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Arctic Potential: Realizing the Promise of U.S. Arctic Oil and Gas Resources
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Paper #7-9

OVERLAND PIPELINE OPTIONS

Prepared for the
Technology & Operations Subgroup

On March 27, 2015, the National Petroleum Council (NPC) in approving its report, *Arctic Potential: Realizing the Promise of U.S. Arctic Oil and Gas Resources*, also approved the making available of certain materials used in the study process, including detailed, specific subject matter papers prepared or used by the study's Technology & Operations Subgroup. These Topic Papers were working documents that were part of the analyses that led to development of the summary results presented in the report's Executive Summary and Chapters.

These Topic Papers represent the views and conclusions of the authors. The National Petroleum Council has not endorsed or approved the statements and conclusions contained in these documents, but approved the publication of these materials as part of the study process.

The NPC believes that these papers will be of interest to the readers of the report and will help them better understand the results. These materials are being made available in the interest of transparency.

The attached paper is one of 46 such working documents used in the study analyses. Appendix D of the final NPC report provides a complete list of the 46 Topic Papers. The full papers can be viewed and downloaded from the report section of the NPC website (www.npc.org).

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Topic Paper

(Prepared for the National Petroleum Council Study on Research to Facilitate Prudent Arctic Development)

7-9	**Overland Pipeline Options**
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SUMMARY

Overland pipeline options are a safe and reliable means of transporting liquid hydrocarbons from production facilities or onshore facilities to the Trans-Alaska Pipeline System. Pipelines are also more financially viable given the current Jones Act compliance limitations on commercial tankers. Efforts are ongoing to improve an already outstanding safety and reliability record while driving down costs.

PURPOSE

Present pipeline design and construction considerations for onshore pipelines in the Arctic.

BACKGROUND/ONGOING RESEARCH

Onshore pipelines have been successfully installed and operated in Arctic environments for many years. Most notably the Trans Alaska Pipeline has been in service since 1977 safely and reliably transporting crude oil from Prudhoe Bay and other Alaska North Slope oil fields over 800 miles to the Valdez deep water marine terminal. Additionally common carrier oil pipelines connect various North Slope Alaska oil fields to TAPS at Pump Station 1. At present these common carrier pipelines connect remote production from as far as the Alpine Oilfield 60 miles west and the recently developed Pt Thomson field 60 miles to the east of Prudhoe Bay. While having a long record of successful construction and operation, Arctic overland pipelines face unique design, construction and operation challenges. The following discussion highlights some of these unique issues in the Arctic.

<u>Design Considerations</u>

The selected or required operating temperature range of the pipeline directly affects required insulation systems, buried versus above ground design strategies, flow assurance considerations and the level of detail geotechnical characterization needed along the route selected.

Pipelines operating at above 32 degrees F are typically designed to be supported on above ground vertical support members to protect thaw unstable permafrost ground. These pipelines can also be buried in thaw stable permafrost material but geotechnical evaluation of the ground conditions is critical. Over marginal permafrost areas, passive cooling thermo-siphons are often used to maintain ground temperatures below freezing around the vertical support system members to avoid thawing ground failure. Mechanical refrigeration schemes may be required at road crossings or special configurations. These pipelines are preferentially buried wherever thaw stable ground conditions exist.

Pipelines operating below 32 degrees F can be directly buried in permafrost zones but have the opposite consideration in marginal permafrost or thaw unstable ground where the pipeline may cause excessive frost heaving. The correct characterization of ground conditions is critical to selecting the most reliable and cost effective design for a given alignment section.

In the Alaska Arctic coastal plain rivers are typically braided with constantly changing flow channels. Pipeline route selection must consider these long term changes and select river crossing methods suited to each location. Current practice has utilized directionally drilled below river crossings, pipe bridges, suspension bridge systems, and simple piling supports. All of the above ground systems have to be designed for the high peak spring break up flow rates, related ice damning loads and scour. Directionally drilled crossings require stable ground conditions and have to deal with permafrost transition zones.

Seismic risks and fault zone crossings require special design considerations. On November 3, 2002 the magnitude 7.9 Denali Fault earthquake centered near Paxson, Alaska caused a lateral shift of 2.5 meters horizontally across the fault line where the Trans Alaska Pipeline crossed the fault zone. The Tran Alaska pipeline was designed to accommodate a shift of this size through the use of slide supports and did not suffer any damage. Clearly defining these fault areas on pipeline routes and selecting the needed design allowance is an important consideration.

Avalanche and unstable side slope areas pose a significant risk to above ground pipelines requiring route selections to avoid these high risk zones.

Wildfire risks to elevated sections of pipelines are typically addressed by long-term maintenance requirements which require brushing along the right of way minimizing fuel and the highest temperatures which could be encountered by wildfires which often burn uncontrolled in these remote areas.

Wind and flow induced vibration fatigue risks need to be modeled and addressed through the appropriate mitigation methods.

While outside the scope of this review the pipeline route selected can have broad long term socio-economic impacts to this vast road-less region. Route selection appropriate for a single project may not be the route selected in order to maximize the potential for overall economic development in the region. These factors can impact project schedules and cost estimates since they often come in later in the project design cycle in the permitting process which introduces considerations beyond the single project.

Construction Considerations

Pipeline construction in the Arctic has to deal with both the environmental conditions of cold and related seasonal limitations but also the remoteness and limited transportation infrastructure. The nearest deepwater port is Dutch Harbor (1000 miles from south of the Chukchi Sea) and for that matter the shallow bathymetry across the entire north coast of Alaska does not offer the opportunity to effectively develop one. Winter ice road supply and ice construction pads must be built each season. Access to gravel resources to develop permanent pads or local roads is very limited or non-existent in many areas. Long haul distances are likely where permanent roads, airstrips or pads are required.

Permanent versus temporary logistics infrastructure decisions, while not a technical challenge, will drive project economics. The role of Local, State and Federal government in providing these resources for common use needs to be addressed.

Operation Considerations

Due to the high costs and risks associated with maintaining personnel in remote locations fully automated unmanned facilities are the desired operating philosophy to the maximum extent practical. Pump or compressor stations are remotely controlled and monitored. Alyeska Pipeline recently upgraded its pump station equipment and control system to more completely allow unmanned operations. Due to this unmanned operation mode, highly reliable and redundant communications and control networks are required.

Leak detection, integrity inspection and monitoring processes all require reliable communications infrastructure. Third party damage, surveillance and security systems also all require highly reliable communications infrastructure. Shutdown and restart requirements are more complex when long sections of pipeline are remote with difficult direct access.

Emergency response capability typically requires pre-positioned materials and equipment to be maintained along the pipeline alignment

DISCUSSION/POTENTIAL AREAS OF FURTHER RESEARCH

The technology supporting Arctic onshore pipelines is well understood and benefits from many years of successful operations both in Alaska and other arctic regions. There are however several areas where advancing both basic research and furthering current practice can support access to more difficult and remote frontier regions for operations.

- Improved passive thermo-siphon design for heat removal
- Improved automated surveillance and security technology
- Improved data gathering using drone technology for pipeline routing activities
- Adaption of technologies for enhanced pipeline integrity monitoring and leak detection

SUMMARY

Arctic pipelines operate in a severe natural environment that is remote with difficult access. The technology surrounding overland pipeline design is well understood and highly reliable pipeline systems are both operating and being built today. Additional research and technology enhancements mainly fall into the categories of increased reliability and reduced construction and operation costs. Improvements in these areas will help make additional arctic resources economically viable.

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