

SCREENING-LEVEL HAZARD CHARACTERIZATION

Fuel Oils Category

SPONSORED CHEMICALS

Heavy Pyrolysis Fuel Oil	No CASRN
Quench Oil	No CASRN
Light Pyrolysis Fuel Oil	No CASRN
Pyrolysis C10+ Fuel Oil	No CASRN
Combined Fuel Oil (E&P)	No CASRN
Hydrotreated Flux Oil	No CASRN
Biphenyl Concentrate	CASRN 68409-73-4
Combined Fuel Oil (B&P)	CASRN 68513-69-9

SUPPORTING CHEMICALS

(See Table 2)

The High Production Volume (HPV) Challenge Program¹ 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

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>.

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 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.

<p>Chemical Abstract Service Registry Number (CASRN)</p>	<p><u>Sponsored Chemicals</u> See Table 1 <u>Supporting Chemicals</u> See Table 2</p>
<p>Chemical Abstract Index Name</p>	<p><u>Sponsored Chemicals</u> See Table 1 <u>Supporting Chemicals</u> See Table 2</p>
<p>Structural Formula</p>	<p><u>Sponsored Chemicals</u> See Appendix <u>Supporting Chemicals</u> See Appendix</p>
<p style="text-align: center;">Summary</p> <p>The fuel oils category consists of eight petrochemical process streams which are complex mixtures of variable composition and consist of the high molecular weight (generally carbon number 10 and higher) hydrocarbons produced by the olefins manufacturing processes. The substances in this category are typically liquids possessing low to high vapor pressure and low to moderate water solubility. All category members are expected to possess low to moderate mobility in soil. Volatilization is expected to be moderate to high. The rate of hydrolysis is negligible. The rate of atmospheric photooxidation is moderate to rapid. Members of the fuel oils category are expected to possess low to moderate (P1-P2) persistence and low to high bioaccumulation potential (B1-B3).</p> <p>Human Health Hazard</p> <p>No data are available for the sponsored streams; data for supporting chemicals are used to address human health endpoints. Acute oral toxicity for CASRNs 68527-18-4, 68989-41-3, 64742-90-1, 64741-62-4 is low in rats. Acute inhalation toxicity for CASRNs 68527-18-4, 68989-41-3 and 64742-90-1 is low in rats. Acute dermal toxicity for CASRNs 68989-41-3, 64741-62-4 is low in rabbits.</p> <p>A 28-day inhalation toxicity study with CASRN 68527-18-4 in rats showed decreased body weight, hematology changes and increased relative organ weights in both sexes at aerosol concentrations of 0.51 mg/L/day (lowest concentration tested); the NOAEC for systemic toxicity is not established. A dermal 28-day repeated-dose study in rabbits with EDS experimental fuel oil (No CASRN) showed significant increases in absolute/relative liver and kidney weights, dermal irritation (desquamation, blanching, atonia and fissuring) and liver histopathology (hepatocytomegaly, vacuolization, cytoplasmic degeneration) in both sexes at 50 mg/kg/day (lowest dose tested); the NOAEL for systemic toxicity is not established. In two 13-week dermal repeated-dose toxicity studies in rats with CASRN 64741-62-4, epidermal hyperplasia and liver effects (increased liver weight, microcysts, cholangiolitis) in both sexes were observed at or above 8 mg/kg/day (lowest dose tested) in one study and decreased body weight and abnormal thickening of the skin at 40 mg/kg/day (lowest dose tested) in the other; the NOAEL for systemic toxicity is not established. A 13-week oral repeated-dose toxicity study with EDS experimental fuel oil (No CASRN) in rats showed hematology effects in both sexes and organ weight changes (increased absolute liver weight and decreased absolute brain weight)</p>	

in females at 500 mg/kg/day (highest dose tested); the NOAEL for systemic toxicity is 100 mg/kg/day.

No reproductive or developmental effects were reported in an oral one-generation reproductive toxicity study with EDS experimental fuel oil (No CASRN) in rats; the NOAEL for reproductive/maternal/developmental toxicity is 500 mg/kg/day (highest dose tested). An oral prenatal developmental toxicity study with EDS experimental fuel oil in rats showed maternal toxicity (clinical signs, decreases in body weight gain and uterine wet weight) and developmental effects (skeletal anomalies and decreases in pup length/weight and the number of live offspring) at 500 mg/kg/day and above; the NOAEL for maternal/developmental toxicity is 100 mg/kg/day. A prenatal developmental toxicity screening test with the heavy pyrolysis hydrocarbons stream (No CASRN) in rats showed decreased body weight in dams following vapor inhalation at 5.1 mg/L/day (highest concentration tested); the NOAEC for maternal toxicity is 0.74 mg/L/day. Developmental effects (intrauterine mortality and decreased pup weight) were also observed at 0.74 mg/L/day and above; the NOAEC for developmental toxicity is 0.15 mg/L/day. Two dermal prenatal developmental toxicity studies with CASRN 64741-62-4 in rats showed maternal toxicity (decreased body/uterine weights) and developmental effects (increased resorptions, decreased pup weight and developmental delays) at 1 mg/kg/day and above; the NOAELs for maternal and developmental toxicity range from 0.05 - 10 mg/kg/day. A dermal prenatal developmental toxicity study with the heavy pyrolysis hydrocarbons stream (No CASRN) showed maternal toxicity (decreased body weight), dermal irritation (erythema, edema, eschar formation) and an increased incidence of spontaneous abortion in rabbits treated at 10 mg/kg/day (lowest dose tested); the NOAEL for maternal toxicity is not established. There was also an increased incidence of skeletal anomalies (13th rudimentary rib) at 50 mg/kg/day; the NOAEL for developmental toxicity is 25 mg/kg/day. CASRN 64741-62-4 did not induce mutations in a dominant lethal assay in rats following dermal exposure at 250 mg/kg/day (highest dose tested).

CASRN 64741-62-4 and EDS experimental fuel oil (No CASRN), induced gene mutations in bacteria when tested *in vitro*, but the heavy pyrolysis hydrocarbons stream (No CASRN) did not. CASRN 64742-90-1 induced chromosomal aberrations in mammalian cells *in vitro*; CASRN 68989-41-3 and CASRN 68527-18-4 did not. CASRN 64742-90-1 induced mouse micronuclei *in vivo*, whereas CASRN 68527-18-4 and CASRN 68989-41-3 did not. The heavy pyrolysis hydrocarbons stream (No CASRN) and CASRN 64741-62-4 induced sister chromatid exchange in mammalian cells *in vitro*. CASRNs 68989-41-3, 64742-90-1, 68527-18-4 and 64741-62-4 induced unscheduled DNA synthesis in rat hepatocytes. CASRN 69013-21-4 induced tumors (squamous cell carcinoma) in mice during a 28-month skin painting bioassay. CASRNs 64742-90-1 and 68527-18-4 are irritating to rat skin. CASRN 64741-62-4 is irritating to rabbit skin and eyes, but it is not a skin sensitizer in guinea pigs.

No data gaps were identified under the HPV Challenge Program.

Hazard to the Environment

The 96-h LC₅₀ values for acute toxicity to fish for heavy pyrolysis fuel oil (no CASRN) and pyrolysis C10+ fuel oil (no CASRN) are 4.4 and 1.0 mg/L, respectively. The 96-h LC₅₀ for the supporting chemical, CASRN 120-12-7, ranges from 0.001 to 0.012 mg/L. The 48-h EC₅₀ values for acute toxicity to aquatic invertebrates for heavy pyrolysis fuel oil (no

CASRN) and pyrolysis C10+ fuel oil (no CASRN) are 2.7 and 1.2 mg/L, respectively. The 48-h EC_{50} for the supporting chemical, CASRN 120-12-7, ranges from 0.095 to 0.75 mg/L. The 72-h EC_{50} values for toxicity to aquatic plants for heavy pyrolysis fuel oil (no CASRN) and pyrolysis C10+ fuel oil (no CASRN) are 1.3 mg/L (biomass) and 2.0 mg/L (growth rate), and 0.95 mg/L (biomass) and 1.7 mg/L (growth rate), respectively. The 21-d chronic toxicity to aquatic invertebrates for the supporting chemical, CASRN 120-12-7 is 0.002 mg/L.

No data gaps were identified under the HPV Challenge Program.

The sponsor, Olefins Panel of the American Chemistry Council, submitted a Test Plan and Robust Summaries to EPA for the fuel oils category on December 27, 2001. EPA posted the submission on the ChemRTK HPV Challenge website on January 29, 2002 (<http://www.epa.gov/oppt/chemrtk/pubs/summaries/fueloils/c13435tc.htm>). EPA comments on the original submission were posted to the website on August 26, 2002. Public comments were also received and posted to the website. The sponsor submitted updated/revised documents on September 16, 2003, February 19, 2004, December 14, 2004 and April 5, 2005, which were posted to the ChemRTK website on October 30, 2003, March 31, 2004, January 26, 2005 and May 18, 2005, respectively. Members of the fuel oils category are listed in Table 1.

Category Justification

The sponsor proposed grouping eight production streams in the fuel oils category based on reported similarities in (manufacturing process) origin, physicochemical properties and environmental fate. Selected members were included because they share a number of common constituents and are expected to exhibit comparable toxicity; however, these process streams are complex mixtures with significant differences in their respective compositions. As noted in the sponsor's test plan, considerable variation may occur not only between, but also within manufacturing facilities, depending on feedstock type and operating conditions. Although chemical composition (*i.e.*, relative abundance of major constituents) varies between streams, these substances may be grouped as fuel oils in a broader sense. Therefore, EPA concurs with use of these supporting substances in a conservative read-across approach whereby available data exhibiting the highest toxicity, as appropriate, will be used for hazard characterization.

Justification for Supporting Chemicals

The sponsor proposed 13 supporting substances to characterize process streams in the fuel oils category. Table 1 from the Test Plan (see below) shows the 13 supporting CASRNs and their associated process streams. It is unclear whether data provided for these supporting CASRNs adequately reflect toxicities that may be associated with the sponsored process streams; however, much of this information indicates high toxicity. Therefore, EPA will accept data from composite streams and/or stream components, where appropriate, (based on information provided in the Appendix) to characterize the potential human health hazard for this category.

The sponsor proposed using data for four supporting streams (not listed in Table 1): EDS experimental fuel oil (no CASRN specified), biphenyl feedstock (CASRN 68989-41-3), heavy pyrolysis hydrocarbons (no CASRN specified) and No. 2 Fuel Oil (CASRN 68476-30-2). EPA agrees with the use of these supporting streams in a conservative read-across approach, as described above.

For ecotoxicity purposes, EPA has determined that the additional measured data from anthracene (CASRN 120-12-7) provided by EPA, are appropriate to help support this category based on its similar physicochemical properties, environmental fate and trend in mode of toxic action (narcosis). In addition, the supporting chemical CASRN 120-12-7 is used to set the upper toxicity boundary of the high carbon numbers in the category (C14). Therefore, data from the supporting chemical CASRN 120-12-7 can be used to read-across to acute and chronic toxicity

to characterize the aquatic hazard of the category. Table 2 lists the supporting chemicals for the category.

Table 1. Production Streams, CAS RNs, and CAS RN Names in the Fuel Oils Category

Production Streams	CAS RN	CAS RN Name ¹
Heavy Pyrolysis Fuel Oil	68513-69-9	Residues, petroleum, steam-cracked light
	64741-62-4	Clarified oils, petroleum, catalytic cracked
	69013-21-4	Fuel oil, pyrolysis
	8002-05-9	Petroleum
Quench Oil (from the ethylene process unit water quench system)	68513-69-9	Residues, petroleum, steam-cracked light
	69430-33-7	Hydrocarbons, C6-30
Light Pyrolysis Fuel Oil (from the ethylene process unit)	68475-80-9	Distillates, petroleum, light steam-cracked naphtha
	68514-34-1	Hydrocarbons, C9-14, ethylene-manufacturing-by-product
	68527-18-4 ²	Gas oils, petroleum, steam-cracked
Pyrolysis C10+ Fuel Oil (from pyrolysis gasoline distillation)	68513-69-9	Residues, petroleum, steam-cracked light
	68921-67-5	Hydrocarbons, ethylene-manuf.-by-product distillation residues
Combined Fuel Oil (E&P) (from the ethylene process and pyrolysis gasoline units)	64742-90-1	Residues, petroleum, steam-cracked
	68131-05-5	Hydrocarbon oils, process blends
	68527-18-4	Gas oils, petroleum, steam-cracked
	69013-21-4	Fuel oil, pyrolysis
Hydrotreated Flux Oil	64742-47-8 ³	Distillates, petroleum, hydrotreated light
	69013-21-4	Fuel oil, pyrolysis
Biphenyl Concentrate	68409-73-4	Aromatic hydrocarbons, biphenyl-rich
Combined Fuel Oil (B&P) (from benzene HDA and pyrolysis gasoline units)	68513-69-9	Residues, petroleum, steam-cracked light

- 1 The definitions found in the TSCA (Toxic Substances Control Act) Chemical Substance Inventory for the CAS RNs in this category are vague with respect to composition. Therefore, it is not uncommon to find that one CAS RN is correctly used to describe different streams (different compositions) or that two or more CAS RNs are used to describe one stream (similar composition).
- 2 This CAS RN is currently used with the Combined Fuel Oil stream. However, it was previously used with the Light Pyrolysis Fuel Oil stream and test data are identified for this stream and CAS RN.
- 3 This CAS RN was not included in the original list of CAS RNs sponsored in this category. It has been added to this category summary report because it is an additional CAS RN that may be used to represent the Hydrotreated Flux Oil stream.

CASRN	CA Index Name
64741-62-4	Clarified oils (petroleum), catalytic cracked
64742-90-1	Residues (petroleum), steam-cracked
68527-18-4	Gas oils (petroleum), steam-cracked
69013-21-4	Fuel oil, pyrolysis
68476-30-2	Fuel oil, no. 2
No CASRN	EDS experimental fuel oil
68989-41-3	Aromatic hydrocarbons, biphenyl-rich, thermal hydrodealkylation residues
No CASRN	Heavy pyrolysis hydrocarbons (rerun tower bottoms)
120-12-7	Anthracene

1. Chemical Identity

1.1 Identification and Purity

The following description is taken from the 2005 Test Plan and Robust Summary. The fuel oils category consists of eight production streams derived from chemical reaction or separation processes associated with ethylene manufacturing. These process streams represent complex mixtures of variable composition, which typically include high molecular weight (generally C7 to C13) hydrocarbons and varying amounts of higher boiling hydrocarbons (predominantly cyclic olefins and aromatics, but may also include small fractions of saturated hydrocarbons in this carbon range). The primary constituents include indene, dicyclopentadiene, naphthalene, methylnaphthalene, and 1,1'-biphenyl (see Appendix). A detailed description of the CASRNs used to describe this category, the associated chemical structures, and the TSCA definitions for each CASRN are provided in the Appendix.

1.2 Physical-Chemical Properties

Physical-chemical properties for substances contained in the fuel oils category are summarized in Table 3. Members of this category are liquids that possess low to high vapor pressure and low to moderate water solubility. Some of the TSCA definitions for these streams indicate the potential to contain polycyclic aromatic hydrocarbons. Residues (petroleum), steam-cracked (CASRN 64742-90-1) and Fuel oil, pyrolysis (CASRN 69013-21-4) are streams that likely contain 5 wt % or more of 4- to 6-membered condensed ring aromatic hydrocarbons. In addition, Residues (petroleum), steam-cracked light (CASRN 68513-69-9) has a high end boiling range of 555°C (1030°F). The C20+ aromatics may contain 6 ring benzo[a]pyrene analogs, all of which are known carcinogens. Since stream components are not separated, the physical-chemical properties of the higher (> C20) homologs are not considered here [higher homologs would generally be expected to occur as solids, but are considered to represent only a small fraction of the components dissolved by solvent effects (e.g., eicosane linear C20, mp 40° and bp 650° F)].

