MMS U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

Safety Alert

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Contact: Glynn T. Breaux
(504) 736-2560

Diverter Flow Event

Recently a semi-submersible rig's completion operation resulted in a diverter flow event when formation gas that was most likely trapped under the Blowout Preventer Upper Annular (BOPUA) rapidly expanded as it entered the riser. The well had been perforated, reverse circulated and the work string packer unseated with the well monitored in a static condition. Within minutes of rigging down surface lines a 10 bbl trip tank gain was observed. Approximately half of the riser's 800 bbl capacity was discharged through both 12-inch diverter lines within 20 minutes of the BOPUA closure. Rig personnel described the diverter flow noise and vibration as increasing to a "deafening roar." A hot tapping operation was performed to relieve 3,000 psi on the pressure-locked TIW Valve. Bullheading and riser booster operations were then utilized to kill the well while preventing riser collapse.

Although the MMS investigation identified several opportunities for formation gas influx/migration in the wellbore, no <u>clear</u> and <u>specific</u> cause could be identified for the gas bubble to have traveled into the riser prior to the first surface observed trip tank gain and closure of the subsea BOP. Possible causes and possible contributing causes that may have prompted the event include:

Possible Causes

(1) <u>Unintentional momentary opening of the packer's bypass valve and/or sealing elements subsequent to perforating</u>: The reverse shock wave created by 86 feet of 7 inch hollow carrier perforating guns could have been great enough to allow communication to the annulus above the packer from momentary opening of the packer's bypass valve and/or relaxation of the packer's sealing elements.

(2) <u>Intentional elimination of the second reverse circulation step subsequent to unseating the packer</u>: The completion's procedure proposed a second reverse circulation step subsequent to unseating the packer in order to remove any influx that was trapped under the packer following the perforating operation. When the well went on vacuum after perforating, in addition to determining that the well was static subsequent to opening the packer's bypass valve and unseating the packer, the operator eliminated the second reverse circulation operation. Elimination of this step could have complicated the well kill operation through possible additional gas influx/migration.

Possible Contributing Causes

(1) Lack of a high-viscosity pill contingency prior to perforating: The open-hole zone being perforated was drilled with approximately 230 bbl loss of synthetic base mud. Lost circulation material sweeps were necessary during open-hole drilling of the zone in order to control mud loss. Completion fluid loss was experienced subsequent to perforating when the well went on vacuum, thus allowing for the possibility of formation gas/completion fluid swap-out as a result of the decrease in hydrostatic head.

(2) Pit monitoring difficulty as a result of the Driller's Screen's Log scale range: The wide Pit-Volume-Totalizer (PVT) scale range utilized on the Driller's screen (-10 to +600 barrels) was of a magnitude that made it difficult to detect subtle surface fluid system gains/losses.

(3) Lack of a consistently "closed" surface fluid system and undocumented trip tank piping arrangement: Surface system fluid monitoring became confusing as a result of the lack of a consistently "closed" surface fluid system resulting from fluid being continuously moved throughout the system (to a filter tank, cementing tank, filling/draining surface lines, general semi-submersible motion, etc.). Also, there was no documentation on how the surface fluid system piping was arranged during the different phases of the operation to assist the crew in being aware of flow direction.

Based on the investigation findings, MMS recommends that Operators and/or Lessees:

- Spot a high-viscosity completion brine pill utilizing bridging agents across the proposed completion zones that experience open-hole drilling fluid losses.
- Monitor work string and annular pressures closely for any anomalies, in order to isolate any possible work string-to-annular communication prior to proceeding with the proposed operation. When testing the work string packer, the work string might remain open in order to detect fluid from any work string leak(s). This arrangement might also allow the test pressure to bleed off, thereby resulting in a more easily identified pressure decline.
- Sweep the subsea BOP on subsea wells when formation fluids are expected or known to have entered the wellbore and/or when the subsea BOP has been activated for any purpose other than testing. Sweeping is usually followed by circulating through the gas buster upon opening the subsea BOP to remove any remaining formation fluid (especially gas) trapped in the subsea BOP "dead space" cavity.
- Consider a second reverse circulation or bullheading after unseating the work string packer subsequent to perforating in order to control any formation fluid influx below the packer.
- Give special attention to the down-hole perforating forces and the possibility of these forces opening a packer's bypass valve and/or relaxing the sealing elements to allow formation fluids into the annulus above the packer.
- Maintain the surface fluid system as "closed" as possible, since fluid being moved throughout the surface system (to other equipment tanks, filling/draining surface lines, general semi-submersible rig movement, etc.) makes subtle trip tank/pit gains/losses more difficult to accurately monitor. Also, document the surface fluid system piping arrangement during the different phases of the operation to assist rig personnel in being cognizant of the flow path in order to more accurately analyze well flow data while possibly providing more efficient well kill procedures.
- Ensure that the scale range used on the Driller's P-V-T screen is of a magnitude that can be used to readily observe subtle surface fluid system gains/losses.