Casing drilling was used to optimize drilling of the tophole section in the Phase-1 wells of the mature Samarang field redevelopment campaign. Lost-circulation and stuck-casing incidents in the surface section had occurred in previous campaigns, and casing drilling was identified as a solution to mitigate these problems. This study focused on the casing-drilling application to reduce the risk of a shallow-gas blowout.

**Introduction**

The objective of redeveloping the Samarang field was to implement enhanced oil recovery (EOR). The field is in Malaysia, offshore Sabah, in the South China Sea. The field was discovered in 1972, and commercial production started in 1975. New wells were drilled in subsequent revisits in 1986, 1991, and 1998, and a workover and sidetrack campaign took place in 2002. Samarang reservoirs are at depths of 1,500 to 8,000 ft and comprise a series of alternating sand, silts, and clays. Part of the field lies underneath a shallow reef with a water depth of 30 ft.

The redevelopment plan had two phases. Phase 1, completed in 2011, included one sidetrack well from Platform SMDP-B (in 156-ft water depth) and four new wells, of which two are standalone and two are conductor-sharing wells drilled from Platform SMJT-F (in 33-ft water depth). Phase 2 was implementation of the EOR plans and included drilling infill producers and injection wells on seven platform revisits along with upgrading production facilities.

For Phase 1, the surface section of the four new wells was planned as a 16-in. hole, casing drilled with 13⅜-in. casing. Casing-drilling technology was chosen to optimize the drilling time and to reduce the risk of mud losses, hole instability, and stuck casing—problems reported in previous Samarang drilling campaigns and that, in some cases, forced setting the casing shallower than planned. Also, previous experience suggested that casing drilling would prevent problems with the conductor-sharing wells.

Ensuring that the casing is set at the planned depth became particularly important because of the simplified casing design used in Phase 1. The typical casing scheme for previous wells in the field used an 18⅝-in. surface casing set at approximately 1,000 ft, followed by the 13⅜-in. intermediate casing set at approximately 2,000 ft, and then the 9⅝-in. production casing to well total depth (TD).

The simplified casing design consists of a 13⅜-in. surface casing set at approximately 2,000 ft, followed by the 9⅝-in. production casing to well TD. Fig. 1 shows the simplified casing scheme that omits the 18⅝-in. casing string.

**Redevelopment Campaign**

The risk of a shallow-gas blowout exists when drilling the surface section of a well before a blowout preventer has been installed. The danger of shallow gas is that, if an influx occurs, it can develop easily into an uncontrolled flow of formation...
fluid to surface, with no means of shutting the well in. Return-fluid diverters can be used when drilling the surface section of a well, but diverters are not well-control devices and their use is only to direct the flow of formation fluid away from the rig floor.

In producing fields, the uncertainty of shallow gas is lower because information can be obtained from the offset wells. Although more information about the initial conditions of the field was available, the potential for shallow gas accumulations from leaking annuli exists in fields that have produced for a long time. In such situations a new shallow seismic survey might confirm whether new shallow gas horizons have formed. In this field, new seismic data were not conclusive on whether new shallow gas horizons had formed.

**Pilot Hole.** Drilling a pilot hole is an accepted procedure to mitigate the risk of shallow-gas influx. A pilot hole has a smaller diameter than the required hole section, and is drilled below the conductor shoe to the next casing-setting depth to determine the existence of shallow hazards. For shallow-gas application, a smaller-diameter hole is more likely to handle an influx by attempting a dynamic kill. The small annular clearance between the bottomhole assembly (BHA) and the wellbore and between the drillstring and the wellbore) and a high flow rate combine to achieve high annular velocities, increased annular-pressure losses, and high backpressure.

Although drilling a pilot hole provides an opportunity to deal with a shallow-gas influx, it also introduces the risk of swabbing and makes the hole more sensitive to incorrect filling. Swabbing and incorrect hole filling are known to be the most common causes of influx. Also, drilling a pilot hole does not guarantee that the well can be killed dynamically if a flow begins. While it is believed that a dynamic kill can be performed in a small hole size, at the surface section of the well there might not be sufficient hole length to achieve a significant pressure drop from the annular friction losses.

**Casing Drilling.** Casing drilling is a rotary-drilling process that cases the well as it is drilled. The casing string is used as the drillpipe, and it conveys the mechanical and hydraulic energy to the bit and BHA. The system used here was designed for directional applications such that the steerable BHA is locked onto the bottom of the casing, enabling logging of the section while drilling the trajectory. At TD, the BHA is retrieved by use of drillpipe or by wireline and the casing is cemented.

**Mitigating the Risk of a Shallow-Gas Blowout.** The casing-drilling plans for Samarang Phase 1 were to case drilling the surface section of the four new wells with a 12¾-in. bit, followed by a 16-in. hole opener, the drilling BHA, and the 13¾-in. casing. When reaching section TD, the BHA would be released, the casing string lowered down over the BHA, and a retrieving tool run on 5-in. drillpipe to retrieve the casing-drilling BHA. The selected drilling fluid for the surface section was seawater, with sweep pills pumped at each connection.

