NEW TRB SPECIAL REPORT

Effects of Diluted Bitumen on Crude Oil Transmission Pipelines

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PHOTO: JASON WOODHEAD, FLICKR

A large network of pipelines transports crude oil from Canada to refineries in the United States.

An estimated 55,000 miles of transmission pipelines in the United States primarily carry crude oil. Many of these pipelines run through the center of the country, carrying crude oil from offshore platforms and ports on the Gulf of Mexico, as well as from production regions in Texas and Western Canada to refineries along the Gulf Coast and the Great Lakes.

In recent years, the sourcing of crude oil has changed dramatically, with new domestic supplies tapped from the shale plays in Texas and North Dakota and with an increase in imports from Western Canada. The rapid shift in crude oil sourcing has had a significant effect on the transmission pipeline network, increasing the demand for capacity in pipelines running from the north to the south.

Diluted Bitumen in Pipelines

The imports from Western Canada, in particular, tend to be highly viscous, or heavy, crude oils that require specialized refining capacity, much of which is located along the Gulf Coast of Texas. An increasing percentage of these crude oil imports consists of bitumen extracted from the oil sands region of the province of Alberta. Plans by the TransCanada Pipeline Company to build a new, high-capacity pipeline, known as the Keystone XL, to connect the oil sands region to the Gulf Coast refineries, however, have generated public controversy, including questions about the effect of bitumen on pipeline integrity.

Bitumen is a dense and viscous form of petroleum that must be diluted with light oils to flow through unheated pipelines. Pipelines have transported diluted bitumen from Alberta to U.S. refineries for more than 30 years, mainly to facilities in the Midwest.

Federal legislation enacted in January 2012 called on the Pipeline and Hazardous Materials Safety Administration (PHMSA) of the U.S. Department of Transportation to determine if the likelihood of a

release increased for transmission pipelines transporting diluted bitumen.[1] PHMSA asked the Transportation Research Board (TRB) of the National Academies to inform the assessment by convening a committee of experts (see box, page 50) to examine the chemical and physical properties of bitumen diluted for pipeline transportation and any evidence that shipments of this product increase the chances of a pipeline failure that would result in a release. The National Research Council's Boards on Energy and Environmental Systems and on Chemical Sciences and Technology assisted in the study, released as TRB Special Report 311, *Effects of Diluted Bitumen on Crude Oil Transmission Pipelines*.

Study Approach

PHMSA mandates the reporting of accidental releases from U.S. transmission pipelines and categorizes each release according to its immediate, or proximate, cause. Historically, about one-third of reported releases involve forms of corrosion damage. Other causes of releases include damage by outside forces, such as an excavator striking a buried pipe, and faulty equipment, operator error, and deficiencies in welds and other materials used in the manufacture and installation of pipelines.

Incident Data

The committee reviewed U.S. and Canadian pipeline release statistics and investigations for evidence that shipments of diluted bitumen, or heavy oils with similar properties, are associated with a higher occurrence of releases from transmission pipelines. The incident data alone, however, were not sufficient for determining whether pipelines transporting diluted bitumen were more likely to experience releases.

Few of the incident records contained information about the type of crude oil released, and few documented the variety of crude oils transported through the pipeline over its history. Because many pipeline degradation processes, such as corrosion, are time-dependent, this history is important. Causal details also were limited. Incidents categorized as corrosion damage, for example, did not specify the underlying causes, such as the action of microorganisms, stress cracking, or preexisting mechanical damage. Although the incident statistics revealed the main causes of pipeline failures, the causal categories lacked the specificity necessary to assess the ways in which transporting a specific type of crude oil can affect a pipeline's susceptibility to failure.

[1] Public Law 112-90, enacted January 3, 2012.

Chemical and Physical Propoerties

The committee assessed the potential effects of the properties of the transported oil on each of the main causes of pipeline failures exhibited in the incident data. Consideration was given specifically to chemical and physical properties that can contribute to internal degradation, external degradation, and mechanical damage in pipelines.

Because it comes in contact with the transported oil, the inside of the pipe is the most obvious place to search for potentially adverse effects. Corrosion is the main cause of internal pipeline degradation, followed to a lesser degree by erosion. The properties of the shipped product also can affect some other causes of failure—for example, external corrosion and cracking associated with operational parameters, such as temperature, and mechanical damage from overpressurization events.

After identifying the chemical and physical properties of crude oils relevant to the specific pipeline failure mechanisms, the committee compared the properties of diluted bitumen with the range of properties in other crude oils commonly transported through pipelines. A finding that diluted bitumen had properties outside this range would require further inquiry into the potential for diluted bitumen to be more likely than other crude oils to cause pipeline releases. A finding that the properties were within the range would not.

