SCREENING-LEVEL HAZARD CHARACTERIZATION

Refinery Gases Category

SPONSORED CHEMICALS
(See Appendix)

SUPPORTING CHEMICALS
(See Appendix)

The High Production Volume (HPV) Challenge Program[1] was conceived as a voluntary initiative aimed at developing and making publicly available screening-level health and environmental effects information on chemicals manufactured in or imported into the United States in quantities greater than one million pounds per year. In the Challenge Program, producers and importers of HPV chemicals voluntarily sponsored chemicals; sponsorship entailed the identification and initial assessment of the adequacy of existing toxicity data/information, conducting new testing if adequate data did not exist, and making both new and existing data and information available to the public. Each complete data submission contains data on 18 internationally agreed to "SIDS" (Screening Information Data Set[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[3] and is based primarily on hazard data provided by sponsors; however, in preparing the hazard characterization, EPA considered its own comments and public comments on the original submission as well as the sponsor's responses to comments and revisions made to the submission. In order to determine whether any new hazard information was developed since the time of the HPV submission, a search of the following databases was made from one year prior to the date of the HPV Challenge submission to the present: (ChemID to locate available data sources including Medline/PubMed, Toxline, HSDB, IRIS, NTP, ATSDR, IARC, EXTOXNET, EPA SRS, etc.), STN/CAS online databases (Registry file for locators, ChemAbs for toxicology data, RTECS,

[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.

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.

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Summary

The refinery gases category consists of 62 refinery gases which are primarily produced in petroleum refineries as the light end fractions of numerous distillation and cracking processes or in gas plants that separate natural gas and natural gas liquids. These mixtures largely consist of C1 to C5 hydrocarbons together with significant concentrations of other gases, such as hydrogen, nitrogen, hydrogen sulfide, and carbon monoxide. The components of this category are gases or volatile liquids having high vapor pressure and moderate to high water solubility. They are expected to have moderate to high mobility in soil. Volatilization from water is expected to be high based on their Henry's Law constants. The rate of hydrolysis is expected to be negligible. The rate of atmospheric photooxidation is expected to be negligible to rapid for the members of this category. The members of the refinery gases category are expected to have low persistence (P1) and low bioaccumulation potential (B1).

Human Health Hazard
No data are available for the sponsored substances of the refinery gases category. Supporting chemical data are used to address the human health endpoints.

Subcategory I: Refinery gases, C1 – C4
Group 1. No data are available for the sponsored substances for the human health endpoints. The acute inhalation toxicity of 1-propene (CASRN 115-07-1) and 2-butene (CASRN 107-01-7) in rats is low. Rats repeatedly exposed via inhalation to 1-propene for up to 14 weeks showed no adverse treatment-related effects; the NOAEC for systemic toxicity is 10,000 ppm/day (highest concentration tested). In combined inhalation repeated-dose/reproductive/developmental toxicity screening tests in rats, ethane (CASRN 74-84-0), isobutane (CASRN 75-28-5), butane (CASRN 106-97-8) and 1-butene (CASRN 106-98-9) showed no adverse treatment-related effects; the NOAECs for systemic toxicity are 15,502 ppm/day, 9148 ppm/day, 9157 ppm/day and 8000 ppm/day, respectively (highest concentrations tested). In a combined inhalation repeated-dose/reproductive/developmental toxicity screening test in rats, propane (CASRN 74-98-6) showed decreased body weight gain in males, and hematological effects in females at 12,168 ppm/day; the NOAEC for systemic toxicity is 3990 ppm/day. Ethene (CASRN 74-85-1), 2-butene (CASRN 107-01-7) and 2-methylpropene (CASRN 115-11-7) showed no treatment-related effects with repeated inhalation exposure in rats; the NOAECs for systemic toxicity range from 5009 ppm/day (CASRN 107-01-7) to 10,000 ppm/day (ethene, highest concentrations tested). 2-Methylpropene showed no treatment-related effects after 14 weeks of repeated

inhalation exposure in mice; the NOAEC for systemic toxicity is 7980 ppm/day (highest concentration tested). In the combined repeated-dose/reproductive/developmental screening tests previously mentioned, ethane, butane, 2-butene and 1-butene showed no treatment-related effects on reproduction; the NOAECs for reproductive/maternal/developmental toxicity in rats are 15,502 ppm/day, 9157 ppm/day, 5009 ppm/day and 8000 ppm/day, respectively (highest concentrations tested). Repeated inhalation exposure with isobutane in rats showed decreased fertility and increased post-implantation loss at 9148 ppm; the NOAEC for reproductive toxicity is 3122 ppm/day and the NOAEC for maternal/developmental toxicity is 9148 ppm/day (highest concentration tested). The combined repeated-dose/reproductive/developmental screening test with propane in rats showed a decrease in the number of live pups and an increase in the number of stillborn pups after inhalation exposure at 3990 ppm/day; the NOAEC for reproductive/ developmental toxicity is 1230 ppm/day. Based on the systemic effects observed at 12,168 ppm/day (decreased body weight gain and hematological effects), the NOAEC for maternal toxicity is 3990 ppm/day. No specific reproductive toxicity studies are available for 2-methylpropene, but in the 14-week inhalation repeated-dose toxicity study described above, there was a decrease in sperm motility at 7970 ppm/day. However, no adverse developmental effects were observed in the prenatal developmental toxicity study in rats; for 2-methylpropene the NOAEC for maternal/developmental toxicity is 18.4 mg/L/day (highest concentration tested). In a combined inhalation reproductive/developmental toxicity screening test in rats, ethene showed no adverse effects; the NOAEC for reproductive/maternal/ developmental toxicity is 10,000 ppm/day (highest concentration tested). In an inhalation prenatal developmental toxicity study in rats, 1-propene showed no treatment-related effects; the NOAEC for maternal/developmental toxicity is 10,000 ppm/day (highest concentration tested). 1-Propene induced gene mutations in bacteria, but was equivocal for mutagenicity in mouse lymphoma cells *in vitro*. Methane, butane, ethene, 2-methylpropene, 1-butene and 2-butene did not induce gene mutations in bacteria or mouse lymphoma cells *in vitro*. Ethene and 2-butene did not induce chromosomal aberrations in rat lymphocytes or Chinese hamster ovary (CHO) cells *in vitro* and propene, ethene, 2-methylpropene and 1-butene did not induce micronuclei in rats and/or mice *in vivo*. 1-Propene was not carcinogenic in rats or mice when administered via the inhalation route of exposure. 2-Methylpropene increased the incidence of tumors in male rats but not female rats, or mice of both sexes.

Group 2. See also data for Group 1. The acute inhalation toxicity of 1,3-butadiene (CASRN 106-99-0) is low in rats. Repeated-dose studies show the mouse to be more sensitive to 1,3-butadiene exposure than the rat. Several studies of inhalation exposure for up to two years showed minimal effects in rats; the NOAEC for systemic toxicity is 7886 ppm/day. In a 14-week inhalation repeated-dose toxicity study in mice, 1,3-butadiene showed mortality at 1250 ppm/day; the NOAEC for systemic toxicity is 625 ppm/day. The most sensitive reproductive endpoint observed in subchronic studies with 1,3-butadiene was fetal deaths in dominant lethal studies in mice exposed by inhalation for 28-days at 65 ppm/day; the NOAEC for dominant lethal effects is 12.5 ppm/day. In two-year bioassays, the most sensitive reproductive effects were ovarian atrophy in female mice at 6.25 ppm/day and testicular atrophy in male mice at 625 ppm/day. The NOAEC for reproductive toxicity in female mice is not established and in male mice is 200 ppm/day. In a combined reproductive/developmental toxicity screening test, rats exposed to 1,3-butadiene by vapor inhalation showed no effects on reproduction; the NOAEC for reproductive/developmental toxicity is 13.3 mg/L/day (highest concentration tested). Maternal

toxicity, as evidenced by decreased body weight, was observed in dams treated at 3.3 mg/L; the NOAEC for maternal toxicity is 0.66 mg/L/day. Prenatal developmental toxicity studies in rats and mice showed decreased body weight gains in treated dams following inhalation exposure to 1,3-butadiene at 200 and 1000 ppm/day, in mice and rats, respectively. No effects on developmental parameters were observed in rats; the NOAECs for maternal and developmental toxicity are 200 ppm/day and 1000 ppm/day (highest concentration tested), respectively. Reduced fetal body weight was observed in male mice at 40 ppm/day; the NOAECs for maternal and developmental toxicity are not established. 1,3-Butadiene was mutagenic in bacteria *in vitro* and induced chromosomal aberrations *in vivo*. 1,3-Butadiene increased incidences of various tumors at multiple sites in rats and mice and there is "sufficient evidence" from epidemiologic studies of exposed workers to consider 1,3-butadiene carcinogenic to humans.

No data gaps were identified under the HPV Challenge Program.

Subcategory II: Refinery gases, C1 – C4 with ammonia and hydrogen sulfide
No data are available for the sponsored substances for the human health endpoints. The data in subcategory I (excepting data for 1,3-butadiene) can also be used to address the human health endpoints for subcategory II. See the human health summary for subcategory I above.

The acute inhalation toxicity for ammonia (CASRN 7664-41-7) is moderate in rats and mice. In repeated-dose inhalation studies in guinea pigs, chickens and mice, darkening/reddening, edema, congestion and hemorrhage were seen in the lungs of all three species at 0.014 mg/L/day. Guinea pigs also showed grossly enlarged and congested spleens and livers; the NOAEC is not established. No specific reproductive toxicity studies are available for ammonia; however, no effects on reproductive organs were observed in animals in repeated-dose studies. Ammonia did not induce gene mutations in bacteria *in vitro*. Ammonia is a skin and eye irritant and is corrosive in the aqueous form.

The acute inhalation toxicity of hydrogen sulfide (CASRN 7783-06-4) is moderate in rats. In inhalation repeated-dose studies in rats and mice, the olfactory nasal mucosa is the principal target site. Local effects are observed at 80 ppm in mice and 30 ppm in rats; the NOAEC for local effects is 10 ppm/day in rats and 30.5 ppm/day in mice. In different strains of rats, females showed decreased body weights and males showed increased absolute brain weights at 80 ppm; the NOAEC for systemic toxicity is 30.5 ppm/day. In a combined inhalation reproductive/developmental toxicity screening test in rats, no effects on reproduction were observed; the NOAEC for reproductive/maternal/developmental toxicity is 80 ppm/day (highest concentration tested). Hydrogen sulfide did not induce gene mutations in bacteria *in vitro*.

No data gaps were identified under the HPV Challenge Program

Subcategory III: Refinery gases, C1-C4 with carbon monoxide
No data are available for the sponsored substances for the human health endpoints. The data in subcategory I (excepting 1,3-butadiene) can also be used to address the human health endpoints for subcategory III. See human health summary for subcategory I above.

The acute inhalation toxicity of CO is moderate in rats. The mechanism of toxicity of CO

poisoning is well studied. CO binds to hemoglobin (Hb), forming carboxyhemoglobin (COHb), thereby rendering the hemoglobin molecule less able to bind oxygen. Oxygen transportation by the blood and the release of bound oxygen in the tissues are decreased. Tissue damage results from local hypoxia. Organs with a high oxygen requirement, such as the heart and the brain, are especially sensitive to this effect. Rats exposed via inhalation to CO for up to 13 weeks showed no adverse effects up to 0.15 mg/L/day; the NOAEC for systemic effects is 0.15 mg/L/day (highest concentration tested). No specific reproductive toxicity studies are available; however, no effects were observed on the reproductive organs in repeated-dose studies. Prenatal developmental toxicity studies are available in several species. The NOAEC for developmental toxicity is not established based on effects such as mortality, decreased pregnancies and decreased fetal weights at 90 ppm and 30 ppm in rabbits and rats, respectively. The NOAEC for maternal toxicity ranges from 30 ppm/day in rats (increased brain weight and brain edema at 90 ppm/day) to 180 ppm/day in rabbits (no effects at highest concentration tested). CO induces chromosomal aberrations in mammalian cells *in vitro*.

No data gaps were identified under the HPV Challenge Program

Subcategory IV: Refinery gases, C1-C6

No data are available for the sponsored substances for the human health endpoints. The data in subcategory I can also be used to address the human health endpoints for subcategory IV. See human health summary for subcategory I above.

Groups 1 and 2 (includes 1,3-butadiene). The acute oral, inhalation and dermal toxicity of subcategory IV in rats is low. In 90-day vapor inhalation repeated-dose studies in rats, pentane (CASRN 109-66-0) and cyclopentane (CASRN 287-92-3) showed no adverse treatment-related effects; the NOAECs for systemic toxicity are 20 mg/L/day and 30 mg/L/day (highest concentrations tested), respectively. Rats exposed to CASRN 86290-81-5 by inhalation for 13 weeks, showed no adverse treatment-related effects; the NOAEC for systemic toxicity is 20.3 mg/L/day (highest concentration tested). Several representative studies in gasoline are available. In unleaded gasoline (no CASRN), a decrease in brain weight in males was observed at 1.57 mg/L/day, the lowest dose tested in a repeated-dose toxicity study by the inhalation route in rats; the NOAEC for systemic toxicity was not be established. Effects on pulmonary function were observed at 6.35 mg/L/day in a repeated-dose toxicity study by the inhalation route in monkeys; the NOAEC for systemic toxicity is 1.57 mg/L/day. In unleaded gasoline blend (no CASRN), signs of kidney toxicity in males were reported at 0.15 mg/L/day in a repeated-dose toxicity study by the inhalation route in rats; the NOAEC for systemic toxicity is 14.7 mg/L/day in females (highest dose tested). The NOAEC is not established in males. In leaded gasoline (no CASRN), signs of blood toxicity and effects on pulmonary function were reported at 1.53 mg/L/day in repeated-dose toxicity studies by the inhalation route in rats and monkeys; the NOAEC for systemic toxicity is 0.42 mg/L/day in rats and in male monkeys, and 1.53 mg/L/day in female monkeys (highest dose tested).

