More thoughts on Prudhoe Bay

Posted by Heading Out on August 8, 2006 - 11:41am
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As the situation up in Prudhoe Bay has become clearer, over the course of the day, and thanks to information that has appeared in comments, it might be worth an attempt at summarizing some of the issues.

To begin with, thanks to Westexas, the cause of the corrosion appears to be known.

And a tip of the hat to Mike A for an UPDATE, I have moved into the post on these bacteria. (8:35 AM)
And (10:35 AM) I also added a note on where Platts suggests the relief supplies might come from. It gives an idea of the global nature of the business. I also add a comment from the Oil and Gas Journal that perhaps I got out too far by assuming that the new corrosion was the same as the old.

[editor's note, by Prof. Goose] EIA says Prudhoe Bay back to normal after January (thanks Darwinian).

The information comes from a Petroleum News article written after the first spill that occurred back in March. To begin with, oil production from a number of adjacent wells is collected at one of six Gathering Centers that serve the field. (As Triffin found the field has a total of around 1,111 active producing wells, 39 gas reinjection wells, 82 water injection wells and 136 water and miscible gas injection wells). The leak in March, for example occurred beside one of these Centers that serviced 230 wells which had been drilled from a 12 drill pads. The gathering center separates the oil, natural gas and water that comes out of the wells, and then passes the oil into a transit pipeline that carries it toward the main Trans Alaska Pipeline (TAP) terminal. The major corrosion that was found in March was in the line from Gathering Center 2, before it joined with the flow from Gathering Center 1 to flow on to the terminal.

Flow from the individual wells in the field has been decreasing, Triffin (ibid) also noted that:

> The average well production rate was about 546 barrels of oil per day in 2001, 375 barrels per day in 2002, 350 barrels per day in 2003, 317 barrels per day in 2004 and 293 barrels per day in 2005.

Since the diameter of the pipeline remains the same, as the flow drops, then so does the speed of the oil through the line.

The petroleum news article explains further.

> All indications are that the corrosion that caused the hole in the transit line was biological in origin, caused by sulfate reducing bacteria inside the pipeline, Johnson said. . . . . The bacteria form in water, so that problems associated with microbiological corrosion tend to be associated with water carrying pipelines, such as the lines that are used for waterflood operations. . . . . . BP has viewed oil carrying transit lines, such as the line from GC-2 that developed a leak, as much less susceptible to corrosion than a water bearing line. But the company has regularly monitored the Prudhoe Bay oil transit lines for internal corrosion using two techniques: ultrasonic testing and the use of corrosion coupons. . . . . . The company ran a smart pig through the GC-2 transit line in 1990 and again in 1998. According BP's incident investigation report for the transit line oil spill, the 1990 pig run "noted nothing of significance" and the 1998 pig run "showed moderate internal and external corrosion". The evidence for corrosion in 1998 was confirmed by ultrasonic testing -- BP subsequently used the ultrasonic testing to monitor any continuing development of corrosion in the line. . . . It was only in an inspection in September and October of 2005, that evidence of increasing corrosion activity started to appear. . . . . . . However, an inspection of the line after the March 2006 leak showed evidence of high rates of corrosion, even in place that had been free of corrosion in the fall 2005 inspection. Clearly, there had been an exponential growth of corrosion, culminating in the hole that caused the oil spill.

It was in surveying the miles of pipe following this initial accident that the problems with the corrosion damage throughout the transit pipe network have become apparent. Corrosion pits have penetrated almost all the way through the wall in over 12 places. The article notes that the accelerated rate of corrosion is of considerable concern, and posits two different possible causes. The first is due to the nature of the oil that comes from GC-2, which has a higher solids content. These might have adsorbed some of the corrosion inhibitors that are injected into the line, diluting the concentration beyond the point that they were effective.

The other possible cause is a little more worrying. It was noted that the corrosion occurred in the section of the pipe from GC-2 before it joined the flow from GC-1 on the way to the terminal. The speed of the oil is slower where the flow is from only one center. This suggests that as the field production declines, and flow slows, the corrosive bacteria are being able to settle and pit into the walls of the pipe. There are two worries here, one for the transit network, as flow declines, but also now perhaps for the main Trans-Alaska line also, since as flow diminishes (as it now is) both now, transiently, and permanently in the future, then the speed at which the oil moves will also drop. And apparently there may be a speed at which, all of a sudden, bacteria, and thence corrosion, blooms.

