Contents of Keystone Pipeline

Chemical Composition

The physical and chemical properties, environmental fate, and transport of crude oil have previously been described within Section 4.2 of the Risk Assessment (submitted to the DOS in March 2006 and also on file with the PSC). The physical and chemical properties of the crudes transported by Keystone are not unique and are similar to those already being transported across North Dakota by the Enbridge pipeline.

Crude oil is a complex mixture of hydrocarbons, with small amounts of sulfur, nitrogen, and oxygen, and minor amounts of trace elements. The geological origin of the crude is most important is determining its characteristics. Many kinds of crudes are found in North America because there is great variety in the geologic history of its different regions. Crude from the Athabascan oil sands share many characteristics of other heavy oils from Venezeula, Nigeria, Russia, and California.

Crude oil assays are used to characterize the chemical composition of crude oils. Assays for Canadian crude oils have been previously provided to the DOS (DR #1, January 2007) and can be found at: http://www.crudemonitor.ca/. This publicly available website provides assay information on a number of Canadian crude oils, including, but not limited to, density, TAN (Total Acid Number), sulfur, benzene, toluene, ethyl benzene, xylenes, and some trace elements.

Keystone anticipates that a wide variety of crudes could be transported on its pipeline but, in general, the crude oils it will transport will be similar to Western Canadian Select (WCS) and Suncor Synthetic A (Suncor). These crude oils are already being transported through the Enbridge pipeline in North Dakota.

Physical Characteristics

Viscosity: Keystone requires that crude oil transported in its pipeline has a viscosity of 350 centistokes or less.

Density: Density, measured as API gravity, is a primary factor used to characterize crude oil. A crude oil with an API gravity is lighter than water and will float. Based on the most current data (August 2007), WCS has an API gravity of 19.03 (September 2006 assay value) while Suncor's API gravity is 32.48. Consequently, both crude oils are lighter than water and will float.

Heavy crude oils are those oils with API gravities less than 18, intermediate crudes have API gravities between 18 and 36, and light crudes have API gravities more than 36. It is expected that the crude oils that will be transported by the Keystone Pipeline may include heavy, intermediate, and light crudes. Both the WCS and Suncor crudes would be classified as intermediate crudes. (Note: The Canadian Crude Oil Monitor only uses two classes of crude oil: heavy and light. Under this classification system, WCS is classified as heavy crude oil and Suncor is classified as light crude oil.)

Sulfur Content: Crude oils are broadly characterized as "sweet" or "sour", depending upon their sulfur content. Sour crude oils contain more than 0.5 wt% of sulfur. Approximately 81 percent of the world's crude oils are sour (Riegel's Handbook of Industrial Chemicals, 2003, by E.R. Riegel and J.A. Kent. Springer Publishing). Some crude oils transported by the Keystone pipeline will be sour (WCS sulfur content is 3.5 wt% -- August 2007), while others will be sweet (Suncor's sulfur content is 0.2 wt% -- August 2007).

Water and Sediment: Water and sediment content of crude oil will be low, and is required to be less than 0.5% by tariff.

Constituents

Composition of crude oils can be found at: http://www.crudemonitor.ca/. This website includes quantification of light-end compounds, such as propane, butane, pentane, hexane, heptane, octane, nonanes, decanes, and BTEX, in a variety of crude oils. The BTEX concentrations for WCS and Suncor Synthetic A are provided below (August 2007 data, http://www.crudemonitor.ca/). BTEX concentrations would be less than one percent of the crude oil volume. For further information, a useful discussion of the solubility of crude oil compounds can be found in API 4675 (API 1999).

	Western Select % volume	Suncor Synthetic A % volume
Benzene	0.15	0.05
Toluene	0.27	0.22
Ethyl benzene	0.06	0.14
Xylenes	0.3	0.51
Total BTEX	0.78	0.92

With regard to naphthenic acids, crude for the Alberta oil sands are known to contain elevated concentrations of naphthenic acids. Other sources of

crude oils also contain elevated concentrations of naphthenic acids, including crude oil from Venezuela, Russia, Nigeria, and California. Oil derived from oil shale is also high in naphthenic acids.