Table 3. Physical-Chemical Properties of the Fuel Oils Category^{1,2}								
Property	SPONSORED CHEMICAL Heavy Pyrolysis Fuel Oil (68513-69-9, 64741-62-4, 69013-21-4, 8002-05-9)	SPONSORED CHEMICAL Quench Oil (68513-69-9, 69430-33-7)	SPONSORED CHEMICAL Light Pyrolysis Fuel (68475-80-9, 68514-34-1, 68527-18-4)	SPONSORED CHEMICAL Pyrolysis C10+ Fuel Oil (68513-69-9, 68921-67-5)	SPONSORED CHEMICAL Combined Fuel Oil (E&P) (64742-90-1, 68131-05-5, 68527-18-4, 69013-21-4)	SPONSORED CHEMICAL Hydrotreated Flux Oil (64742-47-8, 69013-21-4)	SPONSORED CHEMICAL Biphenyl Concentrate (68409-73-4)	SPONSORED CHEMICAL Combined Fuel Oil (68513-69-9)
Molecular Wt.	Complex mixture	Complex mixture	Complex mixt.	Complex mixture	Complex mixture	Complex mixt.	Complex mixture	Complex mixture
Physical State	Liquid	Liquid	Liquid	Liquid	Liquid	Liquid	Liquid	Liquid
Melting Point	<25°C (liquid)	<25°C (liquid)	<25°C liquid)	<25°C (liquid)	<25°C (liquid)	<25°C (liquid)	<25°C (liquid)	<25°C (liquid)
Boiling Point	201–340°C (measured)	96–339.9°C (measured) ^{3,4,5}	182–244.7°C (measured) ³	114–248°C (measured)	182–244.7°C (measured) ³	167.4–217.9°C (measured) ^{3,4,5}	256.1°C (measured) ³	170.7–256.1°C (measured) ³
Vapor Pressure	1.9 mm Hg at 30°C (measured)	6.5×10 ⁻⁶ to 39.2mmHg at 25°C (measured) ^{3,4,5}	0.067 to 1.1 mm Hg at 25°C (measured) ³	3.7 mm Hg at 30°C (measured)	0.067 to 1.1 mm Hg at 25°C (measured) ³	0.085 to 2.4 mm Hg at 25°C (measured) ^{3,4,5}	0.0089 mm Hg at 25°C (measured) ³	0.0089 to 2.29 mm Hg at 25°C (measured) ³
Dissociation Constant (pK _a)	Not applicable							
Henry's Law Constant	5.65×10 ⁻⁵ to 5.14×10 ⁻⁴ atm-m ³ /mol (measured) ^{3,4,5}	5.65×10 ⁻⁵ to 0.14 atm-m ³ /mol (measured) ^{3,4,5}	4.4×10 ⁻⁴ to 0.0016 atm-m ³ /mol (measured) ^{3,4,5}	4.4×10 ⁻⁴ to 0.020 atm-m ³ /mol (measured) ^{3,4,5}	4.4×10 ⁻⁴ to 0.016 atm-m ³ /mol (measured) ^{3,4,5}	4.4×10 ⁻⁴ to 0.15 atm-m ³ /mol (measured) ^{3,4,5}	3.09×10 ⁻⁴ atm-m ³ /mol (measured) ³	3.09×10 ⁻⁴ to 0.020 atm-m ³ /mol (measured) ^{3,4,5}
Water Solubility	0.04–31 mg/L (measured) ³	0.04–60 mg/L (measured) ^{3,4,5}	25.8–390 mg/L (measured) ^{3,4,5}	20–31 mg/L (measured) ^{3,6}	25.8–390 mg/L (measured) ³	5.6–31 mg/L (measured) ^{3,4,5}	6.94 mg/L (measured) ³	6.94–31 mg/L (measured) ^{3,6}
Log K _{ow}	3.4–5.0 (measured)	3.24–6.18 (measured) ^{3,4,5}	2.92–3.87 (measured) ³	3.3–5.4 (measured)	2.92–3.87 (measured) ³	3.30–4.28 (measured) ^{3,4,5}	3.98 (measured) ³	2.78–3.98 (measured) ^{3,6}

¹ Chemicals Manufacturing Association Olefins Panel, HPV Implementation Task Group. 2005. Revised Test Plan and Robust Summary for Fuel Oils Category. Available online at <http://www.epa.gov/chemrtk/pubs/summaries/fueloils/c13435tc.htm> as of September 30, 2010.

² Data range is based upon the representative structures except for boiling point, vapor pressure, and log K_{ow} endpoints for the heavy pyrolysis fuel oil and pyrolysis C10+ fuel oil where measurements on the streams themselves were performed; see Appendix for detailed information on the structures.

³ SRC. The Physical Properties Database (PHYSPROP). Syracuse, NY: Syracuse Research Corporation. Available online at <http://www.syrres.com/esc/physprop.htm> as of August 18, 2010.

⁴ U.S. EPA. 2010. Estimation Programs Interface Suite™ for Microsoft® Windows, v4.00. U.S. Environmental Protection Agency, Washington, DC, USA. Available online at <http://www.epa.gov/opptintr/exposure/pubs/episuitedi.htm> as of September 15, 2010.

⁵ Both measured and estimated data were employed for this range.

⁶ OECD SIDS Initial Assessment Report for Dicyclopentadiene (77-73-6). Available online at <http://www.chem.unep.ch/irptc/sids/OECD/SIDS/77736.pdf> as of September 28, 2010.

Table 3. Physical-Chemical Properties of the Fuel Oils Category (continued)¹		
Property	SUPPORTING CHEMICAL Fuel oil, no. 2 (68476-30-2)	SUPPORTING CHEMICAL Biphenyl Feedstock (68989-41-3)
Molecular Weight	Complex mixture	Complex mixture
Physical State	Liquid	Liquid
Melting Point	<25°C (liquid)	<25°C (liquid)
Boiling Point	160–360°C (measured) ²	256.1°C (measured) ³
Vapor Pressure	2.12–26.4 mm Hg at 25°C (measured) ²	0.0089 mm Hg at 25°C (measured) ³
Dissociation Constant (pK _a)	Not applicable	
Henry's Law Constant	5.9×10 ⁻⁵ to 7.4 atm·m ³ /mol (measured) ²	3.09×10 ⁻⁴ atm·m ³ /mol (measured) ³
Water Solubility	5 mg/L (measured) ²	6.94 mg/L (measured) ³
Log K _{ow}	3.3–7.06 (measured) ²	3.98 (measured) ³

¹ Chemicals Manufacturing Association Olefins Panel, HPV Implementation Task Group. 2005. Revised Test Plan and Robust Summary for Fuel Oils Category. Available online at <http://www.epa.gov/chemrtk/pubs/summaries/fueloils/c13435tc.htm> as of September 30, 2010.

² ATSDR Toxicological Profile for Fuel Oils/Kerosene. 1995. Available online at <http://www.atsdr.cdc.gov/toxprofiles/index.asp> as of October 4, 2010.

³ SRC. The Physical Properties Database (PHYSPROP). Syracuse, NY: Syracuse Research Corporation. Available online at <http://www.syrres.com/esc/physprop.htm> as of August 18, 2010.

2. General Information on Exposure

2.1 Production Volume and Use Pattern

The fuel oils category consists of eight petroleum streams (which do not have CASRNs assigned to them): Heavy Pyrolysis Fuel Oil, Quench Oil from water quench, Light Pyrolysis Fuel Oil, Pyrolysis C10+ Fuel Oil, Combined fuel oil (E&P), Hydrotreated Flux Oil, Biphenyl Concentrate, and Combined Fuel Oil (B&P). Some of the major constituents for these streams were identified by their CASRN. They include: CASRNs 64741-62-4, 64742-47-8, 64742-90-1, 68131-05-5, 68409-73-4, 68475-80-9, 68513-69-9, 68514-34-1, 68527-18-4, 68921-67-5, 69013-21-4, and 69430-33-7. The following is a summary of IUR information for these chemicals.

The twelve major constituents of streams in the Fuel Oils category had an aggregated production and/or import volume in the United States greater than 5 billion 260 million pounds in calendar year 2005.

- CASRN 68513-69-9: 100 to < 500 million pounds;
- CASRN 64741-62-4: 1 billion pounds and greater;
- CASRN 69013-21-4: 1 billion pounds and greater;

- CASRN 69430-33-7: 50 to <100 million pounds;
- CASRN 68475-80-9: 100 to < 500 million pounds;
- CASRN 68527-18-4: 10 to <50 million pounds;
- CASRN 68921-67-5: 1 billion pounds and greater;
- CASRN 64742-90-1: 1 billion pounds and greater;
- CASRN 64742-47-8: 1 billion pounds and greater;

CASRN 68514-34-1, 68131-05-5, and 68409-73-4 were not reported in the 2006 IUR.

CASRN 68513-69-9, 69430-33-7, 68475-80-9, 68527-18-4, 68921-67-5, and 64742-90-1:
No industrial processing and uses or commercial and consumer uses were reported.

CASRN 64741-62-4:

Non-confidential information in the IUR indicated that the industrial processing and uses of this chemical include basic organic chemical manufacturing as “other” and in petroleum refineries as fuels. Non-confidential commercial and consumer uses of this chemical include “other.”

CASRN 69013-21-4:

Industrial processing and uses and commercial and consumer uses for this chemical were claimed confidential.

CASRN 64742-47-8:

Non-confidential information in the IUR indicated that the industrial processing and uses of this chemical include petroleum refineries as fuels. Non-confidential commercial and consumer uses of this chemical include “other.”

2.2 Environmental Exposure and Fate

The environmental fate properties are provided in Table 4. Members of the fuel oils category are expected to possess low to moderate mobility in soil. Two process streams, heavy pyrolysis fuel oil and pyrolysis C10+ fuel oil, were not readily biodegradable in triplicate studies using Manometric respirometry tests (OECD 301F), achieving 22–33% and 3–12% biodegradation, respectively, in 28 days. The results of these tests suggest that most of the individual components of these two process streams will not be readily biodegradable. However, the biphenyl feedstock concentrate stream attained 57% biodegradation after 28 days using a closed bottle test (OECD 301D), and pure 1,1'-biphenyl (CASRN 92-52-4) was readily biodegradable, achieving 66% of its theoretical biochemical oxygen demand (BOD) over a 14-day incubation period using the modified MITI test (OECD 301C). These results suggest that streams rich in 1,1'-biphenyl content, such as biphenyl concentrate and combined fuel oil (from benzene HDA and pyrolysis gasoline units), will not be highly persistent in the environment. Volatilization is expected to be high to moderate for most members of the fuel oils category given the range of Henry's Law constants exhibited by their components. The rate of hydrolysis is expected to be negligible since the substances in this category do not possess functional groups that hydrolyze under environmental conditions. The overall weight of evidence suggests that the components of these complex mixtures are expected to possess low (P1) to moderate (P2) persistence and low (B1) to high (B3) bioaccumulation potential.

Table 4. Environmental Fate Properties of the Fuel Oils category^{1,2}								
Property	SPONSORED CHEMICAL Heavy Pyrolysis Fuel Oil (68513-69-9, 64741-62-4, 69013-21-4, 8002-05-9)	SPONSORED CHEMICAL Quench Oil (68513-69-9, 69430-33-7)	SPONSORED CHEMICAL Light Pyrolysis Fuel Oil (68475-80-9, 68514-34-1, 68527-18-4)	SPONSORED CHEMICAL Pyrolysis C10+ Fuel Oil (68513-69-9, 68921-67-5)	SPONSORED CHEMICAL Combined Fuel Oil (E&P) (64742-90-1, 68131-05-5, 68527-18-4, 69013-21-4)	SPONSORED CHEMICAL Hydrotreated Flux Oil (64742-47-8, 69013-21-4)	SPONSORED CHEMICAL Biphenyl Concentrate (68409-73-4)	SPONSORED CHEMICAL Combined Fuel Oil (68513-69-9)
Photodegradation Half-life	2.3–5.9 hours (estimated) ³	0.8–3.2 hours (estimated) ³	2.1–5.9 hours (estimated) ³	1.1–5.9 hours (estimated) ³	2.1–5.9 hours (estimated) ³	5.9–11.7 hours (estimated) ³	18.9 hours (estimated) ³	1.1–18.9 hours (estimated) ³
Hydrolysis Half-life	Stable							
Biodegradation	22–33% after 28 days (not readily biodegradable)	No data	No data	3–12 % after 28 days (not readily biodegradable)	No data	No data	57% after 28 days (not readily biodeg.) 66% after 14 days (readily biodeg.) ^{4,5}	No data
Bioaccumulation Factor	BAF = 177–1,151 (est) ³	BAF = 156–1.8×10 ⁶ (est) ³	BAF = 79–500 (estimated) ³	BAF = 59.6–7,952 (est) ³	BAF = 79–500 (estimated) ³	177–863 (estimated) ³	BAF = 410 (estimated) ³	BAF = 177–500 (estimated) ³
Log K _{oc}	3.2–4.2 (est) ³	2.4–5.1 (est) ³	2.9–3.4 (est) ³	3.2–3.4 (est) ³	2.9–3.4 (est) ³	3.1–3.2 (est) ³	3.7 (estimated) ³	3.2–3.7 (est) ³
Fugacity (Level III Model) ³								
Air (%)	0.2–0.9	<0.1–0.9	0.3–0.9	0.1–0.9	0.3–0.9	0.9–19.1	3.3	0.7–3.3
Water (%)	9.4–17.5	7.0–81.3	11.5–20.2	11.5–19.2	11.5–20.2	11.5–59.5	17.4	11.5–17.5
Soil (%)	78.6–86.6	17.6–86.6	78.9–86.6	79.7–86.6	78.9–86.6	18.4–86.6	76.5	76.5–86.6
Sediment (%)	1.0–11.8	1.0–40.4	0.6–1.4	1.0–1.4	0.6–1.4	1.0–3.0	2.7	1.0–2.7
Persistence ⁶	P2 (moderate)	P2 (moderate)	P2 (moderate)	P2 (moderate)	P2 (moderate)	P2 (moderate)	P1 (low)	P1-P2 (low-mod)
Bioaccumulation ⁶	B1-B2 (low-mod)	B1-B3 (low-high)	B1 (low)	B1-B3 (low-high)	B1 (low)	B1 (low)	B1 (low)	B1 (low)

¹ Chemicals Manufacturing Association Olefins Panel, HPV Implementation Task Group. 2005. Revised Test Plan and Robust Summary for Fuel Oils Category. Available online at <http://www.epa.gov/chemrtk/pubs/summaries/fueloils/c13435tc.htm> as of September 30, 2010.

² Data range is based upon the representative structures with the exception of biodegradation data, which was measured for the heavy pyrolysis fuel oil, pyrolysis C10+ fuel oil, and biphenyl concentrate streams; see Appendix for detailed information on the structures.

³ U.S. EPA. 2010. Estimation Programs Interface Suite™ for Microsoft® Windows, v4.00. U.S. Environmental Protection Agency, Washington, DC, USA. Available online at <http://www.epa.gov/opptintr/exposure/pubs/episuite.html> as of September 15, 2010.

⁴ National Institute of Technology and Evaluation. 2002. Biodegradation and Bioaccumulation of the Existing Chemical Substances under the Chemical Substances Control Law. Available online at http://www.safe.nite.go.jp/english/kizon/KIZON_start_hazkizon.html as of October 8, 2010.

⁵ Data for pure biphenyl (CASRN 92-52-4).

⁶ Federal Register. 1999. Category for Persistent, Bioaccumulative, and Toxic New Chemical Substances. *Federal Register* 64, Number 213 (November 4, 1999) pp. 60194–60204.

Table 4. Environmental Fate Properties of Fuel Oils Category (continued)¹		
Property	SUPPORTING CHEMICAL Fuel oil, no. 2²	SUPPORTING CHEMICAL Biphenyl Feedstock³
CASRN	68476-30-2	68989-41-3
Photodegradation Half-life	11.5 hours (estimated) ⁴	18.9 hours (estimated) ⁴
Hydrolysis Half-life	Stable	
Biodegradation	No data	66% after 14 days (readily biodegradable) ⁵
Bioaccumulation Factor	BAF = 940 (estimated) ⁴	BAF = 410 (estimated) ⁴
Log K _{oc}	3.1 (estimated) ⁴	3.7 (estimated) ⁴
Fugacity (Level III Model) ⁴		
Air (%)	26.9	3.3
Water (%)	69.1	17.4
Soil (%)	1.7	76.5
Sediment (%)	2.3	2.7
Persistence ⁶	P1 (low)	P1 (low)
Bioaccumulation ⁶	B1 (low)	B1 (low)

¹ Chemicals Manufacturing Association Olefins Panel, HPV Implementation Task Group. 2005. Revised Test Plan and Robust Summary for Fuel Oils Category. Available online at <http://www.epa.gov/chemrtk/pubs/summaries/fueloils/c13435tc.htm> as of September 30, 2010.

