

**Introduction to Crude Oil
and
Crude Oil Pipelines**

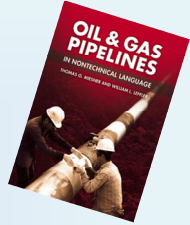
Developed and produced by
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Instructor – Tom Miesner

- Principal Pipeline Knowledge & Development
 - Pipeline Education and Training
 - Strategy and Project Development
 - Expert Testimony and Arbitration
 - Management and Improvement Consulting
- Extensive pipeline background
- President Conoco Pipe Line Company
- Numerous JV Boards and Committees
- Author
 - *Oil and Gas Pipelines in NonTechnical Language*
 - *The Role of Pipelines and Research in the U. S.*
 - *A Practical Guide to US Natural Gas Pipeline Economics*
 - *The Interstate Natural Gas Transmission System: Scale, Physical Complexity, and Business Model*
 - *Pipeline Engineering for McGraw Hill's Transportation Engineering Handbook*
 - *Natural Gas Distribution Pipelines in NonTechnical Language*, for release in 2015



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Topics

- Crude oil
- Pipelines and Breakout Tanks
- Rail Transportation
- Crude Oil Releases
- Pipeline Control Rooms
- Quality and Blending
- Industry Dimensions

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Crude Oil

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Hydrocarbon Molecules

- **Hydrocarbon molecules**
 - Methane C₁ - Natural Gas
 - Ethane C₂
 - Propane C₃
 - Butane C₄
 - Pentane C₅
 - Heavier

C₃+ } LPG } Mix or } Natural gas }
 Autogas } Y grade } liquids (NGL)






C₅+ natural gasoline

- **Crude oil**
- **Bitumen**
 - Synthetic crude oil
 - Bilbit
 - Synbit
- **Crude oil is a complex blend of hydrocarbon molecules**

Pressure and temperature determine whether a particular hydrocarbon is in liquid or gaseous state.

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Natural Gas Liquids

Natural Gas Liquid	Chemical Formula	Applications	End Use Products	Primary Sectors
Ethane	C ₂ H ₆ 	Ethylene for plastics production; petrochemical feedstock	Plastic bags; plastics; anti-freeze; detergent	Industrial
Propane	C ₃ H ₈ 	Residential and commercial heating; cooking fuel; petrochemical feedstock	Home heating; small stoves and barbecues; LPG	Industrial, Residential, Commercial
Butane	C ₄ H ₁₀ 	Petrochemical feedstock; blending with propane or gasoline	Synthetic rubber for tires; LPG; lighter fuel	Industrial, Transportation
Isobutane	C ₄ H ₁₀ 	Refinery feedstock; petrochemical feedstock	Alkylate for gasoline; aerosols; refrigerant	Industrial
Pentane	C ₅ H ₁₂ 	Natural gasoline; blowing agent for polystyrene foam	Gasoline; polystyrene; solvent	Transportation
Pentanes Plus*	Mix of C ₅ H ₁₂ and heavier	Blending with vehicle fuel; exported for bitumen production in oil sands	Gasoline; ethanol blends; oil sands production	Transportation

} Low Octane

C indicates carbon, H indicates hydrogen; Ethane contains two carbon atoms and six hydrogen atoms
 *Pentanes plus is also known as "natural gasoline." Contains pentane and heavier hydrocarbons.
 Source: U.S. Energy Information Administration, Bentek Energy LLC

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Petroleum Characteristics

Pressure, temperature and source material determine petroleum's molecular structure

- Bitumen was exposed to the lowest temperatures and pressures.
- Natural gas was exposed to the highest temperatures and pressures

The organic materials were imbedded in sandstone, siltstone, shale, limestone, and conglomerates – so was (is) the oil and gas produced from it.

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Oil and Gas Production Stream

- **Wells produce**
 - Dry Gas
 - Wet Gas
 - Condensate
 - Light Crude Oil
 - Heavy Crude Oil
- **Bitumen** A naturally occurring viscous mixture, mainly of hydrocarbons heavier than pentane, that may contain sulphur compounds and that, in its natural occurring viscous state, is not recoverable at a commercial rate through a well. – EIA glossary.
- **Other Materials**
 - Solid Debris
 - Salt Water
 - Other Gases

Bitumen is viscous because it lacks pentane plus molecules. Lighter molecules are blended with bitumen to reduce its viscosity.

