Gas pipeline builder plans precautions for spanning earthquake zones

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The proposed multibillion-dollar natural gas pipeline into Canada would be buried for almost its entire 803-mile length within Alaska with only a few exceptions, including where it bridges earthquake faults.

At potentially active earthquake faults, the line likely will be raised above the ground and supported on crossbeams to let the pipe slide sideways or hop up and down without breaking during a tremor, according to the sponsor of the proposed $32 billion to $41 billion project to carry Alaska North Slope gas toward Lower 48 markets.


The trans-Alaska oil pipeline, where it crosses the Denali Fault, is designed to move 20 feet laterally and 5 feet vertically. Source: Alyeska Pipeline Service Co.

The model for how to blunt the destructive force of a big earthquake: The trans-Alaska oil pipeline. On Nov. 3, 2002, that line famously survived a magnitude 7.9 earthquake along the Denali Fault, which it crosses. During that quake, one of the strongest in North America over the past 100 years, the ground shifted seven feet horizontally and leaped 2.5 feet vertically, **according to Alyeska Pipeline Service Co.**, which runs the oil line.

The proposed gas pipeline would not cross the Denali Fault en route from North Slope gas fields to the Canadian border. The Denali lies south of the pipeline corridor.

But the gas pipeline would cross a seismically active region, and the project sponsor – a partnership of TransCanada and ExxonMobil called the **Alaska Pipeline Project** – described its earthquake plans in several documents filed in January with two federal agencies that would regulate the line.

"To allow the pipeline to move in event of seismic activity, APP is planning to install the pipeline at known active faults with an aboveground configuration similar to the existing TAPS (trans-Alaska oil pipeline) design at the Denali Fault," the partnership said in **Draft Resource Report**

1 filed with the Federal Energy Regulatory Commission. "An aboveground support system will be installed to mitigate potential stresses and strains in the pipe due to fault movement. A sliding support design concept will be used for fault crossings with sufficient sliding capacity to accommodate fault rupture."

TransCanada/ExxonMobil also discussed its plans for spanning earthquake faults in two other draft resource reports – numbers 6 (geological resources) and 8 (land use). These are among 11 draft reports totaling more than 4,500 pages that describe and discuss how the pipeline would affect soils, vegetation, wildlife and other aspects of the environment along its corridor. FERC will use the information in preparing an environmental impact statement for the Alaska pipeline. The partnership will finalize the reports before applying to FERC in October for a certificate to build and operate the pipeline.

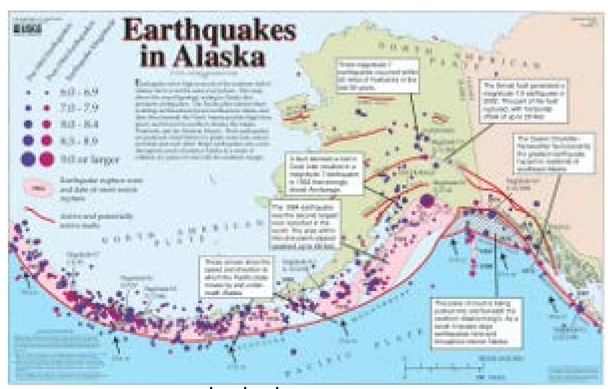
TransCanada/ExxonMobil also discussed crossing earthquake faults in a January application with the Pipeline and Hazardous Material Safety Administration for a permit to use design techniques better suited to the seismic zones the pipeline would cross and to frost heaves and other ground movement that could occur in extreme northern latitudes.

Burial in frozen or partly frozen ground and other conditions in the far north stress and strain pipelines in ways not found in the Lower 48, the partnership said.

EARTHQUAKE COUNTRY

About 11 percent of the world's earthquakes occur in Alaska, according to the state Seismic Hazards Safety Commission.

Most of Alaska's earthquakes are centered along the Pacific coast and Aleutian Chain, where the Pacific plate collides with and scrapes under the North American plate, rather than in the state's Interior or northern region that the gas pipeline would traverse.

