TRANSPORTATION RESEARCH BOARD

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TRB REPORT IN BRIEF

Effects of Diluted Bitumen on Crude Oil Transmission Pipelines

Bitumen is a dense and viscous form of petroleum that will flow through unheated pipelines only when diluted with lighter oils. The source of bitumen refined in North America is the oil sands region of Alberta, Canada. Bitumen from Alberta has been diluted for pipeline transportation to U.S. oil refineries for more than 30 years, mainly to facilities in the Midwest (Figure 1). As production of bitumen has grown, refineries on the U.S. Gulf Coast have sought access to this product along with the other heavy oils imported from western Canada. To accommodate Canadian oil imports as well as the growth in domestic crude oil production, the flow directions of several existing pipelines have been reversed, new transmission pipelines have been constructed, and additional pipeline capacity is planned.

Public Law 112-90, enacted on January 3, 2012, calls on the Pipeline and Hazardous Materials Safety Administration (PHMSA) of the U.S. Department of Transportation to determine whether any increase in the risk of a release exists for pipelines when they transport diluted bitumen. A determination of risk requires an assessment of both the likelihood and the consequences of a pipeline release. To inform its assessment of the former, PHMSA asked the Transportation Research Board to convene a committee of experts to "analyze whether transportation of diluted bitumen by transmission pipeline has an increased likelihood of release compared with pipeline transportation of other crude oils."

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 have involved corrosion damage. Other causes include damage from an outside force, such as an excavator striking a buried pipe; faulty equipment; operator error; and deficiencies in welds and other materials used in pipeline manufacturing and installation.

At the outset of the study, the committee reviewed U.S. and Canadian pipeline release statistics and investigations to look for evidence that shipments of diluted bitumen or oils with similar properties were associated with a higher occurrence of releases. It soon became evident that these historical incident data alone could