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Conclusions

- Petroleum is a **complex blend** or hydrocarbons.
- The mixture determines petroleum's characteristics.
- Each production stream has **unique characteristics**
- These characteristics may change over time.
- Initially **reservoir pressure** pushes the stream to the surface
- This stream is generally **processed** prior to entering the pipeline
- As the reservoir is depleted its pressure drops
- Bitumen is too near the surface and viscous to **produce from wells**.
- Lighter molecules are blended with bitumen to **reduce its viscosity**.

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Fluid Properties

Density – mass/volume

- Specific gravity
 - Gas – compared to air
 - Oil – compared to water
- API gravity for liquids

Viscosity – resistance to flow

Vapor pressure – pressure above which liquids become gases

Compressibility – relative volume change in response to pressure change

- Oil – essentially incompressible
- Gas – critical factor

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API Gravity - Liquids

$$\text{API Gravity} = \frac{141.5}{\text{Specific Gravity}} - 131.5$$
$$\text{API Gravity} = \frac{141.5}{.72} - 131.5 = 55.03^{\circ} [\text{API}]$$

- The higher the API gravity the lighter the material
- Water has an API gravity of 10⁰
- API gravity is a density measurement used in the petroleum industry and has no other special meaning

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Pipelines

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Pipeline Types

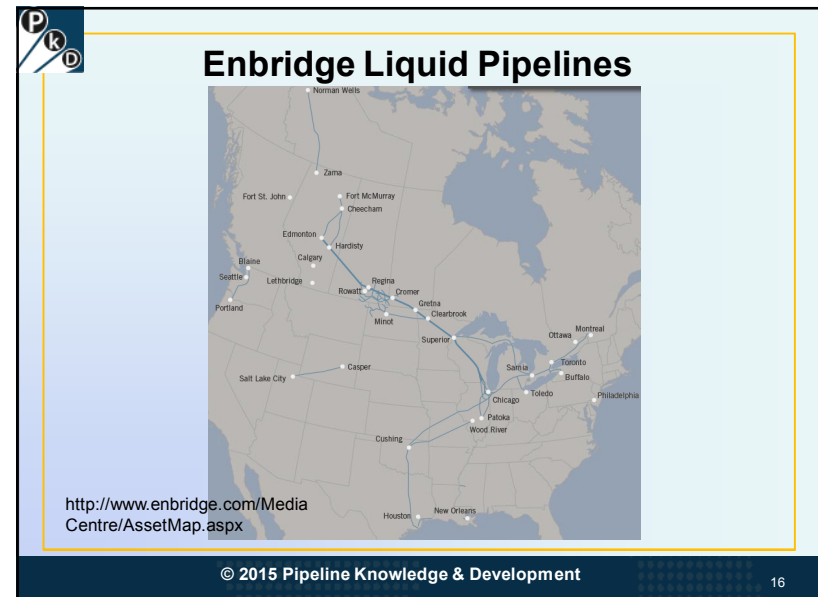
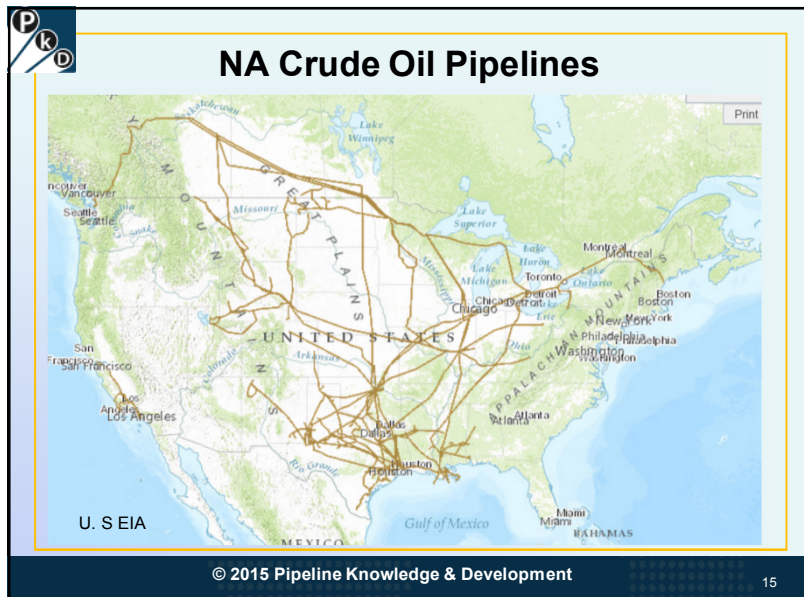
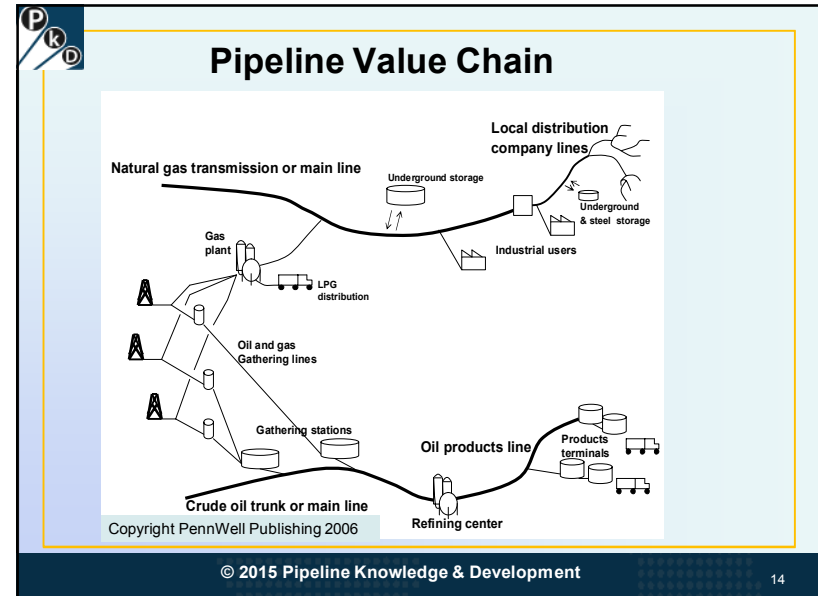
Fluids Transported