In an inhalation combined repeated-dose/reproductive/developmental toxicity screening test in rats, 2-methyl-2-butene (CASRN 513-35-9) showed heart lesions in males and longer clotting times in females at 2026 ppm/day; the NOAEC for systemic toxicity is 584 ppm/day. No effects on reproduction were observed; the NOAEC for reproductive/developmental toxicity is 7097

ppm/day (highest concentration tested). Based on the systemic effects described above, the NOAEC for maternal toxicity is 584 ppm/day. No specific reproductive toxicity studies are available for pentane; however no effects were observed on the reproductive organs in rats following 90-day inhalation exposure. In an oral prenatal developmental toxicity study in rats, pentane showed no maternal or developmental effects; the NOAEC for maternal/developmental toxicity is 1000 mg/kg/day (highest dose tested). A prenatal developmental toxicity study by the inhalation route in rats with CASRN 64741-55-5 showed no signs of maternal toxicity, but an increase in the number of resorptions was observed at 7.7 mg/L/day; the NOAEC for maternal and developmental toxicity are 7.7 mg/L/day and 2.2 mg/L/day, respectively. A prenatal developmental toxicity study by the inhalation route in rats with unleaded gasoline (PONA composition not specified) showed no signs of maternal toxicity, but increases in delayed ossification in offspring were observed at 6.2 mg/L/day; the NOAECs for maternal and developmental toxicity are 6.2 mg/L/day and 1.7 mg/L/day, respectively.

2-Methylbutane, pentane, cyclopentane and 2-methyl-2-butene did not induce gene mutations in mouse lymphoma cells and bacteria *in vitro*. Pentane was equivocal for chromosomal aberrations *in vitro* and negative in a rat micronucleus assay *in vivo*. Cyclopentane was positive in the absence, and negative in the presence of metabolic activation, for chromosomal aberrations *in vitro*, and negative in a mouse micronucleus assay *in vivo*. 2-Methyl-2-butene did not induce chromosomal aberrations *in vitro* but induced micronuclei in rats and mice *in vivo*; whereas a micronuclei test of the same chemical was equivocal in hamsters. CASRN 86290-81-5 induced sister chromatid exchange in rats, but not in micronuclei *in vivo*. 2-Methylbutane is not irritating to the respiratory tract in mice and is not a skin sensitizer in guinea pigs. Pentane is irritating to rabbit eyes, not irritating to rabbit skin or the respiratory tract of mice and not a skin sensitizer in guinea pigs. Cyclopentane is moderately irritating to rabbit eyes and not irritating to rabbit skin. 2-Methyl-2-butene is irritating to rabbit skin, but not to rabbit eyes. Cyclopentane is not irritating to rabbit skin, but is irritating to rabbit eyes. 2-Methyl-2-butene is not a skin sensitizer in guinea pigs. CASRN 64741-55-5 is irritating to rabbit skin, not irritating to rabbit eye and is not a skin sensitizer in guinea pigs. Unleaded and leaded gasolines are neurotoxic in humans.

Group 3. See also data from groups 1 and 2. The acute oral and inhalation toxicity of benzene (CASRN 71-43-2) in rats is low and moderate, respectively. Repeated-dose studies with benzene show that the hematopoietic system is the most sensitive indicator of toxicity. Mice exposed repeatedly via vapor inhalation to benzene showed hematological effects [e.g. decreases in blood cell counts (RBC and WBC), platelets, hemoglobin, hematocrit], thymic atrophy and testicular effects at 0.96 mg/L/day; the NOAEC for systemic toxicity is0.1 mg/L/day. In a similar study in mice, designed to assess specific effects on hematology, increases in spleen weight, total nucleated cells per spleen and nucleated RBCs were seen at 0.03 mg/L; the NOAEC is not established. Repeated inhalation exposure of rats to benzene showed a decrease in WBC counts and percentage of lymphocytes at 0.96 mg/L/day; the NOAEC for hematological effects on peripheral blood circulation is 0.096 mg/L/day. Guideline reproductive toxicity studies are not available; however, in the 13-week inhalation exposures with benzene in mice, adverse effects were observed on the male and female reproductive organs. In a modified prenatal developmental toxicity study, female rats exposed to benzene via vapor inhalation pre- and post-mating and through lactation, had female pups with reduced body and liver weights at 0.96

mg/L/day; the NOAECs for maternal and developmental toxicity are 0.96 mg/L/day (highest concentration tested) and 0.096 mg/L/day, respectively. In an inhalation prenatal developmental toxicity study in mice, benzene showed effects on the hematopoietic system in offspring at 0.064 mg/L/day; the NOAECs for maternal and developmental toxicity are 0.064 mg/L/day (highest concentration tested) and 0.032 mg/L/day, respectively. Benzene induced gene mutations in bacteria *in vitro*, sister chromatid exchange in human lymphocytes *in vitro* and in rat and mouse lymphocytes *in vivo*. Benzene induced micronuclei in rats and mice *in vivo*.

No data gaps were identified under the HPV Challenge Program.

Subcategories V: Refinery gases, C1 – C6 with hydrogen sulfide; Subcategory VI: Refinery gases, C1 – C6 with carbon monoxide; Subcategory VII: Refinery gases, C1 – C6 with carbon monoxide and hydrogen sulfide; Subcategory VIII: Refinery gases, C1 – C6 with ammonia and hydrogen sulfide; and Subcategory IX: Refinery gases, C1 – C6 with ammonia, hydrogen sulfide and carbon monoxide

No data are available for the sponsored substances for the human health endpoints. Available data from subcategories I, II, III and IV can also be used to address the human health endpoints for subcategories V to XI. See these human health summaries.

No data gaps were identified under the HPV Challenge Program

Hazard to the Environment
No data are available for the sponsored substances of the refinery gases category. Supporting chemical data are used to address the ecotoxicity endpoints.

Subcategory I: Refinery gases containing C1 – C6 hydrocarbons
Using the supporting chemicals methane, ethane, ethene, propane, butane, pentane, and hexane, the 96-h LC_{50} for fish is ranged from 2.5-148 mg/L. Using the same supporting chemicals, the 48-h EC_{50} for aquatic invertebrates and the 96-h EC_{50} for aquatic plants ranges from 2.7-69 mg/L and 2.8-72 mg/L, respectively.

No data gaps were identified for the purposes of the HPV Challenge program.

Subcategory II: Refinery gases containing C1 – C6 hydrocarbons, ammonia, and hydrogen sulfide
Using the supporting chemicals methane, ethane, ethene, propane, butane, pentane, hexane, hydrogen sulfide, and ammonia, the 96-h LC_{50} for fish is ranged from 0.007-148 mg/L. Using the same supporting chemicals, the 48-h EC_{50} for aquatic invertebrates and the 96-h EC_{50} for aquatic plants ranges from 0.022-69 mg/L and < 1-72 mg/L, respectively.

No data gaps were identified for the purposes of the HPV Challenge program.

Subcategory III: Refinery gases (without hydrocarbons), ammonia and hydrogen sulfide
Using the supporting chemicals hydrogen sulfide and ammonia, the 96-h LC_{50} for fish is 0.007

mg/L. Using the same supporting chemicals, the 48-h EC_{50} for aquatic invertebrates and the 96-h EC50 for aquatic plants are 0.022 mg/L and < 1 mg/L, respectively.

No data gaps were identified for the purposes of the HPV Challenge program.

Subcategory IV: Refinery gases with carbon monoxide
Owing to a lack of ecotoxicity data for carbon monoxide, the hazard to the environment for the sponsored streams containing carbon monoxide (>2%) cannot be determined.

Acute toxicity to fish and aquatic invertebrates, and toxicity to aquatic plants were identified as data gaps under the HPV Challenge program.

The sponsor, the American Petroleum Institute Petroleum HPV Testing Group, submitted a Test Plan and Robust Summaries to EPA for the Petroleum Hydrocarbon Gases Category on August 15, 2000. EPA posted the submission on the ChemRTK HPV Challenge website on September 11, 2000 (http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm). EPA comments on the original submission were posted to the website on January 9, 2001. Public comments were also received and posted to the website. The sponsor submitted updated/revised documents, which were posted to the ChemRTK website on October 12, 2001. The sponsor subsequently divided the Petroleum Hydrocarbon Gases Category into a Petroleum Gases Category and a Refinery Gases Category. The sponsor submitted revised robust summaries for the Refinery Gases Category to EPA, which were posted to the ChemRTK website on June 28, 2010. The members of the refinery gases category are listed in the Appendix (Tables 7 and 8). A hazard characterization for the Petroleum Hydrocarbon Gases Category is available and can be viewed at: http://iaspub.epa.gov/oppthpv/hpv_hc_characterization.get_report?doctype=2.

Category Justification

The refinery gases category consists of 62 refinery gases that are primarily produced in petroleum refineries as the light end fractions of numerous distillation and cracking processes or in gas plants that separate natural gas and natural gas liquids (see Appendix). The streams are composed primarily of paraffinic and olefinic C1 – C4 and C5 – C6 hydrocarbons. Some streams also contain varying amounts of other chemicals including, ammonia, hydrogen, nitrogen, hydrogen sulfide, mercaptans, carbon monoxide, carbon dioxide, 1,3-butadiene and/or benzene. The sponsor provided compositional ranges for the sponsored chemicals, based on limited historical (1992 – 2002) data from several U.S. petrochemical and petroleum company refineries in the Gulf Coast and mid-continent areas. A complete list of the hydrocarbon constituents was not provided for each mixture; instead, the hydrocarbon composition is expressed as percentages of 1,3-butadiene, benzene, C1 – C4 hydrocarbons and C5 – C6 hydrocarbons. The chemical compositions of category members, as provided by the sponsor, are presented in the Appendix (Table 9).

Using these chemical compositions, for the human health endpoints, the refinery gases category has been divided into several subcategories (see Table 1) which in some instances have been further subdivided into groups, based upon the predominant constituents. Neither CASRN 68527-13-9 nor CASRN 68783-05-1 contains any hydrocarbon component and they are considered separately.

Table 1. Refinery Gases Subcategories for Human Health Endpoints		
I	Refinery gases, C1 – C4 (Group 1 = without 1,3 butadiene) (Group 2 = with 1,3 butadiene)	Paraffinic and olefinic hydrocarbons in the range of C1 – C4; < 0.5% ammonia and hydrogen sulfide; ≤ 2% 1,3-butadiene; does not contain carbon monoxide, mercaptans or benzene
II	Refinery gases, C1 – C4 with ammonia and hydrogen sulfide	Paraffinic and olefinic hydrocarbons in the range of C1 – C4; 0.1 – 15% ammonia; 0.5 – 45% hydrogen sulfide; ≤ 1.5% mercaptans; does not contain carbon monoxide, 1,3-butadiene or benzene
III	Refinery gases, C1 – C4 with carbon monoxide	Paraffinic and olefinic hydrocarbons in the range of C1 – C4; 0.5 – 30% carbon monoxide; < 0.5% ammonia and hydrogen sulfide; does not contain, mercaptans, benzene or 1,3-butadiene
IV	Refinery gases, C1 – C6 (Group 1 = without benzene or 1,3 butadiene) (Group 2 = with 1,3 butadiene) (Group 3 = with benzene and 1,3 butadiene)	Paraffinic and olefinic hydrocarbons in the range of C1 – C6; < 0.5% ammonia and hydrogen sulfide; ≤ 2% 1,3-butadiene and benzene; does not contain carbon monoxide or mercaptans
V	Refinery gases, C1 – C6 with hydrogen sulfide	Paraffinic and olefinic hydrocarbons in the range of C1 – C6; 0.1 – 4% hydrogen sulfide; ≤ 0.5% ammonia; ≤ 2% 1,3-butadiene; does not contain carbon monoxide, mercaptans or benzene
VI	Refinery gases, C1 – C6 with carbon monoxide (Group 1 = without benzene) (Group 2 = with benzene)	Paraffinic and olefinic hydrocarbons in the range of C1 – C6; 0.5 –20% carbon monoxide; ≤ 2% benzene; does not contain ammonia, hydrogen sulfide, mercaptans or 1,3-butadiene
VII	Refinery gases, C1 – C6 with carbon monoxide and hydrogen sulfide	Paraffinic and olefinic hydrocarbons in the range of C1 – C6; 0.1 – 1% hydrogen sulfide; 0.5 – 5% carbon monoxide; ≤ 0.5% ammonia; does not contain mercaptans, benzene or 1,3-butadiene
VIII	Refinery gases, C1 – C6 with ammonia and hydrogen sulfide (Group 1 = without 1,3 butadiene) (Group 2 = with 1,3 butadiene)	Paraffinic and olefinic hydrocarbons in the range of C1 – C6; 0.1 – 15% ammonia; 1 – 35% hydrogen sulfide; ≤ 2% 1,3-butadiene; does not contain carbon monoxide, mercaptans or benzene

Table 1. Refinery Gases Subcategories for Human Health Endpoints		
IX	Refinery gases, C1 – C6 with ammonia, hydrogen sulfide and carbon monoxide (Group 1 = without benzene or 1,3-butadiene) (Group 2 = with 1,3 butadiene) (Group 3 = with benzene and 1,3 butadiene)	Paraffinic and olefinic hydrocarbons in the range of C1 – C6; 0.1 – 10% ammonia; 0.1 – 25% hydrogen sulfide; 0.5 – 15% carbon monoxide; ≤ 1.5% mercaptans; ≤ 2% 1,3-butadiene and benzene
X	Refinery gases, ammonia and hydrogen sulfide	46 – 60% ammonia; 20 – 30% hydrogen sulfide; does not contain hydrocarbons or carbon monoxide
XI	Refinery gases, ammonia, hydrogen sulfide and carbon monoxide	1 – 10% ammonia; 35 – 45% hydrogen sulfide; 1 – 10% carbon monoxide; does not contain hydrocarbons

For ecotoxicity purposes, using chemical compositions provided by the sponsor, the refinery gases category has been divided into four subcategories based upon the predominant constituents (i.e., composing > 0.5% of a given sponsored stream). Other than hydrogen, nitrogen and carbon dioxide, the predominant non-hydrocarbon constituents in the refinery gases category are ammonia, hydrogen sulfide, and carbon monoxide. For ecotoxicity purposes, the four subcategories have been defined as subcategory I: refinery gases containing C1 – C6 hydrocarbons, subcategory II: refinery gases containing C1 – C6 hydrocarbons, ammonia and hydrogen sulfide, subcategory III: refinery gases (without hydrocarbons), ammonia and hydrogen sulfide, and subcategory IV: refinery gases with carbon monoxide. Owing to the expected high ecotoxicity associated with ammonia and hydrogen sulfide, the sponsored category stream containing ammonia and/or hydrogen sulfide was separated from the category members that do not contain (or contain ≤ 2% of) these inorganic constituents (see Table 2). The third subcategory was created because one CASRN did not contain any hydrocarbons in the sponsored gas stream nor did it contain carbon monoxide (see Table 2). The scientific literature does not provide ecotoxicity data for carbon monoxide. As a result, the sponsored streams containing carbon monoxide (>2%), subcategory IV, are considered data gaps.

