

# Effects of Diluted Bitumen on Crude Oil Transmission Pipelines

Committee for a Study of Pipeline  
Transportation of Diluted Bitumen

**THE NATIONAL ACADEMIES**

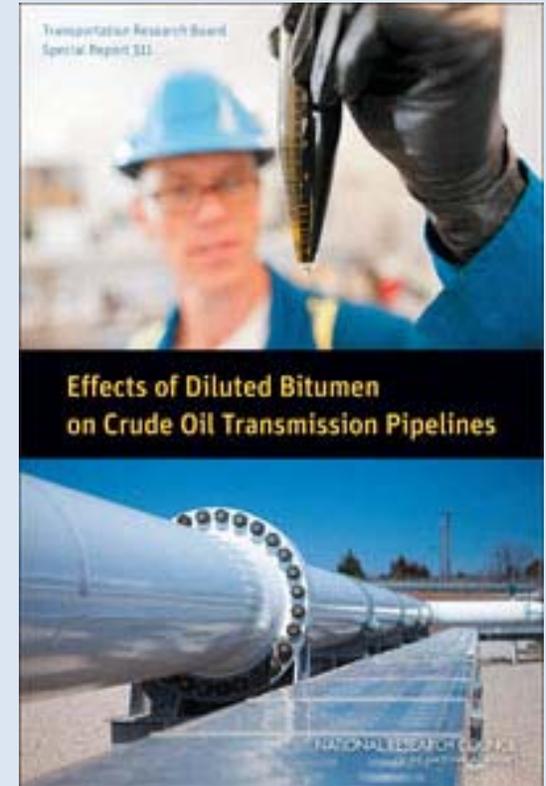
*Advisers to the Nation on Science, Engineering, and Medicine*

## **PHMSA contracted with National Academy of Sciences to answer the basic question:**

- **Do shipments of diluted bitumen (dilbit) have greater likelihood of release from transmission pipelines than shipments of other crude oils?**
- **Asked to focus on the “likelihood of release,” not the consequences of releases.**

# Study Process

- **Appoint expert committee**
  - Chemical and corrosion engineering
  - Pipeline operations and maintenance
  - Risk analysis and pipeline safety regulation
- **5 meetings (July 2012 – April 2013)**
  - Fact-finding, presentations from experts
  - Visit to pipeline facility
- **Presentations available at:**  
<http://www.trb.org/PolicyStudies/DilbitCommittee.aspx>
- **Peer reviewed report released in June 2013.**



# Study Committee

- **Mark A. Barteau**, University of Michigan, Ann Arbor, *Chair*
- **Y. Frank Cheng**, University of Calgary, Alberta, Canada
- **James F. Dante**, Southwest Research Institute, San Antonio, Texas
- **H. Scott Fogler**, University of Michigan, Ann Arbor
- **O. B. Harris**, O. B. Harris, LLC, Missouri City, Texas
- **Brenda J. Little**, Naval Research Laboratory, Stennis Space Center, Mississippi
- **Mohammad Modarres**, University of Maryland, College Park
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- **Richard A. Rabinow**, Rabinow Consortium, LLC, Houston, Texas
- **George W. Tenley, Jr.**, Hedgesville, West Virginia

## What is diluted bitumen?

- **Form of petroleum with high density and viscosity, extracted from Canadian oil sands.**
- **Bitumen will not flow in unheated pipelines unless diluted with light oils.**
- **Diluents consist of common distillates and light oils; diluent portion is 25% to 50% of shipment volume.**
- **Dilbit imports are transported in thousands of miles of U.S. pipeline.**

## Study Scope and Approach

- Review data on pipeline accidents. Any statistical evidence of release rate differences?
- Examine ways in which pipelines can fail and how properties of crude oil shipments can contribute to failures
- Are there relevant properties of dilbit outside the range of other crude oil shipments?

# Insights from Incident/Accident Statistics

- **“Incident” defined differently. Some data bases include gathering lines, which differ from transmission lines.**
- **Incident reports do not specify type of crude oil involved in release or history of crudes transported through the pipeline.**
- **Incident statistics can help in identifying general causes of releases, but not in assessing the role of the transported crude per se.**

# Three broad categories of pipeline failure causes

## 1. Internal corrosion and erosion

### Main Factors:

- Water, sediment, acid, and gas content of shipments
- Shipment flow rate and turbulence

## 2. External Corrosion and cracking

### Main Factors:

- Pipeline operating temperature and pressure

## 3. Mechanical damage (e.g., outside forces and pressure surges)

### Main Factors:

- Density and viscosity of shipments
- Hydrocarbon composition of shipments

## Internal Corrosion—What we know

- Water must be in crude stream and in contact with pipe bottom—oil by itself is not corrosive to pipe steel.
- Sediment in crude that deposits to the pipe bottom can exacerbate corrosion by forming sludge with water.
- CO<sub>2</sub>, H<sub>2</sub>S, and Oxygen in crude can exacerbate corrosion if dissolved in water contacting the pipe bottom.
- Acids in crude can exacerbate corrosion if dissolved in water.
- Microorganisms in water-laden sediment can cause corrosion.
- Maintaining turbulent flow is important to keep water and sediment suspended.

## Relevant Findings About Dilbit

- Water and sediment content: same or lower than shipments of other crude oils—Canadian shipping standards more restrictive—1% BS&W
- Corrosive gas and acid content: same or lower; acids in dilbit not corrosive at pipeline temperatures; sulfur is bound to HCs
- Flow regime: Turbulent. Comparable to shipments of other crudes of similar density and viscosity
- **No evidence that dilbit should be more corrosive to the interior of transmission pipelines**

## External Corrosion and Cracking—What we know

- Shipments do not contact the outside of the pipe.
- High and fluctuating operating pressure can create stresses that cause or exacerbate external cracking.
- Elevated operating temperature can cause disbonding of exterior coating (which protects against external corrosion).
- Viscous crudes require higher pressure to maintain same flow velocity.
- Viscous crudes require more pumping energy to maintain flow velocity—translates to higher operating temperatures.

## Relevant Findings

- **Density and viscosity**: within the range of other heavy crude oils—must meet pipeline shipping standards
- **Flow regime**: comparable to shipments of other crudes of similar density and viscosity
- **Operating temperature and pressure**: same for shipments of other crudes of similar density and viscosity
- **No evidence that dilbit shipments should cause or exacerbate external degradation of pipelines any more than other crudes of similar density and viscosity**

## **Mechanical Force Damage—What we know**

- **Pressure surge events are a possible concern. Can damage valves, fittings, even main pipe.**
- **It has been claimed that the diluents in dilbit separate into gas phase in pipeline, causing a vapor void that will collapse to cause a damaging pressure surge (i.e., water hammer effect).**

## Relevant Findings

--Light-end, high vapor pressure component (C4-C10) of dilbit is smaller than in medium and light crudes

--Diluted bitumen is mixed to be fully miscible in pipelines, or uniform in all proportions

--No evidence that shipments are unstable in pipelines so as to be a concern for column collapse.

## Summary of Study Results

- **No evidence of causes of pipeline failure unique to shipments of dilbit.**
- **No evidence of chemical or physical properties of dilbit that are outside the range of other crude oil shipments.**
- **No evidence of unique or extreme properties that make dilbit shipments more likely to cause internal corrosion.**
- **No evidence of properties that make dilbit shipments more likely to cause external corrosion and cracking or to cause damage from mechanical forces.**

**Thank you  
Questions?**