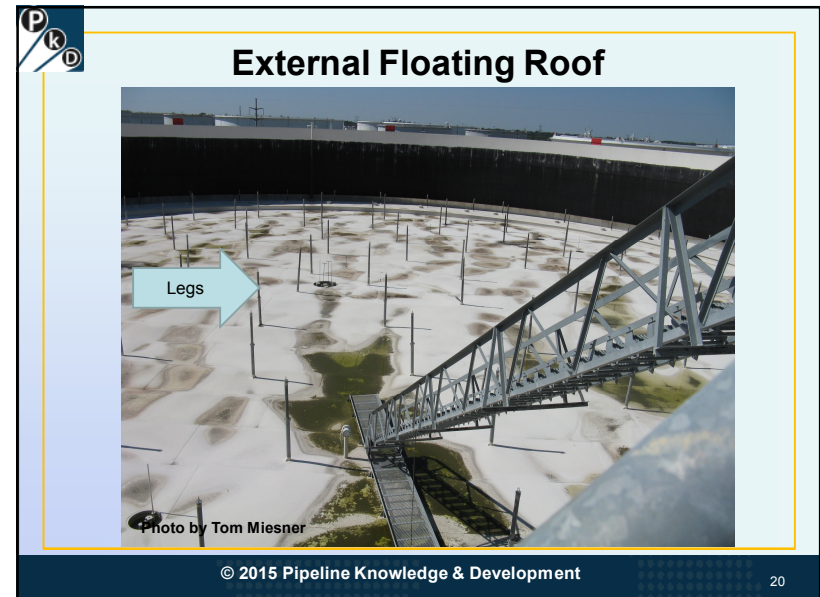
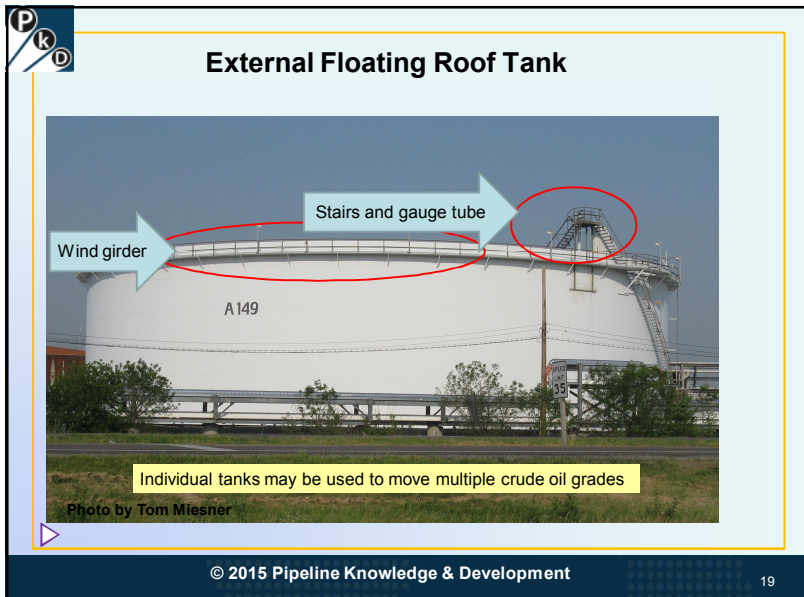
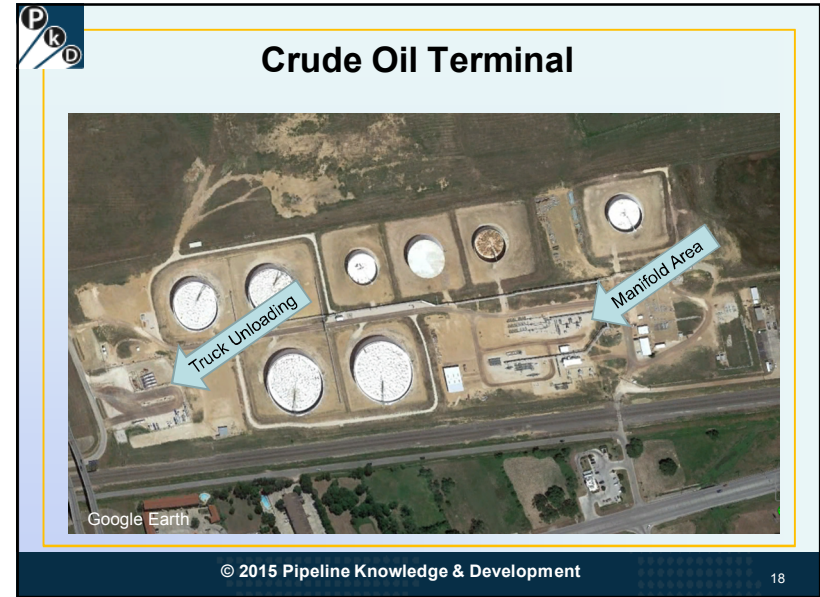
