.88 to 8.76 hours over three test sets.

SPE/IADC 119808

Enhanced Real-time Wellbore Stability Monitoring Using High Definition Imaging With Wired-Pipe Telemetry. Christopher Wolfe, INTEQ; Stephen Edwards, BP; Ansgar Baule and Stephen Morris, Baker Hughes.

Despite pre-drill geomechanical modeling to define the mud weight window, many wells still experience significantly nonproductive time associated with wellbore instability. This can be attributed to many factors but is predominantly due to the lack of appropriate data while drilling. Since rock properties, stresses and pore pressure often vary from the pre-drill model predictions, critical wells frequently require real-time updating of the geomechanical models using LWD data.

A case history is presented where memory-quality, high-definition LWD image logs were obtained via high-speed telemetry systems and used to assess wellbore conditions in real time.

SPE/IADC 119435

Early Detection of Drilling Conditions Deterioration Using Real-Time Calibration of Computer Models: Field Example from North Sea Drilling Operations. Eric Cayeux and Benoit Daireaux, International Research Institute of Stavanger; Brikt Hansen, StatoilHydro; Mohsen Balov, StatoilHydro; Mike Herbert, ConocoPhillips Norge.

Friction tests are performed at regular intervals, and measurements are used to monitor trend variations in order to detect poor hole-cleaning or increased borehole tortuosity. The quality of the detection can vary greatly with the work load and experience of the drilling staff. Real-time measurements through data servers make it possible to automate and systemize the monitoring process.

This paper presents a computer system to systematically analyse real-time data in order to monitor downhole conditions. Such a system can utilize much more data than friction tests because mechanical, hydraulic and temperature models can calculate predicted hook load and surface torque in any drilling conditions.

The system has been run on recorded data from three wells on the Statfjord oil field in the North Sea. A data filtering technique has been developed and applied to solve problems with noisy and erratic real-time signals. With correct input parameters, the system has clearly indicated unexpected measurements just prior to a lost-circulation problems.

SPE/IADC 119650

Real-Time Optimization of the Drilling Process - Challenges in Industrialization. Erik Dvergsnes, Eric Cayeux and Fionn Iversen, International Research Institute of Stavanger.

A new drilling control system for real-time optimization and automation control was recently tested offshore in the North Sea and is now entering an industrialization phase. It is based on application of advanced real-time process models for calculation of both hydraulic and mechanical forces. Results from the calculation modules are applied directly in the drilling control system, affecting parameters such as pipe acceleration, velocity and deceleration and the pump startup profile.

Here we give an overview of lessons learned from field test and discuss how important challenges revealed during the test can be solved. We also discuss how such a system will benefit from future technology with a higher degree of automation than the present equipment.

SPE/IADC 119660

A New Stick-Slip Prevention System. Age Kyllingstad, National Oilwell Varco.

In 1988 (SPE 18049), it was demonstrated experimentally that stick-stick oscillations could be cured

SPE/IADC 118656, "Applying Precision Drill Pipe Rotation and Oscillation to Slide Drilling Problems."

by smart control of the rotary drive. Instead of keeping the rotary speed constant, it was varied proportionally to the torque fluctuations measured directly by a kelly bushing torque meter. Since then, several stick-slip prevention systems have been introduced.

This paper presents a new stick-slip prevention method that is simpler and more robust than the torque feedback method. It is based on the same idea – that the rotary drive impedance should be adjusted to partly match the characteristic string impedance in order to absorb torsional wave energy around the stick-slip frequency. But in contrast, it does not require any measurements of torque and acceleration. Field test results will be included.

Technical Session: Directional Drilling

SPE/IADC 119661

Targeting Challenges in Northern Areas Due to Degradation of Wellbore Positioning Accuracy. Torgeir Torkildsen, Jon Bang, SINTEF Petroleum Research; Bjoern Bruun, StatoilHydro; Stein Havardstein, Total.

Due to proximity to the magnetic and geographical poles and the prevalence of magnetic storms in the auroral zone, precise wellbore positioning becomes more challenging as drilling activities approach northern areas. This paper addresses the targeting challenges posed by drilling in far north regions. The Barents Sea (75°N) and the Northern Sea (60°N) were compared. Surveys with six magnetic (MWD) services and two gyroscopic services were simulated in realistic wellbore geometries. Wellbore position accuracies were analyzed at both latitudes.

When moving from 60°N to 75°N, geological targets must be expanded horizontally by 60%-100% to accommodate for increased wellbore position uncertainty. This holds for all surveying services and all wellbore geometries in our study. As an example, the horizontal uncertainty (95% level) at 7,000-m MD of a combined gyro and MWD survey is ±250 m at 75°N, compared with ±140 m at 60°N.

SPE/IADC 119851

Confidence Limits Associated With the Earth's Magnetic Field Used for Directional Drilling. Susan Macmillan, British Geological Survey; Stephen Grindrod, Copsegrove Developments; Allan McKay, Petroleum GeoServices.

The declination, dip angle and total field strength of the Earth's magnetic field are used with magnetic survey tools for surveying the wellbore. These values are often obtained from mathematical models, such as the British Geological Survey Global Geomagnetic Model (BGGM). The BGGM is updated annually to maintain accuracy. However, a global predictive model cannot capture all sources of the Earth's magnetic field, which results in uncertainties of the predicted parameters.

The Industry Steering Committee on Wellbore Surveying Accuracy (ISCWSA) published a MWD error model in 2000 (SPE 67616). Since then, more accurate data from magnetic survey satellites have been introduced into the BGGM and the uncertainty of the predicted geomagnetic field parameters has been reduced.

In this paper's approach, clean orientated magnetic downhole data is simulated using geomagnetic observatory data. Spot absolute measurements of the magnetic field made at observatories around the world are adjusted for the crustal magnetic field to make them applicable to hydrocarbon geology. The adjusted observatory data are then compared with the predicted values from the BGGM to assess uncertainty. The uncertainties do not fit a "normal" distribution so they are expressed as limits for various confidence levels. They vary with time, location and, in their derivation, do not assume any underlying empirical error distribution. Options to further reduce the uncertainties using data from local magnetic surveys (in-field referencing) and observatories (interpolation in-field referencing) are also described.

SPE/IADC 118656

Applying Precision Drill Pipe Rotation and Oscillation to Slide Drilling Problems. Colin Gillan, Nabors; Scott Boone, Epoch Well Services; Marc LeBlanc, Ryan Energy Technologies; Gregory Kostiuk, Canrig.

The paper describes how a computer-controlled top drive can address slide drilling problems. It presents its advantages in setting downhole toolface orientation and compares with current practice. The paper explains further improvements in drilling efficiency and toolface control in four case studies using field data and log analysis.

In directional drilling with conventional steerable motor systems, solving the problems of toolface setting and control are fundamental. The application described provides solutions to both these problems in a manner the driller and directional driller can readily understand. Deviated wellbores produce sidewall frictional forces, which render slide drilling less effective than rotary drilling. The system described provides an oscillation program which reduces these frictional forces.

Results are based on four case studies, using field data from three US onshore wells and one well drilled offshore China. Observations are backed up with drilling performance data. Conclusions drawn are: that significant improvements in reducing rig flat time can be achieved using the toolface setting capabilities of the application; that the oscillation program improves delivery of weight to the bit; that fine control of toolface while in the slide drilling mode improves wellbore directional control.

SPE/IADC 119959

Innovative Design Rotary Steerable Technologies Overcome Challenges of Complex Well Profiles in a Fast Growing Unconventional Resource – Woodford Shale. Sandeep Janwadkar, Baker Hughes INTEQ; Steve Simonton, and Donald Black, Cimarex Energy.

In Oklahoma's Woodford Shale, complex well profiles with negative vertical sections and extended-length laterals are required to maximize productivity. This posed challenges such as excessive slide drilling time, difficulty controlling well trajectory, unacceptably low penetration rates, high torque and drag. Engineers determined that wellbore tortuosity and high friction factors caused inefficient transfer of weight on bit and reduced ROP.