The need to make sure that the problem is completely addressed, BP cannot afford another spill, is probably behind the decision to replace at least 16 miles of the pipeline. Since they must also satisfy the Alaskan authorities, the process is likely to take longer rather than shorter.

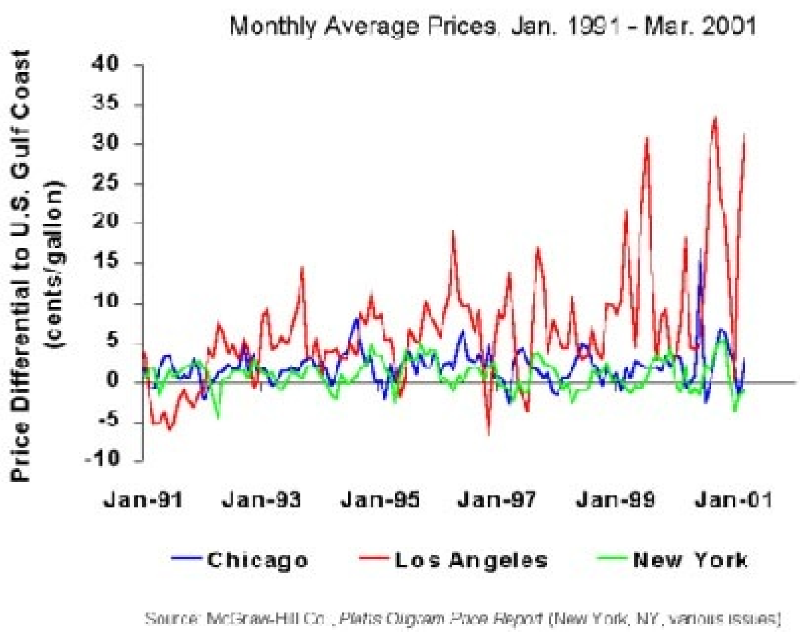
> Oil production at Prudhoe Bay could take six months or, perhaps, as much as a year to return to normal, Societe Generale said, citing an assessment by one of the bank's engineers with an oil-field services background.
> "Three weeks is the absolute minimum," said Deborah White, an energy analyst with Societe Generale in Paris. "Six weeks makes a more likely base case." . . . . . Signaling that the pipeline maintenance effort would be more complex than originally thought, Bob Malone, president of BP America, said BP would replace the field's main transit lines as part of a "wider plan in restoring production and operations in a safe manner." BP will

> also conduct a study, together with supervising government agencies, to determine if it's possible to continue production from some parts of the field, Malone added.

So what do we do in the meanwhile.

Totonella pointed to where the Alaskan oil went, when there was more of it:
Puget Sound: 419,521 barrels/day
San Francisco 123,870 barrels/day
Los Angeles 333,006 barrels/day
Hawaii 42,682 barrels/day
Exports 78,763 barrels/day
Source: Alaska Department of Revenue.

And if one goes to the EIA, they have correlated spot shortages with retail gas prices. It does note, perhaps a little smugly, that the west coast (PADD 5) is almost self-sufficient in gasoline and low-sulfur diesel. However, the downside to that is that gas prices have been the most volatile of the country.



> There are two principal reasons for the greater price volatility in California. First, only 13 refineries in California supply the gasoline and diesel fuel markets in that State. The unexpected loss of supply from one of the larger refineries represents the loss of a significant share of supply. Second, the California Air Resources Board (CARB) product quality requirements for both reformulated gasoline and diesel fuel are more stringent than any other in the United States and all other countries. Because California does not routinely receive product supply from outside the region, refiners in the U.S. Gulf Coast and other countries that may be able to supply CARB quality products do not maintain inventories of these products and any possible response to meeting California supply shortfalls will be delayed. Consequently any unexpected disruption of supply from a California refinery results in short-term price increases.

On the other hand they did not find a consistent response to incidents. So I suppose we will have to watch this one play out.

