SCREENING-LEVEL HAZARD CHARACTERIZATION

Crude Oil Category

SPONSORED CHEMICAL
Crude Oil (CASRN 8002-05-9)

The High Production Volume (HPV) Challenge Program[1] was conceived as a voluntary initiative aimed at developing and making publicly available screening-level health and environmental effects information on chemicals manufactured in or imported into the United States in quantities greater than one million pounds per year. In the Challenge Program, producers and importers of HPV chemicals voluntarily sponsored chemicals; sponsorship entailed the identification and initial assessment of the adequacy of existing toxicity data/information, conducting new testing if adequate data did not exist, and making both new and existing data and information available to the public. Each complete data submission contains data on 18 internationally agreed to "SIDS" (Screening Information Data Set[1,2]) endpoints that are screening-level indicators of potential hazards (toxicity) for humans or the environment.

The Environmental Protection Agency's Office of Pollution Prevention and Toxics (OPPT) is evaluating the data submitted in the HPV Challenge Program on approximately 1400 sponsored chemicals by developing hazard characterizations (HCs). These HCs consist of an evaluation of the quality and completeness of the data set provided in the Challenge Program submissions. They are not intended to be definitive statements regarding the possibility of unreasonable risk of injury to health or the environment.

The evaluation is performed according to established EPA guidance[2,3] and is based primarily on hazard data provided by sponsors; however, in preparing the hazard characterization, EPA considered its own comments and public comments on the original submission as well as the sponsor's responses to comments and revisions made to the submission. In order to determine whether any new hazard information was developed since the time of the HPV submission, a search of the following databases was made from one year prior to the date of the HPV Challenge submission to the present: (ChemID to locate available data sources including Medline/PubMed, Toxline, HSDB, IRIS, NTP, ATSDR, IARC, EXTOXNET, EPA SRS, etc.), STN/CAS online databases (Registry file for locators, ChemAbs for toxicology data, RTECS, Merck, etc.) and Science Direct. OPPT's focus on these specific sources is based on their being of high quality, highly relevant to hazard characterization, and publicly available.

OPPT does not develop HCs for those HPV chemicals which have already been assessed internationally through the HPV program of the Organization for Economic Cooperation and Development (OECD) and for which Screening Initial Data Set (SIDS) Initial Assessment Reports (SIAR) and SIDS Initial Assessment Profiles (SIAP) are available. These documents are presented in an international forum that involves review and endorsement by governmental

[1] U.S. EPA. High Production Volume (HPV) Challenge Program; http://www.epa.gov/chemrtk/index.htm.
[2] U.S. EPA. HPV Challenge Program – Information Sources; http://www.epa.gov/chemrtk/pubs/general/guidocs.htm.
[3] U.S. EPA. Risk Assessment Guidelines; http://cfpub.epa.gov/ncea/raf/rafguid.cfm.

authorities around the world. OPPT is an active participant in these meetings and accepts these documents as reliable screening-level hazard assessments.

These hazard characterizations are technical documents intended to inform subsequent decisions and actions by OPPT. Accordingly, the documents are not written with the goal of informing the general public. However, they do provide a vehicle for public access to a concise assessment of the raw technical data on HPV chemicals and provide information previously not readily available to the public.

Chemical Abstract Service Registry Number (CASRN)	**8002-05-9**
Chemical Abstract Index Name	**Crude Petroleum**
Structural Formula	**See Appendix**

Summary

Petroleum (crude oil) is a complex mixture of paraffinic, naphthenic and aromatic hydrocarbons ranging in carbon number from C1 to >C60. Petroleum typically also contains smaller amounts of heteroatom compounds, metals (either complexed with porphyrins or as salts of carboxylic acids) and hydrogen sulfide. Petroleum is not a uniform substance since its physical and chemical properties vary from oilfield to oilfield and can even vary within wells at the same oilfield. At one extreme, it is a light, mobile, straw-colored liquid. At the other extreme, it is a highly viscous, semi-solid, black substance. The lower molecular weight components of petroleum possess moderate to high water solubility while higher molecular weight fractions tend to form emulsions in water. The lower molecular weight components of petroleum have high vapor pressure while higher molecular weight fractions tend to possess negligible to low vapor pressure. The lighter weight aliphatic and aromatic components of petroleum will have high mobility in soils while the heavier molecular weight constituents will possess low mobility. Volatilization is expected to be moderate to high for most constituents of petroleum. The rate of hydrolysis is negligible since paraffins, naphthenes and the aromatic hydrocarbons contained in petroleum do not possess functional groups that hydrolyze under environmental conditions. The rate of atmospheric photooxidation is expected to be slow to rapid for most components of petroleum. The components of petroleum are expected to possess low (P1) to high (P3) persistence and low (B1) to high (B3) bioaccumulation potential.

The acute toxicity of CASRN 8002-05-9 is low in rats and mice by the oral route, low to moderate in rats and moderate in mice by the inhalation route and low in rabbits by the dermal route. A 28-day dermal repeated-dose toxicity study in rats showed reduced body weight gain in males at 2500 mg/kg-day and no effects in females at 2500 mg/kg-day (highest dose tested). The NOAEL is 250 mg/kg-day in males and 2500 mg/kg-day in females. A 90-day dermal repeated-dose toxicity study in rats showed hypertrophy and hyperplasia of follicular thyroid epithelium in males and females at 30 mg/kg-day; the NOAEL was not established. In a second 90-day dermal repeated-dose toxicity study in rats, both males and females showed hypertrophy and hyperplasia of follicular thyroid epithelium and males showed increased bone marrow cellularity at 30 mg/kg-day; the NOAEL was not established. No specific reproductive toxicity studies are available. In the dermal repeated-dose toxicity study, no effects on the reproductive organs were observed in male rats treated with 500 mg/kg-day (only dose tested). In a prenatal developmental toxicity study in rats administered CASRN 8002-05-9 via gavage, reduced maternal body weight was observed at 887 mg/kg-day; the NOAEL for maternal toxicity was not established. Signs of developmental toxicity consisted of reduced fetal weight, reduced fetal

crown-rump length, increased numbers of resorptions and the number of dead fetuses and decreased number of live fetuses at 887 mg/kg-day; the NOAEL for developmental toxicity was not established. In a prenatal developmental toxicity study in rats administered CASRN 8002-05-9 dermally, reduced maternal body weight was observed at 500 mg/kg-day; the NOAEL for maternal toxicity is 125 mg/kg-day. Signs of developmental toxicity consisted of increased number of resorptions, decreased litter size, decreased fetal weight, incomplete ossification of nasal bones and caudal centra and an increased incidence of pup mortality during lactation at 500 mg/kg-day; the NOAEL for developmental toxicity is 125 mg/kg-day. In another prenatal developmental toxicity study in rats administered CASRN 8002-05-9 dermally, reduced maternal body weight was observed at 500 mg/kg-day; the NOAEL for maternal toxicity is 125 mg/kg-day. Incomplete ossification of fetal nasal bones was observed in pups at 125 mg/kg-day; the NOAEL for developmental toxicity was not established. In a third prenatal developmental toxicity study in rats administered CASRN 8002-05-9 dermally, reduced maternal body weight was observed at 1000 mg/kg-day; the NOAEL for maternal toxicity is 500 mg/kg-day. Signs of developmental toxicity consisted of reduced pup body weight and body weight gain at 1000 mg/kg-day; the NOAEL for developmental toxicity is 500 mg/kg-day. CASRN 8002-05-9 was mutagenic in bacteria *in vitro* but did not show evidence of chromosomal aberrations in mammalian cells *in vitro.* CASRN 8002-05-9 did induce chromosomal aberrations in mice *in vivo*. CASRN 8002-05-9 is irritating to rabbit skin and eyes and did not induce sensitization in guinea pigs. CASRN 8002-05-9 is carcinogenic to mice via dermal exposure.

Reproductive toxicity was identified as a data gap under the HPV Challenge Program.

The 96-h LC_{50} of CASRN 8002-05-9 for fish ranges from 0.73 to 42 mg/L. The 48-h EC_{50} of CASRN 8002-05-9 for aquatic invertebrates ranges from 0.61 to 28 mg/L. The 21-d chronic toxicity to aquatic invertebrates ranges from 0.5 to 6 mg/L.

The toxicity to aquatic plants endpoint was identified as a data gap under the HPV Challenge Program.

The sponsor, American Petroleum Institute (API) Petroleum HPV Testing Group, submitted a Test Plan and Robust Summaries to EPA for Crude Oil (CASRN 8002-05-9) on November 25, 2003. EPA posted the submission on the ChemRTK HPV Challenge website on December 19, 2003 (http://www.epa.gov/oppt/chemrtk/pubs/summaries/crdoilct/c14858tc.htm). EPA comments on the original submission were posted to the website on May 20, 2004. Public comments were also received and posted to the website. The sponsor submitted updated/revised documents on January 14, 2011, which were posted to the website on February 3, 2011.

Category Justification

The crude oil category contains only CASRN 8002-05-9 and represents all conventional crude oils, including synthetic crude oils derived from tar sands, regardless of source or hydrocarbon distribution. Crude oil is a Class 2[4] substance which may contain varying concentrations of paraffinic, naphthenic and aromatic hydrocarbons with carbon numbers ranging from C1 to C60+. The proportions of paraffinic, naphthenic, and aromatic hydrocarbons, as well as other components, differ among geographic regions. Crude oils also contain varying amounts of nitrogen, oxygen, and sulfur compounds, organometallic complexes (notably of sulfur and vanadium), dissolved gases such as hydrogen sulfide, heteroatoms (e.g., nitrogen- and oxygen-containing hydrocarbon analogs), and asphaltenes. The heterogeneity in the composition of the different crude oils, could produce different profiles of toxic effects in mammals and aquatic organisms. EPA agrees, however, that grouping these mixtures into a single category is appropriate based on the general composition profile and physicochemical properties. EPA recognizes that due to the nature of crude oil and the compositional variation that can occur with region of origin and even location within a geographic formation, the specific crude oils represented in the studies presented in this hazard characterization may not be representative of the hazard observed following exposure to different crude oils which have not been tested.

1. Chemical Identity

1.1 Identification and Purity

The following description is taken from the 2003 Test Plan and Robust Summary. Crude oil is a complex combination of hydrocarbons consisting predominantly of aliphatic, alicyclic and aromatic hydrocarbons covering the carbon number range from C1 to C60+. It also contains sulfur, oxygen and nitrogen compounds, organometallic complexes notably of sulfur and vanadium, and dissolved gases such as hydrogen sulfide. In appearance, crude oils range from thin, light colored oils consisting mainly of gasoline-quality stock to heavy, thick tar-like

[4] Class 2 denotes a chemical that occurs as a complex mixture of different individual substances rather than existing as a single chemical species with a well-defined molecular structure (e.g., a paraffin wax). Class 2 compounds also include unknown or variable composition complex reaction products, biological materials (UVCB). UVCB substances can for example be described by structural features (e.g. acid chlorides, alkaline earth compounds, polyoxyalkylenes), a significant precursor (e.g. Castor Oil or Tallow) or by a more general description (e.g. Resins or Waxes.)

materials. The chemical composition of crude oils from different producing regions, and even from within a particular formation, can vary tremendously. An "average" crude contains 84% carbon, 14% hydrogen, 1-3% sulfur, and approximately 1.0 % nitrogen, 1.0% oxygen and 0.1% minerals and salts. Crude oils are identified by the predominant proportion of similar hydrocarbon molecules and are further classified by viscosity, specific gravity (density) and by American Petroleum Institute (API) gravity. API gravity is an indication of the gasoline potential of crude oil with higher API gravity indicating greater gasoline potential and thus more valuable crude oil. Paraffinic crude oils are rich in straight chain and branched paraffins, have a high API gravity, low density and viscosity, and contain a higher concentration of gasoline grade naphtha. Naphthenic crude oils contain mainly cycloparaffins and aromatic hydrocarbons, have low API gravity, higher density and viscosity and contain residual materials and heteroatoms (e.g. sulfur, nitrogen, and oxygen-containing hydrocarbon analogs).

1.2 Physical-Chemical Properties

The physical-chemical properties of crude oil are summarized in Table 1. Petroleum (crude oil) is not a uniform substance since its physical and chemical properties vary from oilfield to oilfield and can even vary within wells at the same oilfield. At one extreme, it is a light, mobile, straw-colored liquid. At the other extreme, it is a highly viscous, semi-solid, black substance from which little can be distilled at atmospheric pressure before thermal decomposition occurs. The lower molecular weight components of petroleum possess moderate to high water solubility while higher molecular weight fractions tend to form emulsions in water. The lower molecular weight components of petroleum have high vapor pressure while higher molecular weight fractions tend to possess negligible to low vapor pressure.