Existing rotary steerable systems are typically cost prohibitive for this application/

SPE/IADC 119959, "Innovative Design Rotary Steerable Technologies Overcome Challenges of Complex Well Profiles in a Fast Growing Unconventional Resource – Woodford Shale."

environment. A new rotary steerable system, specifically designed for 3-D wellbores for low-spread-cost land-drilling applications, uses an automated rotary steerable rib-steering closed-loop system. Since its introduction, many wells have been drilled in North America with build/drop of 8°/100 ft. In the Woodford Shale, the new system, coupled with advanced BHA modeling software, has significantly improved drilling performance. Drilling complex well profiles with negative vertical sections have increased the length of laterals by 350 ft. Days required to drill the lateral interval have reduced by 30%.

SPE/IADC 119260

Drill String Vibration Mitigation During Simultaneous Drilling and Hole Enlargement. Stefano Mancini, Graham Hitchcock and J. Opsahl, Halliburton.

Drill string vibrations can create significant issues in operations requiring simultaneous drilling and hole enlargement because of the complex BHA dynamics involved in simultaneously creating two hole sizes. Using case history data, this paper describes the application of a hole-enlargement tool that generated minimal drill string vibration during deepwater drilling and simultaneous enlargement operations, leading to successful completion of well objectives.

Specific design features are discussed, including dormant and deactivation capabilities that allow normal drilling hydraulics to be used while not enlarging the hole; an articulated arm that enables cutting arm "auto-blocking" to reduce the likelihood of vibration due to arm movement; and a self-stabilized tool body that helps minimizes BHA vibrations.

SPE/IADC 118870

The Evolution of Rotary Steerable Practices to Drill Faster, Safer and Cheaper Salt Sections in the Gulf of Mexico. Robert Clyde and Marco Aburto Perez, Schlumberger.

Drilling salt in different regions implies different drilling practices and challenges. Due to the variable range of salt properties and because of the impact on nonproductive time, to date there has been no substitute recognized for salt drilling experience.

The petroleum industry is continually pushing to drill longer, faster and safer salt sections. The first push-the-bit rotary steerable salt-drilling run in the Gulf of Mexico was executed in 2000. Since then, more than 150 runs and almost half a million feet have been drilled in salt with this type of rotary steerable system. This paper summarizes the analysis of push-the-bit rotary steerable runs in the North American Gulf of Mexico, concluding the successful drilling assembly design and drilling techniques to yield optimum salt-drilling performance.

SPE/IADC 119428

A Fit-for-Purpose Combination of Positive Displacement Motor and Rotary Steerable Systems Delivers a Step Change in Drilling Optimization in Tomoporo Field: A West Venezuela Case Study. Danny Ochoa, Julio Palacio, Goke Akinniranye and Aamer Zaheer, Schlumberger.

Wellbore instability, differential sticking and weak sand zones are common problems drilling directional wells in the Tomoporo field in western Venezuela. The use of conventional positive displacement motors (PDM) escalates the risk of stuck pipe when difficult sliding and low ROPs increase exposure to open-hole conditions. Rotary steerable systems (RSS) mitigate some hazards. However, high shocks and vibrations (S&V) in laminated formations result in downhole tool failure and unplanned bit trips.

In this case study, a drilling assembly consisting of a rotary steerable tool below a high-torque PDM provided the benefits of both conventional PDM and RSS drilling by delivering faster rotation per minute (RPM) at the bit and continuous rotation of the drill string. The increase in RPM reduced vibration perpetuation and transmission in the rest of the drill string. The PDM dampened S&V and mitigated the effects of stick/slip. The combination of PDM and RSS had a positive impact on the life of the bit and downhole tools and resulted in an increase in both drilling and average rate of penetration.

This paper will present a detailed study of this fit-for-purpose solution to increasing footage per day, mitigating S&V and dramatically reducing risk in directionally drilled wells.

SPE/IADC 118872

Signal Attenuation for Electromagnetic Telemetry Systems. Jochen Schnitger and John Macpherson, INTEQ.

Electromagnetic (EM) systems are used for MWD telemetry during drilling. Their deployment is only successful when the signal does not vanish in noise. Knowing the attenuation profile with depth of an EM signal is a helpful guide for predicting successful deployment. This paper details case studies on different attenuation profiles in North America.

The case studies were conducted by first simulating the signal attenuation against depth. The simulations were based on available resistivity logs from wells. The actual signal strength was then measured by an EM surface system at the wellsite, with a field operator logging the measurement against depth. The results of the simulation and the measured signal strength were compared against the resistivity log of the local area.

EM signal generally attenuates exponentially against depth, although this is highly dependent on mud and formation resistivities. While simulation provides information about expected signal tendencies, EM transmission is heavily influenced by the extreme resistivities of thin beds, which are hard to include in the simulations. The comparison between actual measurements and resistivity logs showed correlation. Case studies illustrate the different relationships between simulations, actual measurements and resistivity of the formation over depth.

Technical Session: Managed Pressure Drilling& Underbalanced Drilling

SPE/IADC 119442

Control Requirements for High-end Automatic MPD Operations. John-Morten Godhavn, StatoilHydro.

Automatic control solutions for drilling are expected to become widely used in the near future. Basic PID and other more advanced control tools are well established in other communities like offshore processing systems and oil refineries. Drilling systems, however, have traditionally been operated manually. There is a great economic potential for the introduction of automatic control to reduce drilling time, increase regularity and improve performance in managed pressure drilling (MPD) operations. Narrow drilling margins, especially in depleted reservoirs, ask for highly accurate pressure control.

StatoilHydro applied automatic MPD operations successfully offshore at Kvitebjoern in the North Sea in 2007, and several MPD projects are being prepared. This paper presents results from Kvitebjoern and discusses automatic control requirements for drill-

SPE/IADC 119402, "Revolutionising the Top Drive for Improved Efficiency and Uptime on a Major International Drilling Contractor's Rigs."

ing operations. These requirements include a specified accuracy for a set of normal operations, such as pressure set point step changes, rate changes and set point ramping during connections, surge and swab, and down-linking, and some failure operations, such as power loss, kick/well control and blocked choke. The paper also includes some ideas for the future of intelligent drilling operations with increasing automization.

SPE/IADC 119964

A Novel Strategy for Reducing Well Cost in the Piceance Basin by Using ECD Measurements and Air Injection through a Parasite String. Zimuzor Okafor, Goke Akinniranye, Shannon Higgins and Tom Bratton, Schlumberger.

arious strategies (underbalanced drilling, casing while drilling) have been deployed to tackle significant loss circulation and stuck pipe problems on top of the Mesa in the Piceance Basin. This paper describes a new technique that involves acquiring real-time circulating density measurements and control of mud weight in the annulus, using direct air injection through a parasite string. Approximately 4000 bbl of mud is lost when the intermediate section is drilled using conventional techniques. This is due to a combination of natural fractures and weak rock.

During the development stages of this new process, an annular pressure sub was run to gather diagnostic data. Analysis of the data shows up to 3-ppg variation in circulating density, fracture re-opening gradient of approximately 8.3 ppg and huge circulating density variations during connections. The new strategy results in equivalent circulating densities as low as 5 ppg using conventional water-based mud systems, allowing wells with a very narrow mud weight window to be drilled safely.

This simple approach avoids the use of complex multiphase models, giving the flexibility to quickly deploy the technique to the well site without the need for expert personnel.

SPE/IADC 119641

A New Systematic and Dynamic UBD Procedures Applied to Prevent Formation Damage, Wellbore Collapse and Improve Oil Production in Hassi Massoud Field. Hani Qutob, Weatherford; Ali Berkat, Khelil Kartobi, Amine Mazouzi, Okba Dhina, Sonatrach; Naiem Barakat, Weatherford.

Hassi Messaoud is the largest oil field in Algeria. The reservoir was discovered in 1956 and produces from a Cambrian-age at an average depth of 3400 meters depth (TVD). It currently produces oil from a thick Cambro-Ordovician sandstone formation.