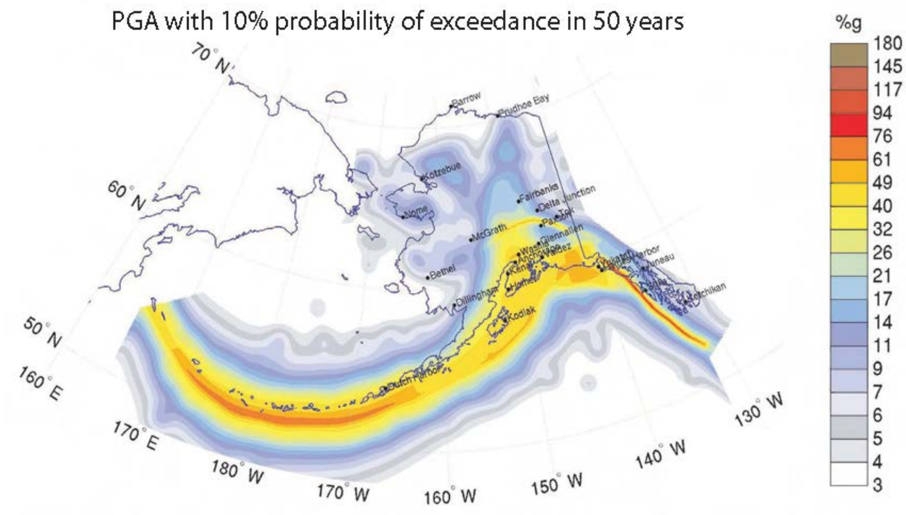


Source: U.S. Geological Survey

But the Interior and north have a history of seismic activity, as the 2002 earthquake along the Denali Fault illustrates. About 10 percent of Alaska's earthquakes occur in the Interior, according to Draft Resource Report 6.

The Alaska Earthquake Information Center "lists more than 1,400 earthquake events with magnitude greater than 4.0 since 1898 in the general geographic area encompassing the project," the report says. Nine of them have been strong enough to frighten people and rattle heavy furniture.

But in most cases the force – called a g-force – that a typical earthquake exerts on bridges, buildings and other structures from Interior earthquakes has been milder than the g-force a human body endures on a twisty rollercoaster, or that you'd feel if somebody shoved you hard. The **U.S. Geological Survey** has mapped the country showing the probability that an earthquake's peak ground motion will be exceeded within 50 years. The maps are used to develop building codes for design of safe buildings and other structures. They show a relatively low probability of severe ground shaking along the gas pipeline route, much lower than the possibility along coastal Alaska.



Source: U.S. Geological Survey

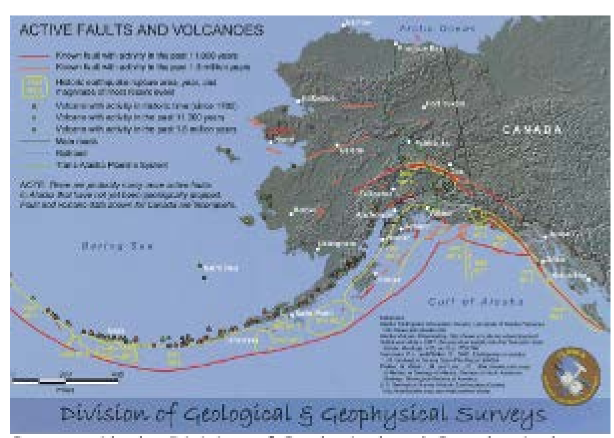
As with bridges and buildings, the gas pipeline would be designed to withstand massive earthquakes. The oil pipeline, for example, is designed to survive earthquakes up to magnitude 8.5. Earthquakes stronger than that are rare – **only 11 of them worldwide** since 1900.

DEALING WITH FAULTS

The TransCanada/ExxonMobil partnership has been investigating the earthquake potential along the gas pipeline corridor for several years. This work involved studying USGS research and **other materials**, as well as conducting on-the-ground reconnaissance and trenching, and aerial surveys that included light detection and ranging (LiDAR) imaging to map the corridor. It also relied on past studies for the oil pipeline, road construction nearby and other activities.

The investigations yielded a surprise in 2011 – discovery of a new active fault.

But for the most part, the companies merely confirmed what already was known about the region's geology concerning earthquakes.



Source: Alaska Division of Geological and Geophysical Surveys

They concluded that although Alaska's Beaufort Sea coast has experienced seismic activity on occasion, it is a region where earthquakes will pose little meaningful problem for the gas pipeline project. The largest recorded earthquake in the northern region was magnitude 5.3 in 1968.

In the more earthquake-prone Interior, the **key seismic sector** is framed by the Denali Fault to the south and the Kaltag/Tintina Fault systems to the north.