Keystone has no information regarding the specific concentration of naphthenic acids within the crudes that will be transported by the pipeline. Napthenic acid concentrations are difficult to accurately measure and unavailable. However, TAN (total acid number) values for Canadian crudes are available as a surrogate measure (http://www.crudemonitor.ca/). Although TAN is not directly correlated to naphthenic acid concentration, naphthenic acids are a subset of the TAN value.

TAN is considered high when values exceed 1.5 mg KOH/g. There are some crude oils with very high TAN of greater than 5 mg KOG/g. The TAN value for WCS is 0.75 mg KOH/g, while TAN is not reported for light crudes, such as Suncor Synthetic A. While Alberta crudes can be moderately acidic (defined as TAN values ranging from 0.2 to 1.0 mg KOH/g), these values are less than other crudes (see table).

Crude Name	**TAN (mg KOH/g)**	**NAN (mg KOH/g)**	**NAN % of TAN**
Heimdal (Norway)	6.3	2.3	37
Mariner (North Sea)	4.2	2.3	55
Ratawi (Kuwait / Saudi Arabia)	0.4	0.1	25
Captain (Europe)	2.6	1.6	62
Midway Sunset (California)	4.7	2.1	45
West Texas (Texas)	1.2	0.2	17

Composition of crude oils can be found at: http://www.crudemonitor.ca/. A useful discussion of the solubility of crude oil compounds can be found in API 4675 (API 1999). Heavier oils are generally less soluble than lighter oils. It should be noted, however, that the actual concentrations of oil components in water underneath a slick are controlled not by the solubility limits of those components in water, but by the partitioning between the oil and water phase. Because the individual compounds are much more soluble in oil than in water, they tend to remain in the oil and the amounts that enter the water are much less than aqueous solubility limits (API 1999, O'Reilly et al. 2001).

Polycyclic Aromatic Hydrocarbons (PAHs)

Keystone has no information regarding the specific concentration of polycyclic aromatic hydrocarbons within the crudes that will be transported by the pipeline. Nevertheless, a useful discussion of PAHs found in crude oils and their water solubilities can be found in API 4675 (API 1999). In general, PAHs are non-polar, hydrophobic compounds that do not ionize and, as a consequence, have limited solubility and have a high affinity for suspended particles. A detailed discussion of PAHs in crude oils, their solubilities, and environmental fate and transport can be found in API 1999.

Heavy Metals (Trace Elements)

Trace elements are found in minor concentrations within all crude oils. The concentration of these elements depends upon the geological formations where the oil originates. The most common trace elements in crude are calcium, aluminum, and magnesium. These elements are present at concentrations of parts per thousands. In Alberta bitumen, the most abundant heavy metals are nickel and vanadium. Recent analyses indicate average concentrations of 52.0 parts per million (ppm) of nickel and 125.9 ppm of vanadium (Western Canadian Select – http://www.Crudemonitor.ca/archives/monthly/AprilHeavy2007.pdf). Other elements are present in the few ppm range and these include barium, molybdenum, and zinc. Trace metals that occur in the parts per billion (ppb) range include lead, fluorine, copper, bromine, manganese, selenium, and other elements (API 1999). Mercury is found in crude oils in the ppb range, but Alberta crude oils have mercury concentrations that are orders of magnitude lower (median = 1 ppb) than crudes from other locations (>20 ppb) (http://hgtech.com/Data/Oil/Crude%20Oil%20data.htm).

Potential Additives

Keystone understands that its shippers may add diluent (cutter stock), as necessary to ensure that crude oil to be shipped will meet specifications in Keystone's tariff. Although Keystone has no information on the use or source of any diluent that may be added, Keystone is aware that condensate or synthetic crude are typically used as diluent to achieve a heavy crude blend.

Condensate consists of lightweight petroleum hydrocarbons. Composition of a representative condensate can be found at: http://www.crudemonitor.ca/. Note that the components within the condensate are already incorporated into the overall composition of diluted bitumen and synthetic crudes (i.e., the composition of WCS already contains diluent).

Drag Reducing Agents

Drag Reducing Agents such as ConocoPhillips Liquid Power 100 Flow Improver comprised of 55% - 65% water and 35% - 45% proprietary additives.

Corrosion Inhibitors

Corrosion Inhibitors such as Baker Perolite CRW9110 Corrosion Inhibitor which is water soluble and amine based product.