Sonatrach introduced underbalanced drilling technology to the Hassi Messaoud field in Algeria in 2001. Well xxx is the 37th well drilled underbalanced in the field. In this well, the focus was on production improvement with minimum formation damage, with a secondary objective of increasing the rate of penetration. Another objective was the evaluation of production while drilling and to minimize borehole instability, especially when drilling in the R2 section of the reservoir.

New systematic and dynamic procedures were introduced, taking into account proper UBD candidate screening (geology, geomechanics and reservoir); calculating the actual reservoir pressure before UB mode starts; and completing the well in UB mode. This well proved to be the best well drilled underbalance in the field in terms of reservoir benefits and characterization.

SPE/IADC 119387

Implementation of Middleweight Fluids, Between Lightweight Air or Foam Fluids and Heavyweight Conventional Fluids. Taylor Green, Total.

Development of reservoirs with less-than-normal pressure gradient has led to novel systems delivering equivalent mud weights of 4-8 ppg. These are not lightweight fluids like air or foam and aren't as dense as conventional fluids, which can be thought of as heavyweight fluids in this context. A water-base middleweight system has been developed that facilitates injection and removal of air in the drilling rig's circulation loop. It has been in field trial with a low-pressure cavitation mixer and yard-tested with high-pressure porous membrane mixer.

A low-pressure middleweight fluid has been field-tested. 8.7-ppg fluid was fed into the cavitation mixer, which added a stream of air, discharging a lightened fluid into the rig pump. This was used to drill horizontally with lower pressure, higher ROP, no hole problems and no rig pump problems. Equivalent weights 5-8 ppg were successful.

A high-pressure version has been yard-tested. The same 8.7-ppg fluid is used and air is injected on the high-pressure side of the rig pump before flowing into rig standpipe. The fluid flows through tubes made of porous media. These tubes are in a pressurized chamber, where air is injected into the fluid, for equivalent density required.

SPE/IADC 119882

Drilling Wells with Narrow Operating Windows Applying the MPD Constant Bottom Hole Pressure Technology – How Much the Temperature and Pressure Affects the Operation's Design? Maurizio Arnone, Paco Vieira and Fabian Torres, Weatherford.

Narrow pore/fracture pressure gradient margins is a real drilling hazard scenario, where a slight change in bottomhole pressure conditions could lead to NPT if fluid losses and/or gas kick situations occur. Constant bottomhole pressure (CBHP), a variant of managed pressure drilling (MPD), enables "walking the line" between pore and fracture pressure gradient. The objective is to drill with a fluid so that the bottomhole pressure is constant, whether the fluid column is static or circulating.

CBHP methodology involves accurately determining the change in bottomhole pressure caused by dynamic effects and compensate with an equal change in annular wellhead pressure. The bottomhole temperature and the hydrostatic head of the drilling fluid column increases with the well depth, and both parameters have opposing effect in the resultant static and dynamic equivalent density. An increase in the hydrostatic and dynamic head increases the equivalent fluid density due to compression, but an increase in the temperature causes a reduction in the equivalent fluid density due to thermal expansion.

Conventionally, these parameters considered together results in a cancellation of effects. In reality, this assumption is false, and the effect on a MPD CBHP operation through narrow operating windows cannot be ignored due to the potential impact. Precise estimation of static and dynamic equivalent fluid densities is essential. This paper evaluates the effect of the temperature and pressure on the equivalent density while drilling a section with narrow operational windows using CBHP MPD.

SPE/IADC 119875

Offshore Managed Pressure Drilling Experiences in Asia Pacific. Steve Nas, Julmar Toralde and Kevin Fisher, Weatherford.

MPD can deliver significant cost savings offshore, and both subsea and surface stacks on floaters have been used for MPD. Drilling with a so-called closed wellbore using MPD equipment has proven to be beneficial on all rig types and well types. All drilling, logging and completion installations can be safely executed using MPD equipment. On most installations, only minor modifications are required to enable a closed-wellbore system MPD. This paper describes experiences with MPD equipment installations on floating rigs and on fixed installations and provides case studies of significant time and cost savings resulting from the use of MPD equipment and techniques.

SPE/IADC 119912

First Application in Mexico & New World Depth Record for MPD Concentric Nitrogen Injection to Drill Horizontal Wells in Low Pressure Reservoirs at Samaria Field. Corrado Lupo, Schlumberger; Antonio Urbieta, Pemex Reforma; Oscar Ramirez Lamus, Perenco Colombia; Jose Castellanos de la Fuente, Schlumberger; Gustavo Puerto and Jorge Bedoya, Blade Energy Partners.

The Samaria field in southern Mexico is one of the country's oldest. Formation pressure in these naturally fractured carbonates has been decreasing over the last 20 years, with current values down to 0.4 gr/cc SG. MPD techniques were implemented using nitrogen injected through drill pipe to avoid lost circulation, formation damage and differential sticking. However, the significant amount of nitrogen inside the drill pipe generates important limitations for current MWD tools.

The need for horizontal wells to increase the drainage area had become a priority, thus directional control and LWD capabilities had to be prioritized. The nitrogen concentric injection technique was then taken into consideration to bring solutions to the MWD pulse signal transmission and downhole temperature handicaps. This paper describes experience gained in the planning and execution of the first horizontal well drilled using nitrogen concentric string injection in the Samaria field, also recorded as the deepest-ever concentric injection point (4,171-m MD/4,117-m TVD). The paper will discuss the design, planning and execution process: geological review and candidate selection, pre-engineering study, transient and steady state multiphase flow modeling, final drilling program, training, safety, contingencies, directional planning for geosteering with MWD/LWD, lessons learned and production enhancement results.

Technical Session: Rig Equipment

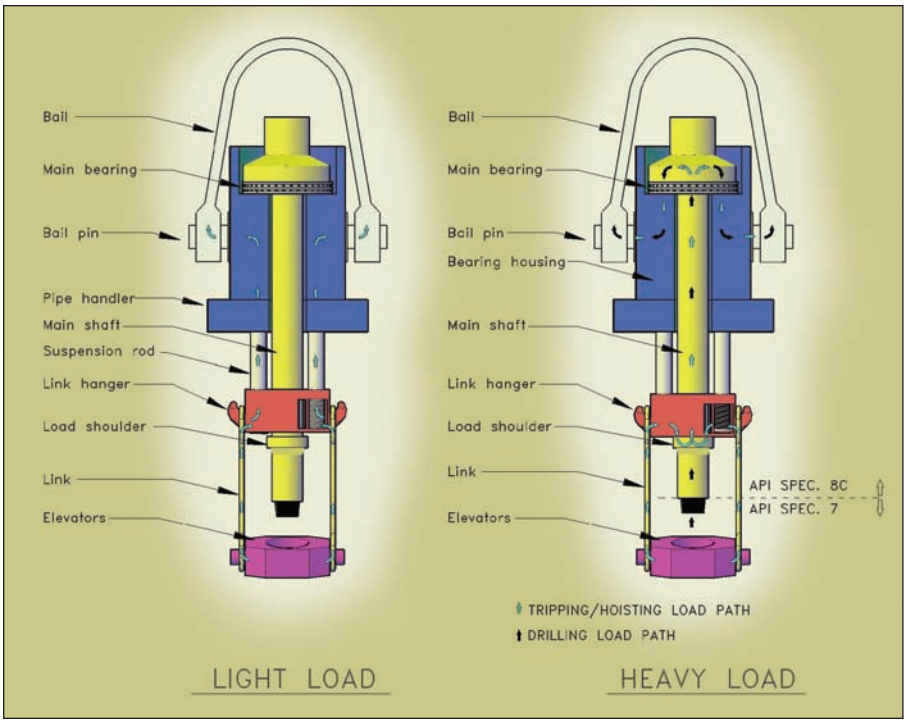
SPE/IADC 119402

Revolutionising the Top Drive for Improved Efficiency and Uptime on a Major International Drilling Contractor's Rigs. Craig Fraser, Hitec Products Drilling; Glenn White, Rowan Drilling UK; Edgar Depeuter, Letourneau Technologies.

Apart from changing from DC to AC motors, the basic design of a top drive has remained the same, i.e., motor(s) connected to a gearbox, driving a shaft. A new type of top drive has now been developed. A major drilling contractor analysed their rig downtime and found that the most failures (40%) were related to gearbox issues (gears, bearings and seals). Another significant failure was with motors. A lack of available spare parts exacerbated problems.