In the same way it will be interesting to see, given that the oil seems to need to be refined in CA to meet their specifications, where they get it. It can either be piped from the Gulf, or it might come from OPEC. Well if we look at where Intertanko tells us that China is getting their oil, maybe we can see who is shipping that way.

China's Top 10 Crude Suppliers:

('000 b/d)	June-06	Jun-05	Volume	% change
Angola	561	493	68	13.8%
Saudi Arabia	508	541	-33	-6.1%
Russia	495	293	202	68.9%
Iran	396	377	19	5.0%
Equatorial Guinea	239	142	97	68.3%
Oman	153	211	-58	-27.5%
Brazil	70	0	70	NA
UAE	67	61	6	9.8%
Libya	66	0	66	NA
Yemen	63	166	-103	-62.0%
Others	486	678	-192	-28.3%
Total	**3,104**	**2,962**	**142**	**4.8%**

Well Saudi supplies to China have been dropping, and they have those tankers full of oil, with no place to go . . . . . .? (Of course the refineries would have to be able to refine that oil . . . .)

It will be interesting to see.
UPDATE: 8:35 AM EST And, thanks to Mike A there is more information on the bacteria that are causing the problem.

> I'm a corrosion engineer in the industry with some experience with sulphate reducing bacteria (SRB) so I'll give a quick primer on SRB for those that are interested.
>
> SRB are small (5 microns long by 1 micron wide), anaerobic (require absence of oxygen) and ubiquitous, a typical North Sea concentration might be 1 cell per gram. When conditions are right they can multiply to the level of millions of cells per gram and generate significant quantities of hydrogen sulphide (H2S). The H2S together with the stagnant conditions formed by the colony on the pipewall lead to enhanced pitting corrosion rates, which are on the order of 1-2mm/year, depending on conditions.
>
> SRB get their energy from the reduction of sulphate(SO4 2-) to sulphide (S 2-). They thus require another species to be oxidised, usually volatile fatty acids (VFAs) such as acetate (i.e. vinegar!) which are present in most reservoir waters. The requirements for their growth are:
> 1 Nutrients, ie. sulphate & VFAs for their metabolism, together with trace nutrients such as Nitrogen & Phosphorous
> 2 Moderate temperature 5-50 deg C, although some thermophiles can grow at temps up to 70 deg C
> 3 Moderate pH (~5-10), salinity (less than 5-10%) and pressure (less than 500 bar).
> 4 Absence of poisoning species such as oxygen or biocide chemicals
> 5 Low enough flowrate to establish colonies on the pipewall
>
> I'd say in the alaskan pipelines all the physical conditions of temperature, pressure, salinity, lack of oxygen and flowrate were met. Acetate and other VFAs will normally be presented in produced reservoir formation waters.
>
> Often reservoirs will sour (ie. start producing H2S) after seawater injection as the seawater provides a large source of sulphate ions. It normally takes many years for

> injected seawater to make its way back to the producing wells but if this has occured that that could be the source of the sulphate for the SRB.

One thing that this event has the potential to show is that oil is possibly entering a phase where it stops being fungible. We have seen some of that in the difficulty that Saudi Arabia have encountered in selling some of their heavier crude. Now, from the other side, the serious question arises as to where the California refineries can find a crude that they can refine. It is not that easy, as an article in Platts discusses. (Hat tip for the tip). However, it also suggests that BP are not totally unprepared.

> "There's about 3 to 4 million barrels of unsold Persian Gulf crude in September; this will help clear it," said one Asian crude trader. He added that "it's in a small number of hands, so will get done quietly." The source noted BP and Shell recently had been buying additional volumes of Persian Gulf crude, possibly in anticipation of a Prudhoe Bay shutdown, which has been experiencing problems for several months.

I just noticed a couple of sentences in the story in the OGJ that suggest that the corrosion is not the same as that discussed above, and which caused the March pipe failure.

> BP Alaska Pres. Steven Marshall reported a wall thickness loss of more than 70% in the 30 in. pipeline. He said the corrosion appears to be of a different type than the corrosion that was responsible for a Mar. 2 leak in Prudhoe Bay Operating Area pipelines. "Clearly, there is another corrosion mechanism occurring here," Marshall said.