² Estimated data presented for n-Decane (CASRN 124-18-5).

³ Data for 1,1'-Biphenyl (CASRN 92-52-4).

⁴ U.S. EPA. 2010. Estimation Programs Interface Suite™ for Microsoft® Windows, v4.00. U.S. Environmental Protection Agency, Washington, DC, USA. Available online at <http://www.epa.gov/opptintr/exposure/pubs/episuitedi.htm> as of September 15, 2010.

⁵ National Institute of Technology and Evaluation. 2002. Biodegradation and Bioaccumulation of the Existing Chemical Substances under the Chemical Substances Control Law. Available online at http://www.safe.nite.go.jp/english/kizon/KIZON_start_hazkizon.html as of October 8, 2010.

⁶ Federal Register. 1999. Category for Persistent, Bioaccumulative, and Toxic New Chemical Substances. *Federal Register* 64, Number 213 (November 4, 1999) pp. 60194–60204.

Conclusion: The fuel oils category consists of eight petrochemical process streams which are complex mixtures of variable composition and consist of the high molecular weight (generally carbon number 10 and higher) hydrocarbons produced by the olefins manufacturing processes. The substances in this category are typically liquids possessing low to high vapor pressure and low to moderate water solubility. All category members are expected to possess low to moderate mobility in soil. Volatilization is expected to be moderate to high. The rate of hydrolysis is negligible. The rate of atmospheric photooxidation is moderate to rapid. Members of the fuel oils category are expected to possess low to moderate (P1-P2) persistence and low to high bioaccumulation potential (B1-B3).

3. Human Health Hazard

A summary of health effects data submitted for SIDS endpoints is provided in Table 5. The table also indicates where data for tested category members are read-across (RA) to untested members of the category.

Acute Oral Toxicity

Gas oils, petroleum, steam-cracked (CASRN 68527-18-4, supporting chemical)

Fischer 344 rats (5/sex/dose) received CASRN 68527-18-4 (light pyrolysis fuel oil) via gavage administration at 2500, 2750, 3000 or 3250 mg/kg and observed for 14 days following dosing. The doses at which mortalities occurred were not specified.

LD₅₀ = 2890 mg/kg

EDS experimental fuel oil (No CASRN, supporting chemical)

Sprague-Dawley rats (5/sex) received EDS experimental fuel oil (70/30 (w/w) blend of recycle solvent and vacuum gas oil) via gavage administration at 5000 mg/kg and observed for 14 days following dosing. Three mortalities occurred (doses not specified).

LD₅₀ > 5000 mg/kg

Biphenyl feedstock (CASRN 68989-41-3, supporting chemical)

Fischer 344 rats (5/sex/dose) were administered CASRN 68989-41-3 (30% suspension in corn oil) via the oral route at 2500, 3000, 3500 or 4000 mg/kg and observed for 14 days following dosing. Mortalities were observed in the 3000, 3500 and 4000 mg/kg test groups.

LD₅₀ = 3700 mg/kg

Residues, petroleum, steam-cracked (CASRN 64742-90-1, supporting chemical)

Fischer 344 rats (5/sex/dose) received CASRN 64742-90-1 (aromatic pyrolysis oil) via gavage administration at 5000 mg/kg and were observed for 14 days following dosing. No mortalities occurred.

LD₅₀ > 5000 mg/kg

Clarified oils (petroleum), catalytic cracked (CASRN 64741-62-4, supporting chemical)

(1) Sprague-Dawley rats (10/sex/dose) received CASRN 64741-62-4 (API 81-15) via gavage administration at 3.2, 4.0, 6.25 or 7.81 g/kg and observed for 14 days after dosing. Mortalities were observed at all doses. For additional details, see:

(<http://www.epa.gov/oppt/chemrtk/pubs/summaries/heavyfos/c15368rs.pdf>)

4320 < LD₅₀ < 5270 mg/kg

(2) Sprague-Dawley rats (10/sex/dose) received CASRN 64741-62-4 (API 81-15) via gavage administration at 4.0, 5.1, 6.2 or 8.4 g/kg and were observed for 14 days. Mortalities occurred at concentrations \geq 5.1 g/kg. For additional details, see TSCATS (OTS0546268).

5230 < LD₅₀ < 5820 mg/kg

Heavy pyrolysis hydrocarbons (rerun tower bottoms) (No CASRN, supporting chemical)

(1) Wistar rats (5/sex/dose) were exposed to heavy pyrolysis hydrocarbons (rerun tower bottoms) via gavage administration at 6670, 10,000, 15,000 or 22,500 mg/kg and observed for 14 days following dosing. (Data for the 15,000 mg/kg dose was taken from a prior project.) Mortalities were observed at 15,000 and 22,500 mg/kg.

LD₅₀ = 14,500 mg/kg

(2) Wistar rats (5/sex/dose) received neat heavy pyrolysis hydrocarbons (rerun tower bottoms) via gavage administration at 15,000 mg/kg and observed for 14 days following dosing. Six mortalities were observed.

LD₅₀ = 15,000 mg/kg

Acute Inhalation Toxicity

Gas oils, petroleum, steam-cracked (CASRN 68527-18-4, supporting chemical)

Fischer 344 rats (5/sex) were exposed to CASRN 68527-18-4 via (whole-body) aerosol inhalation at 4.95 mg/L for four hours (actual chamber concentration ranged from 3.9-5.9 mg/L; median aerodynamic diameter = 3.2 microns) and observed for 14 days following dosing. No mortalities occurred.

LC₅₀ > 4.95 mg/L

Biphenyl feedstock (CASRN 68989-41-3, supporting chemical)

Fischer 344 rats (5/sex/group) received CASRN 68989-41-3 via aerosol inhalation at 3 mg/L for four hours (median aerodynamic diameter = 4.3 microns) and were observed for 13 days following dosing. No mortalities occurred.

LC₅₀ > 3 mg/L

Residues, petroleum, steam-cracked (aromatic pyrolysis oil) (CASRN 64742-90-1, supporting chemical)

(1) Fischer 344 rats (5/sex/group) were exposed to CASRN 64742-90-1 via (whole-body) aerosol inhalation at 3.7 mg/L for four hours and observed for 14 days following dosing. No mortalities occurred.

LC₅₀ > 3.7 mg/L

(2) Fischer 344 rats (5/sex/group) were exposed to CASRN 64742-90-1 via (whole-body) inhalation at 0, 0.54, or 2.0 mg/L for 6 hours/day over a 9-day period. No mortalities occurred.

LC₅₀ > 2 mg/L

Heavy pyrolysis hydrocarbons (rerun tower bottoms) (No CASRN, supporting chemical)

(1) Sprague-Dawley rats (5/sex/group) were administered heavy pyrolysis hydrocarbons via (whole-body) aerosol inhalation at 3.6, 5.2, 5.7, 8.9 or 9.3 mg/L for four hours and observed for 14 days following dosing. Doses at which mortalities occurred were not specified.

LC₅₀ = 6.0 mg/L

(2) Sprague-Dawley rats (10/sex/group) were administered heavy pyrolysis hydrocarbons via (whole-body) vapor inhalation at 0.59, 3.3 or 6.6 mg/L for four hours and observed for 24 hours (5/sex/group) or 14 days (5/sex/group) following dosing. No mortalities occurred.

LC₅₀ > 6.6 mg/L

Acute Dermal Toxicity

EDS experimental fuel oil (No CASRN, supporting chemical)

New Zealand White rabbits (6/sex) were administered EDS experimental fuel oil (70/30 (w/w) blend of recycle solvent and vacuum gas oil) via dermal application to clipped (abraded and non-abraded) skin under semi-occlusive conditions at 3160 mg/kg for 24 hours and observed for 14 days following dosing. No mortalities occurred.

LD₅₀ > 3160 mg/kg

Biphenyl feedstock (CASRN 68989-41-3, supporting chemical)

New Zealand White rabbits (5/sex) were administered CASRN 68989-41-3 via dermal application to clipped, abraded skin under semi-occlusive conditions at 2000 mg/kg for 24 hours and observed for 14 days following dosing. One animal died in this study.

LD₅₀ > 2000 mg/kg

Clarified oils (petroleum), catalytic cracked (CASRN 64741-62-4, supporting chemical)

New Zealand White rabbits (4/sex) were administered CASRN 64741-62-4 (API 81-15) via dermal application to clipped (abraded) skin under occlusive conditions at 2000 mg/kg for 24 hours and observed for 14 days following dosing. No mortalities occurred. . For additional details, see: (<http://www.epa.gov/oppt/chemrtk/pubs/summaries/heavyfos/c15368rs.pdf>)

LD₅₀ > 2000 mg/kg

Heavy pyrolysis hydrocarbons (rerun tower bottoms) (No CASRN, supporting chemical)

New Zealand White rabbits (10 rabbits/dose; sex not specified) were administered heavy pyrolysis hydrocarbons (rerun tower bottoms) via dermal application to clipped, abraded skin under occlusive conditions at 5000 mg/kg for 24 hours and observed for 14 days following dosing. One mortality was observed on day 8.

LD₅₀ > 5000 mg/kg

Repeated-Dose Toxicity

Gas oils, petroleum, steam-cracked (light pyrolysis fuel oil) (CASRN 68527-18-4, supporting chemical)

Fischer 344 rats (10/sex/group) were administered CASRN 68527-18-4 via (whole-body) aerosol inhalation at 0, 0.51, 1.26 or 2.54 mg/L, 6 hours/day, 5 days/week for 28 days. Animals were monitored for clinical signs, morbidity, mortality, and changes in body weight. Two females treated at 1.26 mg/L were moribund at study termination and significant mortality (75%) occurred at 2.54 mg/L. Significantly decreased body weight, increased relative organ weights (not specified) and dose-related increases in clinical signs of toxicity (nasal discharge, ocular porphyrin accumulation and partially or completely closed eyelids) were observed at all levels of exposure. Hematology changes, including decreased mean corpuscular hemoglobin (females)

and increased total white blood cell and platelet counts (both sexes) were reported at concentrations ≥ 0.51 mg/L (level of significance not stated). An increase in blood glucose levels was observed at concentrations ≥ 1.26 mg/L and at 2.54 mg/L in males and females, respectively. Gross pathological findings included alopecia, perianal soiling, abnormal liver coloration and a general lack of body fat (effect concentrations not specified). Necrosis of cortical thymocytes and atrophy of the thymic cortex were noted at concentrations ≥ 1.26 and 2.54 mg/L in males and females, respectively. Pathological changes observed in the thyroid at or above 1.26 mg/L were accompanied by atrophy of splenic lymphoid tissue (most pronounced in high-dose females), hyperplasia of lung lymphoid tissue and hypoplastic bone marrow (both sexes). Generalized vascular congestion (bone marrow, kidney, adrenal, lung and thymus) was seen at concentrations ≥ 1.26 mg/L (both sexes). Degeneration of kidney tubular epithelium and associated hyaline droplet accumulation was noted at concentrations ≥ 1.26 mg/L (males only).

LOAEC = 0.51 mg/L/day (based on decreased body weight, increased relative organ weights and hematological changes)

NOAEC = Not established

EDS experimental fuel oil (No CASRN, supporting chemical)

(1) New Zealand White rabbits (5/sex/dose) were administered EDS experimental fuel oil (70/30 (w/w) blend of recycle solvent and vacuum gas oil diluted in Primol 185) via the dermal route at 0, 50 or 200 mg/kg/day, 5 days/week for 28 days. All animals were necropsied and organ weights were determined for the liver, kidney, epididymides and testes. Tissues preserved for histopathological examination included brain, heart, liver, kidney, spleen, testis, epididymides, prostate, seminal vesicle, ovary, urinary bladder, adrenal gland, pancreas, thymus, bone marrow and skin. No mortality occurred. Skin irritation (desquamation, blanching, atonia and fissuring) at the site of application was noted in all treatment groups. A significant decrease in mean body weight was observed in females treated at 200 mg/kg/day. Significant increases in (absolute/relative) liver and kidney weights and liver effects (diffuse hepato-cytomegaly, vacuolization and cytoplasmic degeneration) were observed at concentrations ≥ 50 mg/kg/day (both sexes). Thymic atrophy (both sexes) was observed only at the highest dose. Changes in clinical chemistry parameters were limited to dose-related increases in blood cholesterol levels (effective dose not specified) in both sexes.

LOAEL = 50 mg/kg/day (based on increased absolute/relative liver and kidney weights, skin irritation and liver histopathology)

NOAEL = Not established

(2) Sprague-Dawley rats (18/sex/dose) received EDS experimental fuel oil (70/30 (w/w) blend of recycle solvent and vacuum gas oil) diluted in refined white oil (CASRN 8012-95-1) via gavage administration at 0, 20, 100 or 500 mg/kg, 5 days/week for 13 weeks. Animals were observed for two weeks following exposure. Body and organ weights (brain, kidneys, adrenals ovaries, testes, epididymides and seminal vesicles) were recorded and the following tissues were preserved for histological examination: brain, heart, liver, kidneys, lymph nodes, testes, epididymides, prostate, seminal vesicles, ovaries and uterus. No treatment-related mortalities were observed. Observed treatment effects included ano-genital staining (both sexes) and organ weight changes (significantly increased absolute liver weight and significantly reduced absolute brain weight; $p < 0.05$) in females treated at 500 mg/kg/day (highest dose tested). Effects observed on hematological parameters included significantly reduced hemoglobin, hematocrit

and erythrocyte counts in high-dose females and significantly reduced hemoglobin in high-dose males ($p < 0.01$). Serum cholesterol levels were significantly elevated and serum glutamic oxaloacetic transaminase levels were significantly reduced in high-dose males and females, respectively (level of significance not stated). Study authors noted that these values were within the range of historical controls. No treatment-related histopathology was observed at the highest dose; tissues taken from low and intermediate dose groups were not examined microscopically.

LOAEL = 500 mg/kg/day (based on organ weight changes and hematological effects)

NOAEL = 100 mg/kg/day

Clarified oils (petroleum), catalytic cracked (CASRN 64741-62-4, supporting chemical)

(1) Sprague-Dawley rats (10/sex/dose) were administered CASRN 64741-62-4 via topical application to clipped (non-abraded) skin under non-occlusive conditions at 0, 8, 30, 125 or 500 mg/kg/day, 5 days/week for 13 weeks. Blood samples were collected on weeks 5 and 13 and hematological determinations were made of red blood cell count, hematocrit, hemoglobin content white blood cell count and differential white blood cell count. The serum was analyzed for glucose, urea nitrogen, uric acid, total protein, albumin, albumin/globulin ratio, alkaline phosphatase, alanine aminotransferase, aspartate aminotransferase, lactate dehydrogenase, cholesterol, triglycerides, total and direct bilirubin, calcium, phosphorus, sodium potassium and chloride. At necropsy, potential target organs (heart, liver, spleen, thymus, adrenals gonads and kidneys) were weighed. The following organs were processed for histology and examined microscopically: gonads, small intestine, kidneys, liver, treated skin, spleen, stomach thymus, urinary bladder, prostate, seminal vesicles, uterus and bone marrow. All rats treated at the highest dose died or were killed in a moribund condition; four animals treated at this dose exhibited slight erythema and thickened, leathery skin. Hepatocyte degeneration, (multinucleated large hepatocytes and vacuolation), bone marrow changes (erythroid hypoplasia) and significantly decreased body weights were reported at doses ≥ 125 mg/kg/day. Changes in hematology (decreased hematocrit) and clinical chemistry parameters (decreased uric acid and increased lactate dehydrogenase levels), histopathology (liver necrosis, fibrosis) and increased thymus weights were reported at doses ≥ 30 mg/kg/day (both sexes). Epidermal hyperplasia (inflammation) significantly increased liver weight and liver lesions (microcysts, cholangiolitis) were reported at doses ≥ 8 mg/kg/day (both sexes). For additional details, see:

<http://www.epa.gov/oppt/chemrtk/pubs/summaries/heavyfos/c15368rs.pdf>

LOAEL = 8 mg/kg/day (based on increased liver weight and liver lesions)

NOAEL = Not established

(2) Fisher 344 rats (10/sex/dose) were administered CASRN 64741-62-4 (API 81-15) via the dermal route at 0, 40, 200 or 400 mg/kg/day, 5 times/week for 13 weeks. All rats in the highest treatment group and seven rats treated at 200 mg/kg/day died or were killed in a moribund condition. Clinical signs observed at doses ≥ 200 mg/kg-bw included emaciation, hunched posture, lethargy and prostration. Gross findings reported at necropsy included thymus atrophy, reddened and/or enlarged lymph nodes, discoloration of the liver and congested and/or dark testes in animals treated at or above 200 mg/kg/day. Increased (absolute/relative) liver weights, changes in hematology and serum chemistry parameters and degenerative changes in the liver (multifocal necrosis, vacuolation, hyperpigmentation and neutrophil accumulation) were also reported at 200 mg/kg/day. Decreased body weight and abnormal thickening of the skin

(epidermal hyperplasia, hyperkeratosis) were reported at all doses tested. No statistical evaluations were reported. For additional details, see: TSCATS (OTS0539134).