Casing drilling had potential of being applied for shallow-gas mitigation in Samarang instead of drilling a pilot hole. If casing-drilling conditions permit high annular-pressure losses when required for controlling an influx, drilling a pilot hole before the casing-drilling operation would not be a significant benefit. Without drilling the pilot hole, several operational steps could be omitted, resulting in a simpler and faster operation.

Another risk involved the operation of opening the pilot hole. To open the pilot hole to the required hole size, a hole-opening BHA with a bull nose would be run on the casing-drilling string. There was high risk of damaging the bull nose and deviating from the original trajectory, especially in the soft shallow formation.

Not drilling a pilot hole eliminates the risk of swabbing when tripping out of the hole. In a casing-drilling operation, the well is drilled and cased at the same time, eliminating trips in the open hole and eliminating the risk of a swab kick. Because most well kicks occur when tripping out of the hole, casing drilling significantly reduces the overall risk of having an influx.

Another cause of influx is downhole losses, which could make the level of drilling fluid drop to a point at which it does not exert sufficient hydrostatic pressure to counter the formation pressure. In a casing-drilling operation, a plastering effect is expected that smears the drilled cuttings against the wellbore wall providing a better mudcake, allowing fewer washouts, and improving hole stability, which also contributes to reduce downhole losses.

**Analysis.** In conventional drilling, a smaller hole size provides a smaller annular clearance. In a casing-drilling operation, the common scenario is to drill a 16-in. hole with an 8-in. BHA followed by a 13¾-in. string. In this case, the annular clearance between the casing and the wellbore is smaller than in any of the conventional-drilling scenarios. The annular clearance of the BHA against the wellbore when drilling an 8½-in. pilot hole is 80% smaller than when drilling a 17½-in. hole with a conventional 8-in. BHA. For casing drilling, the standard hole size to set 13¾-in. casing is 16 in. drilled with an 8½-in. BHA, which gives an annular clearance 16% smaller than that of the conventional-drilling scenar-
The results show that a higher ECD can be obtained for casing drilling, as shown in Fig. 3.

**Implementation**

The four new Samarang wells at Platform SMJT-F were drilled with casing on the surface section in batch-drilling mode, setting the 13 3/8-in.-casing shoes, as per plan, in a range from 1,800 to 2,000 ft for the four wells. All the risk-control measures resulting from the risk-analysis exercise were implemented when drilling the section, and, in the first well, logging-while-drilling tools were included in the BHA. There were no indications of a shallow gas zone.

The plan was to use seawater for the four wells because the drilling fluid was for the casing-drilling operation. Therefore, pumping sweeps were performed at every connection to help with hole cleaning. Following the plans, the first of the four wells was drilled with seawater and sweeps. Soon after drilling out of the conductor, fluid losses were experienced. Loss-control material was pumped downhole and drilling continued, expecting the plastering effect to contribute in building a mudcake that would eventually cease the losses. Drilling-fluid losses decreased but did not stop until section TD was reached and casing was cemented.

Also when drilling the first well, taking accurate position surveys required several attempts at every survey station because data transmission from the measurement-while-drilling (MWD) tools was poor. The result was an increase of 10% in the off-bottom drilling time, compared with other wells. The problems with the MWD transmission also affected the resistivity and gamma ray data that were meant to provide early information of any shallow gas accumulation, making it difficult to interpret the real-time data provided by the logging tool.

Thereafter, the engineering team decided to change the drilling fluid from seawater to a low-viscosity mud, expecting to be able to build a better mudcake and to improve fluid-loss control. To improve the MWD transmission, a low telemetry rate was set on the tools to reduce the time required to take a survey. These measures contributed to drilling the next three wells with no drilling-fluid losses and with no delays from a lengthy survey procedure.

**Lessons Learned.** After the problems faced in the first well, the seawater-and-sweeps system was replaced with a low-viscosity water-based-mud drilling fluid to casing drill the three remaining wells, which resulted in better drilling operations. Severe fluid losses were not observed, and the quality of the telemetry signal improved substantially.

A possible explanation for the problems with the use of seawater as drilling fluid is that it does not have the required properties to create a consistent mudcake around the wellbore wall. The use of seawater also induced turbulent flow that, although good for hole cleaning, would increase the hole washouts in shallow formations. An enlarged wellbore and the inability to create an optimum mudcake might have eliminated the plastering effect and the expected improvements in terms of loss control.

Problems with the telemetry-signal quality were attributed to the telemetry-rate setup and the noise created by the drilling fluid. Setting a low telemetry rate in the MWD proved useful for adapting to the particular condition of casing drilling, where the internal diameter in the drillstring experiences great variations, such as 2.8 in. at the BHA and 12.6 in. for the rest of the string.