Table 2. Refinery Gases Subcategories for Ecotoxicity Endpoints		
I	Refinery gases, C1 – C6	CASRNs 68476-29-9, 68477-77-0, 68478-25-1, 68513-11-1, 68513-13-3, 68513-14-4, 68513-16-6, 68513-18-8, 68513-19-9, 68527-14-0, 68602-84-6, 68607-11-4, 68783-06-2, 68814-67-5, 68814-90-4, 68919-03-9, 68919-07-3, 68919-12-0, 68952-79-4, 68955-33-9, , 68308-27-0, 68477-81-6, 68478-27-3, 68478-28-4, 68478-29-5, 68478-30-8, 68919-08-4, 68952-80-7, and 68513-68-8
II	Refinery gases, C1 – C6 ammonia and hydrogen sulfide	CASRNs 68477-92-9, 68919-01-7, 68477-95-2, 68814-47-1, 68919-02-8, and 68919-04-0
III	Refinery gases (without hydrocarbons), ammonia, and hydrogen sulfide	CASRN 68783-05-1
IV	Refinery gases with carbon monoxide	CASRNs 68476-26-6, 68477-97-4, 68527-15-1, 8006-20-0, 68477-68-9, 68477-98-5, 68478-01-3, 68476-27-7, 68476-28-8, 68477-66-7, 68477-67-8, 68477-80-5, 68602-82-4, 68911-59-1, 68911-59-1, 68477-65-6, 68478-00-2, 68478-03-5, 68478-04-6, 68478-05-7, 68783-07-3, 68783-62-0, 68911-58-0, 68989-88-8, and 68527-13-9

Justification for Supporting Chemicals

No data are available for the sponsored category streams. The sponsor proposed the use of data for several supporting chemicals including carbon dioxide (CASRN 124-38-9), hydrogen (CASRN 1333-74-0), nitrogen (CASRN 7727-37-9), ammonia (CASRN 7664-41-7), hydrogen sulfide (CASRN 7783-06-4), carbon monoxide (CASRN 630-08-0), benzene (CASRN 71-43-2), 1,3-butadiene (CASRN 106-99-0), methanethiol (CASRN 74-93-1), ethanethiol (CASRN 75-08-1) and methanethiol, sodium salt (CASRN 5188-07-8). For the C1 – C4 hydrocarbon fraction, the sponsor proposed propane, 2-methyl (isobutane, (CASRN 75-28-5)), 1-butene (CASRN 106-98-9) and 2-butene (CASRN 107-01-7). For the C5 – C6 hydrocarbon fraction, the sponsor proposed light naphtha (gasoline) stream (no CASRN).

EPA's *Supplementary Guidance for Conducting Health Risk Assessment of Chemical Mixtures*[4] gives three options for evaluating the hazard of complex streams (either alone or in a category): (1) test data for the stream of concern; (2) test data for a toxicologically similar stream; or (3) test data for individual stream components. Therefore, the use of data for stream components to characterize the toxicity of the sponsored stream(s) is supported. The supporting chemicals for each subcategory are listed in the Appendix (Tables 7 and 8) and the data sources are listed in the Appendix (Table 11). Carbon dioxide, hydrogen or nitrogen are gases whose toxicity and environmental impact have been addressed elsewhere (carbon dioxide is a greenhouse gas whose hazard to the environment is described on the EPA website: http://www.epa.gov/climatechange/emissions/index.html; hydrogen (trace) and nitrogen (~78%) are naturally occurring atmospheric gases).

The sponsor proposed the use of data from members of the gasoline blending stream category to describe the toxicity of C5 – C6 hydrocarbons. The gasoline blending streams are volatile liquid petroleum substances consisting of paraffinic, olefinic, naphthenic and aromatic (PONA) hydrocarbons, with carbon numbers approximately in the range of C4 – C12 (as defined in the API Petroleum HPV Testing Group's test plan for gasoline blending streams, dated August 21, 2008; http://www.epa.gov/chemrtk/pubs/summaries/gasnecat/c13409tc.htm). API 83-20, a sample of light catalytic cracked naphtha (CASRN 64741-55-5), was considered an appropriate supporting chemical for subcategories that contain C5 – C6 hydrocarbons (Subcategories IV through IX); API 83-20 contains 31% paraffins, 10% naphthenes, 46% olefins and 13% aromatics, with hydrocarbon chain lengths that are ~ 2% C4, ~ 45% C5 – C6 and ~ 53% > C6.[5] API 81-08, a sample of sweetened naphtha (CASRN 64741-87-3), was considered an appropriate supporting chemical for subcategories that contain C5 – C6 hydrocarbons (Subcategories IV through IX); API 81-08 contains 72% paraffins, 21% naphthenes and 7% aromatics, with hydrocarbon chain lengths that are ~ 90% C5 – C6. API 83-19, a sample of light alkylate naphtha (CASRN 64741-66-8), was not considered an appropriate supporting chemical to describe the toxicity of C5 – C6 hydrocarbons because it contains only ~ 14% C5 – C6 hydrocarbons and ~ 82% > C6. API 83-05, a sample of catalytically reformed naphtha (CASRN 68955-35-1), was not considered an appropriate supporting chemical for refinery gases because it contains a high percentage (63%) of aromatic hydrocarbons, whereas refinery gases contain primarily alkanes and alkenes. API 99-01, a sample of unleaded gasoline vapor condensate, which was used as a supporting chemical for the gasoline blending stream category, was considered an appropriate supporting chemical for subcategories that contain C5 – C6 hydrocarbons (Subcategories IV through IX); it contains ~ 86% paraffins, ~ 2% naphthenes, ~ 4% olefins and ~ 7% aromatics, with hydrocarbon chain lengths that are ~ 14% C4, ~ 72% C5 – C6 and ~ 12% > C6.[6] Additional samples of gasoline (composition not specified) were also used as supporting chemicals for the C5 – C6 petroleum hydrocarbon gases (Subcategories IV through IX). A hazard characterization is being prepared for the gasoline blending streams category which will be available at: http://iaspub.epa.gov/oppthpv/hpv_hc_characterization.get_report?doctype=2.

[4] Published in 2000 and available at: http://www.epa.gov/raf/publications/sup-guidance-hra-chem-mix.htm
[5] The compositions of API 83-20, API 81-08, API 83-19, API 83-05 and API 99-01 were obtained from a document included in the final HPV submission for the gasoline blending streams category, submitted by the Petroleum HPV Testing Group.
[6] The composition of API 99-01 was provided by the sponsor in the robust summaries.

Several other hydrocarbons (i.e., alkanes, alkenes and naphthenes) containing one to six carbon atoms have been included as supporting chemicals to describe the toxicity of the C1 – C6 components of refinery gases. Toxicity data for these supporting chemicals have been derived from the robust summaries and the hazard characterization of the petroleum hydrocarbon gas category, with additional information (where available) added from supplemental sources. Representative C1 – C4 hydrocarbons that are used as supporting chemicals for subcategories that contain C1 – C4 components (Subcategories I through IX) include methane, ethane, ethylene (ethene), propane, 1-propene, butane, propane, 2-methyl (isobutane), 2-methylpropene, 1-butene and 2-butene. Representative C5 – C6 hydrocarbons that are used as supporting chemicals for subcategories that contain C5 – C6 components (Subcategories IV through IX) include pentane, cyclopentane and 2-methyl-2-butene. The hazard of most of these substances was evaluated in the Petroleum Hydrocarbon Gases category for which a hazard characterization has been prepared and is available for viewing at:
http://iaspub.epa.gov/oppthpv/hpv_hc_characterization.get_report?doctype=2.

For read-across purposes for human health endpoints, where more than one potentially toxic constituent is present in the stream, the sponsor and EPA have used a conservative approach and used data for the most toxic constituent to characterize the hazard endpoint for the stream.

For ecotoxicity purposes, the supporting chemicals used were methane, ethane, ethylene (ethene), propane, butane, pentane, hexane, ammonia, and hydrogen sulfide. Hexane was not included in the original submission, but provides useful ecotoxicological information since it is the only useful supporting chemical that is a C6 hydrocarbon. Since the composition of the sponsored member streams consisted of C1-C6 hydrocarbons (neutral organics) and/or ammonia and hydrogen sulfide, it is necessary to include these chemicals (with measured data or robust predictions) that support the sponsored category members based on physico-chemical properties, encompassing the C1-C6 carbon range (for subcategory I and II), environmental fate, and similar mode of toxic action (narcosis).

1. Chemical Identity

1.1 Identification and Purity

The components of this category are gases or volatile liquids having high vapor pressure and moderate to high water solubility. A description of the complex mixtures used for this category or the chemical structures of the specific compounds is provided in the Appendix.

1.2 Physical-Chemical Properties

The physical-chemical properties of the sponsored substances contained in the refinery gases category and its supporting chemicals are summarized in Table 3.

Table 3. Physical-Chemical Properties of Refinery Gases[1]						
Subcategory I: Refinery Gases, C1 – C4						
Property	**SPONSORED CHEMICAL Fuel gases, crude oil distillates[2]**	**SPONSORED CHEMICAL Gases (petroleum), catalytic reformed naphtha stripper overheads[2]**	**SPONSORED CHEMICAL Tail gas (petroleum), catalytic cracker refractionation absorber[2]**	**SPONSORED CHEMICAL Fuel gases, hydrotreater fractionation, scrubbed[2]**	**SPONSORED CHEMICAL Fuel gases, thermal cracked catalytic cracking residue[2]**	**SPONSORED CHEMICAL Gases (petroleum), catalytic reformed straight-run naphtha stabilizer overheads[2]**
CASRN	68476-29-9	68477-77-0	68478-25-1	68513-11-1	68513-13-3	68513-14-4
Molecular Weight	16.04– 58.12 (typical)	16.04– 58.12 (typical)	16.04– 44.10 (typical)	16.04– 58.12 (typical)	16.04– 58.12 (typical)	16.04– 44.10 (typical)
Physical State	Gas or volatile liquids					
Melting Point	-187.6 to -138.2°C (measured)[3]	-187.6 to -138.2°C (measured)[3]	-187.6 to -182.4°C (measured)[3]	-187.6 to -138.2°C (measured)[3]	-187.6 to -138.2°C (measured)[3]	-187.6 to -182.4 °C (measured)[3]
Boiling Point	-161.5 to -0.5°C (measured)[3]	-161.5 to -0.5°C (measured)[3]	-161.5 to -42.1°C (measured)[3]	-161.5 to -0.5°C (measured)[3]	-161.5 to -0.5°C (measured)[3]	-161.5 to -42.1°C (measured)[3]
Vapor Pressure	1,820 – 4.66×10^5 mm Hg at 25°C (measured)[3]	1,820 – 4.66×10^5 mm Hg at 25°C (measured)[3]	7,150 – 4.66×10^5 mm Hg at 25°C (measured)[3]	1,820 – 4.66×10^5 mm Hg at 25°C (measured)[3]	1,820 – 4.66×10^5 mm Hg at 25°C (measured)[3]	7,150 – 4.66×10^5 mm Hg at 25°C (measured)[3]
Dissociation Constant (pK_a)	Not applicable					
Henry's Law Constant	0.66–0.95 atm-m^3/mol (measured)[3]	0.66–0.95 atm-m^3/mol (measured)[3]	0.66–0.707 atm-m^3/mol (measured)[3]	0.66–0.95 atm-m^3/mol (measured)[3]	0.66–0.95 atm-m^3/mol (measured)[3]	0.66–0.707 atm-m^3/mol (measured)[3]
Water Solubility	22–61.2 mg/L at 25°C (measured)[3]	22–61.2 mg/L at 25°C (measured)[3]	22–62.4 mg/L at 25°C (measured)[3]	22–61.2 mg/L at 25°C (measured)[3]	22–61.2 mg/L at 25°C (measured)[3]	22–62.4 mg/L at 25°C (measured)[3]
Log K_{ow}	1.09–2.89 (measured)[3]	1.09–2.89 (measured)[3]	1.09–2.36 (measured)[3]	1.09–2.89 (measured)[3]	1.09–2.89 (measured)[3]	1.09–2.36 (measured)[3]

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.

[2] Data range is based upon the representative structures; 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 November 18, 2010.

Table 3. Physical-Chemical Properties of Refinery Gases[1]						
Subcategory I: Refinery Gases, C1 – C4 (continued)						
Property	**SPONSORED CHEMICAL Gases (petroleum), hydrocracking depropanizer off, hydrocarbon-rich[2]**	**SPONSORED CHEMICAL Gases (petroleum), reformer effluent high-pressure flash drum off[2]**	**SPONSORED CHEMICAL Gases (petroleum), reformer effluent low-pressure flash drum off[2]**	**SPONSORED CHEMICAL Gases, (petroleum), methane-rich off[2]**	**SPONSORED CHEMICAL Gases (petroleum), secondary absorber off, fluidized catalytic cracker overheads fractionator[2]**	**SPONSORED CHEMICAL Petroleum products, refinery gases[2]**
CASRN	68513-16-6	68513-18-8	68513-19-9	68527-14-0	68602-84-6	68607-11-4
Molecular Weight	16.04 – 58.12 (typical)	16.04 – 44.10 (typical)	16.04– 44.10 (typical)	16.04 – 86.18 (typical)	16.04 – 86.18 (typical)	16.04 – 44.10 (typical)
Physical State	Gas or volatile liquids					
Melting Point	-187.6 to -138.2°C (measured)[3]	-187.6 to -182.4°C (measured)[3]	-187.6 to -182.4°C (measured)[3]	-187.6 to -95.3°C (measured)[3]	-187.6 to -95.3°C (measured)[3]	-187.6 to -182.4°C (measured)[3]
Boiling Point	-161.5 to -0.5°C (measured)[3]	-161.5 to -42.1°C (measured)[3]	-161.5 to -42.1°C (measured)[3]	-161.5 to 68.7°C (measured)[3]	-161.5 to 68.7°C (measured)[3]	-161.5 to -42.1°C (measured)[3]
Vapor Pressure	1,820 – 4.66×10^5 mm Hg at 25°C (measured)[3]	7,150 – 4.66×10^5 mm Hg at 25°C (measured)[3]	7,150 – 4.66×10^5 mm Hg at 25°C (measured)[3]	151 – 4.66×10^5 mm Hg at 25°C (measured)[3]	151 – 4.66×10^5 mm Hg at 25°C (measured)[3]	7,150 – 4.66×10^5 mm Hg at 25°C (measured)[3]
Dissociation Constant (pK_a)	Not applicable					
Henry's Law Constant	0.66–0.95 atm-m^3/mol (measured)[3]	0.66–0.707 atm-m^3/mol (measured)[3]	0.66–0.707 atm-m^3/mol (measured)[3]	0.66–1.8 atm-m^3/mol (measured)[3]	0.66–1.8 atm-m^3/mol (measured)[3]	0.66–0.707 atm-m^3/mol (measured)[3]
Water Solubility	22–61.2 mg/L at 25°C (measured)[3]	22–62.4 mg/L at 25°C (measured)[3]	22–62.4 mg/L at 25°C (measured)[3]	9.5–22 mg/L at 25°C (measured)[3]	9.5–22 mg/L at 25°C (measured)[3]	22–62.4 mg/L at 25°C (measured)[3]
Log K_{ow}	1.09–2.89 (measured)[3]	1.09–2.36 (measured)[3]	1.09–2.36 (measured)[3]	1.09–3.90 (measured)[3]	1.09–3.90 (measured)[3]	1.09–2.36 (measured)[3]

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.