Table 1. Physical-Chemical Properties of Petroleum[1]

Property	Petroleum (Crude Oil)
CASRN	8002-05-9
Molecular Weight	Complex Mixture
Physical State	Light, mobile, straw-colored liquid to highly viscous, semi-solid, black substance
Melting Point	-30 to 30 °C (measured pour points)
Boiling Point	-1 to 565 °C (measured distillation range)
Vapor Pressure	142.5 mm Hg at 37 °C (measured Alaska North Slope crude oil); 165.8 mm Hg at 37 °C (measured Arabian medium crude oil); 337.5 mm Hg at 37 °C (measured Alif Temen crude oil); 202.5 mm Hg at 37 °C (measured Amna Libya crude oil); 97.5 mm Hg at 37 °C (measured Ashtart Tunisia crude oil); 45 mm Hg at 37 °C (measured Atkinson Canadian crude oil); 142.5 mm Hg at 37 °C (measured Alberta sweet mixed blend Canadian crude oil); 180 mm Hg at 37 °C (measured United Arab Emirate crude oil); 270 mm Hg at 37 °C (measured Beryl North Sea crude oil); 247.5 mm Hg at 37 °C (measured Bombay High Indiacrude oil);

Table 1. Physical-Chemical Properties of Petroleum[1]	
	Aliphatic Fraction[2,3] 266 mm Hg (estimated >C5-C6); 47.9 mm Hg (estimated >C6-C8); 4.8 mm Hg (estimated >C8-C10); 0.48 mm Hg (estimated >C10-C12); 0.036 mm Hg (estimated >C12-C16); 8.3×10^{-4} mm Hg (estimated >C16-C21); Aromatic Fraction[2,3] 98.8 mm Hg (estimated >C5-C7); 28.9 mm Hg (estimated >C7-C8); 4.8 mm Hg (estimated >C8-C10); 0.48 mm Hg (estimated >C10-C12); 0.036 mm Hg (estimated >C12-C16); 8.3×10^{-4} mm Hg (estimated >C16-C21); 3.3×10^{-7} mm Hg (estimated >C21-C35)
Dissociation Constant (pK_a)	Not applicable
Henry's Law Constant	Aliphatic Fraction[2,3] 0.74 atm-m^3/mol (estimated >C5-C6); 1.12 atm-m^3/mol (estimated >C6-C8); 1.79 atm-m^3/mol (estimated >C8-C10); 2.69 atm-m^3/mol (estimated >C10-C12); 11.7 atm-m^3/mol (estimated >C12-C16); 110 atm-m^3/mol (estimated >C16-C21); Aromatic Fraction[2,3] 0.0052 atm-m^3/mol (estimated >C5-C7); 0.0060 atm-m^3/mol (estimated >C7-C8); 0.011 atm-m^3/mol (estimated >C8-C10); 0.003 atm-m^3/mol (estimated >C10-C12); 0.001 atm-m^3/mol (estimated >C12-C16); 0.0029 atm-m^3/mol (estimated >C16-C21); 1.5×10^{-5} atm-m^3/mol (estimated >C21-C35)
Water Solubility	30 mg/L (measured at 5 °C; Norman Wells crude oil)[1,4]; 29-33 mg/L (measured at 20 °C; Norman Wells crude oil) [1,4]; 31.8-33.5 mg/L (measured at 22 °C; Norman Wells crude oil) [1,4]; 33 mg/L (measured at 20 °C; Norman Wells crude oil) [1,4]; 25.02 mg/L (measured at 22 °C; Alberta crude oil) [1,4]; 35.1 mg/L (measured at 22 °C; Swan Hills) [1,4]; 29.01 mg/L (measured at 22 °C; Prudhoe Bay crude oil) [1,4]; 23.66-25.5 mg/L (measured at 22 °C; Lago Medio crude oil) [1,4]; 10.42 mg/L (measured at 22 °C; Kopanoar crude oil) [1,4]; 28.62 mg/L (measured at 22 °C; Murban crude oil) [1,4]; 29.6 mg/L (measured at 22 °C; Mobil A crude oil) [1,4];

Table 1. Physical-Chemical Properties of Petroleum[1]	
	58 mg/L (measured at 22 °C; Mobil B crude oil) [1,4] Aliphatic Fraction[2,3] 36 mg/L (estimated >C5-C6); 5.4 mg/L (estimated >C6-C8); 0.43 mg/L (estimated >C8-C10); 0.034 mg/L (estimated >C10-C12); 7.6×10^{-4} mg/L (estimated >C12-C16); Aromatic Fraction[2,3] 1,800 mg/L (estimated >C5-C7); 520 mg/L (estimated >C7-C8); 65 mg/L (estimated >C8-C10); 25 mg/L (estimated >C10-C12); 5.8 mg/L (estimated >C12-C16); 0.65 mg/L (estimated >C16-C21); 6.6×10^{-3} mg/L (estimated >C21-C35)
Log K_{ow}	2 to > 6 (estimated)

[1] American Petroleum Institute Petroleum HPV Testing Group. Test Plan and Robust Summary for Crude Oil. November 15, 2003. Available online at http://www.epa.gov/oppt/chemrtk/pubs/summaries/crdoilct/c14858tc.htm as of December 7, 2010.
[2] Total Petroleum Hydrocarbon Criteria Working Group; Human Health Risk- Based Evaluation of Petroleum Release Sites: Implementing the Working Group Approach Volume 5. June 1999.
[3] The Total Petroleum Hydrocarbon Working Group subdivided aromatics and aliphatic hydrocarbons of crude oil into 13 aliphatic and aromatic fractions and provided representative physical-chemical properties for these fractions.
[4] Results based on the water soluble fraction of total benzene, toluene, ethyl benzene + xylenes (combined concentration) and naphthalenes. The lower molecular weight components may dissolve in water while other fractions may float and spread out on water where they may form emulsions.

2. General Information on Exposure

2.1 Production Volume and Use Pattern

The Crude Oil category chemicals had an aggregated production and/or import volume in the United States greater than one billion pounds in calendar year 2005.

No industrial processing and uses and commercial and consumer uses were reported for the chemical.

2.2 Environmental Exposure and Fate

The environmental fate properties are provided in Table 2. The low molecular weight aliphatic and aromatic components of petroleum are expected to possess high mobility in soil while the heavier molecular weight constituents are expected to possess low mobility. Four petroleum samples were tested for biodegradation over the course of a 28 day incubation period by cultures

of Acinetobacter sp. and a mixed microbial consortium isolated from sediment obtained from Shizugawa Bay, Japan. The oils were initially heat treated to 100 °C in order to remove the low molecular weight constituents that may be considered readily biodegradable. Roughly 12-20% biodegradation was observed for the crude oil samples over 28 days with exposure to Acinetobacter sp. and 19-34% biodegradation was observed for exposure to the mixed microbial cultures. Petroleum added to unamended seawater samples was 3% degraded (1% mineralized) in 18 days; however, addition of nitrate and phosphate nutrients to the seawater increased the degradation and mineralization to 70 and 42%, respectively over the 18 day incubation period. Seven petroleum samples were degraded 11-50% after 42 days using nitrate and phosphate amended seawater obtained off the coast of California. Gas-chromatography analysis indicated that paraffinic components (both linear and branched) degraded at a greater rate than aromatic components and the asphaltic components were very slow to degrade. In general, n-alkanes are readily degraded under environmental conditions. Branched-chain or iso-alkanes are less readily biodegraded, but they do ultimately biodegrade. The degradation of cycloalkanes has not been extensively studied, but the ring structure is more resistant to biodegradation, and degrades more slowly. Aromatic hydrocarbons are also resistant to biodegradation, but a few microorganisms are able to utilize them. High molecular weight compounds, the tars and asphaltenes, show little to no degradation, and are persistent. Volatilization of the components of petroleum is expected to be moderate to high. The rate of hydrolysis is expected to be negligible since the substances in petroleum do not possess functional groups that hydrolyze under environmental conditions. The components of petroleum are expected to possess low (P1) to high (P3) persistence and low (B1) to high (B3) bioaccumulation potential.

Conclusion: Petroleum (crude oil) is a complex mixture of paraffinic, naphthenic and aromatic hydrocarbons ranging in carbon number from C1 to >C60. Petroleum typically also contain smaller amounts of heteroatom compounds, metals (either complexed with porphyrins or as salts of carboxylic acids) and hydrogen sulfide. Petroleum is not a uniform substance since its physical and chemical properties vary from oilfield to oilfield and can even vary within wells at the same oilfield. At one extreme, it is a light, mobile, straw-colored liquid. At the other extreme, it is a highly viscous, semi-solid, black substance. The lower molecular weight components of petroleum possess moderate to high water solubility while higher molecular weight fractions tend to form emulsions in water. The lower molecular weight components of petroleum have high vapor pressure while higher molecular weight fractions tend to possess negligible to low vapor pressure. The lighter weight aliphatic and aromatic components of petroleum will have high mobility in soils while the heavier molecular weight constituents will possess low mobility. Volatilization is expected to be moderate to high for most constituents of petroleum. The rate of hydrolysis is negligible since paraffins, naphthenes and the aromatic hydrocarbons contained in petroleum do not possess functional groups that hydrolyze under environmental conditions. The rate of atmospheric photooxidation is expected to be slow to rapid for most components of petroleum. The components of petroleum are expected to possess low (P1) to high (P3) persistence and low (B1) to high (B3) bioaccumulation potential.

Table 2. Environmental Fate Properties of Petroleum[1]	
Property	Petroleum (Crude Oil)
CASRN	8002-05-9
Photodegradation Half-life	0.37 – 6.5 days (estimated)[1,2]
Hydrolysis Half-life	Stable
Biodegradation	12-20% after 28 days (not readily biodegradable)[3]; 19-34% after 28 days (not readily biodegradable)[3]; 70% after 18 days in seawater amended with nitrate and phosphate nutrients[4]; 11-50% after 42 days in seawater amended with nitrate and phosphate nutrients[5]
Bioaccumulation Factor	38 – 5.1×10^5 (estimated)[2,6]
Log K_{oc}	1.6 – 4.2 (estimated)[2,6]
Fugacity (Level III Model)[2,6]	
Air (%)	19.4 – 48.4
Water (%)	41.1 – 69.4
Soil (%)	0.8 – 39.4
Sediment (%)	0.2 – 11.5
Persistence[7]	P1(low) – P3 (high)
Bioaccumulation[7]	B1 (low) – B3 (high)

[1] American Petroleum Institute Petroleum HPV Testing Group. Test Plan and Robust Summary for Crude Oil. November 15, 2003. Available online at http://www.epa.gov/oppt/chemrtk/pubs/summaries/crdoilct/c14858tc.htm as of December 7, 2010.
[2] Estimated values for benzene, n-butane, n-hexane, toluene, cyclohexane, n-decane, n-tetradecane and naphthalene.
[3] Sugiura K. Ishihara M. Shimauchi,T. Harayama S. 1997. Physiochemical properties and biodegradability of crude oil. Environ. Sci. Technol. 31:45-51.
[4] Atlas RM and Barth R. 1972. Degradation and mineralization of petroleum in sea water. Limitation by nitrogen and phosphorus. Biotechnol. Bioeng. 14:309-18.
[5] Atlas R. 1975. Effects of temperature and crude oil composition on petroleum biodegradation. Appl. Microbiol. 30(3) 396-403.
[6] U.S. EPA. 2010. Estimation Programs Interface Suite™ for Microsoft® Windows, v4.00. U.S. Environmental Protection Agency, Washington, DC, USA. Available online from: http://www.epa.gov/opptintr/exposure/pubs/episuitedl.htm as of December 7, 2010.
[7] Federal Register. 1999. Category for Persistent, Bioaccumulative, and Toxic New Chemical Substances. *Federal Register* 64, Number 213 (November 4, 1999) pp. 60194–60204.

3. Human Health Hazard

A summary of health effects data submitted for SIDS endpoints is provided in Table 3.