LOAEL = 40 mg/kg/day (based on decreased body weight and abnormal thickening of the skin)

NOAEL = Not established

(3) Sprague-Dawley rats (number/sex not specified) were administered CASRN 64741-62-4 (API 81-15) via topical application to non-abraded skin under occluded conditions at 0, 550, 1090 or 2730 mg/kg/day, 5 days/week for 28 days. Body weights were decreased at all doses tested in males; however, this effect was only observed at the highest dose in females. Females also showed decreased (absolute/relative) kidney and ovary weights at concentrations \leq 1090 mg/kg/day. Increased liver weight and changes in hematology and clinical chemistry parameters (unspecified) were also noted in all dose groups. Histopathology findings included acanthosis and hyperkeratosis in animals treated at 2730 mg/kg/day (highest dose tested). No statistical evaluations were reported. For additional details, see: TSCATS (OTS0534753).

LOAEL = 550 mg/kg/day (based on decreased body weight, increased liver weight and changes in hematology and clinical chemistry parameters)

NOAEL = Not established

(4) New Zealand White rabbits (5/sex/dose) were administered CASRN 64741-62-4 (API 81-15) via the dermal route at 0, 200, 1000 or 2000 mg/kg/day, 3 times/week for 28 days. One mid-dose (male) and three high-dose animals (two males and one female) died during this study. Clinical signs of toxicity in high-dose animals included decreased food consumption, cracked or flaking skin, moderate to severe erythema, ulceration and necrosis at the site of application. Decreased body weight was observed at concentrations \geq 200 mg/kg/day (males) and at 2000 mg/kg/day (females; highest dose tested). Changes in clinical chemistry parameters (both sexes) and increased liver weights (males) were observed at doses \geq 1000 mg/kg/day. Gross examination revealed hyperkeratosis (both sexes) and increased liver weight (females) at concentrations \geq 200 mg/kg/day. Microscopic changes (unspecified) suggesting dermal and hepatic toxicity were noted at the highest dose (both sexes). No statistical evaluations were reported. For additional details, see: TSCATS (OTS0000901H7).

LOAEL = 200 mg/kg/day [based on decreased body weight (males) and increased liver weight (females) and hyperkeratosis (both sexes)]

NOAEL = Not established

Reproductive Toxicity

EDS experimental fuel oil (No CASRN, supporting chemical)

In a one-generation reproductive toxicity screening test, Sprague-Dawley rats (18M, 36F/dose group; 36M, 72F/control group) received EDS experimental fuel oil (70/30 (w/w) blend of recycle solvent and vacuum gas oil) diluted in refined white oil (CASRN 8012-95-1) via gavage administration at 20, 100 or 500 mg/kg, 5 days/week for 13 weeks. Animals (1M:2F) were housed together for 10 consecutive nights or until mating was confirmed by vaginal plug or sperm in a vaginal rinse. Dams were monitored for clinical signs of toxicity and changes in behavior, viability and body weight. Offspring were examined grossly and then weighed on lactation days (LD) 0, 4, 14 and 21. All dams and surviving litters were sacrificed on LD 21. At necropsy, tissues taken from the brain and visceral organs (not specified) were prepared for

microscopic examination. No treatment-related mortality occurred; however, seven control animals, one low-dose female, and one mid-dose male were euthanized during treatment due to dosing injuries. EDS experimental fuel oil did not adversely affect any of the reproductive parameters assessed in this study. Reproductive performance and fertility indices were comparable among all dose groups. No treatment-related effects were observed on maternal weight gain, gestation length, mean litter size, number of live births, pup body weight or pup survival (from LD 4 to weaning on LD 21). A low incidence of developmental anomalies occurred across all treatment groups; however, no dose-response was observed and the overall incidence was not significantly greater than controls.

NOAEL (systemic and reproductive toxicity) = 500 mg/kg-day (highest dose tested)

NOAEL (developmental toxicity) = 500 mg/kg-day (highest dose tested)

Developmental Toxicity

EDS experimental fuel oil (No CASRN, supporting chemical)

Pregnant Sprague-Dawley rats (25 females/dose) were administered EDS experimental fuel oil (70/30 (w/w) blend of recycle solvent and vacuum gas oil) diluted in refined white oil (CASRN 8012-95-1) via gavage administration at 0, 100, 500 or 1000 mg/kg on gestation days (GD) 6 – 19. Dams were monitored daily for clinical signs of toxicity and body weights were recorded on GD 0, 6, 10, 16 and 20. At necropsy on GD 20, uteri and ovaries were weighed and the number of corpora lutea, implantation sites, early/late resorptions and live/dead pups were determined. Offspring were evaluated for pup body weight, crown-rump distance and developmental malformations. Half of the offspring from each litter were decapitated and heads were prepared for microscopic examination. The remaining offspring were evaluated for skeletal anomalies and variations in skeletal ossification. Clinical signs of toxicity (oral, nasal, ocular, vaginal discharge, rales and unkempt appearance) were accompanied by significant decreases in body weight gain and uterine wet weight in dams treated at concentrations ≥ 500 mg/kg-day. Developmental effects, (skeletal anomalies and decreased pup body weight, crown-rump length and number of live offspring) were also noted at concentrations ≥ 500 mg/kg-day. No other effects were reported.

LOAEL (maternal toxicity) = 500 mg/kg-day (based on clinical signs of toxicity and decreases in maternal body weight gain and uterine wet weight)

NOAEL (maternal toxicity) = 100 mg/kg-day

LOAEL (developmental toxicity) = 500 mg/kg-day (based on skeletal anomalies, decreased pup weight, crown-rump length and number of live offspring)

NOAEL (developmental toxicity) = 100 mg/kg-day

Heavy pyrolysis hydrocarbons (rerun tower bottoms) (No CASRN, supporting chemical)

(1) Pregnant Sprague-Dawley rats (5 females/group) were administered heavy pyrolysis hydrocarbons (rerun tower bottoms) via (whole-body) vapor inhalation at 0, 0.15, 0.74 or 5.1 mg/L for 6 hours/day on GD 6 – 15. Animals were observed twice daily for clinical signs of toxicity on GD 6-20. Rats were weighed on GD 1, 3, 6, 10, 14, 17 and 20. Dams were sacrificed on GD 20. At necropsy, dams were evaluated for congenital abnormalities and gross pathological changes in maternal organs. Developmental abnormalities, pup body weight and the numbers of corpora lutea and viable offspring were also recorded. One half of the pups from each litter were preserved for microscopic examination and the others were evaluated for skeletal

anomalies. Clinical signs of toxicity observed in dams treated at the highest concentration included complete (or partial) closing of the eyelids, inactivity, abnormal body posture, ataxia, increased salivation, lethargy, red staining of snout, vasodilation, increased urination and staining of urogenital region. Other treatment-related effects observed in dams treated at this concentration included reduced food consumption, increased water consumption and decreased body weight. Significantly increased intrauterine mortality and decreased pup weight were observed at concentrations ≥ 0.74 mg/L. No other maternal effects were reported. No developmental malformations or histopathological effects were reported.

LOAEC (maternal toxicity) = 5.1 mg/L/day (based on clinical signs of toxicity and decreased body weight)

NOAEC (maternal toxicity) = 0.74 mg/L/day

LOAEC (developmental toxicity) = 0.74 mg/L/day (based on intrauterine mortality and decreased pup weight)

NOAEC (developmental toxicity) = 0.15 mg/L/day

(2) Pregnant New Zealand White rabbits (5/group) received heavy pyrolysis hydrocarbons (rerun tower bottoms) as a single daily application to shaved (non-abraded) skin at 0, 62.5, 125, 250, 500 or 1000 mg/kg/day under non-occlusive conditions on GD 6-18. Dams were monitored daily for changes in overt toxicity, mortality and body weight. At terminal sacrifice on GD 29, uteri were excised and the number of viable/nonviable fetuses, early/late resorptions, total implantation sites and corpora lutea were recorded. Abdominal/thoracic cavities and associated organs (not specified) were also examined for gross evidence of abnormal morphology. Mortality was observed in dams treated at concentrations ≥ 500 mg/kg/day. Maternal toxicity, evidenced by decreased mean body weight, skin irritation (erythema, edema, fissuring and eschar formation) and an increased incidence of spontaneous abortion was observed in all treatment groups. No other information was provided in the Robust Summaries.

LOAEL (maternal/developmental toxicity) = 62.5 mg/kg/day (based on decreased body weight and spontaneous abortion)

NOAEL (maternal/developmental toxicity) = Not established

(3) Pregnant New Zealand White rabbits (16/group) received undiluted heavy pyrolysis hydrocarbons (rerun tower bottoms) as a single daily application to shaved (non-abraded) skin at 0, 10, 25 or 50 mg/kg/day, under non-occlusive conditions on GD 6-18. Control rabbits were dosed via topical application of distilled water using a comparable treatment regimen. Dams were monitored daily for changes in overt toxicity and mortality; maternal body weights were recorded on GD 0, 6, 12, 18, 24 and 29. At terminal sacrifice on GD 29, uteri were excised and weighed and the number of viable/nonviable offspring, early/late resorptions, total implantation sites and corpora lutea were recorded. Abdominal/thoracic cavities and associated organs (not specified) were examined for gross evidence of abnormal morphology. All offspring were weighed, examined for external malformations and preserved for histological evaluation. Mortality (one non-gravid female), lung congestion, hyperemic tracheal mucosa and soft stools were reported in dams treated at 50 mg/kg/day (highest dose tested). Spontaneous abortion, significantly decreased body weight and dermal irritation were observed in affected dams at all levels of treatment. Study authors also reported substantial weight loss in control animals. A significant decrease in the mean number of corpora lutea and total implantation sites was observed in dams treated at 10 mg/kg/day (with corresponding decreases in the number of viable

offspring); however, there was no dose response. These effects were less apparent at higher doses. No significant, dose-related differences in the number of corpora lutea, total implantation sites, early/late resorptions, viable offspring or sex ratio were noted between control and treated groups. An increased incidence of skeletal anomalies (13th rudimentary rib) was noted at 50 mg/kg/day (21.8 and 25.7% in control versus treated groups, respectively). Study authors stated that all other observed developmental variations were within the range of historical controls.

LOAEL (maternal toxicity) = 10 mg/kg/day (based on dermal irritation, decreased body weight and spontaneous abortion)

NOAEL (maternal toxicity) = Not established

LOAEL (developmental toxicity) = 50 mg/kg/day (based on an increased incidence of skeletal anomalies)

NOAEL (developmental toxicity) = 25 mg/kg/day

Clarified oils (petroleum), catalytic cracked (CASRN 64741-62-4, supporting chemical)

(1) Pregnant Sprague-Dawley rats (24/dose) were administered CASRN 64741-62-4 (undiluted) at 0, 0.05, 1, 10, 50 or 250 mg/kg/day once daily to (non-abraded) clipped skin on GD 0-19. There were no mortalities in dams. Dose-related signs of maternal toxicity (decreased food consumption, body and gravid uterine weights and the occurrence of a red vaginal exudate) were observed at doses ≥ 1 mg/kg/day. A decrease in the number of viable fetuses was observed at 250 mg/kg/day (highest dose tested). A decrease in pup body weights and an increase in the number of early/late resorptions and non-viable offspring were observed at doses ≥ 1 mg/kg/day. No dose-related increases in fetal malformations were observed; however, an increased incidence of developmental variations (not specified, but presumed by study authors to represent reversible delays in development) were reported at doses ≥ 1 mg/kg/day.

(<http://www.epa.gov/oppt/chemrtk/pubs/summaries/heavyfos/c15368rs.pdf>)

LOAEL (maternal toxicity) = 1 mg/kg/day (based on decreased body and uterine weights)

NOAEL (maternal toxicity) = 0.05 mg/kg/day

LOAEL (developmental toxicity) = 1 mg/kg/day (based on increased early/late resorptions, decreased pup weight and delayed development)

NOAEL (developmental toxicity) = 0.05 mg/kg/day

(2) Pregnant Sprague-Dawley rats (20 controls; 15/dose) were administered CASRN 64741-62-4 via topical application to clipped skin at 0, 0.05, 10 or 250 mg/kg/day once daily, from 1 week prior to mating through GD 20. Each female was observed twice daily for viability and once daily for clinical signs of toxicity. Body weights for each female were recorded on days 1-7 (pre-mating); on GD 0, 4, 8, 12, 16 and 20; and on days 0 and 4 of lactation. At necropsy on LD 4 (or GD 25 for females that did not deliver a litter), ovaries and uterine horns were excised and evaluated for the number of corpora lutea and implantation sites, respectively. Each litter was monitored daily during days 0 (parturition) through 4 of lactation for signs of toxicity and mortality. On day 4 of lactation, all surviving pups were examined for external malformations and discarded. No mortality occurred during this study. Decreased body weight and food consumption were observed in dams treated at doses ≥ 10 mg/kg/day. Decreased thymus weight and increased vaginal discharge were reported at 250 mg/kg/day (highest dose tested); none of the dams treated at this dose delivered their litters. No other signs of developmental toxicity (gestation length, pup survival, pup body weight, developmental malformations, number of implantation sites, pups/litter or viable offspring,) were observed in offspring born to dams

treated at doses ≤ 10 mg/kg/day (*i.e.*, no significant developmental effects were noted between dose groups that delivered a litter and controls). For additional details, see:

(<http://www.epa.gov/oppt/chemrtk/pubs/summaries/heavyfos/c15368rs.pdf>)

LOAEL (maternal toxicity) = 10 mg/kg/day (based on decreased body weights)

NOAEL (maternal toxicity) = 1 mg/kg/day

LOAEL (developmental toxicity) = 250 mg/kg/day (based on arrested parturition)

NOAEL (developmental toxicity) = 10 mg/kg/day

(3) Pregnant rats (strain unspecified, 20/dose) were administered CASRN 64741-62-4 at 0, 10, 100 or 1000 mg/kg/day via the dermal route on GD 9-12. Dams showed decreased body weight and food consumption at doses ≥ 100 mg/kg/day. High-dose dams also exhibited significantly decreased thymus and liver weights, decreased litter sizes, increased resorptions and changes in serum chemistry. Decreased fetal survival and fetal body weights were observed only at the highest dose. An increased incidence of developmental anomalies (unspecified) was observed in offspring born to dams treated at ≥ 100 mg/kg/day. For additional details, see TSCATS (OTS0509763-5).

LOAEL (maternal toxicity) = 100 mg/kg/day (based on decreased maternal body weight)

NOAEL (maternal toxicity) = 10 mg/kg/day

LOAEL (developmental toxicity) = 100 mg/kg/day (based on developmental anomalies)

NOAEL (developmental toxicity) = 10 mg/kg/day

Genetic Toxicity – Gene Mutation

In vitro

EDS experimental fuel oil (No CASRN, supporting chemical)

In a reverse-mutation assay, *Salmonella typhimurium* strains TA98 and TA100 were exposed to EDS experimental fuel oil (in dimethylsulfoxide) at 0, 0.1, 1.0, 10.0, 50, 100 or 500 $\mu\text{g}/\text{mL}$ with and without metabolic activation. Additional doses with Tween 80 dispersant were also tested at 1000 and 10,000 $\mu\text{g}/\text{mL}$. Positive and negative controls were included and responded appropriately.

EDS experimental fuel oil was mutagenic in this assay.

