

Energy & Natural Resources

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Industry Update

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Robert MacKenzie . 703.312.1891 . rmackenzie@fbr.com

Doug Garber . 703.312.9555 . dgarber@fbr.com

What Caused the Deepwater Horizon Blowout?

Summary and Recommendation

We have continued to try to piece together the puzzle as to what happened on the Deepwater Horizon leading up to the tragic blowout on April 20, 2010, but substantial uncertainty still remains and lots of questions remain unanswered. What we do know, however, is that the reservoir was not successfully isolated with cement, that either the casing or the wellhead must have failed, and that the blowout preventer (BOP) was unable to seal the well. All of these three “events” were seemingly necessary for the blowout to occur. Had any one of them not occurred, then the well would almost certainly have been contained. Had cement isolated the production zone, there would be no flow. Without either collapsed casing or a wellhead sealing failure, there would be no flow channel for the blowout. Had the BOP sealed the well then the spill would not be ongoing. Whether or not certain procedures used during the construction of the well contributed to the aforementioned “events” remains uncertain.

Our current theory is that incomplete isolation by the cement allowed a buildup of annular pressure, which contributed to a casing collapse during a negative pressure test, after which the BOP was unable to seal the well due to an obstruction too thick for the BOP to crush/shear, such as a tool joint of drill pipe. Below, we analyze this theory as well as some of the unanswered questions.

Key Points

Why didn't the cement isolate the reservoir? Apart from the engineering judgment on what type of cement to use, there are several reasons why the cement might not have isolated the reservoir, including incomplete mud removal, lost circulation, and/or the procedures that were used. Which factor(s) existed or contributed are unknown.

What about the cement design? Halliburton stated that the design used “was consistent with that utilized in other similar applications.” Foamed cement is certainly not a risky technique as some outside of the industry may believe, but our channel checks indicate that a flexible cement system, such as Halliburton's ElastiCem system, might have been a suitable alternative choice for this application. We do not know for certain whether the operator or Halliburton specified the final choice of cement system, but we believe the decision of which cement system to use ultimately rests with the operator, who is also typically involved in its selection.

Was a cement bond log run? If a cement bond log had been performed, there would be a measurement of the top of cement and evidence whether or not a mud channel was left behind the pipe. Our channel checks indicate that a logging crew was aboard the rig but were sent home roughly 10.5 hours prior to the blowout. There would likely not have been enough time to both run a bond log and set a cement plug near TD during the 20-hour period between the primary job and the blowout.

What is the flow channel? The absence of a cement bond to the casing can reduce its collapse resistance by up to 60%. If the casing had been exposed to a buildup of annular pressure during the performance of a negative pressure test it could potentially cause collapse if the differential pressure exceeded the casing's tolerance limits. The other possible path through which the blowout could be flowing, but not our favorite theory, would be if the subsea wellhead failed to seal the annulus.

Why hasn't the BOP sealed the well? We believe that the most likely scenario is that there is some obstruction that is too thick for the BOP's rams to seal the well. Since our preferred theory is that casing collapse is the most likely flow channel for the blowout, then we believe there must be a drill-pipe tool joint, drill collars, or other oversized obstruction preventing closure of the BOP. None of our channel checks indicated any knowledge or concern that the BOP's failed to function as designed.

What are the stock implications? We believe that our analysis shows that a confluence of events outside the control of either Halliburton or Transocean may have contributed to the blowout. Given this analyst's former experience as a cementing engineer and the evidence available today, we can find no fault so far with anything Halliburton may have done and are thus more confident that the stock should gradually recover as investors gain a similar confidence. We believe less clarity is available surrounding the operation of the rig and thus believe that Transocean may be faced with a larger overhang of investor worry.

Additional Technical Details and Analysis

What are some reasons why production zone isolation might not have been achieved?

If the casing had not been adequately centralized then mud removal would have been nearly impossible. Incomplete mud removal with the spacer and cement could have left a channel behind the pipe. If circulation had been lost during cementing, that could have led to the top of cement not being above the top of the reservoir. If the wellbore size was bigger than expected from washouts during drilling, then the top of cement would also be lower than planned. Hypothetically, if the operator were to have directed subsequent wellbore operations to begin before the cement was adequately hard, it could potentially have damaged the integrity of the cement. We do not know which, if any, combination of the above theories may have contributed to the lack of isolation but these questions could potentially be answered were the results of a cement bond log available.

What is Halliburton's ElastiCem system and what are the benefits?

According to a brochure on Halliburton's Web site, "Example installations where ElastiCem systems could provide benefit are high-rate producers, storage wells, deep water, injection wells or high-pressure/high-temperature (HPHT) wells." This brochure also states the following benefits of using this type of cement: "Enhanced cement sheath mechanical properties such as customized elasticity, which reduces the risk of damage during the life of the well; improved mud displacement; Enhanced annulus coverage with cement slurry; a superior competent slurry system that can result in an excellent cement evaluation log."