Acute Oral Toxicity

Beryl light crude oil
Sprague-Dawley rats (5/sex) were administered a single dose of Beryl light crude oil via gavage at 5000 mg/kg and observed for 14 days. No mortalities were observed.
LD_{50} > 5000 mg/kg

Lost Hills light crude oil
Rats (sex/strain/number not specified) were administered Lost Hills light crude oil via an unspecified oral route. No further methods were specified.
LD_{50} > 5000 mg/kg

MCSL crude oil
Rats (sex/strain/number not specified) were administered MCSL crude oil via an unspecified oral route. No further methods were specified.
LD_{50} > 5000 mg/kg

Arab light crude oil
Rats (sex/strain/number not specified) were administered Arab light crude oil via an unspecified oral route. No further methods were specified.
LD_{50} > 5000 mg/kg

Belridge heavy crude oil
Rats (sex/strain/number not specified) were administered Belridge heavy crude oil via an unspecified oral route. No further methods were specified.
LD_{50} > 5000 mg/kg

Wilmington crude oil
Male mice (sex/strain/number not specified) were administered Wilmington crude oil via an unspecified oral route. No further methods were specified.
LD_{50} > 16,000 mg/kg

Recluse crude oil
Male mice (sex/strain/number not specified) were administered recluse crude oil via an unspecified oral route. No further methods were specified.
LD_{50} > 16,000 mg/kg

Mixed petroleum crude oil
Male mice (sex/strain/number not specified) were administered mixed petroleum crude oil via an unspecified oral route. No further methods were specified.
LD_{50} > 10,000 mg/kg

Acute Inhalation Toxicity

Athabasca oil sands synthetic crude oil
Sprague-Dawley rats (5/sex) were exposed via whole-body inhalation to Athabasca oil sands synthetic crude oil as an aerosol at 4.0 mg/L for 6 hours and observed for 14 days. No mortality was observed (Stubblefield *et al.*, 1989).
LD_{50} > 4 mg/L

Athabasca oil sands synthetic crude oil
Swiss-Webster mice (5/sex) were exposed via whole-body inhalation to Athabasca oil sands synthetic crude oil as an aerosol at 4.0 mg/L for 6 hours and observed for 14 days. Five of the 10 mice died within the 14-day observation period (Stubblefield *et al.*, 1989).
LD_{50} = ~ 4 mg/L

Acute Dermal Toxicity

Beryl light crude oil
New Zealand White rabbits (3/sex) were administered Beryl crude light oil via dermal application at 2000 mg/kg to intact or abraded clipped skin, under occluded conditions, for 24 hours and observed for 14 days. No mortalities were observed.
LD_{50} > 2000 mg/kg

Lost Hills light crude oil
Rabbits (sex/strain/number not specified) were administered Lost Hills light crude oil via dermal application. No further methods were specified.
LD_{50} > 2000 mg/kg

MCSL crude oil
Rabbits (sex/strain/number not specified) were administered MCSL crude oil via dermal application. No further methods were specified.
LD_{50} > 2000 mg/kg

Arab light crude oil
Rabbits (sex/strain/number not specified) were administered Arab light crude oil via dermal application. No further methods were specified.
LD_{50} > 2000 mg/kg

Belridge heavy crude oil
Rabbits (sex/strain/number not specified) were administered Belridge heavy crude oil via dermal application. No further methods were specified.
LD_{50} > 2000 mg/kg

Repeated-Dose Toxicity

High-nitrogen crude oil

Sprague-Dawley rats (10/sex/dose) were administered high-nitrogen crude oil (API-HNC-1) via the dermal route at 250 or 2500 mg/kg-day on intact skin under occluded conditions for 6 hours/day, 5 days/week for 4 weeks. An additional control group (20/sex) was sham-treated. Overt signs of toxicity, dermal responses, body weights, food consumption, hematology, clinical chemistry and organ weights were examined. Males exposed to 250 mg/kg-day did not gain as much weight as controls and males exposed to 2500 mg/kg-day showed a significant decrease in body weight as compared to controls (statistical significance not reported). Females exposed to 2500 mg/kg-day had increased absolute and relative liver weights and increased absolute adrenal weights and males exposed to 2500 mg/kg-day had increased relative liver weight (details on absolute liver weight not provided). These data are summarized in TSCATS (OTS0000381 and OTS0000381-1).
LOAEL (male) = 2500 mg/kg-day (based on reduced body weight gain)
NOAEL (male) = 250 mg/kg-day
NOAEL (female) = 2500 mg/kg-day (based on no effects observed at the highest dose tested)

Lost Hills light crude oil
Sprague-Dawley rats (10/sex/dose) were administered Lost Hills light crude oil (50% non-aromatics, 35.3% < 3-ring polyaromatic hydrocarbons [PAHs], 10.2% 3 – 5 ring PAHs, 2.4% sulfur polyaromatic compounds [PACs] and 5.4% nitrogen PACs) via dermal application, to shorn skin under open conditions at 0 (untreated control), 30, 125 or 500 mg/kg-day, 5 days/week for 13 weeks. Animals were fitted with collars to minimize the ingestion of the Lost Hills light crude oil. Endpoints included body weight, hematology, clinical chemistry, organ weights, and histopathology. Additional groups of 10 males/dose were administered crude oil at 0 and 500 mg/kg-day and evaluated for male reproductive health. Measurements included weights of testes and cauda epididymides, number of sperm and percent normal sperm in the cauda and number of spermatids in the testes. Minimal skin irritation (flaking) was observed at the exposure site. No treatment-related mortality was observed. Decreases in red blood cells (RBCs), hemoglobin and hematocrit were observed in males at 500 mg/kg-day. Changes in clinical chemistry at 500 mg/kg-day included decreased calcium (in males), increased glucose (in both sexes), increased urea nitrogen (in males) and decreased potassium (in females). Glucose was also elevated in males at 125 mg/kg-day and in females at 30 mg/kg-day, but glucose was not elevated in females at 125 mg/kg-day. Increases in absolute and relative liver weights were observed in both males and females at 500 mg/kg-day. Hyperplasia and associated dermal inflammatory cell infiltration were observed at all dose levels. Histopathological effects in the liver included multifocal, mononuclear cell infiltration (in three males and two females) and multifocal hepatocellular vaculolation (in three females) at 500 mg/kg-day. Atrophy of the thymus was observed in one male and two females at 500 mg/kg-day. Hypertrophy and hyperplasia of follicular thyroid epithelium were observed in both sexes at all dose levels (incidence rate not specified). No effects were observed on the reproductive health of males.
LOAEL = 30 mg/kg-day (based on hypertrophy and hyperplasia of follicular thyroid epithelium)
NOAEL = Not established

Belridge heavy crude oil
Sprague-Dawley rats (10/sex/dose) were administered Belridge heavy crude oil (37.3% non-aromatics, 41.7% < 3-ring PAHs, 15.7% 3-5 ring PAHs, 2.9% sulfur PACs and 8.4% nitrogen

PACs) to shorn skin under open conditions at 0 (untreated control), 30, 125 or 500 mg/kg-day, 5 days/week for 13 weeks. Animals were fitted with collars to minimize the ingestion of the Belridge heavy crude oil. Endpoints included body weight, hematology, clinical chemistry, organ weights and histopathology. Additional groups of 10 males/dose were administered crude oil at 0 and 500 mg/kg-day and evaluated for male reproductive health. Measurements included weights of testes and cauda epididymides, number of sperm and percent normal sperm in the cauda and number of spermatids in the testes. Minimal skin irritation (flaking) was observed at the exposure site. No treatment-related mortality was observed. Reduced weight gain was observed at 500 mg/kg-day. Decreases in RBCs, hemoglobin and hematocrit in both sexes and a decrease in platelets in males were observed at 500 mg/kg-day. Changes in clinical chemistry at 500 mg/kg-day included decreased uric acid in both sexes, increased urea nitrogen in females and reduced alanine transaminase and potassium in females. Cholesterol was elevated in females at doses ≥ 125 mg/kg-day. Hyperplasia and associated dermal inflammatory cell infiltration were observed at all treatment levels. Increases in absolute and relative liver weights were observed in both males and females at 500 mg/kg-day. Decreases in absolute (both sexes) and relative (females only) thymus weights were also observed at 500 mg/kg-day. Elevated relative liver weights were observed in males at 125 mg/kg-day. Increased cellularity was observed in the bone marrow of two males at 30 and 125 mg/kg-day, in six males at 500 mg/kg-day and in 9 of 10 females at an unspecified dose level. Focal necrosis was noted in the bone marrow of two males at 500 mg/kg-day. Histopathological effects in the liver at 500 mg/kg-day consisted of hepatocellular vacuolation in one male and one female and mononuclear cell infiltration in one male. Atrophy of the thymus was observed in six males and seven females at 500 mg/kg-day. Hypertrophy and hyperplasia of follicular thyroid epithelium was observed in a few animals at all dose levels (details not specified). Effects on the reproductive health of males were not noted.
LOAEL = 30 mg/kg-day (based on hypertrophy and hyperplasia of follicular thyroid epithelium in both sexes and increased cellularity of the bone marrow of males)
NOAEL = Not established

Reproductive Toxicity

Lost Hills light crude oil

In the repeated-dose toxicity study described previously, male Sprague-Dawley rats administered Lost Hills light crude oil via dermal application at 500 mg/kg-day did not exhibit changes in the weights of testes and cauda epididymides, number of sperm and the percent of normal sperm in the cauda or number of spermatids in the testes.

Developmental Toxicity

Prudhoe Bay heavy crude oil

In a prenatal developmental toxicity study, pregnant Sprague-Dawley rats (8 – 11/dose) were administered Prudhoe Bay heavy crude oil via gavage at 1 or 2 mL/kg-day (887 or 1774 mg/kg-day)[5] on gestation days 6 – 17. Animals were sacrificed on gestation day 18. Measured

[5] Volume of crude oil was converted to units of mg/kg-day using an API gravity of 28 (supplied in the sponsor's test plan), which is equivalent to a density of 0.8871 g/mL.

endpoints included the numbers and position of implantations, resorptions and dead fetuses, fetal weights and gross appearance of fetuses. No maternal mortality was observed. Reductions in body weight gain were observed in dams receiving ≥ 1 mL/kg-day. Developmental effects included reduced fetal weights and fetal crown-rump length, increases in the incidence of resorptions and the number of dead fetuses, and a decrease in the number of live fetuses at ≥ 1 mL/kg-day. Examination of fetuses for skeletal and visceral abnormalities was not conducted.
LOAEL (maternal/developmental toxicity) = 887 mg/kg-day (based on reductions in maternal body weight, reduced fetal weights and fetal crown-rump length, increases in the incidence of resorptions and the number of dead fetuses, and a decrease in the number of live fetuses)
NOAEL (maternal/developmental toxicity) = Not established

Belridge heavy crude oil
In a prenatal developmental toxicity study, pregnant Sprague-Dawley rats (12/group) were administered Belridge heavy crude oil (77% paraffins and naphthenes, 15% polynuclear aromatic content and 2% asphaltenes) via the dermal route under open conditions at 0 (sham control), 30, 125 or 500 mg/kg-day on gestation days 0 – 19. Animals were fitted with collars to minimize the ingestion of the Belridge heavy crude oil. One group of females was sacrificed on day 20 and an additional group of females (exposed to 0 or 500 mg/kg-day) was allowed to deliver and was sacrificed, along with their offspring, on postpartum day 4. Measured endpoints included maternal body weights, food consumption and serum chemistry (parameters not specified), number of corpora lutea, number and location of implantations, fetal weight and sex and external, skeletal and visceral anomalies. Skin irritation was observed in dams administered 500 mg/kg- day and included erythema, edema, scabs and open sores. Red vaginal discharge was also observed at 500 mg/kg-day. Reductions in maternal body weight and food consumption and an increase in relative liver weight were all observed at 500 mg/kg-day. Total bilirubin was reduced by 38%, compared to controls, at 500 mg/kg-day. Among the dams allowed to deliver, 2/12 dams had no viable offspring. Developmental effects were observed only at 500 mg/kg-day and included an increase in the mean number and percent of resorptions, a decrease in litter size, a decrease in mean fetal weight for all viable fetuses, incomplete ossification of the nasal bones and caudal centra and an increased incidence of pup mortality during lactation. These data are summarized in TSCATS (OTS0509763-9).
LOAEL (maternal toxicity) = 500 mg/kg-day (based on reductions in maternal body weight)
NOAEL (maternal toxicity) = 125 mg/kg-day
LOAEL (developmental toxicity) = 500 mg/kg-day (based on an increase in the mean number and percent of resorptions, a decrease in litter size, a decrease in mean fetal weight for all viable fetuses, incomplete ossification of the nasal bones and caudal centra and an increased incidence of pup mortality during lactation)
NOAEL (developmental toxicity) = 125 mg/kg-day

Lost Hills light crude oil
(1) In a prenatal developmental toxicity study, pregnant Sprague-Dawley rats (12/group) were administered Lost Hills light crude oil (78% paraffins and naphthenes, 8% polynuclear aromatic content and 1% asphaltenes) via the dermal route under open conditions at 0 (sham control), 125, 500 or 2000 mg/kg-day on gestation days 0 – 19. Animals were fitted with collars to minimize the ingestion of the Lost Hills light crude oil. One group of females was sacrificed on day 20 and an additional group of females (exposed to 0 or 2000 mg/kg-day) was allowed to deliver and

was sacrificed, along with their offspring, on postpartum day 4. Measured endpoints included maternal body weights, food consumption and serum chemistry (parameters not specified), number of corpora lutea, number and location of implantations, fetal weight and sex and external, skeletal and visceral anomalies. Clinical observations consisted of red vaginal discharge, paleness of skin and slight skin irritation at 2000 mg/kg-day. Reductions in weight gain and food consumption were observed at doses ≥ 500 mg/kg-day. Absolute and relative thymus weights were statistically significantly decreased in animals treated with 2000 mg/kg-day and a non-statistically significant decrease in absolute thymus weight was observed at 500 mg/kg-day. Relative liver weight was increased at doses ≥ 500 mg/kg-day. Effects on serum chemistry at 2000 mg/kg-day included increases in aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase, cholesterol, albumin/globulin ratio, phosphorus and sorbitol dehydrogenase. Decreases in triglycerides and total bilirubin were observed at doses ≥ 500 mg/kg-day. Among the dams allowed to deliver, 3/12 dams had no viable offspring and another 2 dams had their entire litter die by postpartum day 3. Developmental effects included an increase in the mean number and percent of resorptions, a decrease in litter size, a decrease in mean fetal weight, reduced pup weight at birth and on lactation day 4 and a decrease in pup survival during lactation at 2000 mg/kg-day. Incomplete ossification was more common in fetuses of treated dams, with the following skeletal areas being significantly ($p < 0.05$) affected: nasal bones at doses ≥ 125 mg/kg-day, thoracic centra and sternebrae at 2000 mg/kg-day and caudal centra at 125 and 2000 mg/kg-day. These data are summarized in TSCATS (OTS0509763-9).
LOAEL (maternal toxicity) = 500 mg/kg-day (based on reductions in maternal weight gain)
NOAEL (maternal toxicity) = 125 mg/kg-day
LOAEL (developmental toxicity) = 125 mg/kg-day (based on incomplete ossification of fetal nasal bones)
NOAEL (developmental toxicity) = Not established