Clarified oils (petroleum), catalytic cracked (CASRN 64741-62-4, supporting chemical)

In a reverse mutation assay, *Salmonella typhimurium* strain TA98 was exposed to CASRN 64741-62-4 at concentrations of 0, 1000, 5000, 10,000, 25,000 or 50,000 $\mu\text{g}/\text{plate}$ in the presence and absence of metabolic activation. A second test was conducted at a lower concentration range of 33 – 3333 $\mu\text{g}/\text{plate}$. Both positive and negative controls were run; however, these responses were not provided in the Robust Summaries. For additional details, see:

(<http://www.epa.gov/oppt/chemrtk/pubs/summaries/heavyfos/c15368rs.pdf>)

CASRN 64741-62-4 was mutagenic in this assay.

Heavy pyrolysis hydrocarbons (rerun tower bottoms) (No CASRN, supporting chemical)

Salmonella typhimurium strains TA98, TA100, TA1535, TA1537, TA1538 and *Saccharomyces cerevisiae* strain D4 were exposed to heavy pyrolysis hydrocarbons (rerun tower bottoms) in dimethyl sulfoxide at 0, 0.001, 0.01, 0.10, 1.0 or 5.0 $\mu\text{L}/\text{plate}$ with and without metabolic activation. Cytotoxicity was observed at 5.0 $\mu\text{L}/\text{plate}$ in *Saccharomyces cerevisiae* strain D4 and

Salmonella strains TA98, TA1535 and TA1537. Positive and negative controls were included. Negative controls responded appropriately; positive control responses were not specified.

Heavy pyrolysis hydrocarbons (rerun tower bottoms) was not mutagenic in this assay.

Genetic Toxicity – Chromosomal Aberrations

In vitro

Gas oils, petroleum, steam-cracked (CASRN 68527-18-4, supporting chemical)

Chinese hamster ovary (CHO) cells were exposed to CASRN 68527-18-4 at 32, 50 or 64 µg/mL without metabolic activation or at 16, 32, 50, 64 or 128 µg/mL with metabolic activation.

Cytotoxicity was observed at doses ≥ 32 µg/mL without metabolic activation and ≥ 16 µg/mL with metabolic activation. Positive and negative controls were included and responded appropriately. No significant increase in mutant colonies was observed.

CASRN 68527-18-4 was not mutagenic in this assay.

Biphenyl feedstock (CASRN 68989-41-3, supporting chemical)

CHO cells were exposed to CASRN 68989-41-3 (in 10% Pluronic polyol F68) at 4, 8, 16, 21, 26, 32 or 64 µg/mL with and without metabolic activation. Cell count toxicity was observed at doses of ≥ 8 µg/mL; colony count toxicity was observed at doses of ≥ 16 µg/mL. Absolute survival was significantly decreased only at concentrations ≥ 26 µg/mL with metabolic activation. Positive and negative controls were included and responded appropriately. No significant increases in mutant frequency were observed.

CASRN 68989-41-3 was not mutagenic in this assay.

Residues, petroleum, steam-cracked (aromatic pyrolysis oil) (CASRN 64742-90-1, supporting chemical)

CHO cells were exposed to CASRN 64742-90-1 (in 50% Pluronic polyol F127) at 32, 64, 96, 128, 175 or 256 µg/mL in the absence of metabolic activation and 128, 175, 256, 375, 512 or 750 µg/mL in the presence of metabolic activation. Dose-related reductions in cell counts were observed with and without metabolic activation. Significant toxicity in colony counts was observed at all doses in the presence of metabolic activation only. Positive and negative controls were included and responded appropriately.

CASRN 64742-90-1 was mutagenic in this assay.

Heavy pyrolysis hydrocarbons (rerun tower bottoms) (No CASRN, supporting chemical)

In a sister chromatid exchange (SCE) assay, human lymphocytes were exposed to heavy pyrolysis hydrocarbons (rerun tower bottoms) in dimethylsulfoxide at doses ranging from 0 to 3.3 µL/mL without metabolic activation. Positive and negative controls were included and responded appropriately. Cytotoxicity data were not included. The frequency of chromosomal aberrations was significantly increased by exposure to Heavy pyrolysis hydrocarbons.

Heavy pyrolysis hydrocarbons (rerun tower bottoms) induced SCE in this assay.

Clarified oils (petroleum), catalytic cracked (CASRN 64741-62-4)

CASRN 64741-62-4 (API 81-15) was tested in mouse embryo cells at 0, 1, 2, 6 or 9 µg/mL in the absence of metabolic activation and 0, 10, 30, 100 or 300 µg/mL in the presence of metabolic activation. Both positive and negative controls were run. Positive controls responded

appropriately; negative control responses were not reported. SCE was increased in the presence of metabolic activation.

(<http://www.epa.gov/oppt/chemrtk/pubs/summaries/heavyfos/c15368rs.pdf>)

CASRN 64741-62-4 induced SCE in this assay.

In vivo

Gas oils, petroleum, steam-cracked (CASRN 68527-18-4, supporting chemical)

In a micronucleus assay, Crl:CD-1 (ICR) BR Swiss mice (2/sex/group) were administered CASRN 68527-18-4 in corn oil via gavage at 0, 250, 500 or 1000 mg/kg/day for two days. A separate group (15/sex) was administered CASRN 68527-18-4 as a single dose via gavage administration at 1000 mg/kg. One animal died in the high-dose group. Positive and negative controls were included. Negative controls responded appropriately; positive control responses were not specified. No significant increase in the frequency of micronucleated polychromatic erythrocytes was observed in mouse bone marrow cells treated with CASRN 68527-18-4.

CASRN 68527-18-4 did not induce micronuclei in this assay.

Biphenyl feedstock (CASRN 68989-41-3, supporting chemical)

In a micronucleus assay, Crl:CD-1 (ICR) BR Swiss mice (2/sex/group) were administered CASRN 68989-41-3 via corn oil gavage at 0, 250, 500 or 1000 mg/kg/day for two days. A separate group (15/sex) was administered CASRN 68989-41-3 as a single dose via gavage administration at 1000 mg/kg. No mortalities were observed. Positive and negative controls were included and responded appropriately. No significant increase in the frequency of micronucleated polychromatic erythrocytes was observed in mouse bone marrow cells treated with CASRN 68989-41-3.

CASRN 68989-41-3 did not induce micronuclei in this assay.

Residues, petroleum, steam-cracked (CASRN 64742-90-1, supporting chemical)

In a micronucleus assay, Crl:CD-1 (ICR) BR Swiss mice (2/sex/group) were administered CASRN 64742-90-1 (in corn oil) via gavage at 0, 1250, 2500 or 5000 mg/kg/day for two days. A separate group (15/sex) was administered CASRN 64742-90-1 as a single dose via gavage at 5000 mg/kg. Positive and negative controls were included. Negative controls responded appropriately while the positive control response was not specified.

CASRN 64742-90-1 induced micronuclei in this assay.

Genetic Toxicity – Other

In vitro

Gas oils, petroleum, steam-cracked (light pyrolysis fuel oil) (CASRN 68527-18-4, supporting chemical)

In an unscheduled DNA synthesis assay, primary cultures of Fischer 344 male rat hepatocytes were exposed to CASRN 68527-18-4 (diluted in 50% Pluronic polyol F127) at 8, 16, 32, 64, 128, 256, 512 or 1024 µg/mL in the absence of metabolic activation. Toxicity was observed at doses of ≥ 64 µg/mL. Positive and negative controls were included and responded appropriately.

CASRN 68527-18-4 induced unscheduled DNA synthesis in this assay.

Biphenyl feedstock (CASRN 68989-41-3, supporting chemical)

In an unscheduled DNA synthesis assay, primary cultures of male Fischer 344 rat hepatocytes were exposed to CASRN 68989-41-3 (in 10% Pluronic polyol F68) at 5, 20, 50 or 100 µg/mL without metabolic activation. Cytotoxicity was observed in the 50 and 100 µg/mL dose groups. Positive and negative controls were included and responded appropriately.

CASRN 68989-41-3 induced unscheduled DNA synthesis in this assay.

Residues, petroleum, steam-cracked (aromatic pyrolysis oil) (CASRN 64742-90-1, supporting chemical)

In an unscheduled DNA synthesis assay, primary cultures of Fischer 344 male rat hepatocytes were exposed to CASRN 64742-90-1 (in 50% Pluronic polyol F127) at 0.5, 2, 10 or 60 µg/mL in the absence of metabolic activation. In a preliminary cytotoxicity test, cytotoxicity was observed at concentrations ≥ 4 µg/mL. Positive and negative controls were included and responded appropriately.

CASRN 64742-90-1 induced unscheduled DNA synthesis in this assay.

In vivo

Clarified oils (petroleum), catalytic cracked (CASRN 64741-62-4, supporting chemical)

Fischer 344 male rats were exposed to CASRN 64741-62-4 (API 81-15) via gavage administration at 50, 200 or 1000 mg/kg at 2 and 12 hours prior to sacrifice. Primary hepatocyte cultures were obtained from the livers of treated rats. Unscheduled DNA synthesis was significantly higher than that seen in solvent controls. For additional details, see:

(<http://www.epa.gov/oppt/chemrtk/pubs/summaries/heavyfos/c15368rs.pdf>)

CASRN 64742-62-4 induced unscheduled DNA synthesis in this assay.

Additional Information

Skin Irritation

Clarified oils (petroleum), catalytic cracked (CASRN 64741-62-4, supporting chemical)

Undiluted CASRN 64741-62-4 (0.5 mL) was applied to intact and abraded skin of rabbits under occlusive conditions for 24 hours; animals were observed for 14 days after application. The degree of erythema and edema was recorded according to the Draize scale (primary irritation index = 5.1 for intact skin and 5.6 for abraded skin). For additional details, see:

<http://www.epa.gov/oppt/chemrtk/pubs/summaries/heavyfos/c15368rs.pdf>

CASRN 64741-62-4 was irritating to rabbit skin in this study.

Residues, petroleum, steam-cracked (aromatic pyrolysis oil) (CASRN 64742-90-1, supporting chemical)

Fischer 344 rats (5/sex/group) were administered CASRN 64742-90-1 (*aromatic pyrolysis oil*) via dermal application to clipped skin at 0, 1000 or 2000 mg/kg/day for 6 hours/day, 5 days/week over a 14-day period. Dermal irritation (moderate to severe erythema with fissuring and peeling of the skin; draize score 3-4) and associated histopathology (moderate to marked acanthosis, epithelial hyperplasia and hyperkeratosis) were observed at the highest dose (both sexes).

CASRN 64742-90-1 was irritating to rat skin in this study.

Gas oils, petroleum, steam-cracked (CASRN 68527-18-4, supporting chemical)

Fischer 344 rats (number not specified) received CASRN 68527-18-4 via dermal application to clipped skin at 0, 1000 or 2000 mg/kg-bw/day, 6 hours/day for 5 days and observed for 2 days following dosing. No mortalities occurred. Decreased body weight was observed in high-dose males. Males and females from both dose groups experienced erythema and eschar formation; slight edema observed in high-dose males and females resolved by day 8.

CASRN 68527-18-4 was irritating to rat skin in this study.

Eye Irritation

Clarified oils (petroleum), catalytic cracked (CASRN 64741-62-4, supporting chemical)

Undiluted clarified oils (petroleum), catalytic cracked (API 81-15) (0.1 mL) was applied to the corneal surface of one eye of each of nine rabbits (opposing eye served as control). Treated eyes were then washed with lukewarm water for one minute. Eyes of the other six rabbits were not washed. Observed irritation (primary irritation index = 2.3) resolved within 24 hours of exposure. For additional details, see:

(<http://www.epa.gov/oppt/chemrtk/pubs/summaries/heavyfos/c15368rs.pdf>)

CASRN 64741-62-4 was irritating to rabbit eyes in this study.

Sensitization

Clarified oils (petroleum), catalytic cracked (CASRN 64741-62-4, supporting chemical)

Ten male guinea pigs (strain unspecified) received CASRN 64741-62-4 (API 81-15) [0.4 mL of 0.3% (w/v) in 80% aqueous ethanol] via topical application to shaved, dorsal skin under occlusive conditions for 6 hours/day, 1 day/week for 3 weeks (induction). Two weeks after the third treatment application, each animal was subjected to a challenge dose of test article (0.4 mL of 0.1% (w/v) suspension in acetone) via dermal application to a previously untreated site. Test sites were graded for sensitization responses at 24 and 48 hours after patch removal. The positive, vehicle and naïve control groups included in this study responded appropriately. No dermal irritation was apparent in test or control groups following challenge administration.

CASRN 64741-62-4 was not a skin sensitizer in this assay.

Carcinogenicity

Fuel oil, pyrolysis (CASRN 69013-21-4, supporting chemical)

C3H/HeJ mice (40/dose; sex not specified) received 25 µL of undiluted CASRN 69013-21-4 (water and oil quenched) via the dermal route, 3 days/week for 28 months. CASRN 69013-21-4 induced surface alterations, including hyperkeratosis, ulcerative dermatitis and surface crusting. Histological examination revealed malignant tumors (two squamous cell carcinomas and two papillomas) at the site of application. Two mesenchymal tumors (fibrosarcoma and lymphosarcoma) were also found in treated mice. No skin tumors were observed in controls.

CASRN 69013-21-4 was carcinogenic to mice in this study.

Other

Clarified oils (petroleum), catalytic cracked (CASRN 64741-62-4, supporting chemical)

In a dominant lethal assay, male Sprague-Dawley rats (10/sex) received CASRN 64741-62-4 via dermal application at 0, 0.1, 1.0, 10, 50 or 250 mg/kg/day for 70 days before mating with unexposed females. Male rats were examined daily for adverse effects during the dosing period and once weekly during the post-exposure period. Females were sacrificed on GD 14 and uterine contents were examined. A gross necropsy of the thoracic and abdominal cavities revealed no abnormalities. The uterus of each rat was evaluated for evidence of pregnancy and the number of implantations, corpora lutea, early resorptions, and live/dead embryos. The testes, epididymides, seminal vesicles, prostate, pituitary, and brain were excised from male rats and weighed. Sperm quality (spermatid/spermatozoa counts, sperm morphology, motility) was evaluated microscopically. No mortality occurred. No effects on reproductive parameters (number of corpora lutea, implantation sites, viable offspring, mating/fertility indices) or histopathological effects were reported in this study.

CASRN 64741-62-4 did not induce dominant lethal mutations in rats.

Conclusion: No data are available for the sponsored streams; data for supporting chemicals are used to address human health endpoints. Acute oral toxicity for CASRNs 68527-18-4, 68989-41-3, 64742-90-1, 64741-62-4 is low in rats. Acute inhalation toxicity for CASRNs 68527-18-4, 68989-41-3 and 64742-90-1 is low in rats. Acute dermal toxicity for CASRNs 68989-41-3, 64741-62-4 is low in rabbits.

A 28-day inhalation toxicity study with CASRN 68527-18-4 in rats showed decreased body weight, hematology changes and increased relative organ weights in both sexes at aerosol concentrations of 0.51 mg/L/day (lowest concentration tested); the NOAEC for systemic toxicity is not established. A dermal 28-day repeated-dose study in rabbits with EDS experimental fuel oil (No CASRN) showed significant increases in absolute/relative liver and kidney weights, dermal irritation (desquamation, blanching, atonia and fissuring) and liver histopathology (hepatocytomegaly, vacuolization, cytoplasmic degeneration) in both sexes at 50 mg/kg/day (lowest dose tested); the NOAEL for systemic toxicity is not established. In two 13-week dermal repeated-dose toxicity studies in rats with CASRN 64741-62-4, epidermal hyperplasia and liver effects (increased liver weight, microcysts, cholangiolitis) in both sexes were observed at or above 8 mg/kg/day (lowest dose tested) in one study and decreased body weight and abnormal thickening of the skin at 40 mg/kg/day (lowest dose tested) in the other; the NOAEL for systemic toxicity is not established. A 13-week oral repeated-dose toxicity study with EDS experimental fuel oil (No CASRN) in rats showed hematology effects in both sexes and organ weight changes (increased absolute liver weight and decreased absolute brain weight) in females at 500 mg/kg/day (highest dose tested); the NOAEL for systemic toxicity is 100 mg/kg/day.