[2] Data range is based upon the representative structures; 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 November 18, 2010.

Table 3. Physical-Chemical Properties of Refinery Gases[1]						
Subcategory I: Refinery Gases, C1 – C4 (continued)						
Property	**SPONSORED CHEMICAL Gases (petroleum), hydrocracking low-pressure separator[2]**	**SPONSORED CHEMICAL Gases (petroleum), refinery[2]**	**SPONSORED CHEMICAL Gases (petroleum), platformer products separator off[2]**	**SPONSORED CHEMICAL Gases (petroleum), fluidized catalytic cracker scrubbing secondary absorber off[2]**	**SPONSORED CHEMICAL Gases (petroleum), platformer stabilizer off, light ends fractionation[2]**	**SPONSORED CHEMICAL Gases (petroleum), unifiner stripper off[2]**
CASRN	68783-06-2	68814-67-5	68814-90-4	68919-03-9	68919-07-3	68919-12-0
Molecular Weight	16.04 – 44.10 (typical)	16.04 – 44.10 (typical)	30.07 – 58.12 (typical)	30.07 – 58.12 (typical)	16.04 – 44.10 (typical)	16.04 (typical)
Physical State	Gas or volatile liquids					
Melting Point	-187.6 to -182.4°C (measured)[3]	-187.6 to -182.4°C (measured)[3]	-187.6 to -138.2°C (measured)[3]	-182.8 to -138.2°C (measured)[3]	-187.6 to -182.4°C (measured)[3]	-182.4°C (measured)[3]
Boiling Point	-161.5 to -42.1°C (measured)[3]	-161.5 to -42.1°C (measured)[3]	-88.6 to -0.5°C (measured)[3]	-88.6 to -0.5°C (measured)[3]	-161.5 to -42.1°C (measured)[3]	-161.5°C (measured)[3]
Vapor Pressure	7,150 – 4.66×10^5 mm Hg at 25°C (measured)[3]	7,150 – 4.66×10^5 mm Hg at 25°C (measured)[3]	1,820 – 3.15×10^4 mm Hg at 25°C (measured)[3]	3.15×10^4 – 4.66×10^5 mm Hg at 25°C (measured)[3]	7,150 – 4.66×10^5 mm Hg at 25°C (measured)[3]	4.66×10^5 mm Hg at 25°C (measured)[3]
Dissociation Constant (pK_a)	Not applicable					
Henry's Law Constant	0.66–0.707 atm-m^3/mol (measured)[3]	0.66–0.707 atm-m^3/mol (measured)[3]	0.500–0.95 atm-m^3/mol (measured)[3]	0.500–0.95 atm-m^3/mol (measured)[3]	0.66–0.707 atm-m^3/mol (measured)[3]	0.66 atm-m^3/mol (measured)[3]
Water Solubility	22–62.4 mg/L at 25°C (measured)[3]	22–62.4 mg/L at 25°C (measured)[3]	60.2–61.2 mg/L at 25°C (measured)[3]	60.2–61.2 mg/L at 25°C (measured)[3]	22–62.4 mg/L at 25°C (measured)[3]	22 mg/L at 25°C (measured)[3]
Log K_{ow}	1.09–2.36 (measured)[3]	1.09–2.36 (measured)[3]	1.81–2.89 (measured)[3]	1.81–2.89 (measured)[3]	1.09–2.36 (measured)[3]	1.09 (measured)[3]

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.

[2] Data range is based upon the representative structures; 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 November 18, 2010.

Table 3. Physical-Chemical Properties of Refinery Gases (*continued*)[1]				
Subcategory I: Refinery Gases, C1 – C4 (continued)			***Subcategory II: Refinery Gases, C1 – C4 with Ammonia and Hydrogen Sulfide***	
Property	**SPONSORED CHEMICAL Tail gas (petroleum), catalytic hydrodesulfurized naphtha separator[2]**	**SPONSORED CHEMICAL Gases (petroleum), sponge absorber off, fluidized catalytic cracker and gas oil[2]**	**SPONSORED CHEMICAL Gases (petroleum), dry sour, gas-concn.-unit-off[2]**	**SPONSORED CHEMICAL Gases (petroleum), distillate unifiner desulfurization stripper off[2]**
CASRN	68952-79-4	68955-33-9	68477-92-9	68919-01-7
Molecular Weight	16.04 – 44.10 (typical)	16.04 – 58.12 (typical)	16.04 – 44.10 (typical)	16.04 – 44.10 (typical)
Physical State	Gas or volatile liquids	Gas or volatile liquids	Gas or volatile liquids	Gas or volatile liquids
Melting Point	-187.6 to -182.4°C (measured)[3]	-187.6 to -138.2°C (measured)[3]	-187.6 to -182.4°C (measured)[3]	-187.6 to -182.4°C (measured)[3]
Boiling Point	-161.5 to -42.1°C (measured)[3]	-161.5 to -0.5°C (measured)[3]	-161.5 to -42.1°C (measured)[3]	-161.5 to -42.1°C (measured)[3]
Vapor Pressure	7,150 – 4.66×10^5 mm Hg at 25°C (measured)[3]	1,820 – 4.66×10^5 mm Hg at 25°C (measured)[3]	7,150 – 4.66×10^5 mm Hg at 25°C (measured)[3]	7,150 – 4.66×10^5 mm Hg at 25°C (measured)[3]
Dissociation Constant (pK_a)	Not applicable			
Henry's Law Constant	0.66–0.707 atm-m^3/mol (measured)[3]	0.66–0.95 atm-m^3/mol (measured)[3]	0.66–0.707 atm-m^3/mol (measured)[3]	0.66–0.707 atm-m^3/mol (measured)[3]
Water Solubility	22–62.4 mg/L at 25°C (measured)[3]	22–61.2 mg/L at 25°C (measured)[3]	22–62.4 mg/L at 25°C (measured)[3]	22–62.4 mg/L at 25°C (measured)[3]
Log K_{ow}	1.09–2.36 (measured)[3]	1.09–2.89 (measured)[3]	1.09–2.36 (measured)[3]	1.09–2.36 (measured)[3]

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.
[2] Data range is based upon the representative structures; 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 November 18, 2010.

Table 3. Physical-Chemical Properties of Refinery Gases[1]				
Subcategory III: Refinery Gases, C1 – C4 with Carbon Monoxide				
Property	**SPONSORED CHEMICAL Fuel gases[2]**	**SPONSORED CHEMICAL Gases (petroleum), hydrogen-rich[2]**	**SPONSORED CHEMICAL Gases (petroleum), oil refinery gas distn. off[2]**	**SPONSORED CHEMICAL Fuel gases, producer gas[2]**
CASRN	68476-26-6	68477-97-4	68527-15-1	8006-20-0
Molecular Weight	16.04 – 30.07 (typical)	16.04 – 30.07 (typical)	16.04 – 30.07 (typical)	16.04 – 30.07 (typical)
Physical State	Gas or volatile liquids	Gas or volatile liquids	Gas or volatile liquids	Gas or volatile liquids
Melting Point	-182.8 to -182.4°C (measured)[3]	-182.8 to -182.4°C (measured)[3]	-182.8 to -182.4°C (measured)[3]	-182.8 to -182.4°C (measured)[3]
Boiling Point	-161.5 to -88.6°C (measured)[3]	-161.5 to -88.6°C (measured)[3]	-161.5 to -88.6°C (measured)[3]	-161.5 to -88.6°C (measured)[3]
Vapor Pressure	3.15×10^4 – 4.66×10^5 mm Hg at 25°C (measured)[3]	3.15×10^4 – 4.66×10^5 mm Hg at 25°C (measured)[3]	3.15×10^4 – 4.66×10^5 mm Hg at 25°C (measured)[3]	3.15×10^4 – 4.66×10^5 mm Hg at 25°C (measured)[3]
Dissociation Constant (pK_a)	Not applicable			
Henry's Law Constant	0.500–0.66 atm-m^3/mol (measured)[3]	0.500–0.66 atm-m^3/mol (measured)[3]	0.500–0.66 atm-m^3/mol (measured)[3]	0.500–0.66 atm-m^3/mol (measured)[3]
Water Solubility	22.0–60.2 mg/L at 25°C (measured)[3]	22.0–60.2 mg/L at 25°C (measured)[3]	22.0–60.2 mg/L at 25°C (measured)[3]	22.0–60.2 mg/L at 25°C (measured)[3]
Log K_{ow}	1.09–1.81 (measured)[3]	1.09–1.81 (measured)[3]	1.09–1.81 (measured)[3]	1.09–1.81 (measured)[3]

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.
[2] Data range is based upon the representative structures; 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 November 18, 2010.

Table 3. Physical-Chemical Properties of Refinery Gases[1]						
Subcategory IV: Refinery Gases, C1 – C6						
Property	**SPONSORED CHEMICAL Fuel gases, refinery[2]**	**SPONSORED CHEMICAL Gases (petroleum), C6 – 8 catalytic reformer[2]**	**SPONSORED CHEMICAL Tail gas (petroleum), catalytic reformed naphtha separator[2]**	**SPONSORED CHEMICAL Tail gas (petroleum), catalytic reformed naphtha stabilizer[2]**	**SPONSORED CHEMICAL Tail gas, (petroleum), cracked distillate hydrotreater separator[2]**	**SPONSORED CHEMICAL Tail gas (petroleum), hydrodesulfurized straight-run naphtha separator[2]**
CASRN	68308-27-0	68477-81-6	68478-27-3	68478-28-4	68478-29-5	68478-30-8
Molecular Weight	16.04–72.15 (typical)	16.04–72.15 (typical)	16.04 – 86.18 (typical)	16.04 – 86.18 (typical)	16.04–72.15 (typical)	16.04 – 86.18 (typical)
Physical State	Gas or volatile liquids					
Melting Point	-187.6 to -129.7°C (measured)[3]	-187.6 to -129.7°C (measured)[3]	-187.6 to -95.3°C (measured)[3]	-187.6 to -95.3°C (measured)[3]	-187.6 to -129.7°C (measured)[3]	-187.6 to -95.3°C (measured)[3]
Boiling Point	-161.5 to 36°C (measured)[3]	-161.5 to 36°C (measured)[3]	-161.5 to 68.7°C (measured)[3]	-161.5 to 68.7°C (measured)[3]	-161.5 to 36°C (measured)[3]	-161.5 to 68.7°C (measured)[3]
Vapor Pressure	514 – 4.66×10^5 mm Hg at 25°C (measured)[3]	514 – 4.66×10^5 mm Hg at 25°C (measured)[3]	151 – 4.66×10^5 mm Hg at 25°C (measured)[3]	151 – 4.66×10^5 mm Hg at 25°C (measured)[3]	514 – 4.66×10^5 mm Hg at 25°C (measured)[3]	151 – 4.66×10^5 mm Hg at 25°C (measured)[3]
Dissociation Constant (pK_a)	Not applicable					
Henry's Law Constant	0.66–1.25 atm-m^3/mol (measured)[3]	0.66–1.25 atm-m^3/mol (measured)[3]	0.66–1.8 atm-m^3/mol (measured)[3]	0.66–1.8 atm-m^3/mol (measured)[3]	0.66–1.25 atm-m^3/mol (measured)[3]	0.66–1.8 atm-m^3/mol (measured)[3]
Water Solubility	22.0–39 mg/L at 25°C (measured)[3]	22.0–39 mg/L at 25°C (measured)[3]	9.5–22.0 mg/L at 25°C (measured)[3]	9.5–22.0 mg/L at 25°C (measured)[3]	22.0–39 mg/L at 25°C (measured)[3]	9.5–22.0 mg/L at 25°C (measured)[3]
Log K_{ow}	1.09–3.39 (measured)[3]	1.09–3.39 (measured)[3]	1.09–3.90 (measured)[3]	1.09–3.90 (measured)[3]	1.09–3.39 (measured)[3]	1.09–3.90 (measured)[3]

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.

[2] Data range is based upon the representative structures; 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 November 18, 2010.

Table 3. Physical-Chemical Properties of Refinery Gases[1]				
Subcategory IV: Refinery Gases, C1 – C6 (continued)				*Subcategory V: Refinery Gases, C1 – C6 with Hydrogen Sulfide*
Property	**SPONSORED CHEMICAL Gases (petroleum), preflash tower off, crude distn.[2]**	**SPONSORED CHEMICAL Tail gas (petroleum), straight-run naphtha hydrodesulfurizer[2]**	**SPONSORED CHEMICAL Residues (petroleum), deethanizer tower[2]**	**SPONSORED CHEMICAL Gases (petroleum), dry sour, gas-concn.-unit-off[2]**
CASRN	68919-08-4	68952-80-7	68513-68-8	68477-95-2
Molecular Weight	16.04–72.15 (typical)	16.04–72.15 (typical)	16.04 – 86.18 (typical)	30.07 – 58.12 (typical)
Physical State	Gas or volatile liquids	Gas or volatile liquids	Gas or volatile liquids	Gas
Melting Point	-187.6 to -129.7°C (measured)[3]	-187.6 to -129.7°C (measured)[3]	-187.6 to -95.3°C (measured)[3]	-182.8 to -138.2°C (measured)[3]
Boiling Point	-161.5 to 36°C (measured)[3]	-161.5 to 36 °C (measured)[3]	-161.5 to 68.7 °C (measured)[3]	-88.6 to -0.5°C (measured)[3]
Vapor Pressure	514 – 4.66×10^5 mm Hg at 25°C (measured)[3]	514 – 4.66×10^5 mm Hg at 25°C (measured)[3]	151 – 4.66×10^5 mm Hg at 25°C (measured)[3]	1,820 – 3.15×10^4 mm Hg at 25°C (measured)[3]
Dissociation Constant (pK_a)	Not applicable			
Henry's Law Constant	0.66– 1.25 atm-m^3/mol (measured)[3]	0.66–1.25 atm-m^3/mol (measured)[3]	0.66–1.8 atm-m^3/mol (measured)[3]	0.500–0.95 atm-m^3/mol (measured)[3]
Water Solubility	22.0–39 mg/L at 25°C (measured)[3]	22.0–39 mg/L at 25°C (measured)[3]	9.5–22.0 mg/L at 25°C (measured)[3]	60.2–61.2 mg/L at 25°C (measured)[3]
Log K_{ow}	1.09–3.39 (measured)[3]	1.09–3.39 (measured)[3]	1.09–3.90 (measured)[3]	1.81–2.89 (measured)[3]

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.