(2) In a prenatal developmental toxicity study, pregnant Sprague-Dawley rats (12/group) were administered Lost Hills light crude oil via the dermal route at 0 (sham control), 125, 500 or 1000 mg/kg-day to intact skin under open conditions on gestation days 0 – 19. Animals were fitted with collars to minimize the ingestion of the Lost Hills light crude oil. Dams were sacrificed on postpartum day 21 and their litters on postpartum day 28. One female in the 500 mg/kg/day group had excessive salivation one day during gestation. One female in the 1000 mg/kg/day group was sacrificed moribund on gestation day 14. The animal had decreased motor activity, decreased stool, red vaginal discharge, pale extremities and felt cool to the touch. Upon macroscopic examination, this female was noted to have enlarged adrenals. Uterine examination revealed total litter resorptions (13 fetuses), which would account for the red vaginal discharge. Scabbing was observed at the dose site of three treated animals (doses not specified). This finding was considered to be animal-induced (via scratching or biting). One high-dose female exhibited erythema and flaking of the skin at the dose site. Females in the 1000 mg/kg/day group gained significantly ($p < 0.05$) less weight towards the end of gestation. Overall weight gain (days 0 – 20) was also significantly ($p < 0.05$) affected for this group as overall weight gain decreased with increasing dose level. No adverse body weight effects were observed during lactation. Upon necropsy, mottled lungs were seen in one female from the high-dose group. This finding was not considered to be related to treatment due to its isolated occurrence. A significant ($p < 0.05$) decrease in pup body weight was first noted in the high-dose female pups

on postpartum day 21. By day 28, both sexes weighed significantly ($p < 0.05$) less than control pups. There were no treatment-related effects on mating, fertility and gestation indices, duration of gestation, the numbers of stillborn and live pups, pup survival or the number of implantation sites per litter. In addition, pup development evaluations, which included monitoring of pinna detachment, hair growth, incisor eruption, eye opening and surface righting, showed no evidence of treatment-related effects. One mid- and one high-dose pup had enlarged ventricles of the brain, but the effect was not statistically significant or dose-dependent. This variation is occasionally seen during visceral examination of the brain of small fetuses. Both pups demonstrating this finding were smaller than their littermates. Varied findings were noted during pup necropsy, but were not considered to be treatment-related due to presence in the control group or lack of a dose-related response. These data are summarized in TSCATS (OTS0509763-9).

LOAEL (maternal/developmental toxicity) = 1000 mg/kg-day (based on reduced maternal body weight gains during gestation and reduced pup body weights and body weight gain)
NOAEL (maternal/developmental toxicity) = 500 mg/kg-day

Genetic Toxicity – Gene Mutation

In vitro

Beryl light crude oil

In a modified Ames assay, *S. typhimurium* strain TA98 was exposed to Beryl light crude oil in dimethyl sulfoxide (DMSO) at concentrations of 1, 3, 5, 7, 10, 15, 25 and 50 µL/plate with metabolic activation. Positive and negative controls were used and responded appropriately. The number of revertants was elevated in cultures exposed to the test substance.
Beryl light crude oil was mutagenic in this assay.

Arab light crude oil

A modified Ames assay was conducted on Arab light crude oil. No further details were provided.
Arab light crude oil was mutagenic in this assay.

MCSL crude oil

A modified Ames assay was conducted on MCSL light crude oil. No further details were provided.
MCSL crude oil was mutagenic in this assay.

Belridge heavy crude oil

A modified Ames assay was conducted on Belridge heavy crude oil. No further details were provided.
Belridge heavy crude oil was mutagenic in this assay.

Lost Hills light crude oil

A modified Ames assay was conducted on Lost Hills light crude oil. No further details were provided.
Lost Hills light crude oil was not mutagenic in this assay.

Genetic Toxicity – Chromosomal Aberrations

In vitro

Lost Hills light crude oil

In a cytogenetic assay, CHO cells were exposed to Lost Hills light crude oil in DMSO at concentrations of 1, 2.5, 5, 10, 15 or 20 µL/mL culture medium for 2 hours with metabolic activation. Positive and negative controls were used and responded appropriately. Cytotoxicity was observed at concentrations ≥ 10 µL/mL. No increase in the proportion of cells with structural chromosomal aberrations was observed in response to the test substance.
Lost Hills light crude oil did not show evidence of chromosomal aberrations in this assay.

Belridge heavy crude oil

In a cytogenetic assay, CHO cells were exposed to Belridge heavy crude oil in DMSO at concentrations of 1, 2.5, 5, 10, 15 or 20 µL/mL culture medium for 2 hours with metabolic activation. Positive and negative controls were used and responded appropriately. Cytotoxicity was observed at concentrations ≥ 10 µL/mL. No increase in the proportion of cells with structural chromosomal aberrations was observed in response to the test substance.
Belridge heavy crude oil did not show evidence of chromosomal aberrations in this assay.

Wilmington crude oil

In a sister chromatid exchange assay, human lymphocytes were exposed to Wilmington crude oil in Tween 80 at concentrations of 20 or 30 mg/L with activation or 40 or 50 mg/L without metabolic activation. Positive and negative controls were used and responded appropriately. An increase in sister chromatid exchange was not observed in response to exposure to crude oil.
Wilmington crude oil did not show evidence of sister chromatid exchange in this assay.

In vivo

Lost Hills light crude oil

In a micronucleus assay, Sprague-Dawley rats (5/sex/dose) were administered Lost Hills light crude oil via the dermal route at 0, 30, 125 or 500 mg/kg-day for 13 weeks. No cytotoxicity was observed. Exposure to the Lost Hills light crude oil did not induce an increase in the formation of micronuclei. The use of a positive control was not noted.
Lost Hills light crude oil did not induce micronuclei in this assay.

Wilmington crude oil

In a sister chromatid exchange assay, Sch:ICR mice (3 males/group) were administered Wilmington crude oil via intraperitoneal injection at doses of 1800, 3600 or 7200 mg/kg. Positive and negative controls were used and responded appropriately. A slight, but significant ($p < 0.05$), increase in sister chromatid exchange was observed at the highest dose of crude oil tested.
Wilmington crude oil induced sister chromatid exchange in this assay.

Additional Information

Skin Irritation

Beryl light crude oil
In the acute dermal study described previously, New Zealand White rabbits administered Beryl light crude oil via the dermal route at 2000 mg/kg exhibited slight to moderate skin irritation after 26 and 72 hours.
Beryl light crude oil was moderately irritating to rabbit skin in this study.

Lost Hills light crude oil
New Zealand White rabbits (6/dose; sex not specified) were administered 0.5 mL of Lost Hills light crude oil via the dermal route at each of six shorn test sites (three intact and three abraded sites on each animal) and observed for 7 days. Four of the sites (two intact and two abraded) were covered with an occlusive dressing and two sites remained open. Two sites were wiped gently after 4 hours and the remaining four sites were wiped after 24 hours. The mean scores (average of scores at 24, 48 and 72 hours) for erythema and edema at the intact sites exposed for 4 hours were 1.69 and 1.3, respectively. The primary irritation index for occluded sites was 2.8 and 3.6 for exposures of 4 and 24 hours, respectively. Conditions of exposure (intact or abraded; occluded or open) had little effect on dermal response.
Lost Hills light crude oil was slightly irritating to rabbit skin in this study.

Arab light crude oil
New Zealand White rabbits (6/dose; sex not specified) were administered 0.5 mL of Arab light crude oil via the dermal route at each of six shorn test sites (three intact and three abraded sites on each animal) and observed for 7 days. Four of the sites (two intact and two abraded) were covered with an occlusive dressing and two sites remained open. Two sites were wiped gently after 4 hours and the remaining four sites were wiped after 24 hours. The mean scores (average of scores at 24, 48 and 72 hours) for erythema and edema at the intact sites exposed for 4 hours were 0.9 and 0.1, respectively. Moderate erythema was observed at the sites exposed for 24 hours. Conditions of exposure (intact or abraded; occluded or open) had little effect on dermal response.
Arab light crude oil was moderately irritating to rabbit skin in this study.

Eye Irritation

Beryl light crude oil
New Zealand White rabbits (6/dose) were administered 0.1 mL of Beryl light crude oil into one eye and observed for 72 hours. No irritation of the cornea or iris was observed. The irritation score for the conjunctivae was 4.0 after 1 hour and 1.0 after 72 hours.
Beryl light crude oil was irritating to rabbit eyes in this study.

Sensitization

Lost Hills light crude oil

In a Buehler test, guinea pigs (10/sex/dose) were administered 0.4 mL of 15% Lost Hills light crude oil in mineral oil to shorn skin under occluded conditions for 6 hours once per week for 3 weeks. Challenge patch application was performed 14 days after the last induction dose had been applied. Dual challenge patches (containing 10 and 15% test substance in mineral oil) were applied to fresh application sites of previously shorn skin of the animals. The patches were then occluded for 6 hours. On the day following challenge patch application, the skin was depilated and 2 hours later, scored for signs of sensitization. The sites were examined after a further 48 hours but this time without depilation. The dermal response was not considered to be positive.
Lost Hills light crude oil was not sensitizing to guinea pig skin in this study.

Carcinogenicity

Crude oil "C"
C3H mice (50 males) were administered crude oil "C" via the dermal route 2 times/week at a dose of 50 mg/application for 18 months or until grossly observable cancer was found. Thirty-three percent of the animals developed tumors and the average time to appearance of the first tumor was 76 weeks.
Crude oil "C" was carcinogenic to mice in this study.

Crude oil "D"
C3H mice (50 males) were administered crude oil "D" via the dermal route 2 times/week at a dose of 50 mg/application for 18 months or until grossly observable cancer was found. Fifty-six percent of the animals developed tumors and the average time to appearance of the first tumor was 64 weeks.
Crude oil "D" was carcinogenic to mice in this study.

San Joaquin Valley heavy crude oil
C3H mice (25/sex/dose) were administered San Joaquin Valley heavy crude oil via the dermal route 3 times/week at a dose of 25 mg/application for ≤ 105 weeks. Survival of treated mice was reduced compared to the controls. Dermal irritation at the test site first appeared at 271 days and males developed irritation earlier than females. Irritation included necrosis, cracking, separation and sloughing of skin. Tumor incidence was 29% for squamous cell carcinomas and 7% for fibrosarcomas in treated mice, compared to 0% for both tumor types in control mice. The average time to appearance of the first tumor was 62 weeks.
San Joaquin Valley heavy crude oil was carcinogenic to mice in this study.

Iranian light crude oil
Male C3H/HeJ mice (40/dose) were administered 25 μL of Iranian light crude oil via the dermal route 3 times/week. Exposures began between 4 and 6 weeks of age and continued until death of the animals. A negative control group was dosed with the same volume of acetone alone and a positive control group received 25 μL of 0.1% methylcholanthrane in acetone. Mice were examined daily for mortality and monthly for skin lesions. Mean survival time of animals exposed to Iranian light crude oil did not differ from negative controls treated with the same volume of acetone, both of which survived greater than 2 times as long as negative controls treated with 25 μL of 0.1% methylcholanthrene. Two papillomas and two squamous carcinomas were recorded in the area of application, along with two mesenchymal tumors in other areas

following dermal exposure to crude oil. Of the 40 oil-exposed animals, 29 were diagnosed as having hyperkeratosis of the skin in the treated area and a few animals exhibited ulcerative dermatitis. Fifteen oil treated animals displayed hepatocellular carcinomas compared with only five in the acetone treated group. Although tumor incidence was not statistically different from acetone controls, the presence of tumors was considered biologically significant because of the zero incidence in historical acetone controls. These data are summarized in TSCATS (OTS0000648).

Iranian light crude oil was carcinogenic to mice in this study.

The International Agency for Research on Cancer (IARC) has determined that Crude Oil is not classifiable as to its carcinogenicity to humans (Group 3) (IARC, 1989).

Epidemiology

In an epidemiology study, blood samples were taken from 68 individuals (control n = 42) exposed to crude oil during the cleanup of a spill and the cytogenetic damage was assessed as determined by sister chromatid exchange (SCE). Workers in the high-pressure cleaner worker category (n = 23) showed a statistically significant increase in their SCE frequency as compared to controls (Perez-Cadahia *et al.*, 2007).

In an epidemiology study of workers exposed to crude oil, workers in the job category "upstream operator offshore" had an excess risk of hematologic neoplasm (blood and bone marrow), RR 1.90, 95% CI 1.19 – 3.02 and multiple myeloma, RR 2.49, 95% CI 1.21-5.13 as compared to that of the general working population (Kirkeleit *et al.*, 2008).