What's the relevance of a cement bond log?

If a cement bond log was performed, then the operator would have faced a decision as to whether the results of the cement job illustrated by the log were adequate or whether a remedial cement job (squeeze) would be necessary. Based on this analyst's experience as a cementing engineer, a squeeze was probably not performed prior to the blowout as the time between the primary cement job and the blowout was likely insufficient to trip out of the hole with the casing landing string, trip in to the production zone depth with a perforating gun, perforate the casing, trip out the wireline, trip in with drill pipe, and perform a remedial cement squeeze. Furthermore, logging crews are not typically sent home if a remedial cement squeeze is planned as a bond log is often re-run after a squeeze to determine whether additional remedial cementing is required. This would seem to indicate that either a cement bond log was run and the results were deemed acceptable, or that a choice was made to not run a cement bond log. The choice to run (or not run) a bond log rests with the operator, in our view, as does determining whether the log indicates a satisfactory cement job.

What is the most likely flow channel?

Since incomplete isolation from cement is a precondition for the blowout, it's also reasonable to think that it could also contribute to potential casing collapse. The absence of a cement bond to the casing can reduce its collapse resistance by up to 60% according to AADE technical paper 05-NTCE-14. We do not know if the rig had displaced the casing to the expected completion fluid, which should control the well, or seawater, which could potentially make collapse more likely. The choice of a tapered casing string could also result in a lower collapse pressure than one uniform-size casing string. The other possible path through which the blowout could be flowing, but not our favorite theory, would be if the subsea wellhead failed to seal the annulus. While we do not know precisely which wellhead was utilized, modern subsea wellheads seal through a metal-to-metal seal that in this application should undoubtedly be rated to at least 15,000 psi, equivalent to the 15,000 psi rating on the BOP. Had the wellhead failed catastrophically though a buildup of pressure below it, it may have caused debris to be blown up into the BOP that could prevent it from sealing the well.

Analysis of Halliburton's Press Release

Since Halliburton's press release on Friday April 30 is the most recent official information as to one possible factor involved, we will attempt to analyze it and see whether it supports or refutes our theories.

The second bullet in Halliburton's press release is the first with data on the incident. That bullet reads "Halliburton had completed the cementing of the final production casing string in accordance with the well design approximately 20 hours prior to the incident. The cement slurry design was consistent with that utilized in other similar applications." Twenty hours is within the range of typical times that it might take the cement to harden to where its compressive strength is competent, but we are not privy to the lab simulations that are typically used to determine the appropriate time to wait.

The third bullet reads "In accordance with accepted industry practice approved by our customers, tests demonstrating the integrity of the production casing string were completed." This statement likely means that after bumping the top plug against the float collar at the end of the cement job, Halliburton increased the pressure in the casing to perform a positive pressure test. A positive pressure test, seemingly referenced earlier by Halliburton, is when the pressure inside the pipe is increased to make sure the plugs at the bottom of the casing, and the casing itself, can seal pressure from escaping. Pressuring up the casing following a cement job is standard industry practice following a cement job and is not inconsistent with our current theory. Following removing the pressure from this type of pressure test, fluid returns are monitored to test whether the float valves (one way check valves) in the casing do not allow cement to flow back into the casing. Based on Halliburton's statement, this seems to have been achieved successfully.

The fourth bullet reads “At the time of the incident, well operations had not yet reached the point requiring the placement of the final cement plug, which would enable the planned temporary abandonment of the well, consistent with normal oilfield practice.” We understand that the standard procedure for temporarily abandoning a discovery well would be to first set a cement plug inside the production casing across the hydrocarbon bearing zone as extra insurance when a long string is used, or to set a cement plug across the top of the production liner if a liner is used. Parsing Halliburton’s language in the context of this understanding, it would seem as if Halliburton may have set the first plug, but had not yet set the second one.

We can find nothing in Halliburton's press release that conflicts with our theory as to the likely causes of the blowout.

Estimated Timeline

March 27, 2010 (Source: MMS filings)

- The rig’s blowout preventer was tested.

Between March 28 and April 3 (Source: MMS filings)

- The second last casing string, a 9/7/8 liner, was set and cemented.
- The shoe of this casing was drilled out and tested to 16 lb/gal equivalent mud weight
- The rig drilled ahead.

Saturday, April 10 (Source: MMS filings)

- The rig’s blowout preventer was tested.

Between April 3 and April 19 (Source: MMS filings, Halliburton press release)

- The well was drilled to TD.
- The production casing was run into the well.
- The cement job was started.

Tuesday, April 20 at approximately 2 a.m. (Source: Halliburton press release April 30, 2010, our interpretation)

- Finished cementing the casing string 20 hours before the blowout.
- Bumped the plug and positive pressure tested the casing.
- Bled off pressure and tested the integrity of the check valves at the bottom of the casing.

Tuesday, April 20 at approximately 10 p.m. (Source: Transocean press release April 21, 2010)

- The blowout started.

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