[2] Data range is based upon the representative structures; 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 November 18, 2010.

Table 3. Physical-Chemical Properties of Refinery Gases[1]							
Subcategory VI: Refinery Gases, C1 – C6 with Carbon Monoxide							
Property	**SPONSORED CHEMICAL Gases (petroleum), blend oil, hydrogen-nitrogen-rich[2]**	**SPONSORED CHEMICAL Gases (petroleum), hydrotreater blend oil recycle, hydrogen-nitrogen-rich[2]**	**SPONSORED CHEMICAL Gases (petroleum), reformer make-up, hydrogen-rich[2]**	**SPONSORED CHEMICAL Fuel gases, amine system residues[2]**	**SPONSORED CHEMICAL Fuel gases, C6 – 8 catalytic reformer[2]**	**SPONSORED CHEMICAL Gases (petroleum), benzene unit hydrodesulfurizer off[2]**	**SPONSORED CHEMICAL Gases (petroleum), benzene unit recycle, hydrogen-rich[2]**
CASRN	68477-68-9	68477-98-5	68478-01-3	68476-27-7	68476-28-8	68477-66-7	68477-67-8
Molecular Weight	16.04–72.15 (typical)	16.04–72.15 (typical)	16.04–72.15 (typical)	44.10–72.15 (typical)	30.07–86.18 (typical)	16.04–86.18 (typical)	16.04–86.18 (typical)
Physical State	Gas or volatile liquid						
Melting Point	-187.6 to -129.7°C (measured)[3]	-187.6 to -129.7°C (measured)[3]	-187.6 to -129.7°C (measured)[3]	-187.6 to -129.7°C (measured)[3]	-182.8 to -95.3°C (measured)[3]	-187.6 to -95.3°C (measured)[3]	-187.6 to -95.3°C (measured)[3]
Boiling Point	-161.5 to 36°C (measured)[3]	-161.5 to 36°C (measured)[3]	-161.5 to 36°C (measured)[3]	-42.1 to 36°C (measured)[3]	-88.6 to 68.7°C (measured)[3]	-161.5 to 68.7°C (measured)[3]	-161.5 to 68.7°C (measured)[3]
Vapor Pressure	514 – 4.66×10^5 mm Hg at 25°C (measured)[3]	514 – 4.66×10^5 mm Hg at 25°C (measured)[3]	514 – 4.66×10^5 mm Hg at 25°C (measured)[3]	514 – 7,150 mm Hg at 25°C (measured)[3]	151 – 3.15×10^4 mm Hg at 25°C (measured)[3]	151 – 4.66×10^5 mm Hg at 25°C (measured)[3]	151 – 4.66×10^5 mm Hg at 25°C (measured)[3]
Dissociation Constant (pK_a)	Not applicable						
Henry's Law Constant	0.66–1.25 atm-m^3/mol (measured)[3]	0.66–1.25 atm-m^3/mol (measured)[3]	0.66–1.25 atm-m^3/mol (measured)[3]	0.707–1.25 atm-m^3/mol (measured)[3]	0.500–1.8 atm-m^3/mol (measured)[3]	0.66–1.8 atm-m^3/mol (measured)[3]	0.66–1.8 atm-m^3/mol (measured)[3]
Water Solubility	22.0–39 mg/L at 25°C (measured)[3]	22.0–39 mg/L at 25°C (measured)[3]	22.0–39 mg/L at 25°C (measured)[3]	39–62.4 mg/L at 25°C (measured)[3]	9.5–60.2 mg/L at 25°C (measured)[3]	9.5–22.0 mg/L at 25°C (measured)[3]	9.5–22.0 mg/L at 25°C (measured)[3]
Log K_{ow}	1.09–3.39 (measured)[3]	1.09–3.39 (measured)[3]	1.09–3.39 (measured)[3]	2.36–3.39 (measured)[3]	1.81–3.90 (measured)[3]	1.09–3.90 (measured)[3]	1.09–3.90 (measured)[3]

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.

[2] Data range is based upon the representative structures; 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 November 18, 2010.

Table 3. Physical-Chemical Properties of Refinery Gases[1]					
	Subcategory VI: Refinery Gases, C1 – C6 with Carbon Monoxide (continued)				*Subcategory VII: Refinery Gases, C1 – C6 with Carbon Monoxide and Hydrogen Sulfide*
Property	**SPONSORED CHEMICAL Gases (petroleum), C6 – 8 catalytic reformer recycle[2]**	**SPONSORED CHEMICAL Gases (petroleum), C6 – 8 catalytic reformer recycle, hydrogen-rich[2]**	**SPONSORED CHEMICAL Gases (petroleum), benzene unit hydrotreater depentanizer overheads[2]**	**SPONSORED CHEMICAL Gases (petroleum), hydrotreated sour kerosine flash drum[2]**	**SPONSORED CHEMICAL Gases (petroleum), reforming hydrotreater[2]**
CASRN	68477-80-5	68477-82-7	68602-82-4	68911-59-1	68478-02-4
Molecular Weight	16.04–86.18 (typical)	16.04–86.18 (typical)	16.04–86.18 (typical)	30.07–72.15 (typical)	16.04 – 30.07 (typical)
Physical State	Gas or volatile liquid				Gas
Melting Point	-187.6 to -95.3°C (measured)[3]	-187.6 to -95.3°C (measured)[3]	-187.6 to -95.3°C (measured)[3]	-182.8 to -129.7°C (measured)[3]	-182.8 to -182.4°C (measured)[3]
Boiling Point	-161.5 to 68.7°C (measured)[3]	-161.5 to 68.7°C (measured)[3]	-161.5 to 68.7°C (measured)[3]	-88.6 to 36°C (measured)[3]	-161.5 to -88.6°C (measured)[3]
Vapor Pressure	151 – 4.66×10^5 mm Hg at 25°C (measured)[3]	151 – 4.66×10^5 mm Hg at 25°C (measured)[3]	151 – 4.66×10^5 mm Hg at 25°C (measured)[3]	514 – 3.15×10^4 mm Hg at 25°C (measured)[3]	3.15×10^4 to 4.66×10^5 mm Hg at 25°C (measured)[3]
Dissociation Constant (pK_a)	Not applicable				
Henry's Law Constant	0.66–1.8 atm-m^3/mol (measured)[3]	0.66–1.8 atm-m^3/mol (measured)[3]	0.66–1.8 atm-m^3/mol (measured)[3]	0.500–1.25 atm-m^3/mol (measured)[3]	0.500–0.66 atm-m^3/mol (measured)[3]
Water Solubility	9.5–22.0 mg/L at 25°C (measured)[3]	9.5–22.0 mg/L at 25°C (measured)[3]	9.5–22.0 mg/L at 25°C (measured)[3]	38–60.2 mg/L at 25°C (measured)[3]	22.0–60.2 mg/L at 25°C (measured)[3]
Log K_{ow}	1.09–3.90 (measured)[3]	1.09–3.90 (measured)[3]	1.09–3.90 (measured)[3]	1.81–3.39 (measured)[3]	1.09–1.81 (measured)[3]

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.

[2] Data range is based upon the representative structures; 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 November 18, 2010.

Table 3. Physical-Chemical Properties of Refinery Gases[1]			
Subcategory VIII: Refinery Gases, C1 – C6 with Ammonia and Hydrogen Sulfide			
Property	**SPONSORED CHEMICAL Waste gases, refinery vent[2]**	**SPONSORED CHEMICAL Gases (petroleum), fluidized catalytic cracker fractionation off[2]**	**SPONSORED CHEMICAL Gases (petroleum), heavy distillate hydrotreater desulfurization stripper off[2]**
CASRN	68814-47-1	68919-02-8	68919-04-0
Molecular Weight	16.04–72.15 (typical)	16.04–72.15 (typical)	16.04–72.15 (typical)
Physical State	Gas or volatile liquid		
Melting Point	-187.6 to -129.7°C (measured)[3]	-187.6 to -129.7°C (measured)[3]	-187.6 to -129.7°C (measured)[3]
Boiling Point	-161.5 to 36°C (measured)[3]	-161.5 to 36°C (measured)[3]	-161.5 to 36°C (measured)[3]
Vapor Pressure	514 – 4.66×10^5 mm Hg at 25°C (measured)[3]	514 – 4.66×10^5 mm Hg at 25°C (measured)[3]	514 – 4.66×10^5 mm Hg at 25°C (measured)[3]
Dissociation Constant (pK_a)	Not applicable		
Henry's Law Constant	0.66–1.25 atm-m^3/mol (measured)[3]	0.66–1.25 atm-m^3/mol (measured)[3]	0.66–1.25 atm-m^3/mol (measured)[3]
Water Solubility	22.0–39 mg/L at 25°C (measured)[3]	22.0–39 mg/L at 25°C (measured)[3]	22.0–39 mg/L at 25°C (measured)[3]
Log K_{ow}	1.09–3.39 (measured)[3]	1.09–3.39 (measured)[3]	1.09–3.39 (measured)[3]

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.
[2] Data range is based upon the representative structures; 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 November 18, 2010.

Table 3. Physical-Chemical Properties of Refinery Gases[1]							
Subcategory IX: Refinery Gases, C1- C6 with Ammonia, Hydrogen Sulfide, and Carbon Monoxide							
Property	**SPONSORED CHEMICAL Gases (petroleum), amine system feed[2]**	**SPONSORED CHEMICAL Gases (petroleum), recycle, hydrogen-rich[2]**	**SPONSORED CHEMICAL Gases (petroleum), reforming hydrotreater, hydrogen-methane-rich[2]**	**SPONSORED CHEMICAL Gases (petroleum), reforming hydrotreater make-up, hydrogen-rich[2]**	**SPONSORED CHEMICAL Gases (petroleum), thermal cracking distn.[2]**	**SPONSORED CHEMICAL Gases (petroleum), refinery blend[2]**	**SPONSORED CHEMICAL Fuel gases, refinery, unsweetened[2]**
CASRN	68477-65-6	68478-00-2	68478-03-5	68478-04-6	68478-05-7	68783-07-3	68783-62-0
Molecular Weight	16.04–72.15 (typical)	16.04–72.15 (typical)	30.07–72.15 (typical)	16.04–72.15 (typical)	16.04–88.18 (typical)	16.04–72.15 (typical)	16.04–72.15 (typical)
Physical State	Gas or volatile liquid						
Melting Point	-187.6 to -129.7°C (measured)[3]	-187.6 to -129.7°C (measured)[3]	-182.8 to -129.7°C (measured)[3]	-187.6 to -129.7°C (measured)[3]	-187.6 to -95.3°C (measured)[3]	-187.6 to -129.7°C (measured)[3]	-187.6 to -129.7°C (measured)[3]
Boiling Point	-161.5 to 36°C (measured)[3]	-161.5 to 36°C (measured)[3]	-88.6to 36°C (measured)[3]	-161.5 to 36°C (measured)[3]	-161.5 to 68.7°C (measured)[3]	-161.5 to 36°C (measured)[3]	-161.5 to 36°C (measured)[3]
Vapor Pressure	514 – 4.66×10^5 mm Hg at 25°C (measured)[3]	514 – 4.66×10^5 mm Hg at 25°C (measured)[3]	514 – 3.15×10^4 mm Hg at 25°C (measured)[3]	514 – 4.66×10^5 mm Hg at 25°C (measured)[3]	151 – 4.66×10^5 mm Hg at 25°C (measured)[3]	514 – 4.66×10^5 mm Hg at 25°C (measured)[3]	514 – 4.66×10^5 mm Hg at 25°C (measured)[3]
Dissociation Constant (pK_a)	Not applicable						
Henry's Law Constant	0.66–1.25 atm-m^3/mol (measured)[3]	0.66–1.25 atm-m^3/mol (measured)[3]	0.500–1.25 atm-m^3/mol (measured)[3]	0.66–1.25 atm-m^3/mol (measured)[3]	0.66–1.8 atm-m^3/mol (measured)[3]	0.66–1.25 atm-m^3/mol (measured)[3]	0.66–1.25 atm-m^3/mol (measured)[3]
Water Solubility	22.0–39 mg/L at 25°C (measured)[3]	22.0–39 mg/L at 25°C (measured)[3]	39–60.2 mg/L at 25°C (measured)[3]	22.0–39 mg/L at 25°C (measured)[3]	9.5–22.0 mg/L at 25°C (measured)[3]	22.0–39 mg/L at 25°C (measured)[3]	22.0–39 mg/L at 25°C (measured)[3]
Log K_{ow}	1.09–3.39 (measured)[3]	1.09–3.39 (measured)[3]	1.81–3.39 (measured)[3]	1.09–3.39 (measured)[3]	1.09–3.90 (measured)[3]	1.09–3.39 (measured)[3]	1.09–3.39 (measured)[3]

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.

[2] Data range is based upon the representative structures; 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 November 18, 2010.