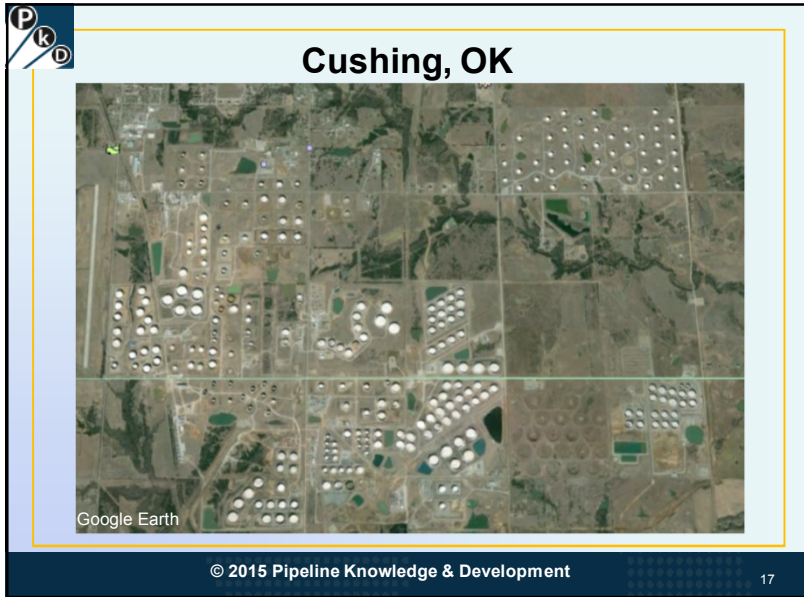
- Natural gas
- Crude oil
- Refined products
- LPG and chemicals
- Specialty

