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A Combination of Expandable Sand Screens and Intelligent Control Systems in the Okwori Completions Offshore Nigeria

Jim Stevenson, formerly Addax Petroleum Development Nigeria Ltd., and Rodger Lacy, SPE, Juergen Neumann, SPE, and Gary Tough, Weatherford Intl.

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Abstract

The Okwori field in Nigerian offshore waters was discovered in 1972 and, though several subsequent lease holders studied the possibility, its geological complexity made development of the field difficult and it was considered to be uneconomic. It was not until the lease was acquired by Addax Petroleum Development (Nigeria) Limited in 1998 that a serious attempt was made to exploit the fields potential. A development plan was eventually put together which was approved by the Nigerian regulatory authorities in 2002.

In order to develop the field in an economic manner and address all the difficulties it posed, it was decided to do so using a series of subsea wells each completed in multiple zones and tied back to an FPSO. The wells were to be completed using a combination of expandable sand screens and remotely operated intelligent completion flow valves. Due to the complexity of the completion Addax elected to use a single contractor to supply all the components. When the initial completion was attempted a vital piece of downhole equipment, which was key to the intelligent completion's operation, failed thus precipitating a rethink of the completion. In very short order and under extreme time constraints, an alternative approach was designed using the same subsea equipment and the first four completions were made successfully within the timetable dictated by Addax production commitments.

In this paper the authors will review the complex nature of the Okwori field, discuss the initial completion plans, review the reasons for the equipment failure and present the solution which was arrived at by a concerted joint effort by the operator and service contractor.

Introduction

Addax Petroleum Development (Nigeria) Limited acquired the Okwori field in 1998, it is located in oil mining lease OML126 offshore south of Port Harcourt in water depths ranging between 165 and 690 feet (50 and 210m) (Refer to Fig. 1 for a map of the area). The Okwori field is extremely complex geologically with a large number of reservoir layers and faulted compartments containing numerous pools with hydrocarbon bearing potential. The development of a collapsed crest anticline along two intersecting sets of syn- and post-sedimentary fault planes explains the structural complexity in which two 3D seismic surveys mapped more than one hundred fault-dip closures. Prior to the beginning of field development by Addax, six wells were drilled in the field and penetrated thirty of these pools. It was found that the oil-water contacts were highly variable among the reservoirs and also among the compartments of the same reservoir[1]. Adding to the field development complexity, the oil bearing sands are all weak to medium consolidated sandstones and very permeable, thus adequate sand control is of paramount importance and is essential to successful production from the reservoirs[2].

The highly faulted and compartmentalized reservoirs of the field required dispersed well locations and Addax developed a Master Field Development plan which called for development using a series of subsea wells each tied back to a central FPSO - Floating Production Storage and Offloading vessel (Refer to Figure 2). Initially the field development plan advocated the use of four existing wells which had been drilled, tested and suspended by a previous operator. However, during risk evaluation of the wells by the Addax well engineering team, the decision was made to drill and complete eight new wells as opposed to re-entering and completing the original wells. The total cost of developing the field in this manner using a semi-submersible rig to drill and complete the wells required that each well have high production capacity and so, in order to make the project economically feasible, each well needed to produce from several of the oil-bearing reservoirs. Each well would require commingled flow in order to meet the financial goals of the project, but host country regulations dictated that independent control be maintained over each individual producing zone so that allocation of production by zone was possible. Once the Master Field Development plan was initiated and the drilling commenced, there would be a scheduled time line to the arrival of the FPSO and the production of first oil from the field, with financial penalties becoming due upon any delays to the deployment of the FPSO and the first oil production.