Table 3. Physical-Chemical Properties of Refinery Gases[1]				
Property	***Subcategory IX: Refinery Gases, C1- C6 with Ammonia, Hydrogen Sulfide, and Carbon Monoxide (continued)***		***Subcategory X: Refinery Gases, Ammonia and Hydrogen Sulfide***	***Subcategory XI: Refinery Gases, Ammonia, Hydrogen Sulfide and Carbon Monoxide***
	SPONSORED CHEMICAL Gases (petroleum), hydrotreated sour kerosine depentanizer stabilizer off[2]	**SPONSORED CHEMICAL Gases (petroleum), crude distn. and catalytic cracking[2]**	**SPONSORED CHEMICAL Gases, (petroleum), ammonia-hydrogen sulfide, water-satd.[2]**	**SPONSORED CHEMICAL Gases, (petroleum), acid, ethanolamine scrubber[2]**
CASRN	68911-58-0	68989-88-8	68783-05-1	68527-13-9
Molecular Weight	58.12–72.15 (typical)	16.04–88.18 (typical)	17.03 – 34.08 (typical)	28.10 – 34.08 (typical)
Physical State	Gas			
Melting Point	-138.2 to -129.7°C (measured)[3]	-187.6 to -95.3°C (measured)[3]	-85.49 to -77.7°C (measured)[3]	-205.02 to -85.49°C (measured)[3]
Boiling Point	-0.5 to 36°C (measured)[3]	-161.5 to 68.7°C (measured)[3]	-60.3 to -33.35°C (measured)[3]	-191.5 to -60.33°C (measured)[3]
Vapor Pressure	514 – 1,820 mm Hg at 25°C (measured)[3]	151 – 4.66×10^5 mm Hg at 25°C (measured)[3]	7,510 – 1.56×10^4 mm Hg at 25°C (measured)[3]	1.56×10^4 – 1.55×10^8 mm Hg at 25°C (measured)[3]
Dissociation Constant (pK_a)	Not Applicable		9.25 (measured for the conjugate acid)[3]	pKa1 = 7.04; pKa2 = 11.96 (measured)[3]
Henry's Law Constant	0.95–1.25 atm-m^3/mol (measured)[3]	0.66–1.8 atm-m^3/mol (measured)[3]	0.009–1.6×10^5 atm-m^3/mol (measured)[3]	1.6×10^5 atm-m^3/mol (measured)[3]
Water Solubility	39–61.2 mg/L at 25°C (measured)[3]	9.5–22.0 mg/L at 25°C (measured)[3]	3,980–482,000 mg/L at 25°C (measured)[3]	23–3,980 mg/L at 20°C (measured)[3]
Log K_{ow}	2.89–3.39 (measured)[3]	1.09–3.90 (measured)[3]	0.23 (estimated)[4,5]	0.23–1.78 (estimated)[4,5]

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.
[2] Data range is based upon the representative structures; see Appendix for detailed information on the structures.
[3] Hazardous Substance Databank. 2010. Available online at http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB as of November 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/episuitedl.htm as of November 18, 2010.
[5] Inorganic compounds are outside the estimated domain.

Table 3. Physical-Chemical Properties of Refinery Gases[1]					
Property	**SUPPORTING CHEMICAL Methane**	**SUPPORTING CHEMICAL Ethane**	**SUPPORTING CHEMICAL Ethylene**	**SUPPORTING CHEMICAL Propane**	**SUPPORTING CHEMICAL 1-Propene**
CASRN	74-82-8	74-84-0	74-85-1	74-98-6	115-07-1
Molecular Weight	16.04	30.07	28.05	44.10	42.08
Physical State	Gas				
Melting Point	-182.4°C (measured)[3]	-182.8°C (measured)[3]	-169°C (measured)[3]	-187.6°C (measured)[3]	-185°C (measured)[3]
Boiling Point	-161.5°C (measured)[3]	-88.6°C (measured)[3]	-103.7°C (measured)[3]	-42.1°C (measured)[3]	-48°C (measured)[3]
Vapor Pressure	4.66×10^5 mm Hg at 25°C (measured)[3]	3.15×10^4 mm Hg at 25°C (measured)[3]	5.21×10^4 mm Hg at 25°C (measured)[3]	7,150 mm Hg at 25°C (measured)[3]	8,690 mm Hg at 25°C (measured)[3]
Dissociation Constant (pK_a)	Not applicable				
Henry's Law Constant	0.66 atm-m^3/mol (measured)[3]	0.500 atm-m^3/mol (measured)[3]	0.228 atm-m^3/mol (measured)[3]	0.707 atm-m^3/mol (measured)[3]	0.196 atm-m^3/mol (measured)[3]
Water Solubility	22.0 mg/L at 25°C (measured)[3]	60.2 mg/L at 25°C (measured)[3]	131 mg/L at 25°C (measured)[3]	62.4 mg/L at 25°C (measured)[3]	200 mg/L at 25°C (measured)[3]
Log K_{ow}	1.09 (measured)[3]	1.81 (measured)[3]	1.13 (measured)[3]	2.36 (measured)[3]	1.77 (measured)[3]

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.
[2] Data range is based upon the representative structures; 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 November 18, 2010.

Table 3. Physical-Chemical Properties of Refinery Gases[1]							
Property	**SUPPORTING CHEMICAL Butane**	**SUPPORTING CHEMICAL Propane, 2 methyl-**	**SUPPORTING CHEMICAL 1-Propene, 2-methyl-**	**SUPPORTING CHEMICAL 1-Butene**	**SUPPORTING CHEMICAL 2-Butene[2]**	**SUPPORTING CHEMICAL Butane, 2-methyl-**	**SUPPORTING CHEMICAL Pentane**
CASRN	106-97-8	75-28-5	115-11-7	106-98-9	107-01-7	78-78-4	109-66-0
Molecular Weight	58.12	58.12	58.12	56.11	56.11	72.15	72.15
Physical State	Gas	Gas	Gas	Gas	Gas	Gas/volatile liquid	Volatile liquid
Melting Point	-138.2°C (measured)[3]	-138.3°C (measured)[3]	-140.4°C (measured)[3]	-185.3°C (measured)[3]	-105.5 to -138.9°C (measured)[3]	-159.9°C (measured)[3]	-129.7°C (measured)[3]
Boiling Point	-0.5°C (measured)[3]	-11.7°C (measured)[3]	-6.9°C (measured)[3]	-6.2°C (measured)[3]	0.8 to 3.7°C (measured)[3]	27.8°C (measured)[3]	36°C (measured)[3]
Vapor Pressure	1,820 mm Hg at 25°C (measured)[3]	2,610 mm Hg at 25°C (measured)[3]	2,310 mm Hg at 25°C (measured)[3]	2,250 mm Hg at 25°C (measured)[3]	1,600 – 1,760 mm Hg at 25°C (measured)[3]	689 mm Hg at 25°C (measured)[3]	514 mm Hg at 25°C (measured)[3]
Dissociation Constant (pK_a)	Not applicable						
Henry's Law Constant	0.95 atm-m^3/mol (measured)[3]	1.19 atm-m^3/mol (measured)[3]	0.218 atm-m^3/mol (measured)[3]	0.233 atm-m^3/mol (measured)[3]	0.231–0.234 m^3/mol (measured)[3]	1.4 atm-m^3/mol (measured)[3]	1.25 atm-m^3/mol (measured)[3]
Water Solubility	61.2 mg/L at 25°C (measured)[3]	48.8 mg/L at 25°C (measured)[3]	263 mg/L at 25°C (measured)[3]	221 mg/L at 25°C (measured)[3]	511–659 mg/L at 25°C (measured)[3]	48 mg/L at 25°C (measured)[3]	39 mg/L at 25°C (measured)[3]
Log K_{ow}	2.89 (measured)[3]	2.76 (measured)[3]	2.34 (measured)[3]	2.40 (measured)[3]	2.31–2.33 (measured)[3]	2.72 (estimated)[4]	3.39 (measured)[3]

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.

[2] Data range is for both isomers: 2-Butene, (2Z)- (CASRN 590-18-1) and 2-Butene, (2E)- (CASRN 624-64-6).

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

Table 3. Physical-Chemical Properties of Refinery Gases[1]								
Property	**SUPPORTING CHEMICAL Cyclopentane**	**SUPPORTING CHEMICAL 2-Butene, 2-methyl-**	**SUPPORTING CHEMICAL Naphtha (petroleum), light catalytic cracked[2]**	**SUPPORTING CHEMICAL Naphtha (petroleum), sweetened[2]**	**SUPPORTING CHEMICAL Gasoline[2]**	**SUPPORTING CHEMICAL Ammonia**	**SUPPORTING CHEMICAL Hydrogen sulfide**	**SUPPORTING CHEMICAL Carbon monoxide**
CASRN	287-92-3	513-35-9	64741-55-5	64741-87-3	86290-81-5 or no CASRN specified	7664-41-7	7783-06-4	630-08-0
Molecular Weight	70.14	70.14	70.14 – 112.21 (typical)	72.15 – 86.18 (typical)	58.12 – 72.15(typical)	17.03	34.08	26.10
Physical State	Volatile liquid	Volatile liquid	Volatile liquid	Volatile liquid	Volatile liquid	Gas	Gas	Gas
Melting Point	-93.8°C (measured)[3]	-133.7°C (measured)[3]	-168.5 to -157.3°C (measured)[3]	-162.9 to -128.8°C (measured)[3]	-159.9 to -138.2°C (measured)[3]	-77.7°C (measured)[4]	-85.49°C (measured)[4]	-205.02°C (measured)[4]
Boiling Point	49.3°C (measured)[3]	38.5°C (measured)[3]	38–182°C (measured)[3]	17–96°C (measured)[3]	-0.5–27.8°C (measured)[3]	-33.35°C (measured)[4]	-60.33°C (measured)[4]	-191.5°C (measured)[4]
Vapor Pressure	318 mm Hg at 25°C (measured)[3]	468 mm Hg at 25°C (measured)[3]	8.29–689 mm Hg at 25°C (measured)[3]	151–689 mm Hg at 25°C (measured)[3]	689 – 1,820 mm Hg at 25°C (measured)[3]	7,510 mm Hg at 25°C (measured)[4]	1.56×10^{4} mm Hg at 25°C (measured)[4]	1.55×10^{8} mm Hg at 25°C (measured)[4]
Dissociation Constant (pK_a)	Not applicable					9.25 (measured for the conjugate acid)[4]	pKa1 = 7.04; pKa2 = 11.96 (measured)[4]	Not applicable
Henry's Law Constant	0.152 atm-m^3/mol (measured)[3]	1.6×10^{5} atm-m^3/mol (measured)[3]	0.00718–1.40 atm-m^3/mol (measured/estimated)[3,5]	0.41–1.80 atm-m^3/mol (measured/estimated)[3,5]	0.95–1.4 atm-m^3/mol (measured)[3]	1.6×10^{5} atm-m^3/mol (measured)[4]	0.009 atm-m^3/mol (measured)[4]	1.04 atm-m^3/mol (measured)[4]
Water Solubility	156 mg/L at 25°C (measured)[3]	482,000 mg/L at 25°C (measured)[3]	4.6 mg/L (measured, freshwater)[6]; 4.3 mg/L (measured, saltwater)[6]	9.5–48 mg/L at 25°C (measured)[3]	48–61.2 mg/L at 25°C (measured)[3]	482,000 mg/L at 25°C (measured)[4]	3,980 mg/L at 20°C (measured)[4]	23 mg/L at 20°C (measured)[4]

Table 3. Physical-Chemical Properties of Refinery Gases[1]								
Property	**SUPPORTING CHEMICAL Cyclopentane**	**SUPPORTING CHEMICAL 2-Butene, 2-methyl-**	**SUPPORTING CHEMICAL Naphtha (petroleum), light catalytic cracked[2]**	**SUPPORTING CHEMICAL Naphtha (petroleum), sweetened[2]**	**SUPPORTING CHEMICAL Gasoline[2]**	**SUPPORTING CHEMICAL Ammonia**	**SUPPORTING CHEMICAL Hydrogen sulfide**	**SUPPORTING CHEMICAL Carbon monoxide**
Log K_{ow}	3.0 (measured)[3]	0.23 (estimated)[4]	2.67–4.11 (measured/estimated)[3,5]	2.72–3.90 (measured/estimated)[3,5]	2.72–2.89 (measured)[3]	0.23 (estimated)[5,7]	0.23 (estimated)[5,7]	1.78 (estimated)[5]

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.
[2] Data range is based upon the representative structures; 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 November 18, 2010.
[4] Hazardous Substance Databank. 2010. Available online at http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB as of November 18, 2010.
[5] 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/episuitedl.htm as of November 18, 2010.
[6] American Petroleum Institute, Petroleum HPV Testing Group. 2008. Revised Test Plan and Robust Summary for the Gasoline Blending Streams Category. Available online at http://www.epa.gov/hpv/pubs/summaries/gasnecat/c13409tc.htm as of October 20, 2010.
[7] Inorganic compounds are outside the estimated domain.

2. General Information on Exposure

2.1 Production Volume and Use Pattern

The Refinery Gases category chemicals had an aggregated production and/or import volume in the United States greater than 20 billion 782 million pounds in calendar year 2005.

- CASRN 68476-29-9: 1 billion pounds and greater;
- CASRN 68477-77-0: 10 to <50 million pounds;
- CASRN 68513-11-1: 1 billion pounds and greater;
- CASRN 68513-13-3: 50 to <100 million pounds;
- CASRN 68513-14-4: 10 to <50 million pounds;
- CASRN 68513-16-6: 100 to <500 million pounds;
- CASRN 68513-18-8: 1 billion pounds and greater;
- CASRN 68513-19-9: 100 to <500 million pounds;
- CASRN 68527-14-0: < 500,000 pounds;
- CASRN 68602-84-6: 1 billion pounds and greater;
- CASRN 68607-11-4: 1 billion pounds and greater;
- CASRN 68783-06-2: 100 to <500 million pounds;
- CASRN 68814-67-5: 1 billion pounds and greater;
- CASRN 68919-03-9: 1 billion pounds and greater;
- CASRN 68919-07-3: 50 to < 100 million pounds;
- CASRN 68952-79-4: 1 to 10 million pounds;
- CASRN 68955-33-9: 500 million to 1 billion pounds;
- CASRN 68477-92-9: 100 to <500 million pounds;
- CASRN 68919-01-7: 100 to <500 million pounds;
- CASRN 68476-26-6: 500 million to 1 billion pounds;
- CASRN 68477-97-4: 1 billion pounds and greater;
- CASRN 8006-20-0: 500 million to 1 billion pounds;
- CASRN 68308-27-0: 1 billion pounds and greater;
- CASRN 68478-27-3: 1 billion pounds and greater;
- CASRN 68478-28-4: 50 to < 100 million pounds;
- CASRN 68478-30-8: 1 billion pounds and greater;
- CASRN 68919-08-4: 10 to < 50 million pounds;
- CASRN 68513-68-8: 100 to <500 million pounds;
- CASRN 68478-01-3: 500 million to 1 billion pounds;
- CASRN 68477-80-5: 100 to <500 million pounds;
- CASRN 68911-59-1: 1 to 10 million pounds;
- CASRN 68814-47-1: 1 billion pounds and greater;
- CASRN 68919-02-8: 500 million to 1 billion pounds;
- CASRN 68919-04-0: 100 to <500 million pounds;
- CASRN 68477-65-6: 100 to <500 million pounds;
- CASRN 68478-00-2: 1 billion pounds and greater;
- CASRN 68478-05-7: 1 billion pounds and greater;

- CASRN 68783-07-3: 1 billion pounds and greater;
- CASRN 68783-62-0: 1 billion pounds and greater;
- CASRN 68989-88-8: 1 billion pounds and greater;
- CASRN 68783-05-1: 100 to <500 million pounds;
- CASRN 68527-13-9: 100 to <500 million pounds;

CASRN 68478-25-1, CASRN 68814-90-4, CASRN 68919-12-0, CASRN 68527-15-1, CASRN 68477-81-6, CASRN 68478-29-5, CASRN 68952-80-7, CASRN 68477-95-2, CASRN 68477-68-9, CASRN 68477-98-5, CASRN 68476-27-7, CASRN 68476-28-8, CASRN 68477-66-7, CASRN 68477-67-8, CASRN 68477-82-7, CASRN 68602-82-4, CASRN 68478-02-4, CASRN 68478-03-5, CASRN 68478-04-6, and CASRN 68911-58-0 were not reported in the 2006 IUR.