Strung between these east-west faults lie **three seismic belts** that generally point north-south:

- The Minto Flats Seismic Zone runs about 100 miles from the Alaska Range northeast of Denali National Park to near Livengood. It has hosted earthquakes up to magnitude 6, but none in the past 10,000 years or so.
- The Fairbanks Seismic Zone runs 75 miles from the Alaska Range foothills to northeast of Fairbanks. Although the pipeline corridor crosses over a corner of this zone that has hosted a cluster of earthquake epicenters, none of its active faults extend to the surface and intersect the corridor.
- The Salcha Seismic Zone runs 75 miles from the Alaska Range foothills to near where the Tanana, Salcha and Little Salcha rivers converge. Interior Alaska's strongest recorded earthquake north of the Denali Fault occurred within this zone in 1937 – a magnitude 7.3 jolt.

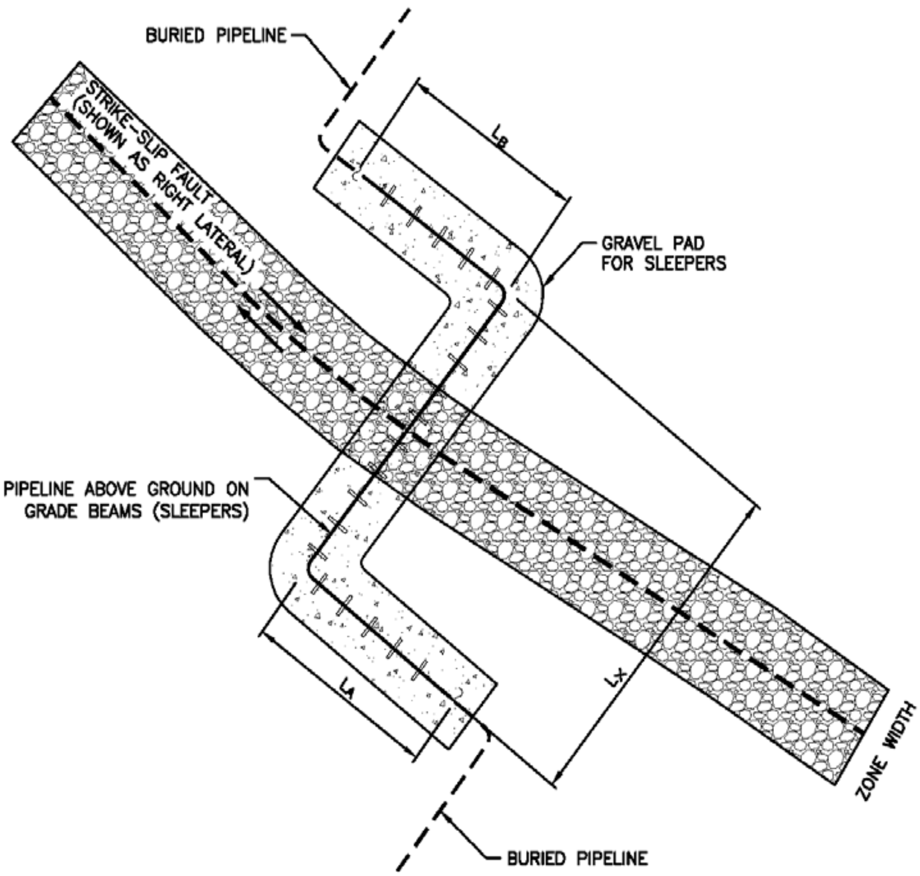
The Salcha zone also produced the surprise. In 2011, field work discovered "a youthful surface fault extending from Harding Lake northeast" to near the pipeline corridor.

In all, the field studies have identified **seven potentially active faults** that the pipeline could cross, all of them along the Alaska Highway between Fairbanks and Tok.

To avoid the faults, TransCanada/ExxonMobil said it "will realign the pipeline along segments that are parallel or coincident with major faults to increase the separation distance from the fault to the pipeline."

To cross the faults – where an earthquake can cause the land on either side of the fault to move in opposite directions, straining the pipe – they plan to get the pipeline out of the ground and lay it on the horizontal crossbeams so it can flex more freely during a tremor, they said.

"The aboveground crossing concept will be similar for all major fault crossings, but the crossing layout dimensions and orientation will vary depending on the type of fault slip, width of the fault zone, and the amount and direction of estimated displacement." They provided to FERC three drawings that show how the pipeline could bridge the faults with minimal risk of a problem.