Conclusion: The acute toxicity of CASRN 8002-05-9 is low in rats and mice by the oral route, low to moderate in rats and moderate in mice by the inhalation route and low in rabbits by the dermal route. A 28-day dermal repeated-dose toxicity study in rats showed reduced body weight gain in males at 2500 mg/kg-day and no effects in females at 2500 mg/kg-day (highest dose tested). The NOAEL is 250 mg/kg-day in males and 2500 mg/kg-day in females. A 90-day dermal repeated-dose toxicity study in rats showed hypertrophy and hyperplasia of follicular thyroid epithelium in males and females at 30 mg/kg-day; the NOAEL was not established. In a second 90-day dermal repeated-dose toxicity study in rats, both males and females showed hypertrophy and hyperplasia of follicular thyroid epithelium and males showed increased bone marrow cellularity at 30 mg/kg-day; the NOAEL was not established. No specific reproductive toxicity studies are available. In the dermal repeated-dose toxicity study, no effects on the reproductive organs were observed in male rats treated with 500 mg/kg-day (only dose tested). In a prenatal developmental toxicity study in rats administered CASRN 8002-05-9 via gavage, reduced maternal body weight was observed at 887 mg/kg-day; the NOAEL for maternal toxicity was not established. Signs of developmental toxicity consisted of reduced fetal weight, reduced fetal crown-rump length, increased numbers of resorptions and the number of dead fetuses and decreased number of live fetuses at 887 mg/kg-day; the NOAEL for developmental toxicity was not established. In a prenatal developmental toxicity study in rats administered CASRN 8002-05-9 dermally, reduced maternal body weight was observed at 500 mg/kg-day; the NOAEL for maternal toxicity is 125 mg/kg-day. Signs of developmental toxicity consisted of increased

number of resorptions, decreased litter size, decreased fetal weight, incomplete ossification of nasal bones and caudal centra and an increased incidence of pup mortality during lactation at 500 mg/kg-day; the NOAEL for developmental toxicity is 125 mg/kg-day. In another prenatal developmental toxicity study in rats administered CASRN 8002-05-9 dermally, reduced maternal body weight was observed at 500 mg/kg-day; the NOAEL for maternal toxicity is 125 mg/kg-day. Incomplete ossification of fetal nasal bones was observed in pups at 125 mg/kg-day; the NOAEL for developmental toxicity was not established. In a third prenatal developmental toxicity study in rats administered CASRN 8002-05-9 dermally, reduced maternal body weight was observed at 1000 mg/kg-day; the NOAEL for maternal toxicity is 500 mg/kg-day. Signs of developmental toxicity consisted of reduced pup body weight and body weight gain at 1000 mg/kg-day; the NOAEL for developmental toxicity is 500 mg/kg-day. CASRN 8002-05-9 was mutagenic in bacteria *in vitro* but did not show evidence of chromosomal aberrations in mammalian cells *in vitro.* CASRN 8002-05-9 did induce chromosomal aberrations in mice *in vivo*. CASRN 8002-05-9 is irritating to rabbit skin and eyes and did not induce sensitization in guinea pigs. CASRN 8002-05-9 is carcinogenic to mice via dermal exposure.

Table 3. Summary of the Screening Information Data Set as Submitted under the U.S. HPV Challenge Program – Human Health Data

Endpoints	**SPONSORED CHEMICAL Crude Oil (8002-05-9)**
Acute Oral Toxicity LD_{50} (mg/kg)	**> 5000**
Acute Dermal Toxicity LD_{50} (mg/kg)	**> 2000**
Acute Inhalation Toxicity LC_{50} (mg/L)	**> 4**
Repeated-Dose Toxicity NOAEL/LOAEL Dermal (mg/kg-day)	**NOAEL = Not established LOAEL = 30**
Reproductive Toxicity	Data Gap

Table 3. Summary of the Screening Information Data Set as Submitted under the U.S. HPV Challenge Program – Human Health Data	
Endpoints	**SPONSORED CHEMICAL Crude Oil (8002-05-9)**
Developmental Toxicity NOAEL/LOAEL Oral gavage (mg/kg-day)	
Maternal Toxicity	**NOAEL = Not established LOAEL = 887 (lowest dose tested)**
Developmental Toxicity	**NOAEL = Not established LOAEL = 887 (lowest dose tested)**
Developmental Toxicity NOAEL/LOAEL Dermal (mg/kg-day)	
Maternal Toxicity	**NOAEL = 125 LOAEL = 500**
Developmental Toxicity	**NOAEL = Not established LOAEL = 125**
Genetic Toxicity – Gene Mutations *In vitro*	**Positive**
Genetic Toxicity – Chromosomal Aberrations *In vitro*	**Negative**
Genetic Toxicity – Chromosomal Aberrations *In vivo*	**Positive**
Additional Information	
Skin Irritation	**Positive**
Eye Irritation	**Positive**
Skin Sensitization	**Negative (guinea pig)**
Carcinogenicity	**Positive (mice)**

Measured data in bold

4. Hazard to the Environment

A summary of aquatic toxicity data submitted for SIDS endpoints is provided in Table 4.

Acute Toxicity to Fish

Crude oil (0.5% paraffinic)
Rainbow trout (*Oncorhynchus mykiss)* were exposed to crude oil (0.5% paraffinic) as water accommodated fractions (WAFs) under static-renewal conditions in a closed test system for 96 hours. The loading rates were 0, 1.4, 3.2, 8.5, 21 and 50 mg/L. Analytical monitoring of test concentrations consisted of measurements of benzene, toluene, ethylbenzene, and xylene (BTEX) concentrations and mean measured concentrations were 0, 0.123, 0.295, 0.822, 1.78 and 4.39 mg/L, respectively. Mortalities were limited to fish exposed to loading rates of 21 (5/10 fish) and 50 mg/L (10/10 fish). No mortalities were observed at a loading rate concentration of 8.5 mg/L.
96-h LL_{50} = 21 mg/L

Crude oil (3% paraffinic)
Rainbow trout (*Oncorhynchus mykiss)* were exposed to crude oil (3% paraffinic) as WAFs under static-renewal conditions in a closed test system for 96 hours. The loading rates were 0, 2.7, 6.8, 16, 40 and 109 mg/L. Analytical monitoring of test concentrations consisted of measurements of BTEX concentrations and mean measured concentrations were 0, 0.085, 0.261, 0.505, 1.13 and 1.96 mg/L, respectively. Mortalities were limited to fish exposed to loading rates of 40 (5/10 fish) and 109 mg/L (10/10 fish). No mortalities were observed at a loading rate concentration of 16 mg/L.
96-h LL_{50} = 41 mg/L

Prudhoe Bay crude oil
(1) Slimy sculpins (*Cottus cognatus*; ≥ 12 juveniles/group) were exposed to five to seven unspecified measured concentrations of Prudhoe Bay crude oil as a water-soluble fraction under static conditions for 96 hours.
96-h LC_{50} = 3 mg/L

(2) Threespine sticklebacks (*Gasterosteus aculeatus*; ≥ 12 adults/group) were exposed to five to seven unspecified measured concentrations of Prudhoe Bay crude oil as a water-soluble fraction under static conditions for 96 hours.
96-h LC_{50} > 6.9 mg/L
ECOTOX database (Reference No. 5622).

(3) Sockeye salmon (*Oncorhynchus nerka*; ≥ 12/group) were exposed to five to seven unspecified measured concentrations of Prudhoe Bay crude oil as a water-soluble fraction under static conditions for 96 hours. Tests were conducted in freshwater and seawater. **96-h LC_{50} = 1.1 mg/L** (seawater)
96-h LC_{50} = 2.2 mg/L (freshwater)
ECOTOX database (Reference No. 5622).

(4) Chinook salmon (*Oncorhynchus tshawytscha*; ≥ 12/group) were exposed to five to seven unspecified measured concentrations of Prudhoe Bay crude oil as a water-soluble fraction under static conditions for 96 hours.
96-h LC_{50} = 1.5 mg/L
ECOTOX database (Reference No. 5622).

(5) Chinook salmon (*Oncorhynchus tshawytscha*; 8/group) were exposed to unspecified measured concentrations of Prudhoe Bay crude oil as WAFs under flow-through conditions for 96 hours. The test was performed in triplicate.
96-h LC_{50} = 7.46 mg/L
ECOTOX database (Reference No. 5622).

(6) Arctic char (*Salvelinus alpines*; ≥ 12/group) were exposed to five to seven unspecified measured concentrations of Prudhoe Bay crude oil as water-soluble fractions under static conditions for 96 hours.
96-h LC_{50} = 2.2 mg/L
ECOTOX database (Reference No. 5622).

(7) Arctic grayling (*Thymallus arcticus*; ≥ 12/group) were exposed to five to seven unspecified measured concentrations of Prudhoe Bay crude oil as water-soluble fractions under static conditions for 96 hours.
96-h LC_{50} = 2.0 mg/L
ECOTOX database (Reference No. 5622).

(8) Dolly Varden (*Salvelinus malma*; ≥ 12/group) were exposed to five to seven unspecified measured concentrations of Prudhoe Bay crude oil as a water-soluble fraction under static conditions for 96 hours. Tests were conducted in freshwater and seawater.
96-h LC_{50} = 1.4 mg/L (seawater)
96-h LC_{50} = 2.7 mg/L (freshwater)

(9) Fourhorn sculpin (*Myoxocephalus quadricornis*) were exposed to Prudhoe Bay crude oil at measured concentrations of 27, 39.5, 49.6 or 52.1 mg/L under static-renewal conditions for 96 hours.
96-h LC_{50} = 42 mg/L

(10) Pink salmon (*Oncorhynchus gorbuscha*; ≥ 12/group) were exposed to five to seven unspecified measured concentrations of Prudhoe Bay crude oil as a water-soluble fraction under static conditions for 96 hours. Tests were conducted in freshwater and seawater.
96-h LC_{50} = 3.7 mg/L (seawater)
96-h LC_{50} = 8.0 mg/L (freshwater)

(11) Coho salmon (*Oncorhynchus kisutch*; ≥ 12/group) were exposed to five to seven unspecified measured concentrations of Prudhoe Bay crude oil as a water-soluble fraction under static conditions for 96 hours.
96-h LC_{50} = 1.5 mg/L
ECOTOX database (Reference No. 5622).

(12) Coho salmon (*Oncorhynchus kisutch*; 12/group) were exposed to crude oil as a water-soluble fraction at unspecified measured concentrations under static conditions for 96 hours.
96-h LC_{50} = 10.4 mg/L
ECOTOX database (Reference No. 477).

Cook Inlet crude oil
(1) Pink salmon (*Oncorhynchus gorbuscha*; 10 – 15/group) were exposed to Cook Inlet crude oil as a water-soluble fraction at unspecified measured concentrations under static conditions for 96 hours.
96-h LC_{50} = 1.5 mg/L at 4 °C
96-h LC_{50} = 1.7 mg/L at 8 °C
96-h LC_{50} = 1.8 mg/L at 12 °C

(2) Coho salmon (*Oncorhynchus kisutch*) were exposed to Cook Inlet crude oil as a water-soluble fraction at unspecified concentrations under flow-through conditions for 96 hours. The LC_{50} was based upon measured concentrations.
96-h LC_{50} = 0.73 – 1.1 mg/L

Crude oil (geographic source not specified)
Pink salmon (*Oncorhynchus gorbuscha*; 25/group) were exposed to crude oil as a water-soluble fraction at measured concentrations of 0.21, 0.40, 0.58 or 0.87 mg/L under flow-through conditions for 96 hours.
96-h LC_{50} = 1.2 mg/L

Crude oil (Arabian Medium)
(1) Inland silversides (*Menidia beryllina*) were exposed to crude oil (arabian medium) as water accommodated fractions (WAFs) under static-renewal conditions in a closed test system for 96 hours. The loading rates were 0 (control), 1.58, 1.65, 3.03, 4.15, and 5.18 and mg/L. Mean measured concentrations were 0 (control), 0.83, 1.38, 2.93, 4.38, and 4.79 mg/L, respectively.
96-h LC_{50} = 5.0 mg/L

(2) Inland silversides (*Menidia beryllina*) were exposed to crude oil (arabian medium) as water accommodated fractions (WAFs) under static-renewal conditions in a closed test system for 96 hours. Measure concentrations were not specified.
96-h LC_{50} = 15.6 mg/L

(3) Inland silversides (*Menidia beryllina*) were exposed to crude oil (arabian medium) as water accommodated fractions (WAFs) under static-renewal conditions in a closed test system for 96 hours. The loading rates were not specified. Mean measured concentrations were 0 (control), 2.5, 5.4, 6.9, 9.0 and 14.5 mg/L, respectively.
96-h LC_{50} = 14.5 mg/L

Crude oil (Arabian Medium)
(1) Sheepshead minnows (*Cyprinodon variegatus*) were exposed to crude oil (arabian medium) as water accommodated fractions (WAFs) under flow-through test system for 96 hours. The loading rates were 0 (control), 3.12, 5.09, 4.72, 5.94, and 6.73 and mg/L. Mean measured concentrations were 0 (control), 1.99, and 5.42 mg TPH/L, respectively.
96-h LC_{50} = 4.0 mg/L

(2) Sheepshead minnows (*Cyprinodon variegatus*) were exposed to crude oil (arabian medium) as water accommodated fractions (WAFs) under flow-through conditions in a closed test system for 96 hours. The loading rates were not specified. Mean measured concentrations were 0 (control), 1.7, 2.6, 4.8, 4.7 and 5.7 mg/L, respectively.
96-h LC_{50} = 5.7 mg/L

Crude oil (Prudhoe Bay)
(1) Inland silversides (*Menidia beryllina*) were exposed to crude oil (Prudhoe Bay) as water accommodated fractions (WAFs) under static-renewal conditions in a closed test system for 96 hours. Measure concentrations were not specified.
96-h LC_{50} = 14.80 mg/L