The drilling contractor decided to help develop a direct drive top drive with fewer parts, no gearbox and improved motor. These systems have been field-trialed with significant success, and the drilling contractor has decided to fit these top drives to its complete fleet of rigs (31 land rigs, 31 jackups), and the first DNV-certified 750-ton version is being retrofitted on a jackup in the North Sea.

Technical and field data will be presented, along with discussion regarding retrofitting on older plat-



SPE/IADC 119777, "Drilling at the Limit, Can Your Top Drive Handle It?"

SPE/IADC 118890, "Electrical Cranes and Winches for Improved Safety and Better Operational Performance for Use in Extreme Weather Conditions."

form drilling rigs and availability of this technology to others.

SPE/IADC 119292

Improving the Reliability of Slip Joint Packer Systems. Thomas Upton, ExxonMobil.

The loss of drilling mud past the primary sealing element of marine riser slip (telescoping) joints has been a recurring source of spills. This paper discusses work processes and equipment arrangements implemented to improve the sealing reliability of slip joint packer systems.

Slip joint packer designs have not changed significantly since they were first introduced in the early 1960s. They were originally designed for use with water-based mud systems, and typically a minor amount of fluid seepage was relied on to lubricate the packer. In order to achieve complete containment of non-aqueous drilling fluids (NADF), it has become common practice to apply higher closing pressure to the sealing element which has reduced lubricity and led to premature wear of the sealing element and occasional critical failure of packer elements.

In order to contain NADF in the event of failure of the primary packer system, the operator now employs an independent backup pressure supply system that automatically energizes the lower packer in the event of loss of pressure in the primary system. The operator has also established a routine inspection and surveillance program intended to detect slip joint problems before they result in accidental NADF discharges.

SPE/IADC 119470

Test of a BOP/Riser Connection with an External Inflate (EI) Inflatable Packer. David Vaucher, Christopher Parrish and Robert Brooks, TAM International.

In deepwater, a leak detected after latching the lower marine riser package (LMRP) can cost up to a staggering $6 million in lost rig time. Clearly, there is a need to be able to test the BOP/riser connection for pressure integrity at surface before running to depth with the LMRP. This paper describes a procedure to test for leaks inside the BOP/riser connection at the moon pool. All connections are tested off-line. Once placed inside the BOP above the riser connection, the tool is inflated to a predetermined pressure, and pressure is applied from above or below the tool to test the various component connections. By observing the applied pressure, it is possible to confirm the presence or absence of a leak, as well as its location.

SPE/IADC 118890

Electrical Cranes and Winches for Improved Safety and Better Operational Performance for Use in Extreme Weather Conditions. Hege Kverneland, and Arne Austefjord, National Oilwell Varco.

Exploration has moved into more hostile and challenging areas like the Barents Sea, onshore in northern Siberian territories, and in hot desert areas like Sahara and the Saudi Arabian desert. As a result, hoisting and drilling equipment must be designed to operate reliable and safely in extreme temperatures. This may be a problem for hydraulically powered equipment, which are highly temperature-dependant.

A new electrical winch using permanent magnet (PM) motor technology has been implemented on hoisting appliances ranging from small manrider winches to large offshore cranes. This technology using an "inside-out" PM motor integrated in the winch drum was introduced to the offshore market two years ago, in a manrider winch application. It is now adapted to larger horsepower winches.

This paper will focus on the benefits of using electrically powered cranes in extreme-temperature environments. Improved operational performance with higher availability of the equipment, easier installation and maintenance, as well as HSE issues will be discussed. The paper will focus on PM motor technology. It will also discuss the enhanced safety aspect for emergency lowering operations in offshore cranes for a PM motor compared with AC motor.

SPE/IADC 119777

Drilling at the Limit, Can Your Top Drive Handle It? Eric Deutsch, WEST Engineering Services.

As deepwater drilling has advanced, the weight expected to be borne by a top drive has increased to levels at or near the advertised load rating of the machine. However, the single load rating number normally associated with a top drive model (e.g., 1,000 tons) is a nominal figure that does not apply to every operating situation. A typical top drive has two main load paths – hoisting and drilling. Hoisting load passes through the elevators and link hanger, while drilling load passes through the saver sub, IBOPs and main shaft bottom end connection. Limitations inherent to rotary-shouldered connections can lead to diminished drilling load capacity vis-à-vis hoisting. Further complicating matters is the fact that the drilling load path is governed by disparate API specifications: 7 and 8C, which provide different calculation guidelines with regard to safety factors and are subject to a certain amount of interpretation.

The result is confusion about how much load a top drive can realistically handle. A 1,000-ton top

drive may not be officially rated to hoist 1,000 tons through its IBOPs. Additionally, API sets forth a different load rating for the swivel bearing, so load rating for rotation differs from overall top drive load rating. This paper discusses the technical aspects of top drive load rating and clarifies the usable load capacity of a top drive in real-world conditions.

Technical Session: Risk Management & Mature Fields

SPE/IADC 118378

Under-Rig-Floor Open-Hole Logging in the Gulf of Thailand: Operational Implementation of the Oil Industry's First Simultaneous Open-Hole Wireline Logging and Drilling Operation. Eric Upchurch, Chevron; Kyle Graves, Apache.

Chevron Thailand has introduced the world's first simultaneous open-hole wireline logging and drilling operation on its tender-assist and jackup rigs. The concept of the new logging technique: The rig drills a hole section and moves to drill another well, leaving the recently drilled open hole available for simultaneous off-line open-hole logging. The rig returns within 2-3 days to run casing after logging is completed. This creates an additional 10% savings per well.

SPE 116335 detailed the design aspects of this logging system. This paper will describe the processes used to implement this system, as well as its inherent risks and rewards. In the case of this new technology, our phased approach to implementation has resulted in a smooth, incident-free introduction to the various rig sites.

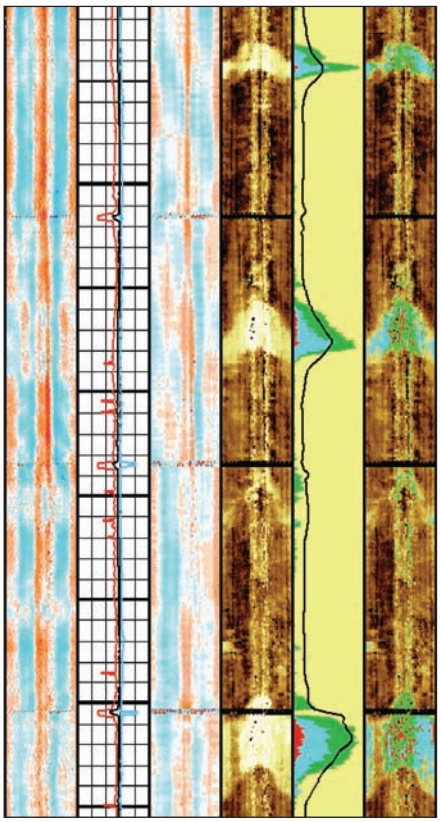
SPE/IADC 119321

Identification and Qualification of Shale Annular Barriers Using Wireline Logs During Plug and Abandon Operations. Stephen Williams and Truls Carlsen, StatoilHydro; Arne Guldahl, Schlumberger; Kevin Constable and Nils Eriksen, StatoilHydro.

It has long been recognised that during and after drilling through certain formations, the rock moves inward and begins to close off the well. Normally this phenomenon is considered undesirable. However, it can be put to good use as the mechanism to create an annular barrier behind casing. To extend the life of North Sea brown fields, many well slots on production platforms and subsea templates are being re-used. This involves permanent plug and abandonment of the old well track, and regulatory requirements dictate that double barriers be in place. With the shortage of sufficient traditional cement barriers, these wells often need costly remedial work in order to meet abandonment requirements.

