From: Knox, Tom
Sent: Sat Jul 17 12:23:40 2010
To: Tooms, Paul J; Brookes, David; Grounds, Cheryl A.
Cc: Webster, Simon; Cook, Howard H; Allen, Timothy J
Subject: Riser Inspection 3 analysis.doc
Importance: Normal
Attachments: Riser Inspection 3 analysis.doc

Folks,

just following up on yesterday's discussion. I have gone through the data from the third inspection and I believe we can draw some fairly strong conclusion as I have laid out in this note. I have tried to stick to verifiable facts though in the end some interpretation on my part does creep in. The outcome of my review is that I believe we can show that the damage to the right hand string did not occur at it's current location and that the only possibility is that this came from below the left hand string. I have tried not to take the interpretation too far and conscious that Tim has been looking at what happened in the BOP at the time of the incident. I am still trying to find footage of the BOP stack at the point when the flange was removed or photos or footage of the "pluminator" in the hope that we might identify the string which is connected to the BOP.

Tom

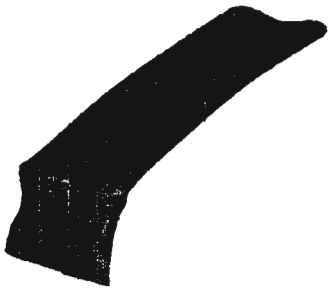
Riser Inspection 3. Analysis of Drill String Location

Initial analysis of the data gathered from the third inspection of the recovered riser in conjunction with the Welaptega 3D model generated from the photographs taken on the first inspection provide some insight to the processes that have resulted in two drill strings being present side by side in the collapsed riser.

Initial Analysis:

Cut Drill String at DS end to Measure Diameter

The riser section has collapsed to form a so-called dog-bone shape around the drill strings. The image on the right is a rendition of that model showing the riser from the end which had been attached to the BOP and looking downstream. This image does not represent the full length of the riser but extends beyond the clearly discernable bump in the right hand lobe of the riser. This bump was noted on the first inspection and subsequently x-rayed. It was found that the right hand string had a tool joint at this location.



During the 3rd inspection, a "window" was cut in the underside of the riser between the 7' and 12' marker points on the riser (zero being the BOP cut end of the riser). Careful inspection of the removed section of the riser wall clearly showed indentations caused by the outer circumference of the drill string tool joint. When measured from the upstream extremity of this indentation it is found that this feature is 27" from one end to the other. A full analysis of the Welaptgea modelling work shows that across the majority of the length (approximately 32') the wall of the riser has collapsed onto the drill string and has distorted the drill string by as much as 1" in places and creating an oval cross section. In the area of the tool joint where wall thickness is greater the tool joint diameter has not been compressed. The table below shows the cross sectional heights through the region in the riser where the tool joint is found. The nominal diameter of a 5.5" drill string is 7" which corresponds almost exactly with the model results. The refernce point at 0" is taken from the start of the tool joint from the upstream or BOP side.