Function

- Gathering
- Transmission, main or trunk line
- Distribution

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Floating Roof Tank Legs

During normal operations most tanks are not completely drained resulting in a "heel"

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Tank Types (Usage)

- **Breakout tanks** – used to “decouple” sections of the pipeline from each other. Fluids are not normally retained in breakout tanks for long periods or time. Breakout tanks are required to facilitate pipeline operations.
- **Storage tanks** – tanks which are not required for pipeline operations, but rather used only to store fluids. Fluids may remain in storage tanks for long periods or time. Storage tanks are often used to balance supply and demand over time and to capture market opportunities.
- Both breakout and storage tanks are typically designed and constructed in accordance with **API Standard 650 – Welded Tanks for Oil Storage**

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Header and Manifold

Manifolds are a collection of pipes and valves used to direct flow from tanks to the pipeline and from the pipeline to the tanks

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Crude Oil Mainline Pump Station


Pump stations are spaced about every 50 miles apart and add pressure to the pipeline to facilitate flow.

Photo by Tom Miesner

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PKD


Manifold Area



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PKD

Refinery Tank Farm



Crude oil grades are segregated at the refinery

Photo by Tom Miesner

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PKD

Refinery




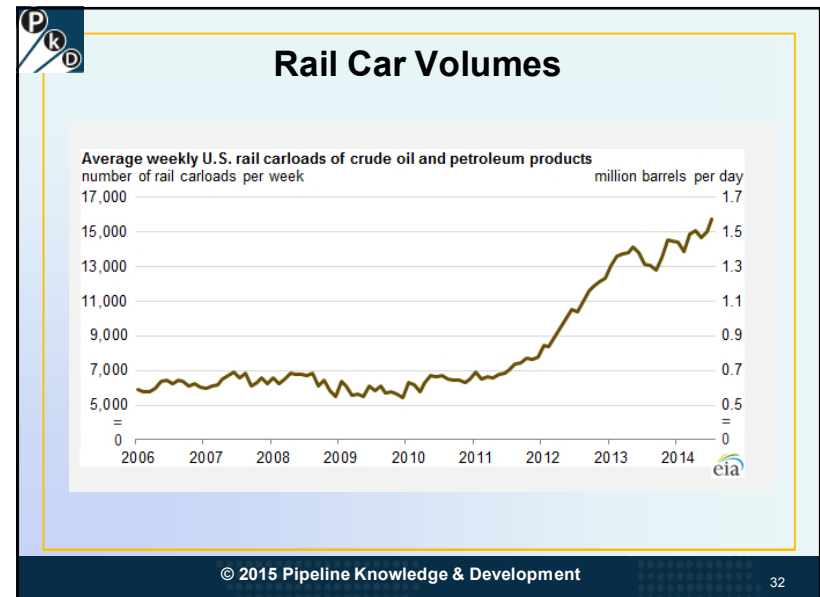
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Rail Transportation


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Crude Oil Releases

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Stress Corrosion Cracking Leak




Flow

M4

Source NTSB

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Crude Oil Spill Cleanup



Source NTSB

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Crude Oil Spill Clean Up

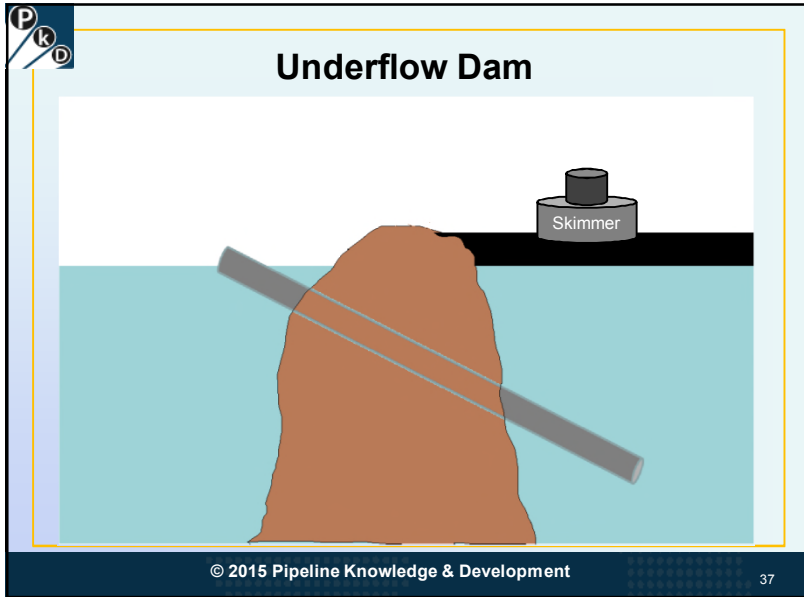


Earthen underflow dam

Talmadge Creek

Source NTSB

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Operator Characteristics

- **Thoughtful attention to details**
 - **Optimization**
 - Efficiency of different stations along the pipeline
 - Ensuring sufficient quantities are available
 - **Problem solving**
- **Ability to react quickly and decisively**
 - Upset conditions
 - Releases
- **Tolerance for the lifestyle**
 - Shifts and weekends
 - Varying days

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Control Room Operations

Flow

Functions

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Segregation

Batched systems

- Different grades or types of liquids are **moved end to end** (batched) on the same pipeline