No reproductive or developmental effects were reported in an oral one-generation reproductive toxicity study with EDS experimental fuel oil (No CASRN) in rats; the NOAEL for reproductive/maternal/developmental toxicity is 500 mg/kg/day (highest dose tested). An oral prenatal developmental toxicity study with EDS experimental fuel oil in rats showed maternal

toxicity (clinical signs, decreases in body weight gain and uterine wet weight) and developmental effects (skeletal anomalies and decreases in pup length/weight and the number of live offspring) at 500 mg/kg/day and above; the NOAEL for maternal/developmental toxicity is 100 mg/kg/day. A prenatal developmental toxicity screening test with the heavy pyrolysis hydrocarbons stream (No CASRN) in rats showed decreased body weight in dams following vapor inhalation at 5.1 mg/L/day (highest concentration tested); the NOAEC for maternal toxicity is 0.74 mg/L/day. Developmental effects (intrauterine mortality and decreased pup weight) were also observed at 0.74 mg/L/day and above; the NOAEC for developmental toxicity is 0.15 mg/L/day. Two dermal prenatal developmental toxicity studies with CASRN 64741-62-4 in rats showed maternal toxicity (decreased body/uterine weights) and developmental effects (increased resorptions, decreased pup weight and developmental delays) at 1 mg/kg/day and above; the NOAELs for maternal and developmental toxicity range from 0.05 - 10 mg/kg/day. A dermal prenatal developmental toxicity study with the heavy pyrolysis hydrocarbons stream (No CASRN) showed maternal toxicity (decreased body weight), dermal irritation (erythema, edema, eschar formation) and an increased incidence of spontaneous abortion in rabbits treated at 10 mg/kg/day (lowest dose tested); the NOAEL for maternal toxicity is not established. There was also an increased incidence of skeletal anomalies (13th rudimentary rib) at 50 mg/kg/day; the NOAEL for developmental toxicity is 25 mg/kg/day. CASRN 64741-62-4 did not induce mutations in a dominant lethal assay in rats following dermal exposure at 250 mg/kg/day (highest dose tested).

CASRN 64741-62-4 and EDS experimental fuel oil (No CASRN), induced gene mutations in bacteria when tested *in vitro*, but the heavy pyrolysis hydrocarbons stream (No CASRN) did not. CASRN 64742-90-1 induced chromosomal aberrations in mammalian cells *in vitro*; CASRN 68989-41-3 and CASRN 68527-18-4 did not. CASRN 64742-90-1 induced mouse micronuclei *in vivo*, whereas CASRN 68527-18-4 and CASRN 68989-41-3 did not. The heavy pyrolysis hydrocarbons stream (No CASRN) and CASRN 64741-62-4 induced sister chromatid exchange in mammalian cells *in vitro*. CASRNs 68989-41-3, 64742-90-1, 68527-18-4 and 64741-62-4 induced unscheduled DNA synthesis in rat hepatocytes. CASRN 69013-21-4 induced tumors (squamous cell carcinoma) in mice during a 28-month skin painting bioassay. CASRNs 64742-90-1 and 68527-18-4 are irritating to rat skin. CASRN 64741-62-4 is irritating to rabbit skin and eyes, but it is not a skin sensitizer in guinea pigs.

Table 5. Summary Table of the Screening Information Data Set as Submitted under the U.S. HPV Challenge Program - Human Health Data								
Endpoints	SPONSORED CHEMICAL Heavy pyrolysis fuel oil (68513-69-9, 64741-62-4, 69013-21-4, 8002-05-9)	SPONSORED CHEMICAL Quench oil (68513-69-9, 69430-33-7)	SPONSORED CHEMICAL Light pyrolysis fuel oil (68475-80-9, 68514-34-1, 68527-18-4)	SPONSORED CHEMICAL Pyrolysis C10+ fuel oil (68513-69-9, 68921-67-5)	SPONSORED CHEMICAL Combined fuel oil (E&P) (64742-90-1, 68131-05-5, 68527-18-4, 69013-21-4)	SPONSORED CHEMICAL Hydrotreated flux oil (64742-47-8, 69013-21-4)	SPONSORED CHEMICAL Biphenyl concentrate (68409-73-4)	SPONSORED CHEMICAL Combined fuel oil (B&P) (68513-69-9)
Acute Oral Toxicity LD₅₀ (mg/kg)	No Data 2890 (RA)							
Acute Inhalation Toxicity LC₅₀ (mg/L)	No Data > 3 (RA)							
Acute Dermal Toxicity LD₅₀ (mg/kg)	No Data >2000 (RA)							
Repeated-Dose Toxicity NOAEL/LOAEL Oral (mg/kg/day)	No Data NOAEL = 100 LOAEL = 500 (RA)							
Repeated-Dose Toxicity NOAEL/LOAEL Inhalation (mg/L/day)	No Data NOAEC = Not established LOAEC = 0.51 (28 d) (RA)							
Repeated-Dose Toxicity NOAEL/LOAEL Dermal (mg/kg/day)	No Data NOAEL = Not established LOAEL = 8 (RA)							
Reproductive Toxicity NOAEL/LOAEL Oral (mg/kg/day)	No Data NOAEL = 500 (RA)							

Table 5. Summary Table of the Screening Information Data Set as Submitted under the U.S. HPV Challenge Program - Human Health Data								
Endpoints	SPONSORED CHEMICAL Heavy pyrolysis fuel oil (68513-69-9, 64741-62-4, 69013-21-4, 8002-05-9)	SPONSORED CHEMICAL Quench oil (68513-69-9, 69430-33-7)	SPONSORED CHEMICAL Light pyrolysis fuel oil (68475-80-9, 68514-34-1, 68527-18-4)	SPONSORED CHEMICAL Pyrolysis C10+ fuel oil (68513-69-9, 68921-67-5)	SPONSORED CHEMICAL Combined fuel oil (E&P) (64742-90-1, 68131-05-5, 68527-18-4, 69013-21-4)	SPONSORED CHEMICAL Hydrotreated flux oil (64742-47-8, 69013-21-4)	SPONSORED CHEMICAL Biphenyl concentrate (68409-73-4)	SPONSORED CHEMICAL Combined fuel oil (B&P) (68513-69-9)
Developmental Toxicity NOAEL/LOAEL Oral (mg/kg/day)	No Data NOAEL = 100 LOAEL = 500 (RA)							
Developmental Toxicity NOAEC/LOAEC Inhalation (mg/L/day) Maternal Toxicity Developmental Toxicity	No Data NOAEC = 0.74 LOAEC = 5.1 NOAEC = 0.15 LOAEC = 0.74 (RA)							
Developmental Toxicity NOAEL/LOAEL Dermal (mg/kg/day) Maternal Toxicity Developmental Toxicity	No Data NOAEL = 0.05 LOAEL = 1.0 NOAEL = 0.05 LOAEL = 1.0 (RA)							

Table 5. Summary Table of the Screening Information Data Set as Submitted under the U.S. HPV Challenge Program - Human Health Data								
Endpoints	SPONSORED CHEMICAL Heavy pyrolysis fuel oil (68513-69-9, 64741-62-4, 69013-21-4, 8002-05-9)	SPONSORED CHEMICAL Quench oil (68513-69-9, 69430-33-7)	SPONSORED CHEMICAL Light pyrolysis fuel oil (68475-80-9, 68514-34-1, 68527-18-4)	SPONSORED CHEMICAL Pyrolysis C10+ fuel oil (68513-69-9, 68921-67-5)	SPONSORED CHEMICAL Combined fuel oil (E&P) (64742-90-1, 68131-05-5, 68527-18-4, 69013-21-4)	SPONSORED CHEMICAL Hydrotreated flux oil (64742-47-8, 69013-21-4)	SPONSORED CHEMICAL Biphenyl concentrate (68409-73-4)	SPONSORED CHEMICAL Combined fuel oil (B&P) (68513-69-9)
Genetic Toxicity – Gene Mutation <i>In vitro</i>	No Data Positive (RA)							
Genetic Toxicity – Chromosomal Aberrations <i>In vitro</i>	No Data Positive (RA)							
Genetic Toxicity – Chromosomal Aberrations <i>In vivo</i>	No Data Positive (RA)							
Genetic Toxicity – Other Unscheduled DNA synthesis <i>In vitro</i>	No Data Positive (RA)							

Table 5. Summary of the Screening Information Data Set as Submitted under the U.S. HPV Challenge Program – Human Health Data

Endpoints	SUPPORTING CHEMICAL Clarified oils, petroleum, catalytic cracked (64741-62-4)	SUPPORTING CHEMICAL Residues, petroleum, steam-cracked (64742-90-1)	SUPPORTING CHEMICAL Fuel Oil, Pyrolysis (69013-21-4)	SUPPORTING CHEMICAL Residues, petroleum, steam-cracked light (68513-69-9)	SUPPORTING CHEMICAL Gas oils, petroleum, steam-cracked (68527-18-4)	SUPPORTING CHEMICAL Heavy Pyrolysis Hydrocarbons (No CASRN)	SUPPORTING CHEMICAL Biphenyl Feedstock (68989-41-3)	SUPPORTING CHEMICAL EDS Experimental Fuel Oil (No CASRN)
Acute Oral Toxicity LD₅₀ (mg/kg)	> 4320	> 5000	–	–	2890	14,500	3700	> 5000
Acute Inhalation Toxicity LC₅₀ (mg/L)	–	> 3.7	–	–	> 4.95	6.0	> 3.0	–
Acute Dermal Toxicity LD₅₀ (mg/kg)	> 2000	–	–	–	–	> 5000	> 2000	> 3160
Repeated-Dose Toxicity NOAEL/LOAEL Oral (mg/kg/day)	–	–	–	–	–	–	–	NOAEL = 100 LOAEL = 500
Repeated-Dose Toxicity NOAEC/LOAEC Inhalation (mg/L/day)	–	–	–	–	(28-d) NOAEC = Not established LOAEC = 0.51	–	–	–
Repeated-Dose Toxicity NOAEL/LOAEL Dermal (mg/kg/day)	(rat) NOAEL = Not established LOAEL = 8 (rabbit) NOAEL = Not established LOAEL = 200	–	–	–	–	–	–	NOAEL = Not established LOAEL = 50

Table 5. Summary of the Screening Information Data Set as Submitted under the U.S. HPV Challenge Program – Human Health Data

Endpoints	SUPPORTING CHEMICAL Clarified oils, petroleum, catalytic cracked (64741-62-4)	SUPPORTING CHEMICAL Residues, petroleum, steam-cracked (64742-90-1)	SUPPORTING CHEMICAL Fuel Oil, Pyrolysis (69013-21-4)	SUPPORTING CHEMICAL Residues, petroleum, steam-cracked light (68513-69-9)	SUPPORTING CHEMICAL Gas oils, petroleum, steam-cracked (68527-18-4)	SUPPORTING CHEMICAL Heavy Pyrolysis Hydrocarbons (No CASRN)	SUPPORTING CHEMICAL Biphenyl Feedstock (68989-41-3)	SUPPORTING CHEMICAL EDS Experimental Fuel Oil (No CASRN)
Reproductive Toxicity NOAEL/LOAEL Oral (mg/kg/day)	–	–	–	–	–	–	–	NOAEL = 500 (highest dose tested)
Developmental Toxicity NOAEL/LOAEL Oral (mg/kg-day)								
Maternal Toxicity	–	–	–	–	–	–	–	NOAEL = 100 LOAEL = 500
Developmental Toxicity	–	–	–	–	–	–	–	NOAEL = 100 LOAEL = 500
Developmental Toxicity NOAEC/LOAEC Inhalation (mg/L/day)								
Maternal Toxicity	–	–	–	–	–	NOAEC = 0.74 LOAEC = 5.1	–	–
Developmental Toxicity	–	–	–	–	–	NOAEC 0.15 LOAEC = 0.74	–	–

Table 5. Summary of the Screening Information Data Set as Submitted under the U.S. HPV Challenge Program – Human Health Data

Endpoints	SUPPORTING CHEMICAL Clarified oils, petroleum, catalytic cracked (64741-62-4)	SUPPORTING CHEMICAL Residues, petroleum, steam-cracked (64742-90-1)	SUPPORTING CHEMICAL Fuel Oil, Pyrolysis (69013-21-4)	SUPPORTING CHEMICAL Residues, petroleum, steam-cracked light (68513-69-9)	SUPPORTING CHEMICAL Gas oils, petroleum, steam-cracked (68527-18-4)	SUPPORTING CHEMICAL Heavy Pyrolysis Hydrocarbons (No CASRN)	SUPPORTING CHEMICAL Biphenyl Feedstock (68989-41-3)	SUPPORTING CHEMICAL EDS Experimental Fuel Oil (No CASRN)
Developmental Toxicity NOAEL/LOAEL Dermal (mg/kg/day) Maternal	NOAEL = 0.05 LOAEL = 1.0	–	–	–	–	NOAEL = Not established LOAEL = 10	–	–
Developmental	NOAEL = 0.05 LOAEL = 1.0	–	–	–	–	NOAEL = 25 LOAEL = 50	–	–
Genetic Toxicity – Gene Mutation <i>In vitro</i>	Positive	–	–	–	–	Negative	Negative	Positive
Genetic Toxicity – Chromosomal Aberrations <i>In vitro</i>	Positive	Positive	–	–	Negative	Positive	–	–
Genetic Toxicity – Chromosomal Aberrations <i>In vivo</i>	–	Positive	–	–	Negative	–	Negative	–
Genetic Toxicity – Other Unscheduled DNA synthesis	Positive	Positive	–	–	Positive	–	Positive	–

Table 5. Summary of the Screening Information Data Set as Submitted under the U.S. HPV Challenge Program – Human Health Data								
Endpoints	SUPPORTING CHEMICAL Clarified oils, petroleum, catalytic cracked (64741-62-4)	SUPPORTING CHEMICAL Residues, petroleum, steam-cracked (64742-90-1)	SUPPORTING CHEMICAL Fuel Oil, Pyrolysis (69013-21-4)	SUPPORTING CHEMICAL Residues, petroleum, steam-cracked light (68513-69-9)	SUPPORTING CHEMICAL Gas oils, petroleum, steam-cracked (68527-18-4)	SUPPORTING CHEMICAL Heavy Pyrolysis Hydrocarbons (No CASRN)	SUPPORTING CHEMICAL Biphenyl Feedstock (68989-41-3)	SUPPORTING CHEMICAL EDS Experimental Fuel Oil (No CASRN)
Additional Information								
Skin Irritation	Irritating	Irritating	–	–	Irritating	–	–	–
Eye Irritation	Irritating	–	–	–	–	–	–	–
Sensitization	Negative	–	–	–	–	–	–	–
Carcinogenicity	–	–	Positive	–	–	–	–	–

Measured data in bold text; (RA) = Read Across; – indicates that endpoint was not evaluated for this substance

4. Hazard to the Environment

A summary of aquatic toxicity data submitted for SIDS endpoints is provided in Table 6. The table also indicates where data for tested category members are read-across (RA) to untested members of the category.

Acute Toxicity to Fish

Pyrolysis C10+ fuel oil (CASRN 68513-69-9, and 68921-67-5)

Rainbow trout (*Oncorhynchus mykiss*) were exposed to pyrolysis C10+ fuel oil at measured concentrations of 0, 0.4, 0.79, 1.7, 3.7 or 6.3 mg/L under static-renewal conditions for 96 hours. **96-h LC₅₀ = 1.0 mg/L**

Heavy pyrolysis fuel oil (CASRN 68513-69-9, 64741-62-4, 69013-21-4, and 8002-05-9)

Rainbow trout (*Oncorhynchus mykiss*) were exposed to heavy pyrolysis fuel oil at measured concentrations of 0, 0.4, 0.79, 1.7, 3.7 or 6.3 mg/L under static-renewal conditions for 96 hours. **96-h LC₅₀ = 4.4 mg/L**

Anthracene (CASRN 120-12-7, supporting chemical)

(1) Bluegill sunfish (*Lepomis macrochirus*) were exposed to the test substance at unreported concentrations under flow-through conditions for 96 hours. The toxicity reported is based on the measured concentrations (McCloskey *et al.*, 1991).

96-h LC₅₀ = 0.001 mg/L

(2) Bluegill sunfish (*Lepomis macrochirus*) were exposed to the test substance at unreported concentrations under static conditions for 96 hours. The toxicity reported is based on the measured concentrations (Oris *et al.*, 1984).