Traditional sonic and ultrasonic azimuthal bond logging provides information on the material immediately behind the casing. Many such bond logs show solid material behind the casing far above the theoretical cement top. Clear correlations of this bonding pattern with shales, known to cause problems during drilling, indicates that the cause of the good bond response is that the shale has sealed off the annular region. Logging and pressure-testing sealed-off zones in a number of wells allowed the bond log response to be qualified for a certain formation. In this manner, it can provide a clear answer of whether shale successfully seals off certain zones and consequently provides a natural annular barrier.

This technique has been employed successfully on over 30 wellss.



SPE/IADC 119321, "Identification and Qualification of Shale Annular Barriers Using Wireline Logs During Plug and Abandon Operations."

SPE/IADC 119695

The Successful Application of Combined New Technologies to Reach Isolated Hydrocarbon Reserves Offshore Dubai. Thomas Lagler, Dubai Petroleum - SPD; Jonathan Rhodes, Niall Drumm, Wael Al Kholy, Baker Hughes INTEQ; Mouad Al Haj and Gamal Iskander, M-I SWACO.

In the mature offshore Dubai province, in order to access isolated hydrocarbon reserves, it is necessary to expose unstable sections of troublesome shale during drilling. Wellbore time based instability issues have been experienced in the Aruma and Laffan shales on offset wells with shorter build-up sections. To minimize exposure time, it is necessary to drill these sections as efficiently as possible, minimizing the time these shales are exposed. Dubai Petroleum looked at a combination of technologies available in the market that could help them to optimize drilling and to meet directional objectives.

For controlling the shales, a high-performance water-base mud (HPWBM) system with triple inhibition was proposed; also, a performance drilling system (rotary steerable tool in combination with a modular motor) and drilling dynamics sub were introduced.

The section was drilled safely in a single run, with all drilling objectives achieved and breaking all previous 24-hours ROP drilling records for an offshore Dubai Petroleum well. No shale instability issues were experienced, including the longest Aruma shale section ever drilled by Dubai Petroleum.

SPE/IADC 112486

Drilling and Completion Challenges of the Statfjord Late Life Project. Claas Van der Zwaag, Ove Hoevring, Geir Loeklingholm, Jamie Andrews, Olaf Steensland, Synnoeve Lind Rygh and Knut Taugboel, StatoilHydro.

The further development of the Statfjord field for the late-life pressure blowdown phase requires the drilling and completion of many infill wells from existing slots. The overall objective is to maximize oil production in the short term whilst securing future gas delivery potential for the late-life phase.

Engineering well designs to meet this objective is challenging. The Statfjord and Brent formations are sand-prone, and robust mechanical sand-control completions are required to secure off-take rates during late-life production. Also, after 29 years of production and water injection, the drilling and completion of wells through the differentially depleted formations would be challenging. In addition, the reservoir formations on Statfjord are substantially interlayered with shale sections. This meant that wellbore stability issues would pose challenges.

Initial late-life well designs were based on drilling horizontal reservoir sections with a low ECD oil-based drilling fluid system, then displacing the well to brine, running sand screens and gravel packing the open-hole screen with a conventional water pack. During the last three years, 23 late-life producers have been drilled and completed. This paper summarizes the operator's experiences with emphasis on well design, drilling and completion tools, well fluid technology and well productivity.

Technical Session: Case Histories II

SPE/IADC 119509

60 Days Ahead of Schedule - Reducing Drilling Risk at Valhall Using Computational Geomechanics. Tron Kristiansen, and Roar Flatebø, BP Norge AS.

SPE/IADC 118898, "New Washpipe Technology: Why Operators Should Care."

Valhall is a compacting and subsiding field becoming a difficult drilling environment in the overburden with time. The largest impact is in the crest of the field. This has led to the installation of flank platforms to access flank reserves effectively and the abandonment of the ERD drilling program. A new waterflood platform was installed in order to provide water injection into the depleted crest. This paper presents the technology developed for de-risking wells going into the most depleted, compacted crestal area with the most overburden changes.

The computational geomechanics technology developed and implemented is presented. The technology is based on a finite element based geomechanics model to calculate stresses, strains and displacements. The results are exported from the finite element model to GOCAD in order to do wellbore stability calculations using BP's Well Planning Toolkit. In this environment, one can also use supporting data as 4D seismic from the permanent life of field seismic array. The paper describes the process used for implementing and verifying the technology.

The first application of this technology on a new water injector delivered it 60 days ahead of schedule with reduced costs at around US$20 million and a potential train wreck avoidance of US$60 million. The observations while drilling the well strongly indicate that the trajectory modifications done based on this new method were crucial in order to get the well in place for successful injection.

The authors believe this is the first field application of computational geomechanics in detailed well planning in the industry. It illustrates the potential for using this technology in complex field developments where production alters the in-situ stress conditions in such a way that other methods for predicting drillabillity fails.

SPE/IADC 119262

Execution Success in a Platform Drilling Campaign. Kolby Burmaster, Jesse Chando and Kenneth Vaczi, ExxonMobil.

The challenges associated with planning and executing an offshore extended reach drilling (ERD) project are compounded when combined with restarting a cold-stacked platform rig. Execution requires a well thought-out, focused effort by the drilling team to achieve the planned scope at or below the estimated cost.

The operator restarted a cold-stacked platform rig to drill a five-well ERD program from an existing platform. This paper will focus on the key elements of the project that resulted in execution success. The paper will also describe the results and associated learnings during the program, including the significant improvement in ROP, as well as the marked reduction in overall NPTn.

SPE/IADC 119746

Case History: Automated Performance Measurement of Crews and Drilling Equipment. Ketil Andersen and Per Sjowall, StatoilHydro; Eric Maidla, PathFinder Energy Services; Buddy King, Consultant; Gerhard Thonhauser, TDE Thonhauser Data Engineering.

A new method and tool has been developed to automatically measure the performance of crews, drilling equipment and downtime, making it possible to compare equipment and crew best practice performance a cross installations. The system was tested on Kristin, Gullfaks, Snorre, and West Epsilon in the North Sea.

The event recognition tool measure how long time it takes to do each task and by using the following formula: Downtime time + Equipment technical limit time + Crew handling time = Operation time.

When this information is plotted as histograms, it's easy to see the time distribution of each individual task and this provides:

- The management a tool to select the best vendor when it comes to time performance of equipment to do the task (technical limit of equipment).
- The crews to find a safe way of working that have optimal performance (best practice) .
- The management and crew to find a way to set the best key performance indicators (KPIs) for each task to set targets for crew performance and when bonuses should be paid out.

SPE/IADC 119383

An Aggressive Approach to Reducing Failure-Driven Non-Productive Time in Onshore Drilling Operations. Jeffery Everage and Shawn Altizer, T.H. Hill Associates; Geoffrey Roberts and Fred Kellow, Devon Energy.

In determining the necessity of drill string quality assurance initiatives, an operator must answer two primary questions: 1) What is the probability of failure? and 2) What would be the impact, financial or otherwise, of a failure event?

Typically, balancing the answers to these questions with the expense of additional quality management measures has presented a challenge to onshore operators. However, recent increases in drilling activity have dramatically changed the evaluation process. First, supply chain pressures have limited the availability of suitable drill string components and experienced personnel. Additionally, greater demand for all inputs of the drilling process has driven well costs to extremely high levels. Referencing the questions posed earlier, both the probability and impact of failure events have significantly increased.

To address this issue, an operator drilling in the Barnett Shale region implemented an aggressive quality management plan to reduce risks and expenses resulting from drill string failures. The operator first established a baseline for NPT due to drill pipe and HWDP failures, then tracked the changes in NPT over a two-year period. The primary work scope of the quality consulting company was to ensure that industry-accepted standards were followed. Initial quality audits on machine shops, hardbanding applicators and inspection companies

allowed formal documentation of quality gaps and development of individual quality plans.

At the end of the two-year period, NPT due to drill pipe and HWDP failures had been reduced by 47%.

SPE/IADC 118898

New Washpipe Technology: Why Operators Should Care. Jeremy Ogg, National Oilwell Varco; Brett Borland, ConocoPhillips.