Common stream

- **Crude oil** which is moved through a facility and is **commingled or intermixed** with crude oils of similar quality or characteristics

Natural gas liquids

- **Hydrocarbons recovered in natural gas processing plants or refineries**, normally consisting of ethane, propane, normal butane, iso-butane, and heavier hydrocarbons such as condensate and natural gasoline

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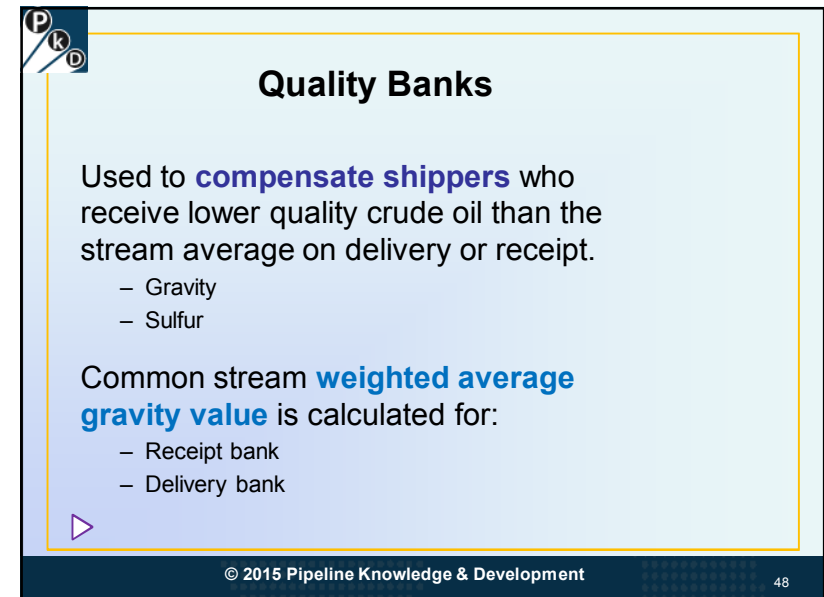
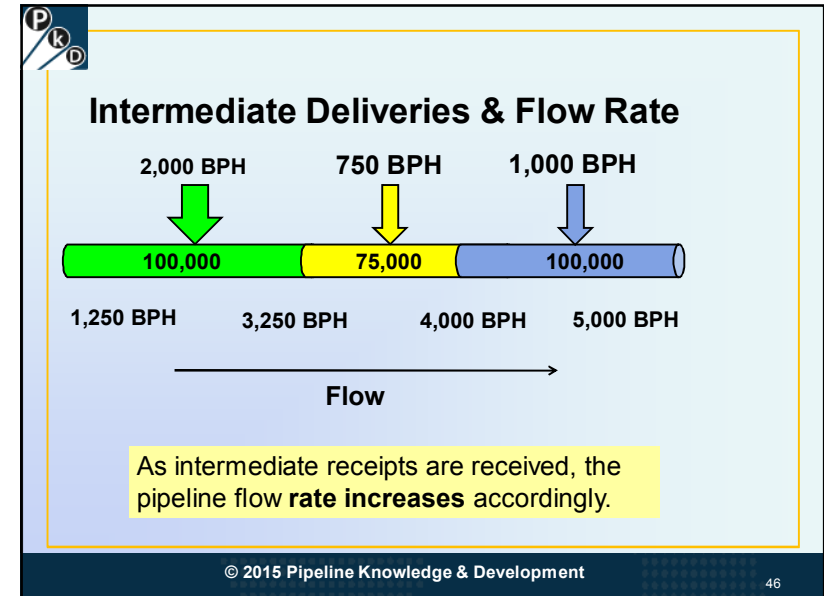
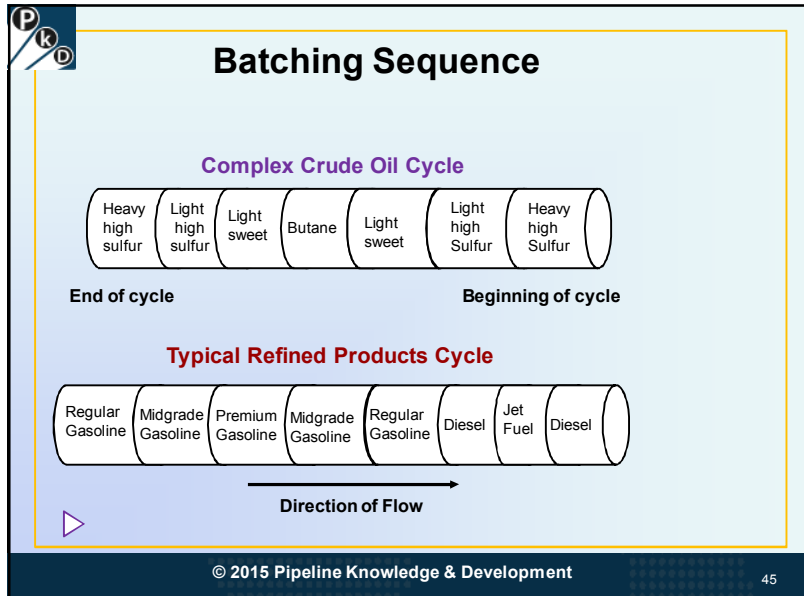
Enbridge Classifications and Tanks

