The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Tech Talk - The Coming Problems for the Alaskan Pipeline

Posted by Heading Out on August 28, 2011 - 12:57am
Topic: Supply/Production
Tags: alaska, ice formation, north pole refinery, north slope, northumberland, pipe corrosion, prudhoe, wax buildup [list all tags]

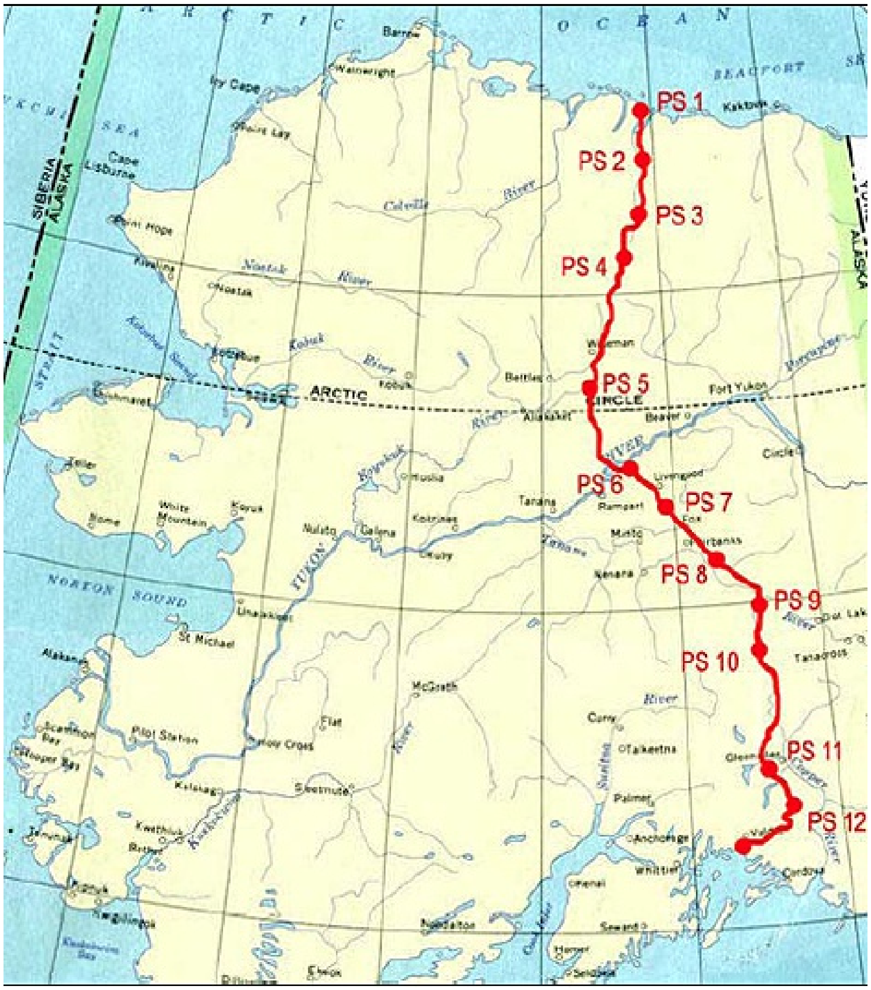
The original Prudhoe is a small village with a medieval castle on the south bank of the Tyne, in the northeast of England. It lies in a coal-mining region within five miles of Prudhoe Colliery, where there were, over time, an additional 157 mines and pits and five working seams of coal in the 1860s. Not in itself out of the ordinary, but by 1828 Prudhoe had given its name to a region in Alaska. The naming recognized Admiral Algernon Percy, the first (and only) Baron Prudhoe (after the castle), who later became the fourth Duke of Northumberland. (His dad, the second Duke, led the British retreat from Lexington after the initial battle).

As with the region of Southern Alaska I mentioned last week, Prudhoe Bay would have faded into the obscurity of the original, were it not that oil seeps had been reported there by the Inupiat Eskimo. After the area had been prospected and surveyed between 1901 and 1919, President Warren G. Harding established the Naval Petroleum Reserve No. 4, a region now called the National Petroleum Reserve-Alaska (NPR-A) in an adjacent area of the North Slope of Alaska, that region that lies north of the Brooks Range. This led on to further exploration, and on March 13, 1968, the Prudhoe Bay discovery well was announced.