This paper will provide field results from a HT/HP well where the application of a breakthrough tTop drive washpipe technology was implemented. The design goal of this washpipe was to significantly improve durability over the established industry-accepted performance. Along with the field results, a simple financial model will be provided that shows why the application of this new technology can yield positive results in a relatively short period of time.

National Oilwell Varco has introduced a technical solution that utilizes mechanical sealing technology developed outside the oil and gas industry, which has proven itself in a ConocoPhillips-led field trial with ENSCO in the North Sea. Given the demonstrated positive results of this application, this system is going to lead to improved operating efficiency in the industry.

SPE/IADC 119815

BP Egypt Uses RMR on a Jackup to Solve a Top Hole Drilling Problem. Andrew Hinton, AGR; Edvin Kvalvaag and Arthur Jongejan, BP; Kjartan Seim and Gerhard Becker, AGR.

BP Egypt used a subsea pump on the Rahamat well so that engineered mud could be used to drill the surface hole with returns to the Constellation II rig, (first use of RMR on a jackup). This allowed the 26-in. surface hole to be drilled and 22-in. surface casing cemented at 1,085 m below mud line (BML) without problems.

Firm sand prevented a 30-in. conductor from being driven deeper than 51 m BML. The rig has a 40-m air gap, and the water depth is just 19 m. This resulted in a shoe that would support only 0.8 sg (7 ppg) fluid back to the rig. Inhibited mud, minimum weight 1.13 sg (9.4 ppg), was needed to control the formations. Seabed returns were unacceptable for environmental and mud supply reasons.

RMR installation/retrieval was mainly done off the critical path. Equipment was installed without an ROV. RMR took returns from the conductor at sea level and pumped mud with cuttings back to the rig. Mud was re-circulated after treatment. This allowed good control of the mud properties. ECD pressure was reduced by 0.4 sg (3.5 ppg) at the casing shoe and 0.04 sg (0.3 ppg) at section TD. Mud losses in coarse sands were controlled by adding LCM and fluid loss control material. The hole was drilled to the planned depth. 22-in. casing was run and cemented while controlling the fluid level in the annulus (and therefore downhole pressure) with RMR. No losses were seen during these operations.

RMR allowed surface hole to be drilled with inhibitive mud and returns to the rig because RMR removed the effect of the 40-m airgap.

SPE/IADC 119531

Remotely Managing a Project in a Volatile Security Environment. Hani Qutob, Waleed Asslman and Marwan Sabah, Weatherford.

Iraq is undergoing a period of transition, with a lack of utilities, security and basic services. Furthermore, oil and gas infrastructure was in a very poor state. Weatherford was committed to establishing their business inside Iraq but decided to control and manage their operations remotely. The management team was based in Dubai to plan, manage and support operations and an established team in Iraq to follow directions from management office.

Coordination of operations was done using state-of-the-art communication systems, effective information reporting procedures and experienced technical support on the ground. Field personnel were extensively trained. Finally, an integrated project management system was created to provide clients with experienced project management, well engineering expertise and the optimum technology for integrated projects to jointly create greater value in an environmentally responsible manner. The positive outcomes are better access to technology, teamwork and an alliance spirit with mutually agreed objectives.

Technical Session: Performance Drilling

SPE/IADC 119375

Use of Roller Reamers Improves Drilling Performance in Wells Limited by Bit and Bottomhole Assembly Vibrations. Steven Sowers, and Fred Dupriest, ExxonMobil.

Use of roller reamers has provided continuous performance improvement in areas limited by stick-slip and whirl.

Whirl is a dysfunction characterized by lateral vibration that may occur at the bit or in the BHA. When whirl becomes severe, lateral vibrations cause high side forces in stabilizers. Friction resulting from these side forces cause high torque at stabilizers and can result in stick-slip. The operator refers to this as “coupled stick-slip” because the condition was caused by whirl in stabilizers. Coupled stick-slip is detrimental to ROP and causes premature failure of bit and BHA components. When these conditions exist, the replacement of stabilizers with roller reamers eliminates the potential for torque-generation in the stabilizers. Consequently, stick-slip does not occur until a deeper depth for a given well.

Whirl can also cause borehole patterns, spiraling ridges cut into the borehole wall. While the average diameter of the hole drilled with these patterns will always be overgauge, it is possible for the diameter measured from ridge to ridge to be less than the gauge of the bit. This condition can be so severe that it is not possible to trip pipe on elevators. Roller reamers remove part of the ridge in such drilling conditions and allow pipe to be tripped on elevators without excessive drag.

This paper details the conditions where roller reamers provide benefits allowing improved performance. A conceptual model for coupled stick-slip is provided, as well as a summary of borehole patterns that may be removed with roller reamers. Examples of wells where performance was improved as roller reamers mitigated these conditions are also provided.

SPE/IADC 118809

Beyond the Technical Limit: Turbodrilling a Paradigm Shift to World Class Horizontal Well Construction. Todd Mushovic, BP; Raymond Morlock, David Shuler and Dave Conroy, Smith Technologies.

Wells in the Pennsylvanian reservoir are drilled horizontally within extremely low permeable Ordovician layer before fracture stimulation. Previous attempts to drill these wells vertically with PDCs/inserts using PDMs had proved uneconomic. The challenge was to efficiently finish drilling the build section and land the well horizontally in the Bromide before extending the reach to its maximum extent. Wellbore placement was critical to ensure that fracture stimulation would optimize production.

A turbodrilling system was recommended to improve economics drilling. Advantages included higher mechanical horsepower, excellent directional control and improved wellbore quality. The new BHA was run with excellent results, building to 90° before landing horizontally with three bits. On the next well, the turbodrill was optimized for directional response by shortening the tool, and the impreg was downsized to 6 1/8 in. in order to leverage available design options.

Following that success, optimization of a Middle Atoka horizontal drilling program with turbodrilling was undertaken. Previous wells required four PDMs/PDCs per lateral. After analysis, engineers concluded the well could be drilled with a single turbodrill BHA. The turbodrilling BHA run completed the section in one run. Following this success, the new-style turbodrilling system used on the next well set a state record for slimhole total footage/ROP. On the subsequent well, the section was completed with one turbodrill run, this time establishing a world single-run footage record for 6 1/8 in. impreg.

SPE/IADC 119826

Performance Drilling – Definition, Benchmarking, Performance Qualifiers, Efficiency and Value. Graham Mensa-Wilmot, Chevron ETC; Panurach Dumrongthai, Chevron; Stephen Southland, Smith; Patrick Mays, Chevron.

Challenging drilling conditions have resulted in increases in operational costs. Improving drilling performance will help drive down costs. There are several positions in the industry on what constitutes performance drilling. In some instances the use of new technology, sophisticated tools or expensive drive systems is classified as performance drilling. This position is severely faulted.

In addition to defining what performance drilling actually is, the importance and process of benchmarking will be discussed. Drilling program success depends on the optimization of the following performance qualifiers – footage, vibrations control, rate of penetration, durability, and directional effectiveness. These qualifiers must be specifically ranked for different wells, based on their effect on operational costs. The ranking process for the qualifiers, as well as their effects on maximization of “on-bottom” time, NPT reduction, minimization of unexpected events will be supported with field data. Drilling efficiency will be defined and discussed.

SPE/IADC 119421

Tracking Drilling Efficiency Using Hydro-Mechanical Specific Energy. Robello Samuel, Halliburton; Kshitij Mohan, Faraaz Adil and Nehal Patel, University of Houston.

Different types of bits have been introduced to meet the challenges of steerable and rotary steerable systems; and it is imperative that bits be utilized optimally in the system. A new correlation identifying inefficient drilling conditions is presented in this paper. Mechanical specific energy (MSE) has been used to improve drilling rates, with mixed results. Drilling specific energy (DSE), which is introduced here, encompasses hydraulic as well as mechanical energy. DSE quantifies the amount of energy required to drill a unit volume of rock and remove it from underneath the bit. DSE includes axial, torsional and hydraulic energy.