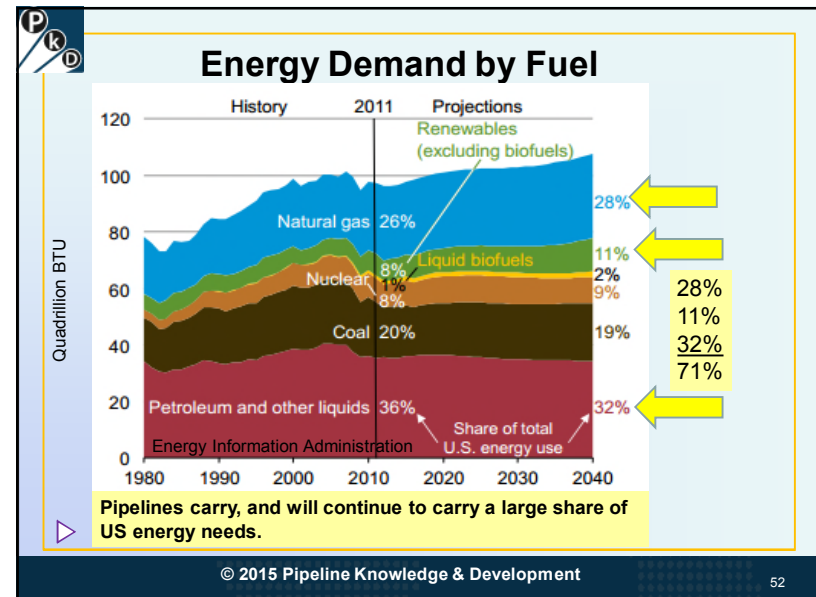
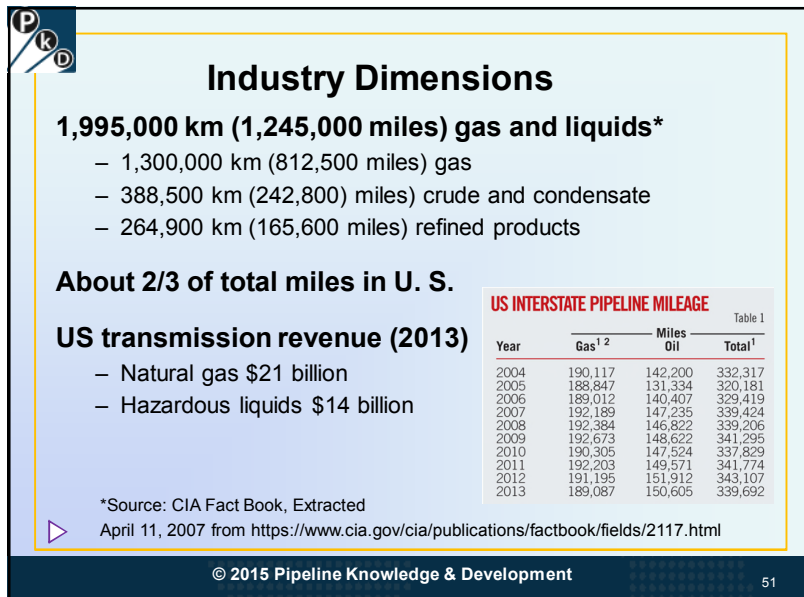
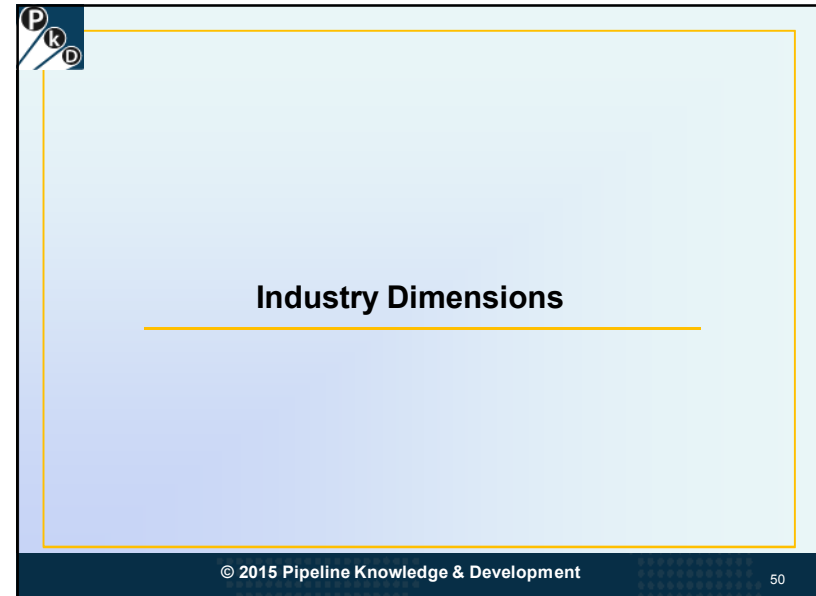
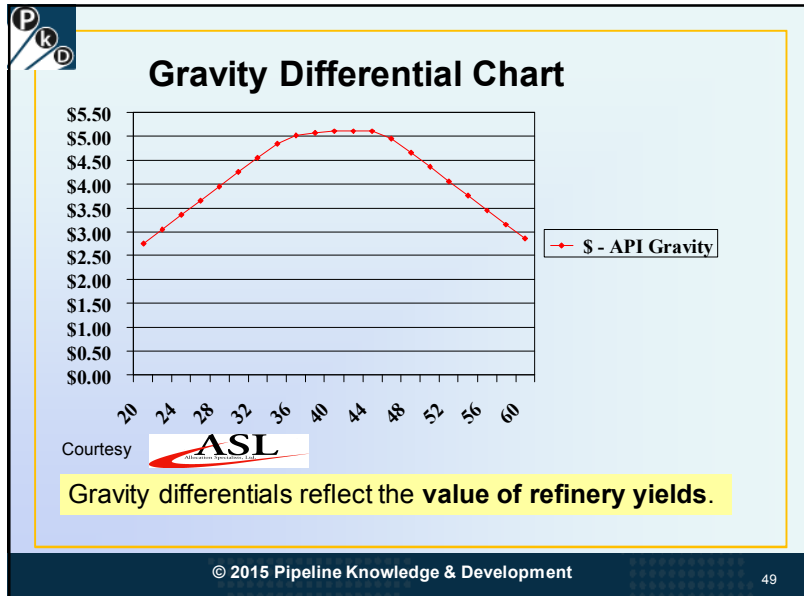
Crude Quality Category	Edmonton	Hardisty	Regina	Cromer	Clearbrook	Superior	Flanagan	Griffith	Stockbridge	Samia	Westover
Condensate (J)	K, I	K	K	K, I		K, I	K, I	K, I		K, I	K, I
Light Synthetic (K)	J, I	J, I	J, I	J, I		J, I	J, I	J, I		J, I	J, I
Sweet (I)	J, K, H	J, K, H	J, K, H	J, K, H	J, K, H	J, K, H	J, K, H	J, K, H	J, K, H	J, K, H	J, K, H
Light Sour (H)				G	G	G	G	G	G	G	G, A
Medium Sour (G)				H	H	H	H, A	H, A	H, A	H, A	H, A
Heavy (A)	B, C	B, C				B, C	B, C	B, C	B, C	B, C	B, C, G, H
Heavy High Tan DilBit (B)	C, A	C, A				C, A	C, A	C, A	C, A	C, A	C, A, G, H
Heavy High Tan SynBit (C)	B, A	B, A				B, A	B, A	B, A	B, A	B, A	B, A, G, H
Heavy Low Residue (D)	B, C, A					B, C	B, C	B, C	B, C	B, C	
Cracked (E)	Note 1	Note 1									


A-Heavy, B-Heavy HighTan DilBit, C-Heavy HighTan SynBit, D-Heavy Low Residue, E-Cracked, G-Medium Sour, H-Light Sour, I-Sweet, J-Condensate, K-Light Synthetic

<http://www.enbridge.com/~media/www/Site%20Documents/Delivering%20Energy/Shipper%20Table%205%20%20Tank%20Utilization%20Effective%20May%201%202014.pdf?a=en>

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