(2) Inland silversides (*Menidia beryllina*) were exposed to crude oil (Prudhoe Bay) as water accommodated fractions (WAFs) under flow-through test system for 96 hours. Measure concentrations were not specified.
96-h LC_{50} > 19.86 mg/L

Crude oil (Bass Strait)
Crimson-spotted rainbow fish (*Melanotaenia fluviatilis*) were exposed to crude oil (bass strait) as water accommodated fractions (WAFs) under static-renewal conditions in a closed test system for 96 hours. The loading rates were 0 (control), 5, 10, 20, 40, and 80% water soluble fraction of crude oil. Mean measured concentrations were 0 (control), 0.2, 0.4, 0.7, 1.4, and 2.7 mg/L, respectively.
96-h LC_{50} = 1.28 mg/L

Crude oil (Louisiana Sweet)
Inland silversides (*Menidia beryllina*) were exposed to crude oil (Louisiana Sweet) as water accommodated fractions (WAFs) under static-renewal conditions in a closed test system for 96 hours. Measure concentrations were not specified.
96-h LC_{50} > 3.0 mg/L

Crude oil (Alaska North Slope)
(1) Inland silversides (*Menidia beryllina*) were exposed to crude oil (Alaska North slope) as water accommodated fractions (WAFs) under flow-through test system for 96 hours. Measure concentrations were not specified.
96-h LC_{50} = 26.4 mg/L

Acute Toxicity to Aquatic Invertebrates

Crude oil (0.5% paraffinic)
Kelp forest mysid shrimp *(Holmesiysis costata)* were exposed to crude oil (0.5% paraffinic) as WAFs under static-renewal conditions for 96 hours. The loading rates were 0, 0.14, 0.28, 1.4, 3.5 and 11 mg/L. Analytical monitoring of test concentrations consisted of measurements of BTEX concentrations and all measured concentrations were ≤ 0.5 mg/L. Mortality was 0, 10, 10, 5, 75 and 100% at loading rates of 0, 0.14, 0.28, 1.4, 3.5 and 11 mg/L, respectively.
96-h LL_{50} = 2.7 mg/L

Crude oil (3% paraffinic)
Kelp forest mysid shrimp *(Holmesiysis costata)* were exposed to crude oil (3% paraffinic) as WAFs under static-renewal conditions for 96 hours. The loading rates were 0, 0.6, 1.7, 3.6, 8.3 and 21 mg/L. Analytical monitoring of test concentrations consisted of measurements of BTEX concentrations and all measured concentrations were ≤ 0.247 mg/L. Mortality was 5, 10, 15, 30, 100 and 100% at loading rates of 0, 0.6, 1.7, 3.6, 8.3 and 21 mg/L, respectively.
96-h LL_{50} = 4.1 mg/L

Kuwait crude oil
(1) Mysid shrimp (*Mysidopsis bahia)* were exposed to Kuwait crude oil (68.56% paraffins, 15.69% aromatics and 11.86% naphthenes) as WAFs under static-renewal conditions in a closed test system for 96 hours. The loading rates were not specified. The measured concentrations were 0 (control), 1.05, 1.54, 2.85, 3.62, and 5.63 mg/L
96-h LC_{50} = 0.56 mg/L

Crude oil (Alaska North Slope)
Mysid shrimp (*Mysidopsis bahia)* were exposed to Alaska North slope crude oil as WAFs under static-renewal conditions in a closed test system for 96 hours. The loading or measure rates were not specified.
96-h LC_{50} = 2.6 mg/L

Crude oil (Arabian Medium)
Mysid shrimp (*Americamysis bahia)* were exposed to Arabian medium slope crude oil as WAFs under flow-through test system for 96 hours. Mean measured concentrations were 0 (control), 2.4, 3.1, 4.7, 11.6 mg TPH/L. Loading rates were not specified.
96-h LC_{50} = 11.6 mg/L

Crude oil (Louisiana Sweet)
Mysid shrimp (*Americamysis bahia)* were exposed to Louisiana sweet crude oil as WAFs under static-renewal conditions in a closed test system for 96 hours. The loading or measure rates were not specified.
96-h LC_{50} = 2.7 mg/L

Crude oil (Alaska North Slope)
Mysid shrimp (*Americamysis bahia)* were exposed to Alaska North slope crude oil as WAFs under flow-through test system for 96 hours. The loading or measure rates were not specified.
96-h LC_{50} = 9.6 mg/L

Crude oil (Pitas Point)
Water fleas (*Daphnia magna)* were exposed to crude oil (Pitas point) as WAFs under static-renewal conditions in a closed test system for 96 hours. The loading or measure rates were not specified.
96-h EC_{50} = 5.9 mg/L

Amauligak crude oil
Daphnia magna were exposed to Amauligak crude oil as a water-soluble fraction at unspecified concentrations under static conditions in sealed test chambers for 48 hours. The test was conducted twice. The EC_{50} was calculated by combining data from both tests and was based upon concentrations measured using fluorescence spectroscopy.
48-h EC_{50} = 1.66 mg/L
Maclean and Doe (1989).

Sable Island crude oil
Daphnia magna were exposed to Sable Island crude oil as a water-soluble fraction at unspecified concentrations under static conditions in sealed test chambers for 48 hours. The test was conducted in triplicate. The EC_{50} was calculated by combining data from the three tests and was based upon concentrations measured using fluorescence spectroscopy.
48-h EC_{50} = 0.41 mg/L
Maclean and Doe (1989).

Hibernia crude oil
Daphnia magna were exposed to Hibernia crude oil as a water-soluble fraction at unspecified concentrations under static conditions in sealed test chambers for 48 hours. The test was conducted twice. The EC_{50} was calculated by combining data from both tests and was based upon concentrations measured using fluorescence spectroscopy.
48-h EC_{50} = 1.1 mg/L

Bent Horn crude oil
Daphnia magna were exposed to Bent Horn crude oil as a water-soluble fraction at unspecified concentrations under static conditions in sealed test chambers for 48 hours. The test was conducted twice. The EC_{50} was calculated by combining data from both tests and was based upon concentrations measured using fluorescence spectroscopy
48-h EC_{50} = 1.1 mg/L
Maclean and Doe (1989).

Western sweet crude oil blend
Daphnia magna were exposed to Western sweet crude oil blend as a water-soluble fraction at unspecified concentrations under static conditions in sealed test chambers for 48 hours. The test

was conducted twice. The EC_{50} was calculated by combining data from both tests and was based upon concentrations measured using fluorescence spectroscopy.
48-h EC_{50} = 1.12 mg/L

Transmountain crude oil
Daphnia magna were exposed to Transmountain crude oil as a water-soluble fraction at unspecified concentrations under static conditions in sealed test chambers for 48 hours. The test was conducted twice. The EC_{50} was calculated by combining data from both tests and was based upon concentrations measured using fluorescence spectroscopy.
48-h EC_{50} = 1.1 mg/L
Maclean and Doe (1989).

Norman Wells crude oil
Daphnia magna were exposed to Norman Wells crude oil as a water-soluble fraction at unspecified concentrations under static conditions in sealed test chambers for 48 hours. The test was conducted in triplicate. The EC_{50} was calculated by combining data from the three tests and was based upon concentrations measured using fluorescence spectroscopy.
48-h EC_{50} = 1.66 mg/L
Maclean and Doe (1989).

Venezuelan BCF-22 crude oil
Daphnia magna were exposed to Venezuelan BCF-22 crude oil as a water-soluble fraction at unspecified concentrations under static conditions in sealed test chambers for 48 hours. The test was conducted twice. The EC_{50} was calculated by combining data from both tests and was based upon concentrations measured using fluorescence spectroscopy.
48-h EC_{50} = 1.72 mg/L

Lago Medio crude oil
Daphnia magna were exposed to Lago Medio crude oil as a water-soluble fraction at unspecified concentrations under static conditions for in sealed test chambers 48 hours. The test was conducted twice. The EC_{50} was calculated by combining data from both tests and was based upon concentrations measured using fluorescence spectroscopy.
48-h EC_{50} = 3.22 mg/L
Maclean and Doe (1989).

Prudhoe crude oil
Daphnia magna were exposed to Prudhoe crude oil as a water-soluble fraction at unspecified concentrations in sealed test chambers under static conditions for 48 hours. The test was conducted twice. The EC_{50} was calculated by combining data from both tests and was based upon concentrations measured using gas chromatography.
48-h EC_{50} = 3.4 mg/L
Maclean and Doe (1989).

Atkinson crude oil
Daphnia magna were exposed to Atkinson crude oil as a water-soluble fraction at unspecified concentrations in sealed test chambers under static conditions for 48 hours. The test was

conducted twice. The EC_{50} was calculated by combining data from both tests and was based upon concentrations measured using fluorescence spectroscopy.
48-h EC_{50} = 0.61 mg/L
Maclean and Doe (1989).

Venture condensate crude oil
Daphnia magna were exposed to Venture condensate crude oil as a water-soluble fraction at unspecified concentrations in sealed test chambers under static conditions for 48 hours. The test was conducted twice. The EC_{50} was calculated by combining data from both tests and was based upon concentrations measured using fluorescence spectroscopy.
48-h EC_{50} = 0.83 mg/L
Maclean and Doe (1989).

Tarsuit crude oil
Daphnia magna were exposed to Tarsuit crude oil as a water-soluble fraction at unspecified concentrations in sealed test chambers under static conditions for 48 hours. The test was conducted twice. The EC_{50} was calculated by combining data from both tests and was based upon concentrations measured using gas chromatography.
48-h EC_{50} = 0.85 mg/L
Maclean and Doe (1989).

Crude oil (Oseberg)
Water fleas (*Daphnia magna)* were exposed to crude oil (Oseberg) as WAFs under static-renewal conditions in a closed test system for 96 hours. The loading or measure rates were not specified.
96-h EC_{50} = 13.3 mg/L

Crude oil (Hondo)
Water fleas (*Daphnia magna)* were exposed to crude oil (Hondo) as WAFs under static-renewal conditions in a closed test system for 96 hours. The loading or measure rates were not specified.
96-h EC_{50} = 11.8 mg/L

Crude oil (Dos Cuadras)
Water fleas (*Daphnia magna)* were exposed to crude oil (Dos Cuadras) as WAFs under static-renewal conditions in a closed test system for 96 hours. The loading or measure rates were not specified.
96-h EC_{50} = 4.6 mg/L

Crude oil (Carpinteria)
Water fleas (*Daphnia magna)* were exposed to crude oil (Carpinteria) as WAFs under static-renewal conditions in a closed test system for 96 hours. The loading or measure rates were not specified.
96-h EC_{50} = 5.5 mg/L

Crude oil (BCF 24)
Water fleas (*Daphnia magna)* were exposed to crude oil (BCF 24) as WAFs under static-renewal conditions in a closed test system for 96 hours. The loading or measure rates were not specified.
96-h EC_{50} = 10.6 mg/L

Crude oil (Santa)
Water fleas (*Daphnia magna)* were exposed to crude oil (Santa) as WAFs under static-renewal conditions in a closed test system for 96 hours. The loading or measure rates were not specified.
96-h EC_{50} = 7.5 mg/L

Crude oil (Sockeye)
Water fleas (*Daphnia magna)* were exposed to crude oil (Sockeye) as WAFs under static-renewal conditions in a closed test system for 96 hours. The loading or measure rates were not specified.
96-h EC_{50} = 12.1 mg/L

Crude oil (West Texas Sour***)***
Water fleas (*Daphnia magna)* were exposed to crude oil (West Texas Sour) as WAFs under static-renewal conditions in a closed test system for 96 hours. The loading or measure rates were not specified.
96-h EC_{50} = 28.7 mg/L

Crude oil (West Texan Intermediate)
Water fleas (*Daphnia magna)* were exposed to crude oil (West Texan Intermediate) as WAFs under static-renewal conditions in a closed test system for 96 hours. The loading or measure rates were not specified.
96-h EC_{50} = 12.7 mg/L

Crude oil (Iranian Light)
Water fleas (*Daphnia magna)* were exposed to crude oil (Iranian Light) as WAFs under static-renewal conditions in a closed test system for 96 hours. The loading or measure rates were not specified.
96-h EC_{50} = 12.3 mg/L

Crude oil (Waxy Light Heavy Blend)
Water fleas (*Daphnia magna)* were exposed to crude oil (waxy light heavy blend) as WAFs under static-renewal conditions in a closed test system for 96 hours. The loading or measure rates were not specified.
96-h EC_{50} = 4.8 mg/L

Crude oil (Arabian Light)
Water fleas (*Daphnia magna)* were exposed to crude oil (Arabian light) as WAFs under static-renewal conditions in a closed test system for 96 hours. The loading or measure rates were not specified.
96-h EC_{50} = 11.4 mg/L

Crude oil (Arabian Medium)
Water fleas (*Daphnia magna)* were exposed to crude oil (Arabian medium) as WAFs under static-renewal conditions in a closed test system for 96 hours. The loading or measure rates were not specified.
96-h EC_{50} = 7.4 mg/L

Crude oil (Empire)
Water fleas (*Daphnia magna)* were exposed to crude oil (empire) as WAFs under static-renewal conditions in a closed test system for 96 hours. The loading or measure rates were not specified.
96-h EC_{50} = 17.3 mg/L