Experimental and field data presented in this paper show that DSE can identify inefficient drilling conditions. Extensive simulations have been carried out and will be reviewed. The new hydraulic term

included in the specific energy correlation is the key to correctly match the amount of energy required to drill and overcome the rock stresses. Also, this new term illustrates how much hydraulic energy is needed to drill faster when the mechanical energy (axial and torsional) is increased. The results also show the importance of including the bit hydraulic energy term into any specific energy analysis for drilling optimization. The pump-off force on the weight on bit due to the fluid force is also included in the calculation.

Field results reveal specific patterns for inefficient drilling conditions and a good correlation between the calculated DSE and the expected requirements for rock removal under existent conditions of stress at the bit face. The practical usefulness of the theory will be demonstrated with numerical examples.

SPE/IADC 119887

Drilling Optimization Study for the China Chuandongbei Luojiazhai Field. Xianjie Yi, Yoseph Harjadi, James Sabolcik, Jozina Dirkzwager, Peter Connolly and Peng Ray, Chevron.

Chevron signed a 30-year production-sharing contract with China National Petroleum Corporation (CNPC) to jointly develop the Chuandongbei natural gas area in Sichuan, which has nearly 15% H_2S content. Luojiazhai Field has been determined to be the first to be developed.

Drilling in the Luojiazhai Field by CNPC had proven extremely challenging. Two blowouts had occurred, one of which killed 243 people. Formations were so hard to drill that 5-6 ft/hr ROP was considered fast. Slow drilling also led to long exposure of the open wellbore to water-based mud that caused tight hole and stuck tool problems. Natural fractures caused significant mud losses. In addition, due to high tectonic stresses in this region, wellbore stability needed to be considered.

To ensure safe drilling and optimum performance for new wells, geological, petrophysical, drilling and completions data from the existing 16 wells in the Luojiazhai Field were reviewed and analyzed thoroughly. This paper will describe how multidisciplinary approaches in rock mechanics, mechanical earth modeling, pore pressure prediction, and MaxDrill drilling optimization can be applied to ensure that new wells be drilled faster and more safely through optimum bit selection and design, fluid selection and mud weight design, as well as careful well trajectory planning.

SPE/IADC 119230

Minimizing Risks, Maximizing On-Bottom Drilling Time: Turbodrilling with Impregnated Bits Improves Efficiency and Circumvents Trouble Time, Southern Oklahoma. Peter Langille, Marathon Oil; Carl Deen and Jay Klassen, Smith Bits.

Drilling in the Anadarko Basin in southern Oklahoma can present challenges like fractured formations, conglomerates and other eccentric geologic phenomena. In this unpredictable drilling environment, it's difficult to optimize/refine the bit/tool and BHA selections, resulting in unacceptable/inconsistent drilling performance.

To maximize on-bottom time and cut costs, an in-depth analysis was conducted to improve section economics. A consistently troublesome application was selected where inconsistencies in the use, performance and dull conditions of bits in close offsets were driving up field development costs. From this group, a specific interval was selected for analysis, and the data compared with direct offset runs. In the study, engineers considered bit design/materials, turbodrill and BHA stabilization and drilling parameter optimization. Finally, turbodrill/impreg limitations were considered.

The analysis determined that turbodrilling with impregnated bits was an option to create savings and could effectively optimize drilling.

The new-style turbine/impreg BHA was run with outstanding results. The test interval was successfully drilled, eliminating multiple bit trips and reducing overall days. Cost savings were substantial versus a direct offset well that experienced 38 days of trouble time through the same formations. This trial run gives considerable strength to the hypothesis that impreg/turbine drilling can significantly reduce risk compared with traditional BHAs used in direct offsets.

SPE/IADC 119914

Drilling an F 2-in.-in-diameter Hole in Granites Submerged in Water by CO_2 Lasers. Toshio Kobayashi, Japan Drilling Co.; Komei Okatsu and Satoshi Kubo, Japan Oil, Gas and Metals National Corp; Masahiro Nakamura, Japan Drilling Co.

As part of a fundamental study of rock drilling by laser irradiation, this paper describes laser drilling of a f2-in.-in-diameter hole in granites submerged in water. In the air, molten granite produced by laser irradiation reflects or absorbs successively irradiated laser beams, thereby refraining laser heat from being transmitted into the rock. This absorption leads both to a temperature rise of the molten granite and a further increase in absorption of laser radiation by the molten granite, causing the rock destruction process to cease completely.

From consideration of the lack of success in past laser rock drilling methods, we arrived at the idea that laser-induced mechanical forces could be utilized to generate a hole in rocks by laser irradiation in water. A granite specimen was submerged at 50 mm from a water-surface and then 10.6 mm carbon dioxide laser (CO_2) beams, which have a high absorption coefficient in water, were intermittently irradiated.

The laser beams induced underwater shock waves, bubble formations and micro-water jet formations upon bubble collapse. High-speed video observations revealed the generation of an initial cone-shaped water cavity, propagation of the laser beams through the cavity and eventual ablation of the granite surface. The laser beams locally melt the granite surface to form small glassy beads, which are readily removable by mechanical methods. Repetition of this procedure demonstrated that a high-power laser beam propagating in water can be used to generate a hole in rocks.

The laser beam irradiation indeed drilled the granite specimen submerged in the water. f 2-inch-in-diameter holes in the underwater granites were successfully generated by two methods that were melting and spalling by the laser. Melting the granite to generate a f 2-inch-in-diameter hole requires energy almost 3 times as much as spalling the granite to generate the same size hole.

SPE/IADC 119491

Reelwell Drilling Method. Ola Vestavik, ReelWell A.S.; Scott Kerr, StatoilHydro; Stuart Brown, Shell.

A new drilling method combines MPD and liner drilling. The method is being developed in a joint industry project funded by StatoilHydro, Shell and the Research Council of Norway. The new method uses a dual drill string and a downhole sliding piston attached to the drill string. The sliding piston is used for improved downhole traction and pressure control and can optionally be used in combination with an expander tool for downhole liner expansion.

A full-scale test at the research rig Ullrigg in Stavanger successfully demonstrated the method during the fall of 2007 and spring of 2008. The tests demonstrated the features of the new concept and its possibilities for improved pressure control and drilling performance. The presentation will cover the new developments and the results from the tests.

Technical Session: Downhole Tools

SPE/IADC 118435

Analysis of Hook Load Forces During Jarring. Kenneth Newman, NOV CTES; Ray Procter, Fearnley Procter Group.

Twice during the last year, on opposite sides of the world, drilling rigs have collapsed after prolonged jarring operations. This paper documents the analysis performed afterwards to determine if the jars could generate enough force to overload the rig structure.

Data from the drilling logs was taken at time intervals of 10 seconds or greater. These large time intervals did not allow the peak shock loads to be recorded. The rig instrumentation tends to damp out these peak shock loads. Thus, during prolonged jarring operations, the loading can be more significant than what is displayed by the rig instrumentation.

A dynamic finite element jarring analysis was done for both of these cases. This analysis calculates the loads along the drill string before and after the jar is released. The impact load travels up and down the string at the speed of sound in steel, causing spikes in the surface loads. To simulate these dynamic loads, the model is run with a time interval of 100th of a second. This allowed the loading seen by the rig structure to be simulated The input parameters and modeling results from both of these analysis will be presented.

SPE/IADC 119540

Along String Pressure and Temperature Measurements in Real-Time: Early Field Use and Resultant Value. Monte Johnson and Michael Reeves, IntelliServ; Maximo Hernandez, GrantPrideco; Chris McCartney and Scott Allen, Oxy Oil and Gas USA.

High-speed drill string telemetry technology is being adopted with increased frequency into challenging drilling environments around the world. In addition to allowing instantaneous transmission of data between surface and measurement tools located close to the drill bit, this technology enables measurements to be acquired and transmitted to surface in real time from many points along the string.

Along-string annular pressure and temperature measurements provide dramatically improved visibility of hole cleaning, equivalent circulating density and fluid influx/loss issues at multiple points along a well. Early use of the information delivered by this technology includes more effective management of flow rates, mud weight, rate of penetration, string rotation and the use of lost-circulation material to significantly reduce the risk of stuck pipe, formation fracture and excessive losses.

This paper shares and discusses previously unseen data from early field uses of along-string pressure and temperature measurements with comparisons to normally available data from bottomhole measurement tools.