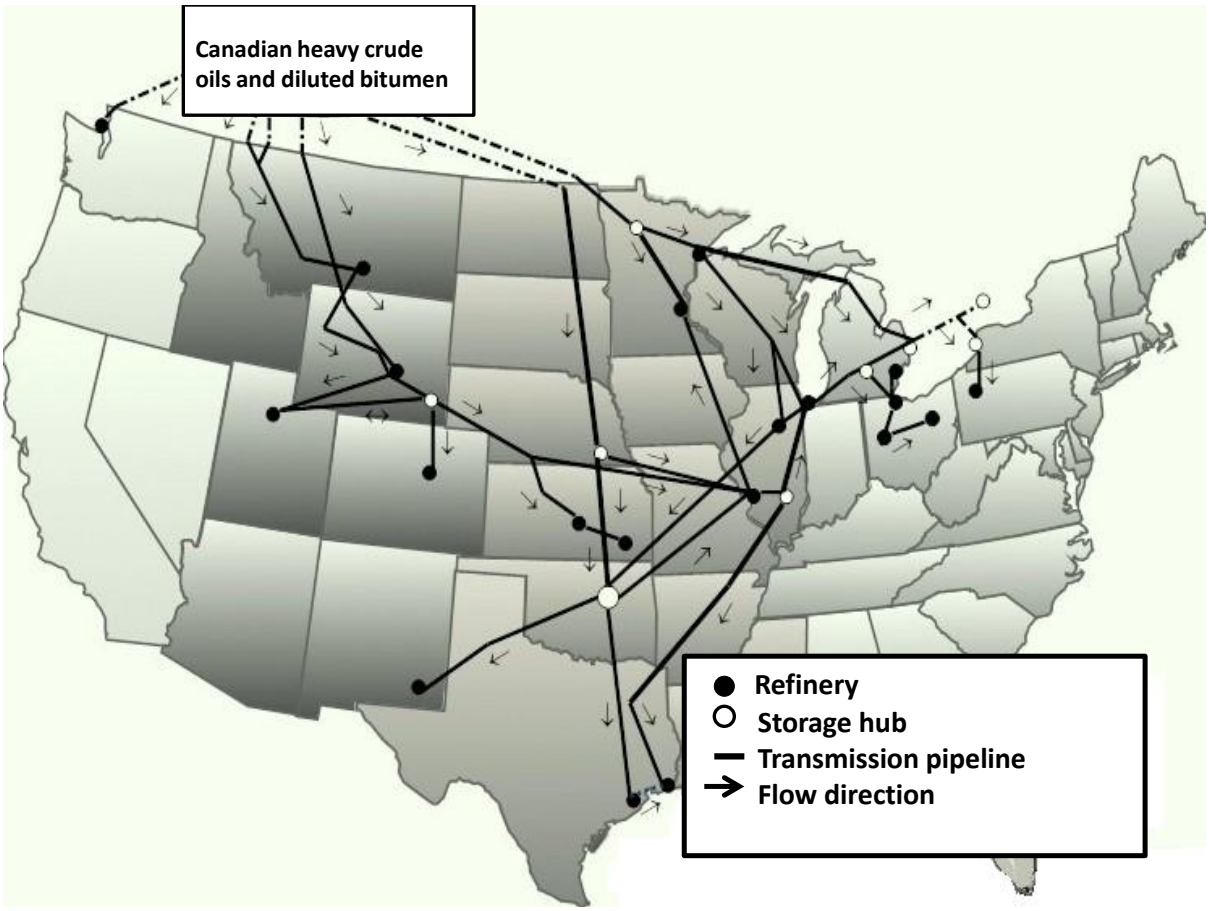

FIGURE 1 Main pipeline corridors moving Canadian crude oil to U.S. refineries.

not be used to determine whether pipelines are more likely to experience releases when they transport diluted bitumen. Few incident records contain information on the type of crude oil released or document the variety of crude oils transported through the pipeline over time. Causal details are also limited in the records. Incidents categorized as corrosion damage, for example, do not identify whether the damage occurred as a result of the action of microorganisms, in combination with stress cracking, or at sites of preexisting mechanical damage. Although incident statistics are helpful in revealing the general causes of pipeline failures, the causal categories lack the specificity needed to assess the particular ways in which transporting a given crude oil can affect the susceptibility of pipelines to failure.

Having identified the main causes of pipeline failures, the committee assessed each cause with respect to its potential to be affected by the properties of the transported oil. Consideration was given specifically to chemical and physical properties that can contribute to internal degradation, external degradation, and mechanical damage in pipelines. Because the inside of the pipe comes in contact with the transported oil, it is the most obvious place to search for potentially adverse effects. Corrosion is the main cause of internal degradation, followed, to a lesser degree, by erosion. Other causes of pipeline failure that can plausibly be affected by the transported product are external degradation from corrosion, and cracking and mechanical damage from overpressurization and outside forces.

After identifying the chemical and physical properties of crude oils relevant to specific failure mechanisms, the committee compared the properties of diluted bitumen with the range of properties found in other crude oils. A finding that diluted bitumen had properties outside this range would have required further inquiry into the potential for this product to have a greater propensity to cause pipeline releases than other crude oils. A finding of properties within the range would not.

FINDINGS

Internal Corrosion and Erosion

A review of the chemical and physical properties pertaining to internal pipeline corrosion and erosion did not find that diluted bitumen was any more likely than other crude oils to cause these failure mechanisms. 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. The densities and viscosities of diluted bitumen are within the range of those of other crude oils, and the velocity and turbulence with which diluted bitumen flows through pipelines are comparable with those of other crude oils and limit the formation of corrosive deposits. On the basis of an examination of the factors that influence microbial growth, diluted bitumen does not have a higher likelihood than other crude oils of causing microbiologically influenced corrosion. Because diluted bitumen has solids content and flow regimes comparable with those of other crude oils, it does not have a higher propensity to cause erosion of transmission pipelines.

External Corrosion and Cracking

Pipelines can sustain external damage from corrosion and cracking. Because diluted bitumen only contacts the inside of a pipeline, it can contribute to these forms of external degradation only as a result of changes in pipeline operational parameters—specifically, pipeline 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 rates of certain degradation mechanisms. Elevated operating pressures can cause stress loadings and concentrations that lead to stress-related cracking, particularly at sites of corrosion and preexisting damage. Because the densities and viscosities of diluted bitumen are comparable with those of other crude oils, it 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 will not create a higher propensity for external corrosion and cracking in transmission pipelines.

Mechanical Damage

Mechanical damage to the pipeline and its components can occur as a result of overpressurization or outside forces. Mechanical forces can cause an immediate release or make the pipeline more susceptible to release by destabilizing support structures; damaging other components, such as valves and joints; and weakening resistance to other failure mechanisms, such as corrosion attack. The study examined several possible causes of an increased potential for mechanical damage due to the properties of the transported liquid, including the potential for diluted bitumen to cause pressure surges or to interact with outside forces that can cause damage in pipelines. None of the properties or operating parameters of diluted bitumen shipments were found to be sufficiently different from those of other crude oils to

suggest a higher potential to cause or exacerbate mechanical damage in pipelines.

CONCLUSION

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

While the results of this study do not suggest that diluted bitumen will cause pipeline releases at a rate higher than its share of the crude oil stream, one can expect that future pipeline releases will occur and that 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 their consequences or to determine whether such a study of consequences is warranted.

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