CASRN 68476-29-9, CASRN 68477-77-0, CASRN 68513-11-1, CASRN 68513-13-3, CASRN 68513-14-4, CASRN 68513-16-6, CASRN 68513-18-8, CASRN 68513-19-9, CASRN 68527-14-0, CASRN 68602-84-6, CASRN 68607-11-4, CASRN 68783-06-2, CASRN 68814-67-5, CASRN 68919-03-9, CASRN 68919-07-3, CASRN 68952-79-4, CASRN 68955-33-9, CASRN 68477-92-9, CASRN 68919-01-7, CASRN 68476-26-6, CASRN 68477-97-4, CASRN 8006-20-0, CASRN 68478-27-3, CASRN 68478-28-4, CASRN 68478-30-8, CASRN 68919-08-4, CASRN 68513-68-8, CASRN 68478-01-3, CASRN 68477-80-5, CASRN 68911-59-1, CASRN 68814-47-1, CASRN 68919-04-0, CASRN 68477-65-6, CASRN 68478-00-2, CASRN 68478-05-7, CASRN 68783-07-3, CASRN 68783-62-0, CASRN 68989-88-8, CASRN 68783-05-1 and CASRN 68527-13-9:
No industrial processing and uses and commercial and consumer uses were reported for these chemicals.

CASRN 68308-27-0:
Industrial processing and uses are claimed confidential. No commercial and consumer uses were reported for this chemical.

CASRN 68919-02-8:
Industrial processing and uses and commercial and consumer uses are claimed confidential.

2.2 Environmental Exposure and Fate

The members of the refinery gases category are expected to have moderate to high mobility in soil. Experimental biodegradation data is available for several supporting individual chemicals; these data are extrapolated to the process streams which are complex mixtures. n-Pentane was found to be readily biodegradable in the OECD Guideline 301C (MITI (I) test), showing 96% biodegradation after 28 days. 1-Butene and 1-propene were not readily biodegradable, achieving approximately 1% of their theoretical BOD within 28 days using the OECD Guideline 301C (MITI (I)) test. It is most probable that in this test, the highly volatile hydrocarbons resided mainly in the vessel headspace and were not bioavailable to the microbes present in the aqueous medium, hence the low level of biodegradation observed. However, alkane- and alkene-utilizing bacteria present in soil would most likely be able to metabolize these hydrocarbons. In an

unspecified OECD guideline ready test, 2-methyl-butane was found to be readily biodegradable. When tested in a non-standard aerobic ready test, 2-methyl-propane and n-propane showed 49 and 57% degradation over 30 days, respectively, by CO_2 evolution. In an unspecified OECD guideline inherent test, cyclopentane was found to be inherently biodegradable. In non-standard inherent tests, methane and ethane demonstrated 66 and 73% degradation over 35 days, respectively, suggesting that these two low molecular weight hydrocarbons will be inherently biodegradable when test conditions are modified to take into account the gaseous nature of these two chemicals. Volatilization from water is expected to be high for all category members given their Henry's Law constants; thus, this is expected to be an important fate process. The rate of hydrolysis for all members is expected to be negligible since none of the substances in this category possess functional groups that are susceptible to hydrolysis under environmental conditions. The rate of atmospheric photooxidation is considered slow to moderate for nearly all individual chemicals. The exceptions are methane and ethane, which have negligible rates of photooxidation. For the category members that are complex mixtures, the effective rates of photooxidation will depend on the particular compositions of individual hydrocarbons present in each member. The overall weight of experimental evidence and data from structurally similar compounds from these studies suggest that all members of the category will have low persistence (P1). The members of the refinery gases category are expected to have low bioaccumulation potential (B1).

The environmental fate properties are provided in the Table 4.

Table 4. Environmental Fate Characteristics of Refinery Gases[1]						
Subcategory I: Refinery Gases, C1 – C4						
Property	**SPONSORED CHEMICAL Fuel gases, crude oil distillates[2]**	**SPONSORED CHEMICAL Gases (petroleum), catalytic reformed naphtha stripper overheads[2]**	**SPONSORED CHEMICAL Tail gas (petroleum), catalytic cracker refractionation absorber[2]**	**SPONSORED CHEMICAL Fuel gases, hydrotreater fractionation, scrubbed[2]**	**SPONSORED CHEMICAL Fuel gases, thermal cracked catalytic cracking residue[2]**	**SPONSORED CHEMICAL Gases (petroleum), catalytic reformed straight-run naphtha stabilizer overheads[2]**
CASRN	68476-29-9	68477-77-0	68478-25-1	68513-11-1	68513-13-3	68513-14-4
Photodegradation Half-life	4.1 days to 4.3 years (estimated)[3]	1.1 days to 4.3 years (estimated)[3]	8.4 days to 4.3 years (estimated)[3]	1.1 days to 4.3 years (estimated)[3]	1.1 days to 4.3 years (estimated)[3]	8.4 days to 4.3 years (estimated)[3]
Hydrolysis Half-life	Stable					
Biodegradation	No data	No data	No data	No data	No data	No data
Bioaccumulation Factor	BAF = 1.9–61 (estimated)[3]	BAF = 1.9–61 (estimated)[3]	BAF = 1.9–21 (estimated)[3]	BAF = 1.9–61 (estimated)[3]	BAF = 1.9–61 (estimated)[3]	BAF = 1.9–21 (estimated)[3]
Log K_{oc}	0.60–1.6 (estimated)[3]	0.60–1.6 (estimated)[3]	0.60–1.3 (estimated)[3]	0.60–1.6 (estimated)[3]	0.60–1.6 (estimated)[3]	0.60–1.3 (estimated)[3]
Fugacity (Level III Model)[3]						
Air (%)	48–57	48–57	50–57	48–57	48–57	50–57
Water (%)	42–51	42–51	42–49	42–51	42–51	42–49
Soil (%)	0.50–0.80	0.50–0.80	0.50–0.60	0.50–0.80	0.50–0.80	0.50–0.60
Sediment (%)	<0.1–0.16	<0.1–0.16	<0.1–0.1	<0.1–0.16	<0.1–0.16	<0.1–0.1
Persistence[4]	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)
Bioaccumulation[4]	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.

[2] Data range is based upon the representative structures; 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/episuitedl.htm as of November 18, 2010.

[4] 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 Characteristics of Refinery Gases[1]						
Subcategory I: Refinery Gases, C1 – C4 (continued)						
Property	**SPONSORED CHEMICAL Gases (petroleum), hydrocracking depropanizer off, hydrocarbon-rich[2]**	**SPONSORED CHEMICAL Gases (petroleum), reformer effluent high-pressure flash drum off[2]**	**SPONSORED CHEMICAL Gases (petroleum), reformer effluent low-pressure flash drum off[2]**	**SPONSORED CHEMICAL Gases, (petroleum), methane-rich off[2]**	**SPONSORED CHEMICAL Gases (petroleum), secondary absorber off, fluidized catalytic cracker overheads fractionator[2]**	**SPONSORED CHEMICAL Petroleum products, refinery gases[2]**
CASRN	68513-16-6	68513-18-8	68513-19-9	68527-14-0	68602-84-6	68607-11-4
Photodegradation Half-life	4.1 days to 4.3 years (estimated)[3]	8.4 days to 4.3 years (estimated)[3]	8.4 days to 4.3 years (estimated)[3]	2.0 days to 4.3 years (estimated)[3]	2.0 days to 4.3 years (estimated)[3]	8.4 days to 4.3 years (estimated)[3]
Hydrolysis Half-life	Stable					
Biodegradation	No data	No data	No data	No data	No data	No data
Bioaccumulation Factor	BAF = 1.9–61 (estimated)[3]	BAF = 1.9–21 (estimated)[3]	BAF = 1.9–21 estimated)[3]	BAF = 1.9–307 (estimated)[3]	BAF = 1.9–307 (estimated)[3]	BAF = 1.9–21 (estimated)[3]
Log K_{oc}	0.60–1.6 (estimated)[3]	0.60–1.3 (estimated)[3]	0.60–1.3 (estimated)[3]	0.60–2.1 (estimated)[3]	0.60–2.1 (estimated)[3]	0.60–1.3 (estimated)[3]
Fugacity (Level III Model)[3]						
Air (%)	48–57	50–57	50–57	38.5–57	38.5–57	50–57
Water (%)	42–51	42–49	42–49	42–60.1	42–60.1	42–49
Soil (%)	0.50–0.80	0.50–0.60	0.50–0.60	0.50–1.0	0.50–1.0	0.50–0.60
Sediment (%)	<0.1–0.16	<0.1–0.1	<0.1–0.1	<0.1–0.4	<0.1–0.4	<0.1–0.1
Persistence[4]	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)
Bioaccumulation[4]	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.

[2] Data range is based upon the representative structures; 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/episuitedl.htm as of November 18, 2010.

[4] 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 Characteristics of Refinery Gases[1]						
Subcategory I: Refinery Gases, C1 – C4 (continued)						
Property	**SPONSORED CHEMICAL Gases (petroleum), hydrocracking low-pressure separator[2]**	**SPONSORED CHEMICAL Gases (petroleum), refinery[2]**	**SPONSORED CHEMICAL Gases (petroleum), platformer products separator off**	**SPONSORED CHEMICAL Gases (petroleum), fluidized catalytic cracker scrubbing secondary absorber off[2]**	**SPONSORED CHEMICAL Gases (petroleum), platformer stabilizer off, light ends fractionation[2]**	**SPONSORED CHEMICAL Gases (petroleum), unifiner stripper off[2]**
CASRN	68783-06-2	68814-67-5	68814-90-4	68919-03-9	68919-07-3	68919-12-0
Photodegradation Half-life	8.4 days to 4.3 years (estimated)[3]	8.4 days to 4.3 years (estimated)[3]	4.1–39 days (estimated)[3]	4.1–39 days (estimated)[3]	8.4 days to 4.3 years (estimated)[3]	4.3 years (estimated)[3]
Hydrolysis Half-life	Stable					
Biodegradation	No data	No data	No data	No data	No data	No data
Bioaccumulation Factor	BAF = 1.9–21 (estimated)[3]	BAF = 1.9–21 (estimated)[3]	BAF = 6.9–61 (estimated)[3]	BAF = 6.9–61 (estimated)[3]	BAF = 1.9–21 (estimated)[3]	BAF = 1.9 (estimated)[3]
Log K_{oc}	0.60–1.3 (estimated)[3]	0.60–1.3 (estimated)[3]	1.12–1.6 (estimated)[3]	1.12–1.6 (estimated)[3]	0.60–1.3 (estimated)[3]	0.60 (estimated)[3]
Fugacity (Level III Model)[3]						
Air (%)	50–57	50–57	48–55	48–55	50–57	57
Water (%)	42–49	42–49	44–51	44–51	42–49	42
Soil (%)	0.50–0.60	0.50–0.60	0.56–0.80	0.56–0.80	0.50–0.60	0.50
Sediment (%)	<0.1–0.1	<0.1–0.1	0.11–0.16	0.11–0.16	<0.1–0.1	<0.1
Persistence[4]	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)
Bioaccumulation[4]	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.

[2] Data range is based upon the representative structures; 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/episuitedl.htm as of November 18, 2010.

[4] 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 Characteristics of Refinery Gases (continued)[1]				
	Subcategory I: Refinery Gases, C1 – C4 (continued)		*Subcategory II: Refinery Gases, C1 – C4 with Ammonia and Hydrogen Sulfide*	
Property	**SPONSORED CHEMICAL Tail gas (petroleum), catalytic hydrodesulfurized naphtha separator[2]**	**SPONSORED CHEMICAL Gases (petroleum), sponge absorber off, fluidized catalytic cracker and gas oil[2]**	**SPONSORED CHEMICAL Gases (petroleum), dry sour, gas-concn.-unit-off[2]**	**SPONSORED CHEMICAL Gases (petroleum), distillate unifiner desulfurization stripper off[2]**
CASRN	68952-79-4	68955-33-9	68477-92-9	68919-01-7
Photodegradation Half-life	8.4 days to 4.3 years (estimated)[3]	1.1 days to 4.3 years (estimated)[3]	8.4 days to 4.3 years (estimated)[3]	8.4 days to 4.3 years (estimated)[3]
Hydrolysis Half-life	Stable			
Biodegradation	No data	No data	No data	No data
Bioaccumulation Factor	BAF = 1.9–21 (estimated)[3]	BAF = 1.9–61 (estimated)[3]	BAF = 1.9–21 (estimated)[3]	BAF = 1.9–21 (estimated)[3]
Log K_{oc}	0.60–1.3 (estimated)[3]	0.60–1.6 (estimated)[3]	0.60–1.3 (estimated)[3]	0.60–1.3 (estimated)[3]
Fugacity (Level III Model)[3]				
Air (%)	50–57	48–57	50–57	50–57
Water (%)	42–49	42–51	42–49	42–49
Soil (%)	0.50–0.60	0.50–0.80	0.50–0.60	0.50–0.60
Sediment (%)	<0.1–0.1	<0.1–0.16	<0.1–0.1	<0.1–0.1
Persistence[4]	P1 (low)	P1 (low)	P1 (low)	P1 (low)
Bioaccumulation[4]	B1 (low)	B1 (low)	B1 (low)	B1 (low)

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.

[2] Data range is based upon the representative structures; 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/episuitedl.htm as of November 18, 2010.