NOTES:

1. "ZEE" CONFIGURATION MAY BE OPPOSITE HAND.
2. DESIGN PARAMETERS TO BE DETERMINED ON A SITE SPECIFIC BASIS INCLUDE:
   - TRANSITION LEGS, L_A AND L_B
   - CROSSING LEG, L_X
   - SLEEPER SPACING
   - SLEEPER BEAM LENGTH
   - PIPE SHOE LENGTH
   - TYPE AND THICKNESS OF GRANULAR PAD TO SUPPORT SLEEPERS

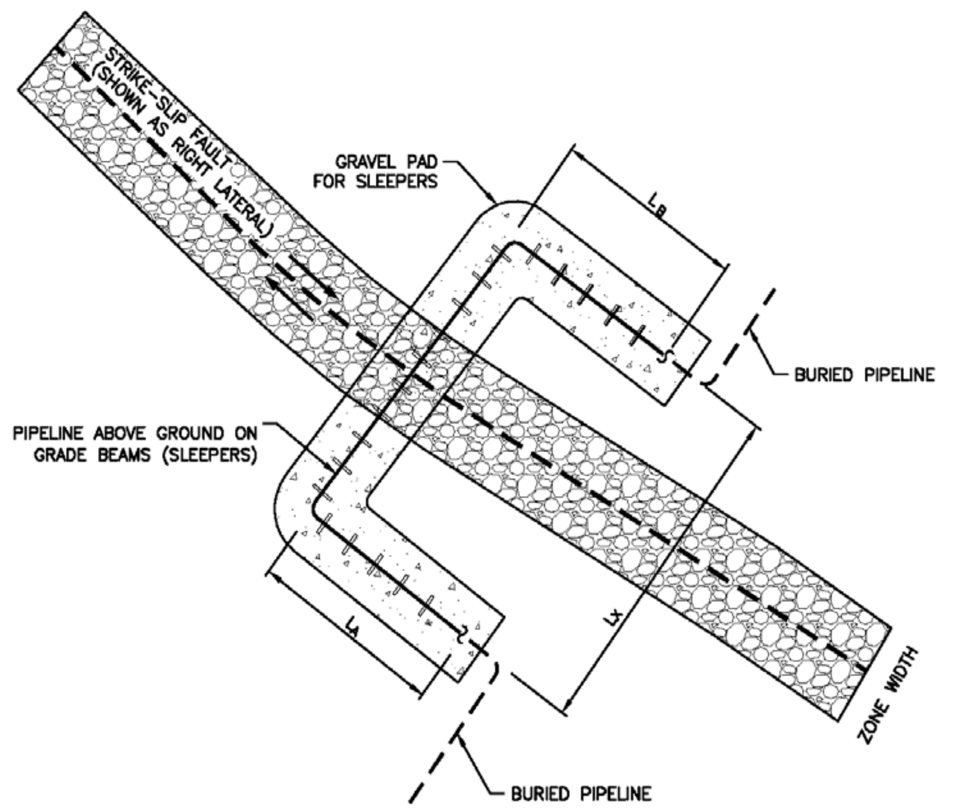
DRAFT 1 FERC APPLICATION
NOT FOR CONSTRUCTION

Appendix 1E FAULT–01

Alaska Pipeline Project

Conceptual "Zee" Fault Crossing Design – Strike–Slip Faults Rev. C

Source: Alaska Pipeline Project Draft Resource Report Appendix 1E, Rev. 0 DRAFT



NOTES:

1. "U" CONFIGURATION MAY BE OPPOSITE HAND.
2. DESIGN PARAMETERS TO BE DETERMINED ON A SITE SPECIFIC BASIS INCLUDE:
   - TRANSITION LEGS, L_A AND L_B
   - CROSSING LEG, L_X
   - SLEEPER SPACING
   - SLEEPER BEAM LENGTH
   - PIPE SHOE LENGTH
   - TYPE AND THICKNESS OF GRANULAR PAD TO SUPPORT SLEEPERS