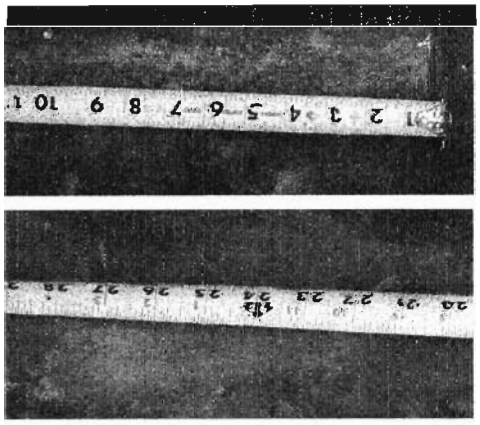
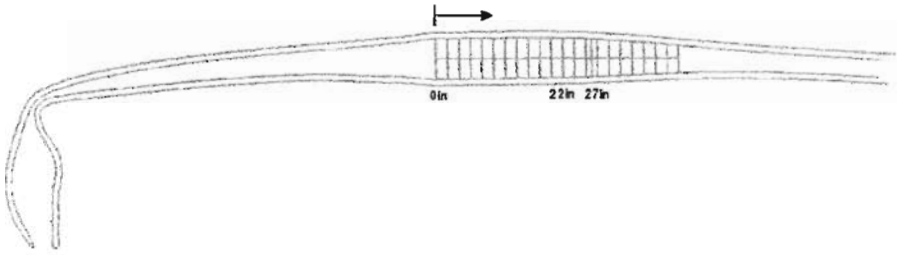
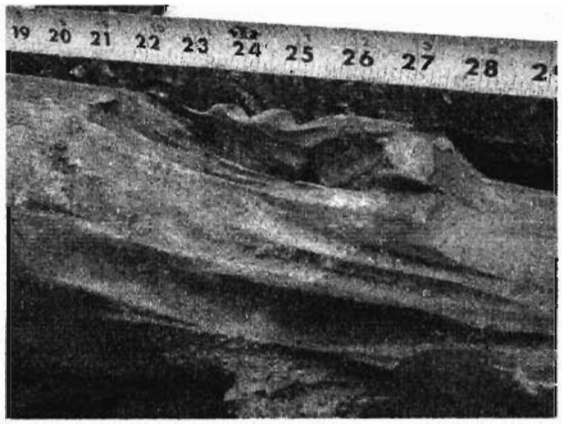


Table 1: Cross-section Heights through Right Tooling Joint

Cross-section (distance from upstream end of right tooling joint, inches)	Height of Cross-section (inches)
0	7.09
2	7.07
4	7.06
6	7.03
8	7.02
10	6.99
12	6.97
14	6.94
16	6.92
18	6.9
20	6.88
22	6.86
24	6.74
26	6.62
27	6.57
28	6.45
30	6.22
32	5.99
34	5.75
36	5.51
38	5.28
40	5.04
42	4.8

The above table can be visualised by a longitudinal or axial cross section of the riser. The diagram below shows the cross section with a representation of the tool joint within it. The tool joint as shown below starts at the zero point and is fairly constant in thickness through approximately 22", beyond this it narrows to the 27" mark and then narrows further.





The photograph on the right is taken of the Pin or downstream end of the tool joint. The reference point at 0" is the upstream edge of the tool joint. It can be seen that at approximately 22" the tool joint shows considerable damage but the end of the tool joint is shown at 27". This is confirmed by the chamfer on the edge of the tool joint where serial numbers were found and also the circumferential grooves found at 23". 24" and 25"; these are standard API markings indicating tool joint type and material strength rating. The fact that the riser conforms so tightly to the tool joint is very important. It is already known that both drill string sections were in their current positions immediately prior to the collapse of the riser. The riser when it collapsed can in fact be considered to have taken a "picture" of the position of the drill strings. Further, the fact that the profile of this tool joint is near perfectly matched by the riser and that there is absolutely no indication of erosion or mechanical damage to the internal wall of the riser at this point, the damage to this tool joint did not occur here and was done prior to the collapse of the riser. It should be noted that the damage observed occurred between the time of the incident and the point of collapse of the riser which suggests significant flow induced erosion, mechanical damage or both.

Initial Interpretation:

The above discussion is directly verifiable by physical measurement and is therefore taken (by the author) as fact. What follows should be regarded as interpretation of the above facts and is not directly verifiable at this stage no matter how plausible.

Having determined that the tool joint on the right hand string was damaged before the collapse of the riser and that only one continuous drill string was present in the riser prior to the incident; it follows that the drill string fractured in at least one location and that two or more parts were displaced with respect to each other.

Prior to collapse the 5.5" drill string (7" diameter tool joint) was inside a 19" annular riser. There are no locations above the BOP and below the drill table of the Deepwater Horizon that have a significant flow restriction to cause erosion or mechanical damage similar to that shown above. If the drill string did not come from above it therefore must have come from below.

Below the current position the most obvious location for either a flow restriction causing erosion or for mechanical damage to have occurred is the BOP itself. There are a number of locations within the BOP where such damage could have occurred: