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**From:** Fred Ng  
**Sent:** Saturday, May 22, 2010 9:19 PM  
**To:** David Barnett; David W Moody; Kerry L. Girlinghouse; Christopher J. Murphy; Mike Cargol; Dicky J. Robichaux; Michael W. Allen; Shawn Mossman; Joe Dean Thompson; Michael Drieu; Erika V Eriksson; C Scott Jortner  
**Subject:** BP DW Horizon - Top Kill Leakage Calibration (2010-116)  
**Attachments:** Leakage calibration 052210 A.doc; Thomas Boyd.vcf

FYI

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**From:** Boyd, Thomas A [<mailto:Thomas.Boyd@bp.com>]  
**Sent:** Saturday, May 22, 2010 7:29 PM  
**To:** Thomas Selbekk; Bednarz, Michael J; Sharadin, John H; Fowler, Mike R; Fred Ng; Wulf, Gary T; Turnbull, Jon B  
**Subject:** Leakage Calibration

Attached is the first draft of the Leakage Calibration Procedure developed by Fred Ng. We can discuss in tomorrow's meeting

<<Leakage calibration 052210 A.doc>>



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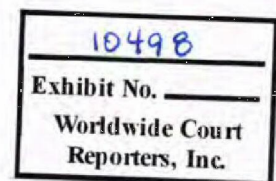


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<<Thomas Boyd.vcf>>



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## **Leakage Calibration – Deep Water Horizon Top Kill**

**May 22, 2010**

### **Objective**

Conduct diagnostic pumping before starting of kill and before starting to pump cement to estimate leakage rate through BOP and rig riser. Data can also be compared with OLGA modeling results to estimate equivalent flow area of leak.

### **Assumption**

- Injection point for fluid pumped through the Q4000 riser into the BOP is upstream of all restrictions (partially closed rams, debris etc.)
- These restrictions remain unchanged (no significant erosion) from start to end of kill pumping, and from start to end of pumping cement.
- Pressure at well head is measured by HPHT gauge in the BOP, and it will continue to be available during entire kill / cement operations.
- Current WHP is 3600 psi with full stream of hydrocarbon flowing through BOP and rig riser.
- Estimated well head shut in pressure (WHSIP) with full hydrocarbon column would be 7000 psi.
- Significant fluid injection into the well bore does not occur until well head pump in pressure WHPIP exceeds the full column WHSIP of 7000 psi.
- Practically all the fluid pumped into the BOP will be leaked out Horizon riser as long as WHPIP is below 7000 psi.
- Diagnostic pumping before kill will involve a mixed flow stream of pumped fluid and hydrocarbons. This is assumed not to have a significant effect on flow calibration for the single phase pumped fluid.

### **Procedure and application**

- Conduct diagnostic pumping before the kill operation with 14.2 ppg mud.
- Pump down Q4000 riser at increasing rates from 5 to 50 bpm at 5 bpm increments.
- Hold pump rate constant at each increment until WHPIP levels off, record data and increase rate to the next increment.
- Continue to increase rate until WHPIP is above 8000 psi or rate reaches 50 bpm, whichever first occurs.
- Record data in table below and plot as shown in Figure 1.
- Pressure for data points on the 16.4 ppg line is obtained by increasing the 14.2 ppg values by the ratio of the two mud weights, i.e. 1.15, or 15% higher.
- When pumping kill mud, use WHPIP to read off leakage rate from Figure 1, subtracting this leakage from total pump rate will show net fluid rate entering the wellbore.

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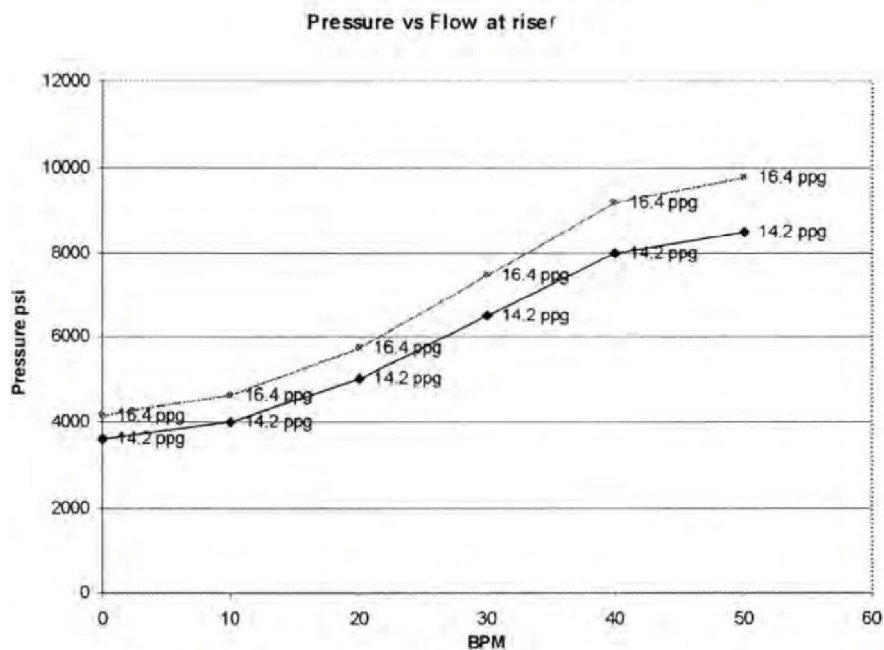
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- When wellbore is determined to be full with 16.4 ppg mud, repeat diagnostic pumping in order to re-calibrate and account for any changes in the restrictions resulting from the kill.
- Apply results from second calibration to cementing operation.

### The Second Calibration

- The second calibration should be conducted 5 and 10 bpm, since maximum rate for the cementing unit is 10 bpm.
- This second calibration may not provide much useful data, especially at the slow pump rates. The hole will not hold a full column of 16.4 ppg mud, and most if not all the mud will be going into the wellbore. In practice, this would not be an unreasonable assumption. It can also be confirmed if no fluid is seen to exit from the rig riser when pumping the 16.4 ppg mud at this slow rate.
- The only way to calibrate this condition is to have a system that can make quantitative measurement of the fluid exiting the riser. An example of such a system would be a gamma ray flow meter which uses induced gamma radiation. Passive tracers such as Mica can be used to enhance the readings.



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