Toxicity to Aquatic Plants

No adequate data were available

Chronic Toxicity to Invertebrates

Sen crude oil
Daphnia magna were exposed to Sen crude oil for 21 days in solutions that contained suspended particles of kaolin clay (2 – 4 μm). Immobility and reproduction were measured. The test included untreated controls and kaolin-exposed controls. No immobility was observed in the controls. Immobility rates were 10, 40 and 60% at crude oil concentrations of 0.5, 1 and 2 mg/L, respectively. Compared to kaolin-exposed controls, the number of total progeny was reduced by 45, 52 and 68% at crude oil concentrations of 0.5, 1 and 2 mg/L, respectively. Based on the more sensitive parameter (reproduction), the EC_{50} was between 0.5 and 1 mg/L.
0.5 mg/L < 21-d EC_{50} < 1 mg/L

Ogarrio crude oil
Daphnia magna were exposed to Ogarrio crude oil for 21 days in solutions that contained suspended particles of kaolin clay (2 – 4 μm). Immobility and reproduction were measured. The test included untreated controls and kaolin-exposed controls. No immobility was observed in the controls. Immobility rates were 30, 100, 100 and 100% at crude oil concentrations of 1.25, 2.5, 5 and 10 mg/L, respectively. Compared to kaolin-exposed controls, the number of total progeny was reduced by 53, 99, 99 and 99% at crude oil concentrations of 1.25, 2.5, 5 and 10 mg/L, respectively. Based on the more sensitive parameter (reproduction), the EC_{50} was < 1.25 mg/L.
21-d EC_{50} < 1.25 mg/L

Caparroso crude oil
Daphnia magna were exposed to Caparroso crude oil for 21 days in solutions that contained suspended particles of kaolin clay (2 – 4 μm). Immobility and reproduction were measured. The test included untreated controls and kaolin-exposed controls. No immobility was observed in the controls. Immobility rates were 0, 0 and 50% at crude oil concentrations of 0.33, 0.67 and 1.3 mg/L, respectively. Compared to kaolin-exposed controls, the number of total progeny was

reduced by 12, 32 and 35% at crude oil concentrations of 0.33, 0.67 and 1.3 mg/L, respectively. Based on the more sensitive parameter (immobility), the EC_{50} was ~ 1.3 mg/L.
21-d EC_{50} = ~ 1.3 mg/L

Castarrical crude oil
Daphnia magna were exposed to Castarrical crude oil for 21 days in solutions that contained suspended particles of kaolin clay (2 – 4 μm). Immobility and reproduction were measured. The test included untreated controls and kaolin-exposed controls. No immobility was observed in the controls. Immobility rates were 90, 100 and 100% at crude oil concentrations of 2.7, 4.0 and 8.1 mg/L, respectively. Compared to kaolin-exposed controls, the number of total progeny was reduced by 83, 95 and 100% at crude oil concentrations of 2.7, 4.0 and 8.1 mg/L, respectively. Based on both parameters, the EC_{50} was < 2.7 mg/L
21-d EC_{50} < 2.7 mg/L

Iride crude oil
Daphnia magna were exposed to Iride crude oil for 21 days in solutions that contained suspended particles of kaolin clay (2 – 4 μm). Immobility and reproduction were measured. The test included untreated controls and kaolin-exposed controls. No immobility was observed in the controls. Immobility rates were 100% at crude oil concentrations ≥ 3.1 mg/L. Compared to kaolin-exposed controls, the number of total progeny was reduced by 89, 98, 100, 100, 100 and 100% at crude oil concentrations of 3.1, 4.7, 9.4, 18.8, 37.5 and 75.2 mg/L, respectively. Based on the both parameters, the EC_{50} was < 3.1 mg/L.
21-d EC_{50} < 3.1 mg/L

Cárdenas crude oil
Daphnia magna were exposed to Cárdenas crude oil for 21 days in solutions that contained suspended particles of kaolin clay (2 – 4 μm). Immobility and reproduction were measured. The test included untreated controls and kaolin-exposed controls. No immobility was observed in the controls. Immobility rates were 0, 100, 90 and 100% at crude oil concentrations of 0.5, 1, 1.9 and 3.9 mg/L, respectively. Compared to kaolin-exposed controls, the number of total progeny was reduced by 27, 88, 96 and 89% at crude oil concentrations of 0.5, 1, 1.9 and 3.9 mg/L, respectively. Based on both parameters, the EC_{50} was between 0.5 and 1 mg/L.
0.5 mg/L < 21-d EC_{50} < 1 mg/L

Presidentes crude oil
Daphnia magna were exposed to Presidentes crude oil for 21 days in solutions that contained suspended particles of kaolin clay (2 – 4 μm). Immobility and reproduction were measured. The test included untreated controls and kaolin-exposed controls. No immobility was observed in the controls. Immobility rates were 80, 100, 100, 100 and 100% at crude oil concentrations of 3.6, 7.2, 14.5, 29 and 58 mg/L, respectively. Compared to kaolin-exposed controls, the number of total progeny was reduced by 71, 100, 100, 100 and 100% at crude oil concentrations of 3.6, 7.2, 14.5, 29 and 58 mg/L, respectively. Based on both parameters, the EC_{50} was < 3.6 mg/L.
21-d EC_{50} < 3.6 mg/L

Conclusion: The 96-h LC_{50} of CASRN 8002-05-9 for fish ranges from 0.73 to 42 mg/L. The 48-h EC_{50} of CASRN 8002-05-9 for aquatic invertebrates ranges from 0.61 to 28 mg/L. The 21-d chronic toxicity to aquatic invertebrates ranges from 0.5 to 6 mg/L.

Table 4. Summary of the Screening Information Data Set as Submitted under the U.S. HPV Challenge Program – Aquatic Toxicity Data

Endpoints	SPONSORED CHEMICAL Crude Oil (8002-05-9)
Fish 96-h LC_{50} (mg/L)	**0.73 - 42**
Aquatic Invertebrates 48-h EC_{50} (mg/L)	**0.61 – 28.7**
Aquatic Plants 72-h EC_{50} (mg/L) (growth rate) (biomass)	Data Gap
21-d Aquatic Invertebrates	**0.5 – 6**

5. References

American Petroleum Institute. (2008). Gasoline Blending Streams Category Assessment Document. API. Washington, DC. http://www.epa.gov/chemrtk/pubs/summaries/gasnecat/c13409rr3.pdf. Accessed January 31, 2011.

Ecotox database at www.epa.gov/ecotox

IARC (International Agency for Research on Cancer). (1989). Occupational Exposures in Petroleum Refining; Crude Oil and Major Petroleum Fuels, Vol. 45. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. World Health Organization, Lyon, France.

Kirkeleit, J., Riise, T., Bratveit, M., and Moen, B. E. 2008. Increased risk of acute myelogenous leukemia and multiple myeloma in a historical cohort of upstream petroleum workers exposed to crude oil. *Cancer Causes Control* **19**, 13-23.

Perez-Cadahia, B., Lafuente, A., Cabaleiro, T., Pasaro, E., Mendez, J., and Laffon, B. 2007. Initial study on the effects of Prestige oil on human health. *Environ Int* **33**, 176-185.

Stubblefield, W. A., McKee, R. H., Kapp, R. W., Jr., and Hinz, J. P. 1989. An evaluation of the acute toxic properties of liquids derived from oil sands. *J Appl Toxicol* **9**, 59-65.

Wikipedia. 2007. Refinery Flow Diagram. Wikimedia Commons. http://en.wikipedia.org/wiki/File:RefineryFlow.png. Accessed February 9, 2011

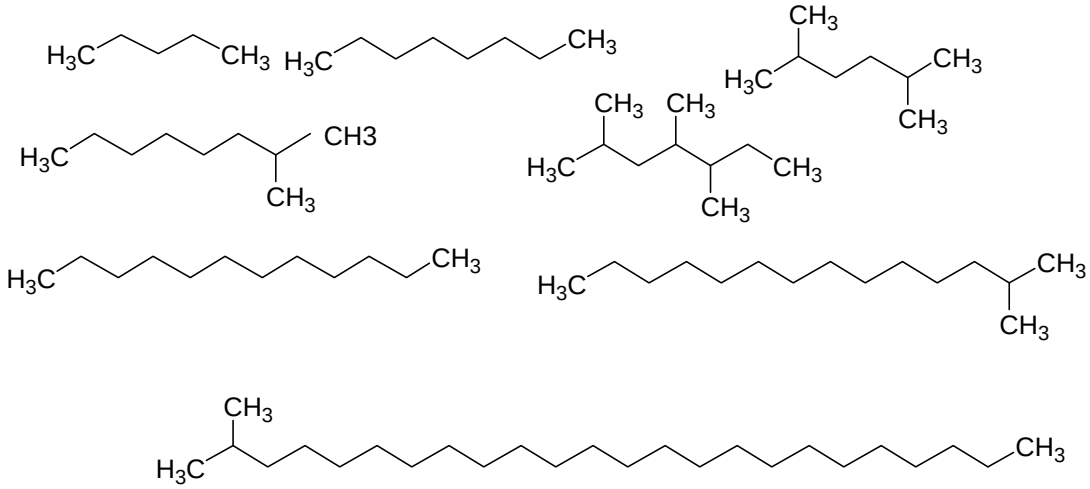
APPENDIX

The following pages show:

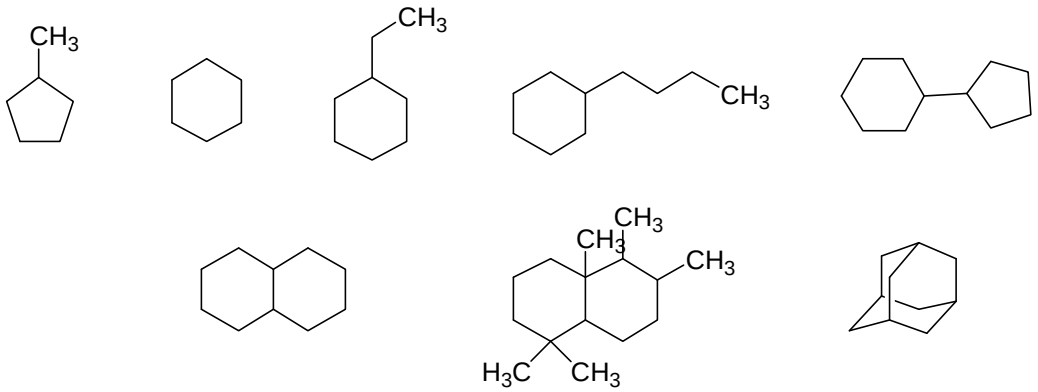
- Table 5: Representative structures for the constituents of Petroleum (Crude Oil).
- Table 6: Examples of Petroleum (Crude Oils) Covered Under CASRN 8002-05-9 (Petroleum)
- Figure 1: Representative schematic of crude oil processing

Table 5 shows representative structures for the constituents of petroleum or crude oil. The hydrocarbons that comprise crude oil – paraffins, naphthenes (cycloparaffins) and aromatics share some structural features but differ in the ratio of hydrogen to carbon atoms and how those atoms are arranged. Olefins are not present in crude oils and are formed from rearrangement of atoms during the cracking process to produce gasoline-blending streams. Paraffins occur in higher concentrations in lower boiling fractions of crude oil while the concentration of naphthenes (cycloparaffins) and aromatics increase at higher boiling ranges.