96-h LC₅₀ = 0.012 mg/L

Acute Toxicity to Aquatic Invertebrates

Pyrolysis C10+ fuel oil (CASRN 68513-69-9, and 68921-67-5)

Daphnia magna were exposed to pyrolysis C10+ fuel oil at measured concentrations of 0, 0.07, 0.14, 0.82, 1.7 or 4.2 mg/L under static conditions for 48 hours. **48-h EC₅₀ = 1.2 mg/L**

Heavy pyrolysis fuel oil (CASRN 68513-69-9, 64741-62-4, 69013-21-4, and 8002-05-9)

Daphnia magna were exposed to heavy pyrolysis fuel oil at measured concentrations of 0, 0.18, 1.6, 1.8, 4.1 or 7.8 mg/L under static conditions for 48 hours

48-h EC₅₀ = 2.7 mg/L

Anthracene (CASRN 120-12-7, supporting chemical)

(1) *Daphnia magna* were exposed to the test substance at unreported concentrations under static conditions for 48 hours. The toxicity reported is based on the nominal concentrations (Munoz *et al.*, 1993).

96-h EC₅₀ = 0.095 mg/L

(2) *Daphnia magna* were exposed to the test substance at unreported concentrations under static conditions for 48 hours. The toxicity reported is based on the nominal concentrations (Smith *et al.*, 1988).

96-h EC₅₀ = 0.75 mg/L

Toxicity to Aquatic Plants

Pyrolysis C10+ fuel oil (CASRN 68513-69-9, and 68921-67-5)

Green algae (*Pseudokirchneriella subcapitata*) were exposed to pyrolysis C10+ fuel oil at measured concentrations of 0, 0.04, 0.12, 0.36, 0.99 or 2.4 mg/L under static conditions for 96 hours.

72-h EC₅₀ (growth rate) = 1.7 mg/L

72-h EC₅₀ (biomass) = 0.95 mg/L

Heavy pyrolysis fuel oil (CASRN 68513-69-9, 64741-62-4, 69013-21-4, and 8002-05-9)

Green algae (*Pseudokirchneriella subcapitata*) were exposed to heavy pyrolysis fuel oil at measured concentrations of 0, 0.07, 0.42, 1.1, 2.1 or 6.4 mg/L under static conditions for 96 hours.

72-h EC₅₀ (growth rate) = 2.0 mg/L

72-h EC₅₀ (biomass) = 1.3 mg/L

Chronic Toxicity to Aquatic Invertebrates

Anthracene (CASRN 120-12-7, supporting chemical)

Daphnia magna were exposed to the test substance at unreported concentrations under static renewal conditions for 21 days for the reproduction. The toxicity reported is based on the measured concentrations (Holst *et al.*, 1989).

21-d Chronic value = 0.002 mg/L

Conclusion: The 96-h LC₅₀ values for acute toxicity to fish for heavy pyrolysis fuel oil (no CASRN) and pyrolysis C10+ fuel oil (no CASRN) are 4.4 and 1.0 mg/L, respectively. The 96-h LC₅₀ for the supporting chemical, CASRN 120-12-7, ranges from 0.001 to 0.012 mg/L. The 48-h EC₅₀ values for acute toxicity to aquatic invertebrates for heavy pyrolysis fuel oil (no CASRN) and pyrolysis C10+ fuel oil (no CASRN) are 2.7 and 1.2 mg/L, respectively. The 48-h EC₅₀ for the supporting chemical, CASRN 120-12-7, ranges from 0.095 to 0.75 mg/L. The 72-h EC₅₀ values for toxicity to aquatic plants for heavy pyrolysis fuel oil (no CASRN) and pyrolysis C10+ fuel oil (no CASRN) are 1.3 mg/L (biomass) and 2.0 mg/L (growth rate), and 0.95 mg/L (biomass) and 1.7 mg/L (growth rate), respectively. The 21-d chronic toxicity to aquatic invertebrates for the supporting chemical, CASRN 120-12-7 is 0.002 mg/L.

Table 6. Summary of the Screening Information Data Set as Submitted under the U.S. HPV Challenge Program – Aquatic Toxicity Data

Endpoints	SPONSORED CHEMICAL Heavy pyrolysis fuel oil (68513-69-9, 64741-62-4, 69013-21-4, 8002-05-9)	SPONSORED CHEMICAL Quench oil (68513-69-9, 69430-33-7)	SPONSORED CHEMICAL Light pyrolysis fuel oil (68475-80-9, 68514-34-1, 68527-18-4)	SPONSORED CHEMICAL Pyrolysis C10+ fuel oil (68513-69-9, 68921-67-5)	SPONSORED CHEMICAL Combined fuel oil (E&P) (64742-90-1, 68131-05-5, 68527-18-4, 69013-21-4)	SPONSORED CHEMICAL Hydro-treated flux oil (64742-47-8, 69013-21-4)	SPONSORED CHEMICAL Biphenyl concentrate (68409-73-4)	SPONSORED CHEMICAL Combined fuel oil (B&P) (68513-69-9)	SUPPORTING CHEMICAL Anthracene (120-12-7)
Fish 96-h LC₅₀ (mg/L)	4.4	No Data 0.001- 4.4 (RA)	No Data 0.001 - 4.4 (RA)	1.0	No Data 0.001- 4.4 (RA)	No Data 0.001- 4.4 (RA)	No Data 0.001- 4.4 (RA)	No Data 0.001 - 4.4 (RA)	0.001 -0.012
Aquatic Invertebrates 48-h EC₅₀ (mg/L)	2.7	No Data 0.095 – 2.7 (RA)	No Data 0.095 – 2.7 (RA)	1.2	No Data 0.095 – 2.7 (RA)	No Data 0.095 – 2.7 (RA)	No Data 0.095 – 2.7 (RA)	No Data 0.095 – 2.7 (RA)	0.095- 0.75
Aquatic Plants 72-h EC₅₀ (mg/L) (biomass) (growth rate)	1.3 2.0	No Data 0.95 - 1.3 1.7- 2.0 (RA)	No Data 0.95 - 1.3 1.7- 2.0 (RA)	0.95 1.7	No Data 0.95 - 1.3 1.7- 2.0 (RA)	No Data 0.95 - 1.3 1.7- 2.0 (RA)	No Data 0.95 - 1.3 1.7- 2.0 (RA)	No Data 0.95 - 1.3 1.7- 2.0 (RA)	– –
Chronic Aquatic Invertebrates 21-d ChV (mg/L)	No Data 0.002 (RA)	No Data 0.002 (RA)	No Data 0.002 (RA)	No Data 0.002 (RA)	No Data 0.002 (RA)	No Data 0.002 (RA)	No Data 0.002 (RA)	No Data 0.002 (RA)	0.002

bold = experimental data (i.e., derived from testing); (RA) = Read Across; – indicates that endpoint was not addressed for this chemical; ChV = chronic value

5. References

Holst, L.L. and J.P. Giesy, 1989. Chronic Effects of the Photoenhanced Toxicity of Anthracene on *Daphnia magna* Reproduction. Environ. Toxicol. Chem. 8(10):933-942

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Oris, J.T., J.P. Giesy, P.M. Allred, D.F. Grant, and P.F. Landrum, 1984. Photoinduced Toxicity of Anthracene in Aquatic Organisms: An Environmental Perspective. In: T.N. Veziroglu (Ed.), The Biosphere: Problems and Solutions, Elsevier Science Publ., Amsterdam, Netherlands:639-658

Smith, S.B., J.F. Savino, and M.A. Blouin, 1988. Acute Toxicity to *Daphnia pulex* of Six Classes of Chemical Compounds Potentially Hazardous to Great Lakes Aquatic Biota. J. Great Lakes Res. 14(4):394-404 / Aquat. Sci. Fish. Abstr. 17(2):139

APPENDIX

The following pages show:

- Table 7 with typical stream constituents as presented in the sponsor's category document for Fuel Oils Category - March 2005,
<http://www.epa.gov/oppt/chemrtk/pubs/summaries/fueloils/c13435tc.htm>
- Table 8 with representative structures of the sponsored substances and the supporting chemicals
- Table 9 with TSCA definition for each CASRN
- Description of ethylene manufacturing process and the associated diagram are taken from the sponsor's original HPV submission of Fuel Oils Category - December 2001,
<http://www.epa.gov/oppt/chemrtk/pubs/summaries/fueloils/c13435tc.htm>

Table 7. Typical Constituent (wt %) Range in Sponsored Streams of the Fuel Oils Category

Constituent	Fuel Oil (FO) Stream Number and Name							
	FO 1	FO 2	FO 3	FO 4	FO 5	FO 6	FO 7	FO 8
	Heavy Pyrolysis Fuel Oil from the Ethylene Process Unit* (wt %)	Quench Oil from the Ethylene Process Water Quench System (wt %)	Light Pyrolysis Fuel Oil from the Ethylene Process Unit (wt %)	Pyrolysis C10+ Fuel Oil from Pyrolysis Gasoline (wt %)	Combined Fuel Oil from Ethylene & Pyrolysis Gasoline (wt %)	Hydro-treated Flux Oil (wt %)	Biphenyl Concentrate (wt %)	Combined Fuel Oil from Benzene HDA & Pyrolysis Fuel Oils (wt %)
1,3-Butadiene		0.1 - 0.3						
C6 Non-aromatics (NOS)					0.2 - 3.1			
C5s and Lighter (NOS)					1.8			
C6s and Lighter (NOS)								0.2
Benzene		0.1			0.2 - 4			0.1 - 0.3
C7 Paraffins & Naphthenes					3			
Toluene		5			0.2 - 1.3		1 - 8	
C8 Paraffins & Naphthenes					6.1			
Ethylbenzene		5					1	
C8 Aromatics (NOS)					0.4 - 2.6			
Xylenes, Mixed		5					2	
Styrene		0 - 5			0.9			
C9 Aromatics (NOS)				2	12.6			
C9s (NOS)						<1		
Other Benzenes to Naphthalene					14.5			11
C9 Paraffins & Naphthenes					12.6			
C10+ (NOS)							3 - 25	
Trimethylbenzenes					1			
Dicyclopentadiene				20	0.9			7.5 - 11.7
C10 & C11 Codimers of C5 & C6 Olefins				30				
Indane (Indan)					1.5			
2,3-Benzindene					2 - 5			5 - 6.4
Methyl Dicyclopentadiene					0.9			
C10 Aromatics (NOS)					32.1			
C10s (NOS)						10		
C11s (NOS)						40		
C12s (NOS)						40		
C13s (NOS)						10		
Indene		5	5 - 15	2	0.7 - 0.8			3.8
Methyl Indenes					5.6			0.2 - 2
1,3-Diethyl-5-methylbenene					1.5			
Dimethylindan					4.0			
Dimethylindene					5.4			

Constituent	Fuel Oil (FO) Stream Number and Name							
	FO 1	FO 2	FO 3	FO 4	FO 5	FO 6	FO 7	FO 8
	Heavy Pyrolysis Fuel Oil from the Ethylene Process Unit* (wt %)	Quench Oil from the Ethylene Process Unit Water Quench System (wt %)	Light Pyrolysis Fuel Oil from the Ethylene Process Unit (wt %)	Pyrolysis C10+ Fuel Oil from Pyrolysis Gasoline (wt %)	Combined Fuel Oil from Ethylene & Pyrolysis Gasoline (wt %)	Hydro-treated Flux Oil (wt %)	Biphenyl Concentrate (wt %)	Combined Fuel Oil from Benzene HDA & Pyrolysis Fuel Oils (wt %)
n-C13					1.3			
Methylcyclopentadiene Dimers					5.1			
Naphthalene		0.7 - 10	30 - 60	7	10 - 47		1 - 4	7 - 13.2
C7-C18 Cyclic Olefins (NOS)		65.0						
Methylnaphthalenes					3.8 - 30		1	
2-Methylnaphthalene				2				0.1 - 13
1-Methylnaphthalene				2				9
Fluoranthene		0 - 1.1						
1,1'-Biphenyl		0.5 - 5		6	1.1 - 5.1		65 - 95	25 - 34.6
Ethyl Naphthalene's					0.8			1.5 - 4
Substituted Naphthalenes				13				
1-Ethyl naphthalene				8				
Dimethylnaphthalenes				8	3.8			
Acenaphthylene		0.1 - 6.9						
Diphenylethane					2 - 7			
Acenaphthene		0.1 - 1.3						2
Fluorene					3			
C10 Paraffins & Naphthenes					1.1			
Phenanthrene					5			7
Anthracene		10			1 - 5			2
Heavy Hydrocarbons and Polycyclic Aromatics (NOS)				7.0				
Terphenyls								2.5
Methylbiphenyls					5 - 10		1 - 3	6.2
>C18 Cyclic Olefins (NOS)		5						
1,2-Dihydro-acenaphthylene				1				

NOS not otherwise specified

* Consists of C10+ and polycyclic aromatic hydrocarbons, NOS. Specific composition data were not available for the Heavy Pyrolysis Fuel Oil stream. This stream is expected to consist of the higher boiling polyaromatic and polycyclic hydrocarbon components (generally naphthalene and higher) that are included in the composition of the other category streams.

Note: The composition data shown are composites of reported values. The balances of these streams are expected to be other hydrocarbons that have boiling points in the ranges of the listed constituents. The composition limits indicated in the above table should not be considered to represent absolute limits for these streams. They represent the high and low reported values, and may be industry typical limit values.

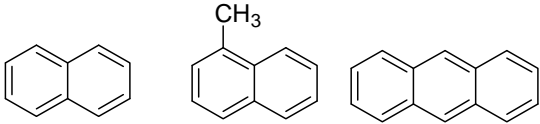
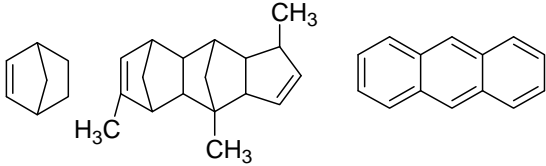
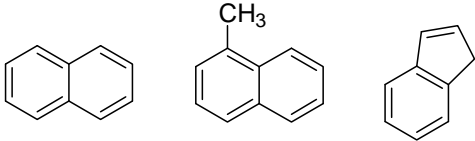
Table 8. Representative Chemical Structures of Fuel Oils Category stream constituents and supporting chemicals		
Name	CASRN	Description or Chemical Structure
Heavy Pyrolysis Fuel Oil	68513-69-9; 64741-62-4; 69013-21-4; 8002-05-9	 <p>This stream is expected to consist of the higher boiling polyaromatic and polycyclic hydrocarbon components (generally naphthalene and higher).</p> <p>In ethylene plants cracking liquid feedstocks, the cracking furnace effluent (after heat recovery) is further quenched by injection of recycled quench oil. This step results in the condensation of higher boiling hydrocarbon compounds that are typically separated from the rest of the furnace effluent as the bottoms of the primary fractionation tower or oil quench tower. Light hydrocarbons are stripped from the excess oils generated from this quench system, resulting in the stream identified here as heavy pyrolysis fuel oil consisting of C10+ and considerable PAHs.</p>
Quench Oil (from ethylene process unit water quench system)	68513-69-9; 69430-33-7	 <p>In ethylene plants cracking only gases, the cracking furnace effluent (after heat recovery) may be further quenched with water. This step results in the condensation of a relatively small amount of higher boiling hydrocarbon components that, after stripping to remove light hydrocarbons, may be isolated as the quench oils from of the ethylene process unit water quench system. This stream is predominantly C7 through components boiling at 650°F or higher. The reported composition indicates approximately 0.1% benzene, 5% toluene, 12% C8 aromatics, 5% naphthalene, 10% anthracene, and 65% C7–C18 cyclic olefins.</p>
Light Pyrolysis Fuel Oil (from the ethylene process unit)	68475-80-9; 68514-34-1; 68527-18-4	 <p>In some cases, a light pyrolysis fuel oil is produced from</p>