The North Slope of Alaska (DOE)

I am going to forgo a discussion of the development of the fields that were then discovered in Prudhoe Bay and its adjacent fields until next time, because the oil reserve in Alaska is only a reserve if it can economically be accessed. Otherwise, it is only a resource and the transition from one to the other, in Alaska, came about with the development of the Alaskan pipeline.

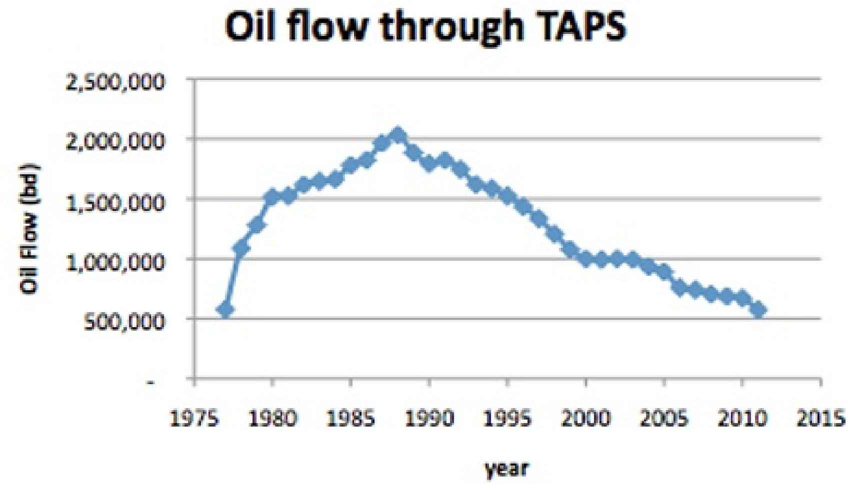
The [Trans-Alaska Pipeline System](#) (TAPS) is the conduit that makes it possible for oil to flow from Prudhoe Bay some [800.302 miles](#) down to the ice-free port at Valdez. From Valdez it can be shipped by tanker (about 25 a month) to customer refineries further south.



The Trans-Alaska Pipeline System ([Alyeska Low Flow Report](#)) (The PS points are the pumping stations).

In July of 2011, TAPS averaged a flow of 459,376 barrels of oil a day, which is down from the average over the past year of some 572,835 bd. And those numbers are becoming something of a concern. While the pipeline produced about 15% of the national domestic production in 2010, the pipeline requires a certain flow level if it is to effectively deliver oil.

The pipeline was built in the years from 1974 to 1977, and between then and now has delivered some 16 billion barrels of oil. At its peak on January 14, 1988, the pipeline flowed at a rate of some 2.145 mbd (the pipe itself contains some 9 mb of oil at any one time), though whenever it flows at higher than 750,000 bd, a drag-reducing agent [has to be added](#) to the oil to reduce turbulence.

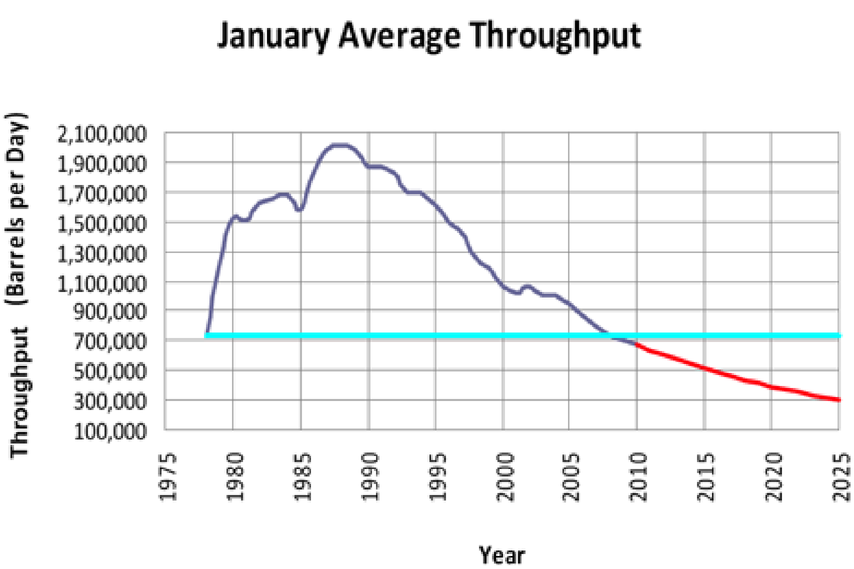


Flow through the Alaskan pipeline by year to date

However, as the flow declines, problems start to arise with the behavior of the oil. The oil comes out of the ground rather hot and enters the pipeline at a temperature of up to 145 deg F. But even though the pipeline is insulated and isolated to ensure that it does not have an effect on the ground that it crosses, some of which is permafrost, it will gradually lose heat as it makes the trip down to Valdez. For example, in 2008, when the flow was still 703 kbd, it took 13 days for the oil to reach Valdez, moving at about 2.6 mph. The oil was entering the pipe at 110 deg F, and was at 55.6 deg F when it reached Valdez. However, the lower the flow rate, then the slower the oil moves, and thus the cooler it becomes.

