

# Appendix U. Riser Fluid Evacuation to Rig Floor

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## 1 Introduction

This appendix attempts to establish the sequence of events on the *Deepwater Horizon* on April 20, 2010, and the action taken by the rig crew as hydrocarbons reached surface (the rig floor).

The analysis in this appendix is based upon:

- Witness account interview notes (identifiable by italics).
- Marine Board of Investigation (MBI) testimony (identifiable by quotation marks).
- The *Transocean Well Control Handbook (TWCH)*\* (excerpts in *Table 1*).

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\* *Manual Number HQS-HB-01, Issue Number 03, Revision Number 01, Revision Date March 31, 2009.*

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## 2 Witness Interview Statements and MBI Testimony

Interview notes from an interview with one of the well site leaders indicated:

*[I] went through the short hall and upstairs there was mud and seawater blowing everywhere, there was a mud film on the deck.*

Interview notes from an interview with the Weatherford rig systems specialist indicated:

- *Around 21:00 to 21:30 (the toolpusher) was called to go to rig floor.*
- *About 10 minutes later, they called the assistant driller to the pit room or shaker house. That was around 21:30 to 21:45. The AD was working at the bucking unit. [The assistant driller] was called to the shakers or mud pits about 5 minutes before the mud started coming out of the well.*
- *Minutes after that [I] noticed mud shoot up the side of the drill pipe. Went midway up the derrick, came down a little bit, then went past the derrick.*
- *There was mud everywhere.*
- *Ran port forward to the lifeboats. By the time [I] got to the BOP storage area there was mud 1 to 2 inches on the floor.*
- *[I] ran/jogged around the bridge under the helideck. The mud stopped around the helideck. [I] could hear mud coming out: 'shshshshshsh'.*
- *[I] saw mud coming up the derrick, and also out of the pipe about 100 ft. up a 6 in. diameter line, the vent line for the poor boy degasser. This was about 2 minutes before the first explosion.*

Interview notes from an interview with the Dril-Quip service technician indicated:

- *At about 21:30 to 21:45 [the assistant driller] was asked to go to the mud pits.*
- *About 30 seconds after [the assistant driller] left the area, [I] saw mud spilling off the rig floor like a waterfall.*
- *[I] heard a whistling sound, which I thought was coming from the mud flowing on the rig floor.*
- *The Dril-Quip service technician and the Weatherford rig systems specialist headed for the shelter of the helideck on the other side of the derrick.*
- *Almost simultaneously, the lights went out and there was a 'boom;' [I] thought the lights went out first.*
- *It was about 1 minute after . . . [I] saw the mud coming off the rig floor . . . heard the first explosion. There was no sign of fire at this stage.*

The Dril-Quip service technician stated during the May 29, 2010, MBI hearing:

- " [The assistant driller] came to me and told me he had to go to the pits."
- "Approximately 30 seconds to a minute later, someone said, 'The well is blowing out.'"
- "Observed drilling mud—the only way I can describe it—it just looked like a waterfall coming off the rig floor onto the main deck."
- ". . . proceeded to walk along the main deck, going toward the forward lifeboat . . . approximately halfway there, and my first thought was—at this time we are getting rained on by this drilling mud that is blowing out of the well . . . "
- "I seem to recall initially, when the gentleman said that the well was blowing out, I can't say I was getting rained on at that time. It seemed like whenever we left from that area and walked along the port side, we got about halfway, that's when I first realized that the mud was hitting us, you know, just kind of raining down on us."

A Transocean roustabout stated during the May 29, 2010, MBI hearing:

- ". . . I started down on the deck seeing that mud had come up, started coming out of somewhere in the rig floor."
- "We noticed more and more mud coming out. It seemed that it stopped for a while—very briefly, not for long—and then came out what to me seemed with much force, because now it was a much louder noise coming out, a lot more mud coming out, even mud flowing out from the rig floor and from the degasser."

The Transocean crane operator who was situated in the gantry crane on the port aft deck stated during the May 29, 2010, MBI hearing:

- ". . . and I seen my guys down on the deck looking up to the rig floor . . . and that's when I seen mud shooting all the way up to the derrick."
- "After I saw the mud shooting up, just several seconds, and then it just quit and went down."
- ". . . and then all of a sudden mud started to come out of the degasser . . . it's on the starboard aft of the derrick, and it's in a gooseneck, and it points back down on deck."

- “And it came out of it so strong and so loud, that it just filled up the whole back deck with gassy smoke, and it was loud enough that it was like taking an air hose and sticking it up to your ear.”
- “And then something exploded. I’m not sure what exploded, but just looking at it, where the degasser is sitting, there’s a big tank and it goes into a pipe. I’m thinking that tank exploded.”
- “And that started the first fire.”

