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Ultra Deep HP/HT Completions: Classification, Design Methodologies, and Technical Challenges

B. Maldonado, A. Arrazola, and B. Morton, Baker Oil Tools

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Abstract

Increased energy demands and revenues for oil and gas has triggered the re-assessment of existing HP/HT fields as well as driven the search for new hydrocarbon sources with more extreme formation environments. In the Gulf of Mexico and world wide, this economic incentive is having a large influence on operations, drilling deeper on land and in shallow and deep waters.

The traditional understanding of HP/HT applications, 10ksi and 300°F are common in today's marketplace. The HP/HT working envelope has been successfully pushed out to 15ksi and 400°F, with some limited gaps related to completion size availability rather than technology needs. As expected, this new larger envelope is now being pushed further out to 20-30ksi and 400-500°F. The technology gaps associated with this new HPHT frontier are not limited to completion equipment but also include casing, tubing, BOPs, wellheads, perforating, lubricators, logging and drilling[1].

In an effort to identify HP/HT operating environments and also technology gaps, a new classification is developing which will segment HP/HT into three tiers. While existing technology embraces most of Tier I applications, Tier II and III demand extraordinary considerations in regard to the selection of the completion equipment. This paper discusses the design methodologies and technical challenges associated with Extreme (Tier II) and Ultra (Tier III) HP/HT completions based on "typical" Deepwater and Deepgas HP/HT well parameters, casing and tubing programs.

Evaluation and recommendation of methods for selecting completion equipment, including sand control, subsurface safety valve, packer to tubing interface, production packer, and flow control technologies will be reviewed.

The completion of Extreme and Ultra HP/HT wells involve high risk and rig costs which demand special considerations and investments. This paper will outline completion technology gaps for these type HPHT wells. The paper will also highlight the importance of upfront planning, design, qualification testing, QA/QC, and contingency options.

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History and Classification

The initial efforts to go after deep hydrocarbon reservoirs in excess of 20,000 feet started back in the 1970's in the highly pressured formations around Jackson Mississippi and the North Sea which were heavily driven by the oil boom. The next development in the 1980's occurred in the Tuscaloosa trend in Louisiana and in Miocenes offshore formations in the Gulf of Mexico. In the 1990's and continuing to present, several developments have taken place worldwide including major projects in the North Sea and Gulf of Mexico. It has been a very steep learning curve that has developed key completions technologies including high strength steels, nickel-based corrosion resistant alloys (CRA) and sealing compounds.

The original definition of HPHT was first introduced by the Department of Trade Industry (Dti) for the United Kingdom continental shelf (UKCS)[2]. It was defined as "Where the undisturbed bottom hole temperature at prospective reservoir depth is greater than 149^{o}C (300^{o}F) and the maximum anticipated pore pressure of any porous formation to be drilled through exceeds 18000 Newton/meter2/meter (0.8 psi/ft) or around 10, 000 psi)[3]". However, to help identify HP/HT operating environments, safe operating envelopes and technology gaps, a new terminology is developing (Figure 1).

The terminology segments HP/HT operations into three tiers. Tier I refers to wells with reservoir pressures up to 15,000 psi (1034 bar) and temperatures up to 350º F (177º C). Most