This first became publically evident as a concern last January when a leak at one of the pumping stations caused the pipeline to shut down. I explained some of the concerns at that time particularly stressing the problems with wax that starts to precipitate out of the oil at a temperature of 75 deg F, and ice that can form as the water starts to precipitate out and then freeze at 31 deg F (the water is slightly salty).

With these concerns on flow rate Alyeska has recently released a report on the consequences of the decreasing flow rates through the pipe, exploring these and other issues in more detail. The greatest temperature effects will occur during the winter months, and in preparing the report they plotted flow rates for January. The following section reviews statements and concerns in that report.



Historic flows with those projected (in red) at an assumed decline rate of 5.4% ([Alyeska Low Flow Report](#))

As I noted above, the average flow this year is below 600 kbd, which signifies a somewhat higher decline rate than that assumed, and that for July was below 500 kbd.

TAPS pipeline reliability	
July	96.10 %
2011 Reliability Rate	95.84 %
There was one proration during July which resulted in 577,466 deferred barrels.	
Barrels pumped from Pump Station 1	
July	14,240,668 BBLS *
Average	459,376 BPD **
Year to date	121,441,067 BBLS *
YTD average	572,835 BPD **

* BBLS (Barrels) = 42 Gallons ** BPD = Barrels Per Day

TAPS performance statistics for July 2011 ([Alyeska](#))

The declining temperature along the pipeline is offset at roughly the half-way mark by the withdrawal of up to 210 kbd of crude to feed the [North Pole Refinery](#) near Fairbanks and the re-injection of the residual fluids from that refinery, which enter the pipeline at 125 deg F. The loss in volume comes from the refined products, including gasoline jet fuel and asphalt, which are used for civilian and military use within the state.

(In what is, perhaps, an example of the Export Land Model, the refinery has grown in size, and thus demand from TAPS. It started at 25 kbd in 1977, shortly after the pipeline began to flow. It grew to 45 kbd in 1980 and was expanded to handle 90 kbd in 1985. It was then expanded to 130 kbd, and then, in 1998, grew to its current capacity of 215 kbd.) However, the report suggests that only 35 kbd is retained at the North Pole refinery and 12 kbd at the Valdez Refinery. The volume removed does slow the speed of the oil in the remaining portions of the pipeline. Thus, at 400 kbd it will take 23.5 days for the oil to reach Valdez, with the speed falling from 2.15 ft/sec to 1.86 ft/sec after the North Pole Refinery.

Temperatures of crude along the pipeline. The uptick at the end is due to the injection of fluids from the Valdez Refinery. ([Alyeska Low Flow Report](#))

When the pipeline was built it was assumed that it would pump a dry oil (without water content) and that flow rates would remain above 500 kbd. Neither of these conditions is likely to hold true in the future. The oil coming from the wells contains a small (0.35%) percentage of water with higher peaks, and flows are falling below 500 kbd at which level the water starts to separate out from the oil.

There are several results from the lower flows of oil. As the above graph shows, even at the highest flows now anticipated (around 600 kbd) the temperatures fall below 75 deg F, and wax begins to precipitate out of the oil. Because this settles against the pipe walls it must be periodically scraped from the walls, and dumped at specially designed traps. At temperatures below 31 deg F, this mixes with ice.

> Based on the nature of ice formation identified in the LoFIS, the HAZID determined that ice crystals will form in the pipeline stream while flowing at temperatures below 31°F. The crystals can then combine with wax and add to the volume of debris pushed in front of a pig or, as seen in the flow loop tests, to be deposited at locations such as valves. Ice deposits could then accumulate at valves and potentially interfere with valve action such

> as the sealing of CVs.

and

> Thermal analysis indicates that the critical throughput at which crude oil temperatures during normal wintertime operation decline through the freezing point of fresh water is about 550,000 BPD during the winter months, provided the heat from the NPR residuum continues to be available.