Table 5. Representative Structures for the Constituents of Petroleum (Crude Oil)

Paraffin	 Representative structures

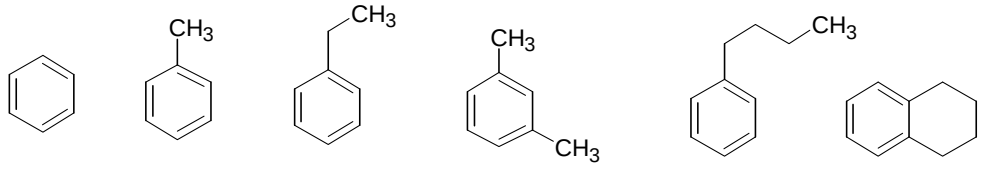
Naphthenes



Representative structures

Aromatics

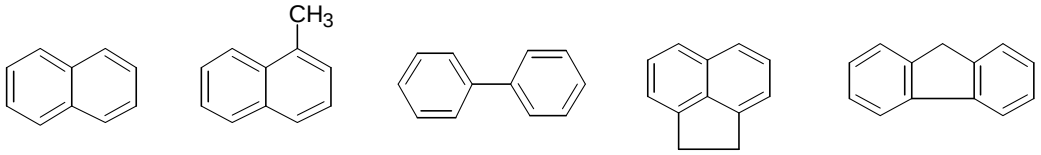
Mononuclear Aromatics 1-ring



benzene toluene ethylbenzene xylene

BTEX compounds

Dinuclear Aromatics 2-ring

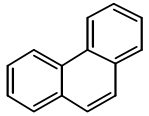


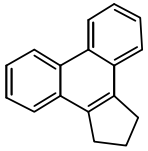
Polyaromatic Compounds

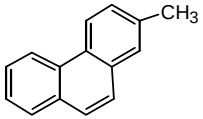
Polyaromatic Compounds (PAC)

Polyaromatic Hydrocarbons (PAH)
{a subset of the PAC compounds}

Trinuclear Aromatics 3-ring

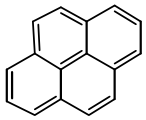




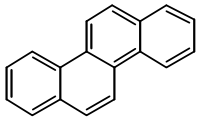


plus many more

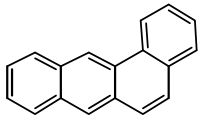
Tetranuclear Aromatics 4-ring



Pyrene



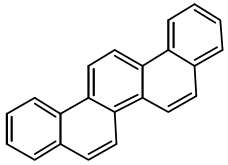
Chrysene



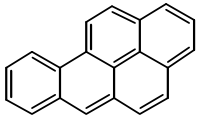
Benzo(a)anthracene

plus many more

Pentanuclear Aromatics 5-ring

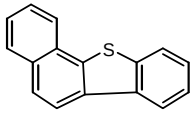


Picene

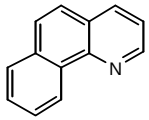


Benzo(a)pyrene

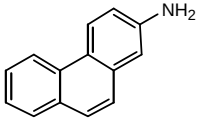
plus many more



Sulfur PAC

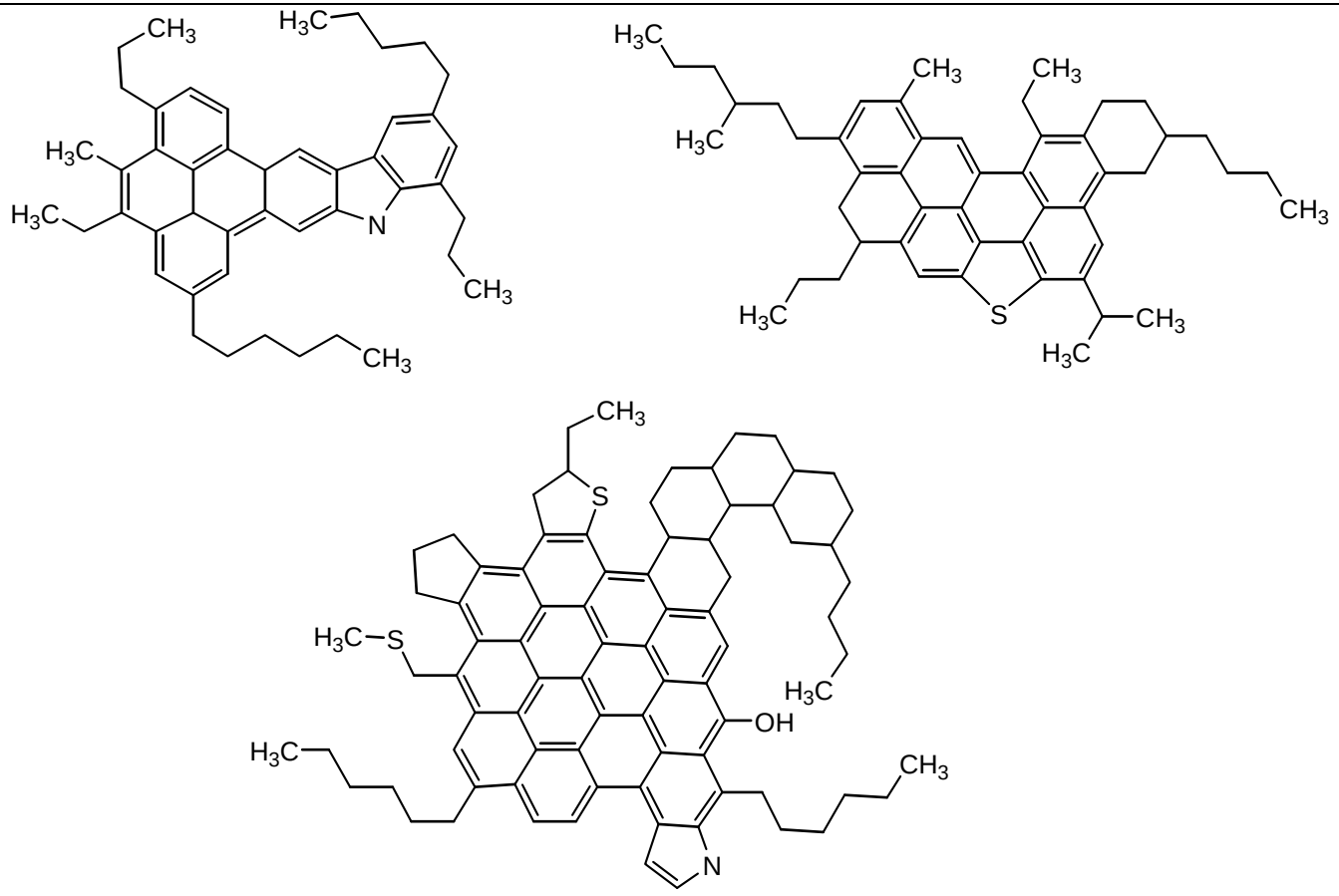


Nitrogen (N)-PAC
Non-basic



Nitrogen (N)-PAC
Basic

plus many more

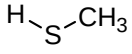
Asphaltenes	 plus many more

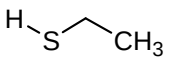
Other Substances

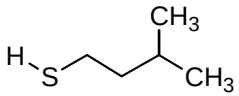
Sulfur Compounds

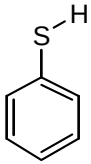
In Sour Crude Oil (High sulfur content crude oils)

Hydrogen sulfide



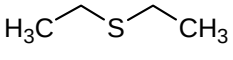


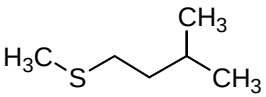


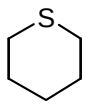


plus others

In Sweet Crude Oil (Low sulfur content crude oils)

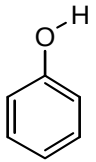


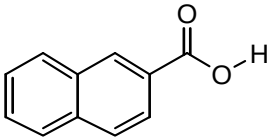


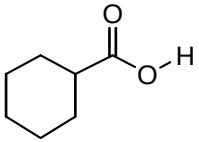


plus others
plus others

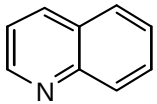
Oxygen Compounds

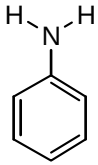


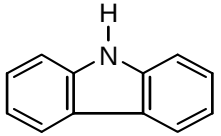




Nitrogen Compounds







plus others

Heavy metals, including nickel, vanadium, arsenic and iron, in trace-1000 ppm quantities
Usually found complexed with large oxygen or nitrogen compounds

Table 6. Examples of Petroleum (Crude Oils) Covered Under CASRN 8002-05-9 (Petroleum)[a]

Crude Oil Source	Paraffins (% vol)	Naphthenes (% vol)	Aromatics (% vol)	Sulfur (% wt.)	API gravity (^{0}API)
Light Crude Oils					
Saudi Light	63	18	19	2.0	34
South Louisiana	79	45	19	0.0	35
Beryl	47	34	19	0.4	37
North Sea Brent	50	34	16	0.4	37
Nigerian Light	37	54	9	0.1	36
Lost Hills Light	Non-aromatics 50%		50	0.9	-
USA Mid Continent sweet	-	-	-	0.4	40
Mid Range Crude Oils					
Venezuela Light	52	34	14	1.5	30
Kuwait	63	20	24	2.4	31
USA West Texas Sour	46	32	22	1.9	32
Heavy Crude Oils					
Prudhoe Bay	27	36	28	0.9	28
Saudi Heavy	60	20	15	2.1	28
Venezuela Heavy	35	53	12	2.3	24
Belridge Heavy	Non-aromatics 37%		63	1.1	-

[a]Reproduced from data in Table 1 on page 7 of test plan and pages 2-3 of the robust summary.

OIL REFINERY PROCESS DESCRIPTION

Crude oil or petroleum is extracted from the ground and shipped to refineries where it is processed to produce a variety of end products. Figure 1 is a representative schematic of an oil refinery and shows several finished products from the various processes in blue. This schematic does not represent all possible processes and end products and is only meant to be an illustrative example. In the diagram, the crude oil is fed to a distillation column where gases, light and heavy naptha (gasoline), jet and kerosene fuel, diesel oil and gas oil are separated at atmospheric pressure. The gases undergo further processing including the removal of sulfur to produce the end products of liquefied petroleum gas (LPG) and butanes. The light naptha may be isomerized to increase octane, or hydrotreated to convert benzene to cyclohexane so that the final gasoline blend meets a benzene specification limit. The heavy naphtha is hydrotreated to remove sulfur and then reformed to improve octane and generate hydrogen for the hydrotreaters. The jet fuel, kerosene and diesel oil can be used without additional processing. The heavy bottoms produced following the atmospheric distillation undergo a vacuum distillation which produces asphalt which can be used as produced, along with light and heavy gas oil and vacuum residuum which are further processed to produce usable endproducts. The separate diagram labeled “sour water steam stripper” illustrates a process where sulfur compounds (mercaptans) are converted to more innocuous compounds to eliminate odor and instability in the gasoline blend (American Petroleum Institute, 2008). Hazard characterization documents for several of the highlighted (in blue) endproducts in Figure 1 can be found at
http://iaspub.epa.gov/oppthpv/hpv_hc_characterization.get_report_by_cas?doctype=2

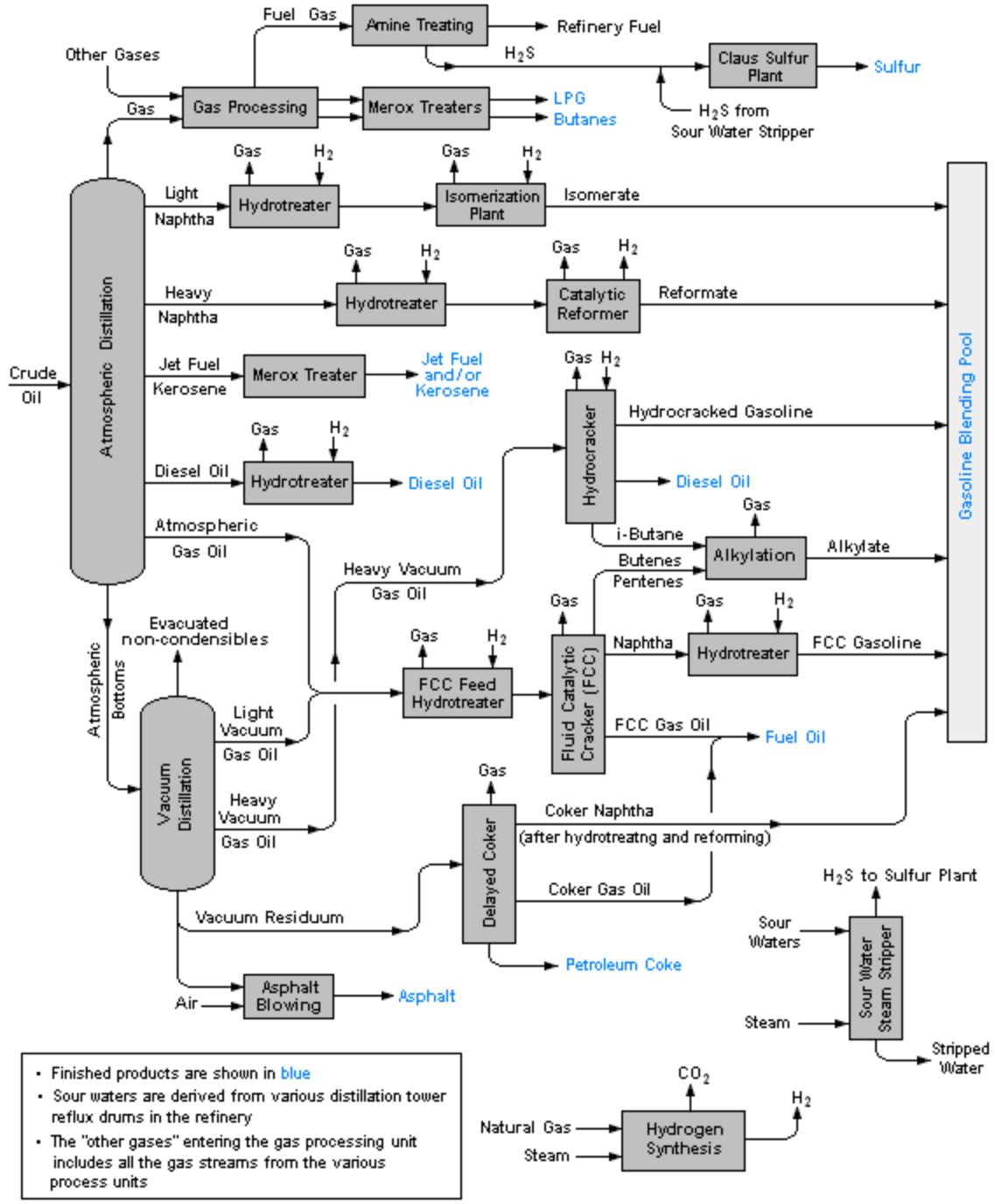


Figure 1. A representative schematic of a modern oil refinery (Wikipedia, 2007). The actual configuration of a refinery may vary and this is only meant to be an illustrative diagram.