During the MBI hearing on May 27, 2010, the chief mate stated with regard to events just before the first explosion:

Question (attorney):

“You mentioned as you stuck your head out the bridge wing there, you could see fluid raining down. Could you tell where it was coming from?”

Answer (chief mate):

“It was going through the center of the rig floor. It looked like it was coming down from the crown basically.”

During the MBI hearing on May 28, 2010, the senior toolpusher stated the following with regard to a telephone call he received from the assistant driller on April 20, 2010:

“[The assistant driller] opened up by saying, ‘We have a situation.’ He said ‘The well is blowing out.’ He said, ‘We have mud going to the crown.’”

Based on these witness accounts and testimonies, the investigation team concluded that drilling mud was ejected through the rig floor at such a high velocity that it reached at least halfway (approximately 120 ft.) up the inside of the derrick. A short respite in flow followed, but seconds later, fluids started coming out of either the mud gas separator (MGS) vent line at the top of the derrick; the MGS vacuum breaker line, which terminated approximately 100 ft. up the derrick; or out of both lines. This indicated that the diverter was closed, routing flow to the MGS. The mud then cascaded down to the rig floor, and the accompanying flammable gas cloud, which was heavier than air, spread across the rig deck.

The crane operator testified that the first explosion occurred in close proximity to the MGS. This may have added to the hydrocarbon plume at the rig floor and deck area. Based on gas dispersion modeling, the investigation team believes that the gas cloud that enveloped the rig deck area likely resulted in the second explosion.

## 3 TWCH – Handling Gas in the Riser

Table 1 contains excerpts from Section 8, Subsection 4 of the TWCH.

**Table 1.** TWCH Specific Environments

Deepwater		
Part	Title	TWCH Excerpt
9.2	Equipment for Handling Gas in the Riser	<ul style="list-style-type: none"> <li>▪ The diverter system above the telescopic joint with two (2) overboard lines and a system to remove gas from large volumes of mud and return it to the mud system (such as a mud box and the overboard line) is preferred.</li> <li>▪ The diverter and overboard lines should be designed to handle high flow rates and be as straight as possible.</li> <li>▪ This system is not designed to choke or control high gas or liquid flow; rather, it is a system to keep combustible gases safely away from sources of ignition and to remove gas from the mud.</li> <li>▪ At any time, if there is a rapid expansion of gas in the riser, the diverter must be closed (if not already) and the flow diverted overboard.</li> </ul>
9.3	Procedure for Handling Gas in the Riser	<p>These procedures are to be conducted along with the shut-in procedures for Subsea BOPs as described in Section 5.</p> <ul style="list-style-type: none"> <li>▪ Limit the volume of gas that may be taken above the BOP stack (early detection).</li> <li>▪ If an influx is suspected, shut off the mud pumps. This will help avoid circulating the gas above the BOP stack.</li> <li>▪ Shut in the well as quickly as possible.</li> <li>▪ Conduct a riser flow check. If the riser is flowing, divert the flow overboard. If so equipped, the flow can be diverted through a gas handling system or MGS.</li> <li>▪ If the riser is not flowing or has stopped flowing, continue to monitor it for flow. Do not leave it unattended.</li> <li>▪ If so equipped and if the MGS is not being used for the primary well control operations, the riser fluid may be circulated through the MGS at slow rates to remove gas from the fluid.</li> <li>▪ Circulate the riser at slow rates. Stop circulation and conduct a riser flow check after every 100 bbls pumped or equivalent volume to +/- 250ft of riser.</li> <li>▪ If gas is seen at surface, stop pumping and watch for flow. Allow the flow to deplete before continuing.</li> <li>▪ If the flow rate increases, be prepared to open the diverter line and send the mud overboard.</li> </ul>

Part 9.2 of the TWCH requires the rig crew to close the diverter and direct the mud flow overboard if rapid gas expansion occurs in the riser.

Part 9.3 of the TWCH states that flow can be diverted through an MGS at slow rates to separate gas from the mud.

The investigation team concluded that during this well control event, the flow rate was of such magnitude that diverting the fluid to the MGS was not the appropriate course of action.

## 4 Conclusions

- The diverter was not closed until significant flow through the rotary table and rig floor occurred.
- It appears that when the diverter was closed, flow was routed through the MGS.
- The MGS was soon overloaded, and mud and gas were ejected from the MGS vent lines onto the rig.
- The *TWCH* stated that in an event of this type, flow should be routed overboard when the diverter is closed.
- The investigation team concluded that if the rig crew had diverted to the overboard discharge lines rather than the MGS, the consequences of the event would likely have been reduced.