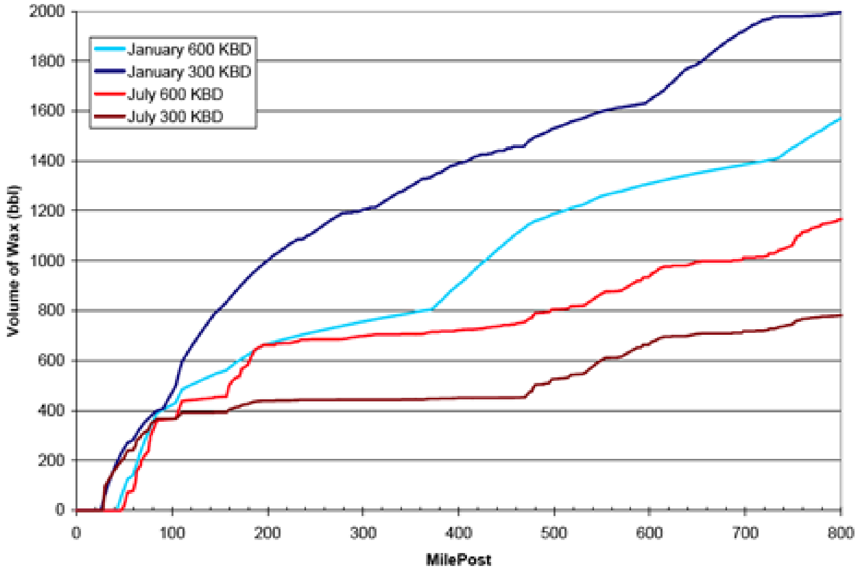
Further, in regard to the use of the pig

> Movement of a pig in the pipeline following an extended shutdown was identified as a particular concern because the pig cannot be stopped and can push considerable volumes of ice, ice slurry, or ice/wax slurry through the pipeline and into instrumentation connections, pumps, strainers, as well as refinery off-takes, mainline relief valve branches, and the backpressure control system in Valdez.

It was noted that pumping stations were not designed to handle the high volumes of ice and wax that might build up in front of an aggressively cleaning pig.

Example pig used in the Alaskan pipeline – see the wipers and note the central compartment within the pig.

The external temperatures through which the flow is moving obviously play a part in the thickness of the wax. The models that were run for the report illustrate the difference in volumes of wax generated, assuming 14 days between pig passes and comparing June with January.



Wax buildup in the pipe as a function of flow rate and season ([Alyeska Low Flow Report](#))

At flow rates above 350 kbd, much of the wax scraped off the wall is assumed to be carried away by the faster moving oil, but at 350 kbd the flow may be insufficient and the wax may then agglomerate and build up in front of the pig.

Wax removed from the pig trap at Pumping Station 4 in March 2010. (([Alyeska Low Flow Report](#))

The third issue of concern is corrosion. There is some evidence that this accelerates in the pipe when the velocity falls below a certain level, and this was discussed on TOD [back in 2006](#). It was not discussed in detail in the report.

The final issue related to the behavior of the ground around the pipe. Where the pipe has historically kept some of this ground thawed, even during winter the fall in flow may now cause it to freeze and form ice lenses that then subsequently thaw and form voids (as was recently discovered with the Big Dig in Boston). While some movement (a foot) was allowed in the design, that will be exceeded if the flow falls below 300 kbd.

A reserve is only a reserve as long as it can be viably extracted, which includes the ability to access and utilize the oil and gas. Should the pipeline stop flowing, and there are credible conditions discussed in the report that may lead to such an event, then the remaining oil in the North Slope will be unavailable, as will that currently held in the NPR-A.

Under current conditions and without additional well development and a significant increase in oil flow, the data would suggest that the critical date will happen sooner than even this report has suggested (which would be when the flow falls below 350 kbd sometime around 2020). The Obama administration is interested in increasing production from the North Slope, but only after significant steps to ensure “responsible drilling” have been put in place. Concerned by a number of factors, Alaskan Governor Parnell wants to boost flow back to 1 mbd by 2022. To this end, and recognizing the problems of low pipeline flow, his new Commissioner of the Department of Natural Resources has put forward steps that could help implement that process, including a road to Umiat.

But that gets into the condition of the oil reservoirs north of the Brooks Range, and I’ll discuss those next time.