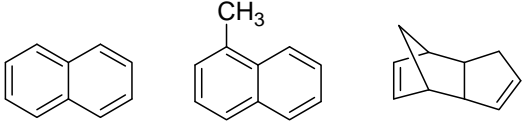
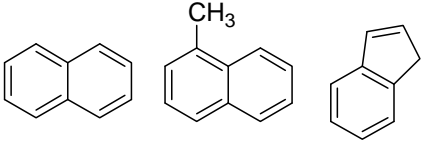
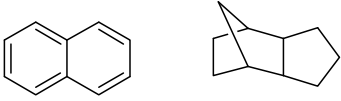
Table 8. Representative Chemical Structures of Fuel Oils Category stream constituents and supporting chemicals		
Name	CASRN	Description or Chemical Structure
		the oil quench system in an ethylene plant that cracks liquid feedstocks. This stream may be produced as a side draw from the primary fractionation tower. The stream typically has a C9-C14 carbon number and the major components are naphthalene (30–60%), methyl naphthalenes and other substituted one- and two-ring aromatics.
Pyrolysis C10+ Fuel Oil (from pyrolysis gasoline distillation)	68513-69-9; 68921-67-5	 <p>This stream is separated by distillation from pyrolysis gasoline as a bottoms product. The reported composition indicates a carbon number distribution from C9 to hydrocarbons boiling at 650°F or higher. The reported typical composition includes approximately 20% dicyclopentadiene, 30% codimers of C5 and C6 monomers, and 20% naphthalene and substituted naphthalenes.</p>
Combined Fuel Oil (E&P) (from ethylene process and pyrolysis gasoline units)	64742-90-1; 68131-05-5; 68527-18-4; 69013-21-4	 <p>A single combined fuel oil stream from the ethylene process unit and the pyrolysis gasoline unit is not an uncommon situation for the industry. The carbon number distribution for this stream is generally C10 to compounds with a boiling point of 650°F or higher. At least in some cases, lower carbon number components are reported for the stream (<i>e.g.</i>, C5s at approximately 2% and benzene at concentrations up to 4%). The major components reported in the stream are typically 25% C9 compounds, 10–47% naphthalene, and 4–30% methylnaphthalenes.</p>
Hydrotreated Flux Oil	64742-47-8; 69013-21-4	 <p>This is a hydrotreated “fuel oil - like” stream with a carbon number distribution that is predominantly C10 to hydrocarbons with a boiling point of 650°F or higher. The</p>

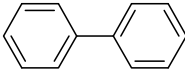
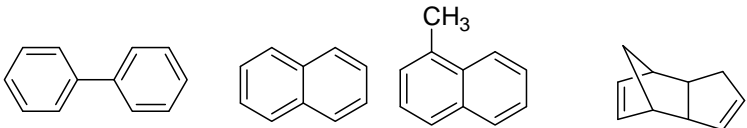
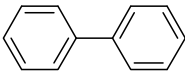
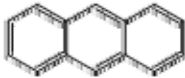
Table 8. Representative Chemical Structures of Fuel Oils Category stream constituents and supporting chemicals		
Name	CASRN	Description or Chemical Structure
		stream may be produced as distillation bottoms from a pyrolysis gasoline hydrotreater unit. The components in the stream are predominantly aromatics, olefins, and cyclic or dicyclic compounds. This stream differs from the other fuel oils described above in that its diolefin and vinyl aromatic contents are very low.
Biphenyl Concentrate	68409-73-4	 <p>Biphenyl concentrate is a coproduct of the benzene hydrodealkylation unit that is isolated by distillation from the HDA reactor effluent. The carbon number distribution for the stream is C7-C18, with major component reported to be biphenyl (65–95%).</p>
Combined Fuel Oil (from benzene HDA and pyrolysis gasoline units)	68513-69-9	 <p>Ethylene process operations that include a pyrolysis gasoline distillation unit and a benzene hydrodealkylation unit may combine these streams resulting in a single isolated product. Fuel oil produced in the benzene HDA process is separated as a distillation bottoms product. The carbon number distribution for this combined fuel stream is C9 through hydrocarbons with a boiling point of 650°F or higher, although low levels of lower carbon number hydrocarbons may be present (<i>e.g.</i>, 0.2% benzene). The major components reported in the stream are approximately 11% C9 aromatics to naphthalene, 7.5–12% dicyclopentadiene, 8–12% naphthalene, 22% methylnaphthalenes, and 25–35% biphenyl.</p>
Fuel oil, no. 2 ¹	68476-30-2	<p>Paraffins (n- and iso-): 41.3%; Monocycloparaffins: 22.1%; Bicycloparaffins: 9.6%; Tricycloparaffins: 2.3%; Total saturated hydrocarbons: 75.3%; Olefins: No data</p>

Table 8. Representative Chemical Structures of Fuel Oils Category stream constituents and supporting chemicals		
Name	CASRN	Description or Chemical Structure
		Alkylbenzene: 5.9%; Indans/tetralins: 4.1%; Dinaphthenobenzenes/indenes: 1.8%; Naphthalenes: 8.2%; Biphenyls/acenaphthenes: 2.6%; Fluorenes/acenaphthylenes: 1.4%; Phenanthrenes: 0.7%; Total aromatic hydrocarbons: 24.7%
Aromatic hydrocarbons, biphenyl-rich, thermal hydro-dealkylation residues (Biphenyl feedstock)	68989-41-3	 <p>The complex combination of hydrocarbons obtained from a thermal hydrodealkylation process. It consists predominantly of aromatic hydrocarbons, primarily biphenyl and those boiling above 110°C.</p>
Anthracene	120-12-7	

¹ Volume percentages as reported by: ATSDR. 1995. Toxicological Profile for Fuel Oils/Kerosene. Agency for Toxic Substances and Disease Registry. U.S. Department of Health and Human Services. Available online at <http://www.atsdr.cdc.gov/ToxProfiles/tp75.pdf> as of October 8, 2010.

Table 9. TSCA Definition of CASRN

Supporting CASRN	Chemical Name	TSCA Definition
8002-05-9	Petroleum	A complex combination of hydrocarbons. It consists predominantly of aliphatic, alicyclic and aromatic hydrocarbons. It may also contain small amounts of nitrogen, oxygen and sulfur compounds. This category encompasses light, medium, and heavy petroleums, as well as the oils extracted from tar sands. Hydrocarbonaceous materials requiring major chemical changes for their recovery or conversion to petroleum refinery feedstocks such as crude shale oils, upgraded shale oils and liquid coal fuels are not included in this definition.
64741-62-4	Clarified oils (petroleum), catalytic cracked	A complex combination of hydrocarbons produced as the residual fraction from distillation of the products from a catalytic cracking process. It consists of hydrocarbons having carbon numbers predominantly greater than C20 and boiling above approximately 350°C (662°F). This stream is likely to contain 5 wt % or more of 4- to 6-membered condensed ring aromatic hydrocarbons.
64742-47-8	Distillates (petroleum), hydrotreated light	A complex combination of hydrocarbons obtained by treating a petroleum fraction with hydrogen in the presence of a catalyst. It consists of hydrocarbons having carbon numbers predominantly in the range of C9-C16 and boiling in the range of approximately 150°C to 290°C (302°F to 554°F).
64742-90-1	Residues (petroleum), steam-cracked	A complex combination of hydrocarbons obtained as the residual fraction from the distillation of the products of a steam cracking process (including steam cracking to produce ethylene). It consists mainly of unsaturated hydrocarbons having carbon numbers predominantly greater than C14 and boiling above approximately 260°C (500°F). This stream is likely to contain 5 wt. % or more of 4- to 6-membered condensed ring aromatic hydrocarbons.
68131-05-5	Hydrocarbon oils, process blends	NONE
68514-34-1	Hydrocarbons, C9-14, ethylene-manuf.-by-product	A complex combination of hydrocarbons (primarily biphenyl) produced by distillation of products from ethylene production. It mainly consists of hydrocarbons having carbon numbers in the range of C9-C14.
68409-73-4	Aromatic hydrocarbons, biphenyl-rich	A complex combination of hydrocarbons produced by the hydrodealkylation and distillation of toluene. It consists mainly of aromatic hydrocarbons having a carbon number C6 or greater and boiling in the range of approximately 79°C to 398°C (175°F to 750 °F).

Table 9. TSCA Definition of CASRN

Supporting CASRN	Chemical Name	TSCA Definition
68475-80-9	Distillates (petroleum), light steam-cracked naphtha	A complex combination of hydrocarbons from the multiple distillation of products from a steam cracking process. It consists of hydrocarbons having carbon numbers that are predominantly in the range of C10-C18.
68476-30-2	Fuel oil, no. 2	Distillate oil having a minimum viscosity of 32.6 SUS at 37.7°C (100°F) to a maximum of 37.9 SUS at 37.7°C (100°F).
68513-69-9	Residues (petroleum), steam-cracked light	A complex residuum from the distillation of the products from a steam-cracking process. It consists predominantly of aromatic and unsaturated hydrocarbons having carbon numbers that are greater than C7 and boiling in the range of approximately 101°C to 555°C (214°F to 1030°F).
68527-18-4	Gas oils (petroleum), steam-cracked	A complex combination of hydrocarbons produced by distillation of the products from a steam cracking process. It consists of hydrocarbons having carbon numbers predominantly greater than C9 and boiling in the range of from approximately 204°C to 343°C (399°F to 649°F).
68921-67-5	Hydrocarbons, ethylene-manuf. by-product distillation residues	The complex combination of hydrocarbons produced by the distillation of products from ethylene manufacturing process. It mainly consists of aromatic hydrocarbons having carbon numbers predominantly in the range of C5 - C11.
69013-21-4	Fuel oil, pyrolysis	The complex combination of hydrocarbons obtained from the initial water quenching of the effluent gases from a thermal cracking of ethane, propane or light naphtha. This stream is likely to contain 5 wt % or more of 4- to 6- member condensed ring aromatic hydrocarbons.
68989-41-3	Aromatic hydrocarbons, biphenyl-rich, thermal hydrodealkylation residues	The complex combination of hydrocarbons obtained from a thermal hydrodealkylation process. It predominantly consists of aromatic hydrocarbons (primarily biphenyl) boiling above approximately 110°C (230°F).
69430-33-7	Hydrocarbons, C6-30	NONE

ETHYLENE PROCESS DESCRIPTION

A. Ethylene Process

1. Steam Cracking

Steam cracking is the predominant process used to produce ethylene. Various hydrocarbon feedstocks are used in the production of ethylene by steam cracking, including ethane, propane, butane, and liquid petroleum fractions such as condensate, naphtha, and gas oils. The feedstocks are normally saturated hydrocarbons but may contain minor amounts of unsaturated hydrocarbons. These feedstocks are charged to the coils of a cracking furnace. Heat is transferred through the metal walls of the coils to the feedstock from hot flue gas, which is generated by combustion of fuels in the furnace firebox. The outlet of the cracking coil is usually maintained at relatively low pressure in order to obtain good yields to the desired products. Steam is also added to the coil and serves as a diluent to improve yields and to control coke formation. This step of the ethylene process is commonly referred to as “steam cracking” or simply “cracking” and the furnaces are frequently referred to as “crackers”.

Subjecting the feedstocks to high temperatures in this manner results in the partial conversion of the feedstock to olefins. In the simplest example, feedstock ethane is partially converted to ethylene and hydrogen. Similarly, propane, butane, or the hydrocarbon compounds that are associated with the liquid feedstocks are also converted to ethylene. Other valuable hydrocarbon products are also formed, including other olefins, diolefins, aromatics, paraffins, and lesser amounts of acetylenes. These other hydrocarbon products include compounds with two or more carbon atoms per molecule, i.e., C₂, C₃, C₄, etc. Propane and propylene are examples of C₃ hydrocarbons and benzene, hexene, and cyclohexane are a few examples of the C₆ hydrocarbons.

2. Refinery Gas Separation

Ethylene and propylene are also produced by separation of these olefins streams, such as from the light ends product of a catalytic cracking process. This separation is similar to that used in steam crackers, and in some cases both refinery gas streams and steam cracking furnace effluents are combined and processed in a single finishing section. These refinery gas streams differ from cracked gas in that the refinery streams have a much narrower carbon number distribution, predominantly C₂ and/or C₃. Thus the finishing of these refinery gas streams yields primary ethylene and ethane, and/or propylene and propane.

B. Products of the Ethylene Process

The intermediate stream that exits the cracking furnaces (i.e., the furnace effluent) is forwarded to the finishing section of the ethylene plant. The furnace effluent is commonly referred to as “cracked gas” and consists of a mixture of hydrogen, methane, and various hydrocarbon compounds with two or more carbon atoms per molecule (C₂+). The relative amount of each component in the cracked gas varies depending on what feedstocks are cracked and cracking process variables. Cracked gas may also contain relatively small concentrations of organic sulfur compounds that were present as impurities in the feedstock or were added to the feedstock to control coke formation. The cracked gas stream is cooled, compressed and then separated into the individual streams of the ethylene process. These streams can be sold commercially and/or put into further steps of the process to produce additional materials. In some ethylene processes, a liquid fuel oil product is produced when the cracked gas is initially cooled. The ethylene process is a closed process and the products are contained in pressure systems.

The final products of the ethylene process include hydrogen, methane (frequently used as fuel), and the high purity products ethylene and propylene. Other products of the ethylene process are typically mixed streams that are isolated by distillation according to boiling point ranges. It is a

subset of these mixed streams that make up the constituents of the fuel oils category. The chemical process operations that are associated with the process streams in the fuel oils category are shown in Figure 1.

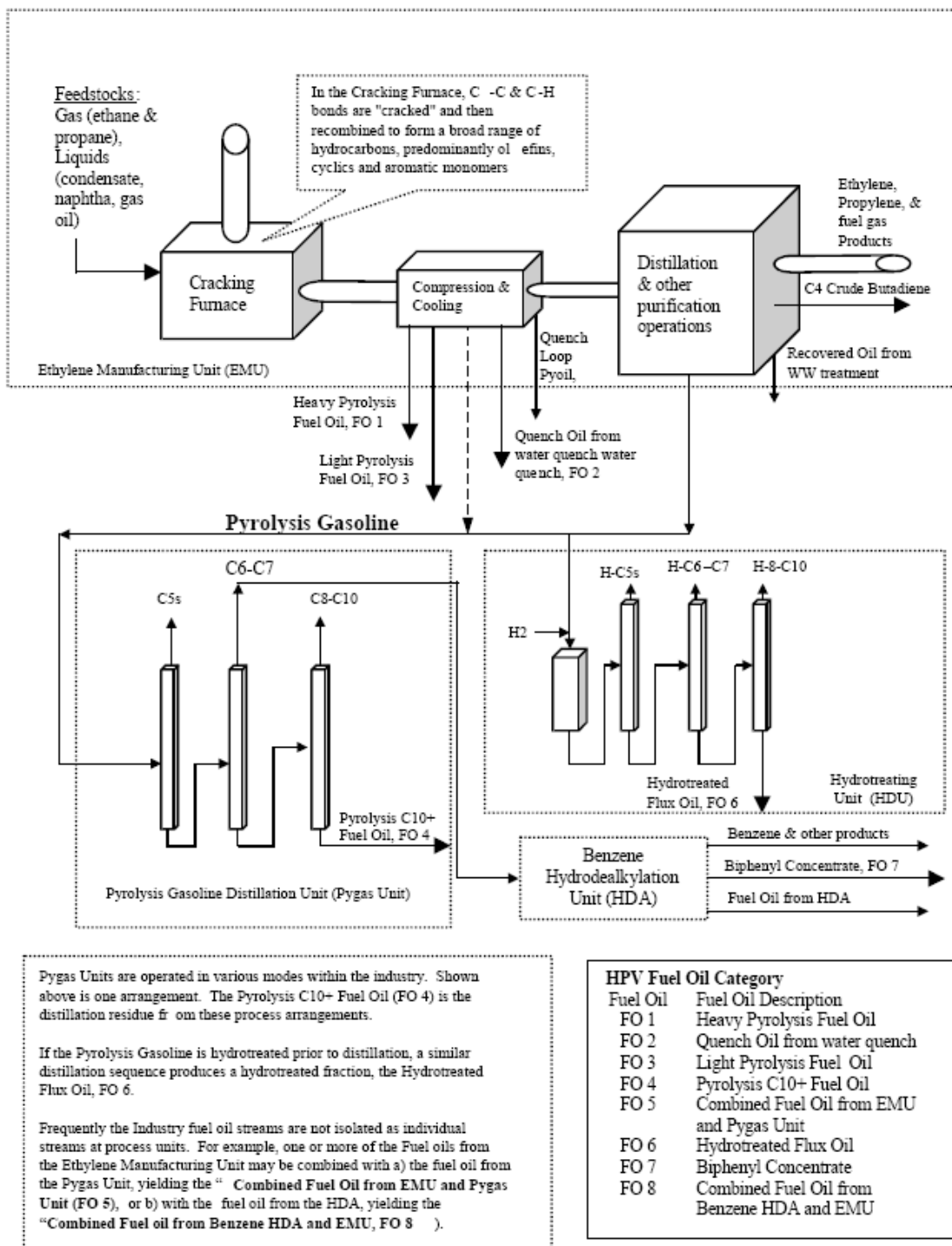


Figure 1. Fuel Oils Process Streams Flow Diagram from Ethylene Manufacturing Process Unit