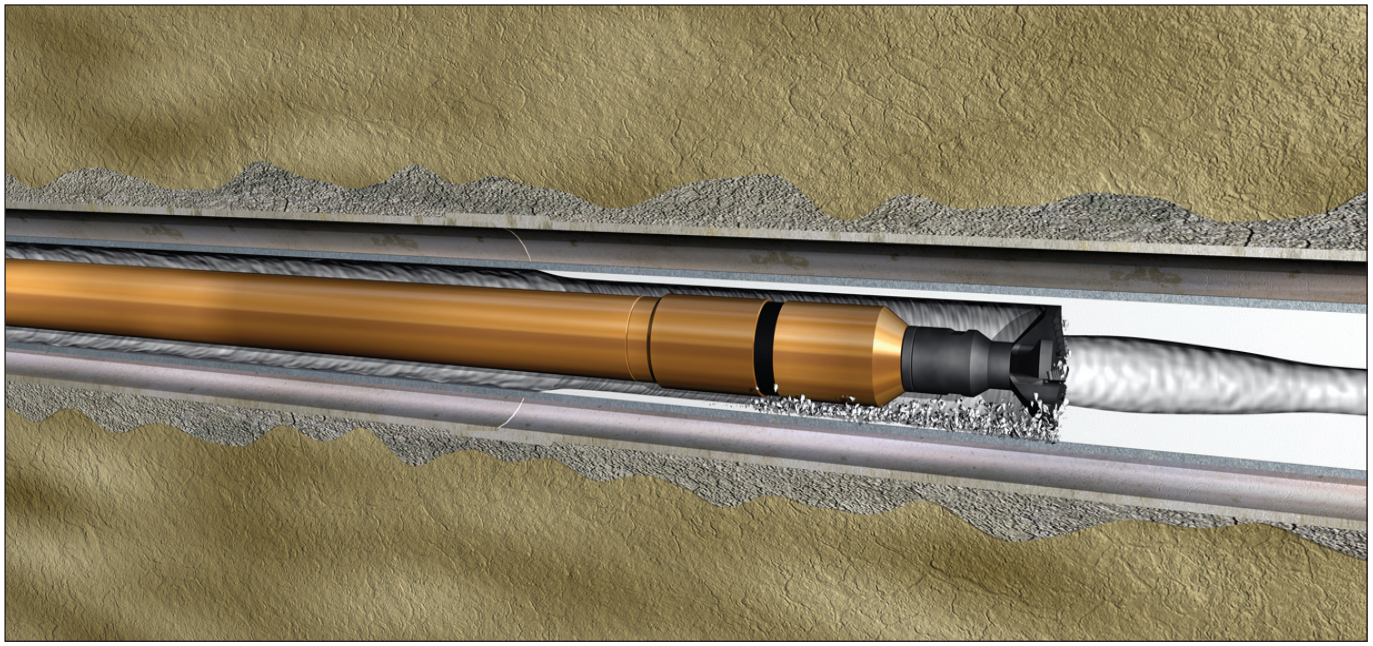
SPE/IADC 119382

Electric Wireline Milling - New Solutions for New Challenges. Robert Joyce, Welltec, Inc.

The concept of milling obstructions in wellbores, utilizing electric wireline deployed services, was introduced in 2005. Since that time, operators have used this well intervention technique efficiently and cost effectively. These wireline-conveyed technologies have performed well in both completion and workover programs by providing the means to drilling out stuck valves, remove non-retrievable plugs and re-establish production by removing scale.

The additional cost of lost, or deferred production is always unwanted. The deployment of a traditional rig or coiled tubing unit to help restore production comes with considerable cost owing to the equipment and personnel requirements to operate. Consequently, operators continually look to new techniques to minimize this burden. Milling on electric wireline is one such technique since it can be performed in a rig-less environment.

Experience has shown that each new milling challenge requires careful study of the problem, along with extensive testing and verification of the technique. Every downhole scenario provides a different characteristic to consider. As a result, many man-hours and research dollars have gone into providing solutions for advanced milling projects.



SPE/IADC 119382, "Electric Wireline Milling – New Solutions for New Challenges."

This paper presents new applications for electric wireline milling. First, a summary of the milling experience to date will be presented, followed by the examination of some complex milling challenges through several varied case histories including the milling of isolation valves, cast-iron bridge plugs, glass plugs, nipple profiles as well as scale removal.

SPE/IADC 119420

Rotating Magnetic Ranging and Single Wire Guidance Tool Facilitates in Efficient Downhole Well Connections. Ray Oskarsen and John Wright, John Wright Co; Don Fitterer, David Winter, Anthony Nekut and Jed Sheckler, Vector Magnetics.

Downhole connections between multiple wellbores have many applications, including being an alternative to multilateral completions. An RD project was undertaken to develop and validate an electromagnetic ranging concept for enabling cost-efficient downhole connections.

After extensive testing and deeming the ranging technology suitable, an existing offshore well jacket located in southeast Asia, in 5.1 m of water and 1.3 km from shore, was identified as a candidate for field validation. In late December, 2006, a well was spudded from a nearby onshore location with the intention of drilling directionally to hydraulically connect to one of the wells drilled from the well jacket.

The objective was to prove the well-connect concept for implementation in future projects, via: achieving close intersection with the existing well, achieving hydraulic connection between the wells and to sustain sufficient flow through the connection. Two electromagnetic-ranging systems were used, namely: single wire ranging (SWR) used from <220-m MD from target and rotating magnetic ranging service (RMRS) used from a depth of <45-m MD from target. The electromagnetic-ranging technology facilitated in the successful intersection of the target well according to plan; by-pass within specified proximity and by-pass occurred in the correct sand.

SPE/IADC 119958

A Step Change in Drilling Efficiency: Quantifying the Effects of Adding an Axial Oscillation Tool Within Challenging Wellbore Environments. John McCarthy, Brett Stanes, Kevin Clark and Greg Leuenberger, National Oilwell Varco; Jorge Rebellon, Andergauge.

Motor steerable (MS) assemblies are used in the majority of directional drilling applications globally. However, the limitations of MS systems are often highlighted as trajectories become more complicated and efficient drilling performance becomes more difficult to obtain. This is a challenge as drilling efficiency continues to be of top importance in the drilling of oil and gas wells.

Drilling tools that impart cyclic, axial oscillations into the drill string have been shown to extend the operating range of MS assemblies, particularly in slide-drilling mode. Based on the successes of over 5,000 field runs, the results appear clear, though intuitively there could be problems associated with adding axial vibration into the drill string. Historically, measuring the actual forces transmitted by the axial oscillation system has been a challenge as most downhole measuring devices record at sample rates significantly lower than the operating frequency of the oscillation tool. In addition, these tools often do not have the number of data channels required to fully describe the downhole dynamic environment. Furthermore, variations in bit type, bottomhole assembly configuration, drilling parameters and formations make detailed comparisons difficult.

This paper will compare a number of field runs with and without an axial oscillation system and will quantify the actual downhole accelerations caused by adding the oscillation system to the drill string.

SPE/IADC 118328

A New Azimuthal Gamma at Bit Imaging Tool for Geosteering Thin Reservoirs. Jason Pitcher, Halliburton; Daniel Schafer, BP; Paul Botterell, Halliburton.

A new azimuthally-sensitive gamma-at-bit imaging tool has been designed for use in geosteering and to provide gamma measurements very close to the bit while drilling. It uses binned azimuthal measurements from four scintillation gamma-ray detectors spaced at 90° around the collar. Continuous image logs are recorded and telemetered to the main LWD string and ultimately to the surface whether the tool is sliding or rotating. When rotating, data can be recorded in quadrants, octants or hexadecants. When sliding, quadrant data is recorded. Typically, quadrant data is sent to the surface in real time, though other data densities are possible.

This paper discusses the tool and its incorporation in an adjustable bent housing motor. Methodology and experiences are discussed for transmitting the data back to the main LWD string and to the surface A field example is presented to demonstrate the geosteering capabilities of this system in a thin reservoir within a complex geological environment.