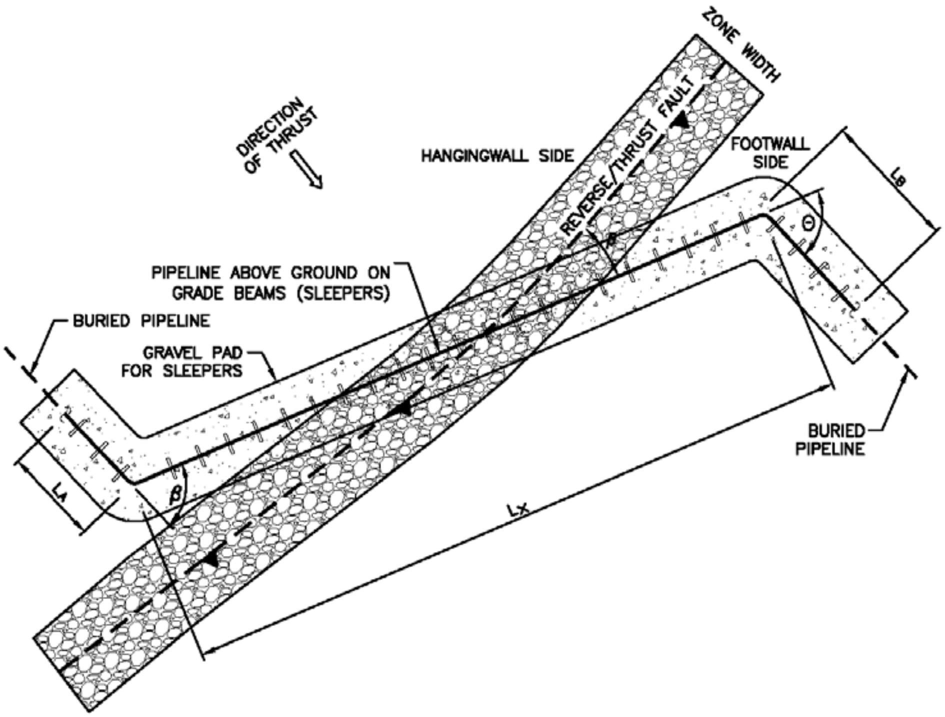
DRAFT 1 FERC APPLICATION
NOT FOR CONSTRUCTION

Appendix 1E FAULT–02

Alaska Pipeline Project

Conceptual "U" Fault Crossing Design – Strike–Slip Faults Rev. C

Source: Alaska Pipeline Project Draft Resource Report Appendix 1E, Rev. 0 DRAFT



NOTES:

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   - CROSSING LEG, L_X
   - SLEEPER SPACING
   - SLEEPER BEAM LENGTH
   - PIPE SHOE LENGTH
   - TYPE AND THICKNESS OF GRANULAR PAD TO SUPPORT SLEEPERS
   - INTERSECTION ANGLE, β
   - BEND ANGLE, Θ

DRAFT 1 FERC APPLICATION
NOT FOR CONSTRUCTION

Appendix 1E FAULT–03

Alaska Pipeline Project

Conceptual "Zee" Fault Crossing Design – Reverse or Thrust Faults

Rev. C

Source: Alaska Pipeline Project Draft Resource Report Appendix 1E, Rev. 0 DRAFT

LOOSE SOIL

Separate from cautiously bridging faults, the pipeline builder must address rippling ground motion that can occur across a wide area as the energy from a powerful earthquake pulses to the surface.

Engineering structures to withstand earthquakes is nothing new in Alaska. The draft reports cite soil liquefaction during earthquakes as a potential problem that the pipeline design and routing will minimize.

Liquefaction can happen when an earthquake jostles loose, saturated, unfrozen soils, typically found along fast-moving streams, riverbanks, lake shorelines and places where groundwater lies within 30 feet of the surface, the report said. The soil can move laterally, or can slump if the terrain is steep.

The partners see little potential for a liquefaction problem along most of the 803-mile corridor.

Their preliminary assessment found less than 7.5 miles of the route where lateral soil movement could be a problem, primarily in floodplains. Options to address this include changing how deep the pipeline is buried or the angle at which it crosses streams, the report said.

They also found less than two miles of potential liquefaction problems on sloped land along the corridor. "To address these areas, mitigation may include techniques such as interceptor ditches and vertical drains. Other techniques may be developed as engineering design progresses."

Another area that got their attention during field research involves one of their eight Alaska compressor stations – at Tetlin Junction along the Alaska Highway. Compressor stations boost the gas pressure to keep it flowing.

TransCanada/ExxonMobil learned the Tetlin station's planned location is in "an area of potential soil liquefaction." They "will continue to evaluate the location of this compressor station and provide updates in the final report."