Findings

Internal Corrosion and Erosion

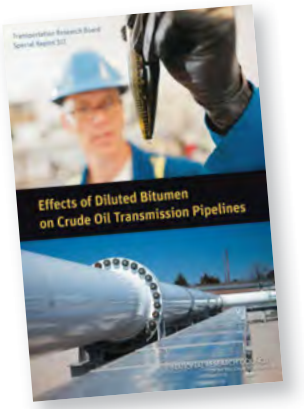
A review of the chemical and physical properties related to the internal corrosion and erosion of pipelines did not indicate that diluted bitumen was

PHOTO: UNIVERSITY OF QUEENSLAND

Bitumen can be extremely viscous and must be combined with lighter oils to move through pipelines. An experiment testing the viscosity of pitch at the University of Queensland, Australia, was begun in 1927; to date, only eight drops have fallen out of the funnel.

PHOTO: TIM EVANSON, FLICKR

The source of oil production in the United States has shifted to shale plays in North Dakota and Texas.



TRB Special Report 311, *Effects of Diluted Bitumen on Crude Oil Transmission Pipelines*, is available from the TRB online bookstore, www.trb.org/bookstore; to view the book online, go to www.trb.org/Publications/Blurbs/169153.aspx.

any more likely than other crude oils to cause these failure mechanisms. Diluted bitumen has densities and viscosities within the range of other crude oils. It flows through pipelines with a velocity and turbulence similar to those of other crude oils and limits the formation of corrosive deposits, as do other crude oils. Shipments of diluted bitumen do not contain unusually high levels of water, sediment, dissolved gases, or other agents that can cause internal corrosion. The organic acids contained in diluted bitumen are not corrosive to steel at pipeline operating temperatures.

Examination of the factors influencing microbial growth revealed that diluted bitumen did not have a higher likelihood than other crude oils of causing microbiologically influenced corrosion. Because its solids content and flow regimes are comparable with those of other crude oils, diluted bitumen does not have a higher propensity to cause the erosion of transmission pipelines.

External Corrosion and Cracking

Pipelines can sustain external damage in the form of corrosion and cracking. Diluted bitumen only contacts the inside of a pipeline and therefore can contribute to external degradation only as a result of changes in a pipeline's operational parameters—specifically, in the pipeline's temperature and pressure levels.

Elevated operating temperatures can increase the likelihood of external corrosion and cracking by causing or contributing to the degradation of protective coatings and by accelerating the rates of certain degradation mechanisms. Elevated operating pressures can cause stress loadings and concentrations that lead to cracking, particularly at sites of corrosion and preexisting damage.

With densities and viscosities comparable with those of other crude oils, diluted bitumen is transported at comparable operating pressures and temperatures. For this reason, the likelihood of temperature- and pressure-related effects is indistinguishable for diluted bitumen and other crude oils of similar density and viscosity. Consequently, diluted bitumen would not create a higher propensity for external corrosion and cracking in transmission pipelines.

Mechanical Damage

Overpressurizing and outside forces can cause mechanical damage to a pipeline and its components. Mechanical forces can cause an immediate release or make a pipeline more susceptible to release by destabilizing the support structures, damaging other components such as valves and joints, and weakening the resistance to other failure mechanisms, such as corrosion.

The study examined several possible ways that the properties of the transported liquid could increase the potential for mechanical damage to the pipe. These included the potential of diluted bitumen to cause pressure surges or to interact with outside forces that can damage pipelines. None of the properties or operating parameters of diluted bitumen shipments, however, differed sufficiently from those of other crude oils to suggest a higher potential for causing or exacerbating mechanical damage in pipelines.

Increased Releases Not Likely

The study committee was asked to "analyze whether transportation of diluted bitumen by transmission pipeline has an increased likelihood of release compared with the pipeline transportation of other crude oils." The committee did not find any causes of pipeline failure unique to the transportation of diluted bitumen. Furthermore, the committee did not find evidence that the physical or chemical properties of diluted bitumen were outside the range of other crude oils, nor did it discover any other aspect of transportation by pipeline that would make diluted bitumen more likely than other crude oils to cause releases.

The results suggest that diluted bitumen will not cause pipeline releases at a rate higher than its share of the crude oil stream. Nevertheless, future pipeline releases will occur and some will involve diluted bitumen. All pipeline releases can be consequential. The committee was not asked to study whether releases of diluted bitumen and other crude oils differ in consequences.

Committee for a Study of Pipeline Transportation of Diluted Bitumen

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