[4] 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 Characteristics of Refinery Gases[1]						
	Subcategory III: Refinery Gases, C1 – C4 with Carbon Monoxide				*Subcategory IV: Refinery Gases, C1 – C6*	
Property	**SPONSORED CHEMICAL Fuel gases[2]**	**SPONSORED CHEMICAL Gases (petroleum), hydrogen-rich[2]**	**SPONSORED CHEMICAL Gases (petroleum), oil refinery gas distn. Off[2]**	**SPONSORED CHEMICAL Fuel gases, producer gas[2]**	**SPONSORED CHEMICAL Tail gas (petroleum), straight-run naphtha hydrodesulfurizer[2]**	**SPONSORED CHEMICAL Residues (petroleum), deethanizer tower[2]**
CASRN	68476-26-6	68477-97-4	68527-15-1	8006-20-0	68952-80-7	68513-68-8
Photodegradation Half-life	39 days to 4.3 years (estimated)[3]	39 days to 4.3 years (estimated)[3]	39 days to 4.3 years (estimated)[3]	39 days to 4.3 years (estimated)[3]	2.7 days to 4.3 years (estimated)[3]	2.0 days to 4.3 years (estimated)[3]
Hydrolysis Half-life	Stable					
Biodegradation	No data	No data	No data	No data	No data	No data
Bioaccumulation Factor	BAF = 1.9–6.9 (estimated)[3]	BAF = 1.9–6.9 (estimated)[3]	BAF = 1.9–6.9 (estimated)[3]	BAF = 1.9-6.9 (estimated)[3]	BAF = 1.9–150 (estimated)[3]	BAF = 1.9–307 (estimated)[3]
Log K_{oc}	0.60–1.12 (estimated)[3]	0.60–1.12 (estimated)[3]	0.60–1.12 (estimated)[3]	0.60–1.12 (estimated)[3]	0.60–1.86 (estimated)[3]	0.60–2.1 (estimated)[3]
Fugacity (Level III Model)[3]						
Air (%)	55–57	55–57	55–57	55–57	43–57	38.5–57
Water (%)	42–44	42–44	42–44	42–44	42–56	42–60.1
Soil (%)	0.50–0.56	0.50–0.56	0.50–0.56	0.50–0.56	0.50–0.91	0.50–1.0
Sediment (%)	<0.1–0.11	<0.1–0.11	<0.1–0.11	<0.1–0.11	<0.1–0.23	<0.1–0.4
Persistence[4]	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)
Bioaccumulation[4]	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.

[2] Data range is based upon the representative structures; 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/episuitedl.htm as of November 18, 2010.

[4] 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 Characteristics of Refinery Gases[1]							
Subcategory IV: Refinery Gases, C1 – C6 (continued)							
Property	**SPONSORED CHEMICAL Fuel gases, refinery[2]**	**SPONSORED CHEMICAL Gases (petroleum), C6 – 8 catalytic reformer[2]**	**SPONSORED CHEMICAL Tail gas (petroleum), catalytic reformed naphtha separator[2]**	**SPONSORED CHEMICAL Tail gas (petroleum), catalytic reformed naphtha stabilizer[2]**	**SPONSORED CHEMICAL Tail gas, (petroleum), cracked distillate hydrotreater separator[2]**	**SPONSORED CHEMICAL Tail gas (petroleum), hydrodesulfurized straight-run naphtha separator[2]**	**SPONSORED CHEMICAL Gases (petroleum), preflash tower off, crude distn.[2]**
CASRN	68308-27-0	68477-81-6	68478-27-3	68478-28-4	68478-29-5	68478-30-8	68919-08-4
Photodegradation Half-life	2.7 days to 4.3 years (estimated)[3]	2.7 days to 4.3 years (estimated)[3]	2.0 days to 4.3 years (estimated)[3]	2.0 days to 4.3 years (estimated)[3]	2.7 days to 4.3 years (estimated)[3]	2.0 days to 4.3 years (estimated)[3]	2.7 days to 4.3 years (estimated)[3]
Hydrolysis Half-life	Stable						
Biodegradation	No data	No data	No data	No data	No data	No data	No data
Bioaccumulation Factor	BAF = 1.9–150 (estimated)[3]	BAF = 1.9–150 (estimated)[3]	BAF = 1.9–307 (estimated)[3]	BAF = 1.9–307 (estimated)[3]	BAF = 1.9–150 estimated)[3]	BAF = 1.9–307 (estimated)[3]	BAF = 1.9–150 (estimated)[3]
Log K_{oc}	0.60–1.86 (estimated)[3]	0.60–1.86 (estimated)[3]	0.60–2.1 (estimated)[3]	0.60–2.1 (estimated)[3]	0.60–1.86 (estimated)[3]	0.60–2.1 (estimated)[3]	0.60–1.86 (estimated)[3]
Fugacity (Level III Model)[3]							
Air (%)	43–57	43–57	38.5–57	38.5–57	43–57	38.5–57	43–57
Water (%)	42–56	42–56	42–60.1	42–60.1	42–56	42–60.1	42–56
Soil (%)	0.50–0.91	0.50–0.91	0.50–1.0	0.50–1.0	0.50–0.91	0.50–1.0	0.50–0.91
Sediment (%)	<0.1–0.23	<0.1–0.23	<0.1–0.4	<0.1–0.4	<0.1–0.23	<0.1–0.4	<0.1–0.23
Persistence[4]	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)
Bioaccumulation[4]	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.

[2] Data range is based upon the representative structures; 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/episuitedl.htm as of November 18, 2010.

[4] 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 Characteristics of Refinery Gases[1]				
Subcategory V: Refinery Gases, C1 – C6 with Hydrogen Sulfide		***Subcategory VI: Refinery Gases, C1 – C6 with Carbon Monoxide***		
Property	**SPONSORED CHEMICAL Gases (petroleum), dry sour, gas-concn.-unit-off[2]**	**SPONSORED CHEMICAL Gases (petroleum), C6 – 8 catalytic reformer recycle, hydrogen-rich[2]**	**SPONSORED CHEMICAL Gases (petroleum), benzene unit hydrotreater depentanizer overheads[2]**	**SPONSORED CHEMICAL Gases (petroleum), hydrotreated sour kerosine flash drum[2]**
CASRN	68477-95-2	68477-82-7	68602-82-4	68911-59-1
Photodegradation Half-life	4.1–39 days (estimated)[3]	2.0 days to 4.3 years (estimated)[3]	2.0 days to 4.3 years (estimated)[3]	2.7–39 days (estimated)[3]
Hydrolysis Half-life	Stable			
Biodegradation	No data	No data	No data	No data
Bioaccumulation Factor	BAF = 6.9–61 (estimated)[3]	BAF = 1.9–307 (estimated)[3]	BAF = 1.9–307 (estimated)[3]	BAF = 6.9–150 (estimated)[3]
Log K_{oc}	1.12–1.6 (estimated)[3]	0.60–2.1 (estimated)[3]	0.60–2.1 (estimated)[3]	1.12–1.86 (estimated)[3]
Fugacity (Level III Model)[3]				
Air (%)	48–55	38.5–57	38.5–57	43–55
Water (%)	44–51	42–60.1	42–60.1	44–56
Soil (%)	0.56–0.80	0.50–1.0	0.50–1.0	0.56–0.91
Sediment (%)	0.11–0.16	<0.1–0.4	<0.1–0.4	0.11–0.23
Persistence[4]	P1 (low)	P1 (low)	P1 (low)	P1 (low)
Bioaccumulation[4]	B1 (low)	B1 (low)	B1 (low)	B1 (low)

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.
[2] Data range is based upon the representative structures; 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/episuitedl.htm as of November 18, 2010.
[4] 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 Characteristics of Refinery Gases[1]								
Subcategory VI: Refinery Gases, C1 – C6 with Carbon Monoxide (continued)								
Property	**SPONSORED CHEMICAL Gases (petroleum), blend oil, hydrogen-nitrogen-rich[2]**	**SPONSORED CHEMICAL Gases (petroleum), hydrotreater blend oil recycle, hydrogen-nitrogen-rich[2]**	**SPONSORED CHEMICAL Gases (petroleum), reformer make-up, hydrogen-rich[2]**	**SPONSORED CHEMICAL Fuel gases, amine system residues[2]**	**SPONSORED CHEMICAL Fuel gases, C6 – 8 catalytic reformer[2]**	**SPONSORED CHEMICAL Gases (petroleum), benzene unit hydrodesulfurizer off[2]**	**SPONSORED CHEMICAL Gases (petroleum), benzene unit recycle, hydrogen-rich[2]**	**SPONSORED CHEMICAL Gases (petroleum), C6 – 8 catalytic reformer recycle[2]**
CASRN	68477-68-9	68477-98-5	68478-01-3	68476-27-7	68476-28-8	68477-66-7	68477-67-8	68477-80-5
Photodegradation Half-life	2.7 days to 4.3 years (estimated)[3]	2.7 days to 4.3 years (estimated)[3]	2.7 days to 4.3 years (estimated)[3]	2.7–8.4 days (estimated)[3]	2.0–39 days (estimated)[3]	2.0 days to 4.3 years (estimated)[3]	2.0 days to 4.3 years (estimated)[3]	2.0 days to 4.3 years (estimated)[3]
Hydrolysis Half-life	Stable							
Biodegradation	No data	No data	No data	No data	No data	No data	No data	No data
Bioaccumulation Factor	BAF = 1.9–150 (estimated)[3]	BAF = 1.9–150 (estimated)[3]	BAF = 1.9–150 (estimated)[3]	BAF = 21–150 (estimated)[3]	BAF = 6.9–307 (estimated)[3]	BAF = 1.9–307 (estimated)[3]	BAF = 1.9–307 (estimated)[3]	BAF = 1.9–307 (estimated)[3]
Log K_{oc}	0.60–1.86 (estimated)[3]	0.60–1.86 (estimated)[3]	0.60–1.86 (estimated)[3]	1.34–1.86 (estimated)[3]	1.12–2.1 (estimated)[3]	0.60–2.1 (estimated)[3]	0.60–2.1 (estimated)[3]	0.60–2.1 (estimated)[3]
Fugacity (Level III Model)[3]								
Air (%)	43–57	43–57	43–57	43–30	55–57	38.5–57	38.5–57	38.5–57
Water (%)	42–56	42–56	42–56	49–56	44–60.1	42–60.1	42–60.1	42–60.1
Soil (%)	0.50–0.91	0.50–0.91	0.50–0.91	0.61–0.91	0.56–1.0	0.50–1.0	0.50–1.0	0.50–1.0
Sediment (%)	<0.1–0.23	<0.1–0.23	<0.1–0.23	0.14–0.23	0.11–0.4	<0.1–0.4	<0.1–0.4	<0.1–0.4

Table 4. Environmental Fate Characteristics of Refinery Gases[1]								
Subcategory VI: Refinery Gases, C1 – C6 with Carbon Monoxide (continued)								
Property	**SPONSORED CHEMICAL Gases (petroleum), blend oil, hydrogen-nitrogen-rich[2]**	**SPONSORED CHEMICAL Gases (petroleum), hydrotreater blend oil recycle, hydrogen-nitrogen-rich[2]**	**SPONSORED CHEMICAL Gases (petroleum), reformer make-up, hydrogen-rich[2]**	**SPONSORED CHEMICAL Fuel gases, amine system residues[2]**	**SPONSORED CHEMICAL Fuel gases, C6 – 8 catalytic reformer[2]**	**SPONSORED CHEMICAL Gases (petroleum), benzene unit hydrodesulfurizer off[2]**	**SPONSORED CHEMICAL Gases (petroleum), benzene unit recycle, hydrogen-rich[2]**	**SPONSORED CHEMICAL Gases (petroleum), C6 – 8 catalytic reformer recycle[2]**
Persistence[4]	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)
Bioaccumulation[4]	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.
[2] Data range is based upon the representative structures; 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/episuitedl.htm as of November 18, 2010.
[4] 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 Characteristics of Refinery Gases (continued)[1]				
Subcategory VII: Refinery Gases, C1 – C6 with Carbon Monoxide and Hydrogen Sulfide		***Subcategory VIII: Refinery Gases, C1 – C6 with Ammonia and Hydrogen Sulfide***		
Property	**SPONSORED CHEMICAL Gases (petroleum), reforming hydrotreater[2]**	**SPONSORED CHEMICAL Waste gases, refinery vent[2]**	**SPONSORED CHEMICAL Gases (petroleum), fluidized catalytic cracker fractionation off[2]**	**SPONSORED CHEMICAL Gases (petroleum), heavy distillate hydrotreater desulfurization stripper off[2]**
CASRN	68478-02-4	68814-47-1	68919-02-8	68919-04-0
Photodegradation Half-life	39 days to 4.3 years (estimated)[3]	2.7 days to 4.3 years (estimated)[3]	2.7 days to 4.3 years (estimated)[3]	2.7 days to 4.3 years (estimated)[3]
Hydrolysis Half-life	Stable			
Biodegradation	No data	No data	No data	No data
Bioaccumulation Factor	BAF = 1.9–6.9 (estimated)[3]	BAF = 1.9–150 (estimated)[3]	BAF = 1.9–150 (estimated)[3]	BAF = 1.9–150 (estimated)[3]
Log K_{oc}	0.60–1.12 (estimated)[3]	0.60–1.86 (estimated)[3]	0.60–1.86 (estimated)[3]	0.60–1.86 (estimated)[3]
Fugacity (Level III Model)[3]				
Air (%)	55–57	43–57	43–57	43–57
Water (%)	42–44	42–56	42–56	42–56
Soil (%)	0.50–0.56	0.50–0.91	0.50–0.91	0.50–0.91
Sediment (%)	<0.1–0.11	<0.1–0.23	<0.1–0.23	<0.1–0.23
Persistence[4]	P1 (low)	P1 (low)	P1 (low)	P1 (low)
Bioaccumulation[4]	B1 (low)	B1 (low)	B1 (low)	B1 (low)

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.

[2] Data range is based upon the representative structures; 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/episuitedl.htm as of November 18, 2010.

[4] 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 Characteristics of Refinery Gases[1]							
Subcategory IX: Refinery Gases, C1 – C6 with Ammonia, Hydrogen Sulfide, and Carbon Monoxide							
Property	**SPONSORED CHEMICAL Gases (petroleum), amine system feed[2]**	**SPONSORED CHEMICAL Gases (petroleum), recycle, hydrogen-rich[2]**	**SPONSORED CHEMICAL Gases (petroleum), reforming hydrotreater, hydrogen-methane-rich[2]**	**SPONSORED CHEMICAL Gases (petroleum), reforming hydrotreater make-up, hydrogen-rich[2]**	**SPONSORED CHEMICAL Gases (petroleum), thermal cracking distn.[2]**	**SPONSORED CHEMICAL Gases (petroleum), refinery blend[2]**	**SPONSORED CHEMICAL Fuel gases, refinery, unsweetened[2]**
CASRN	68477-65-6	68478-00-2	68478-03-5	68478-04-6	68478-05-7	68783-07-3	68783-62-0
Photodegradation Half-life	2.7 days to 4.3 years (estimated)[3]	2.7 days to 4.3 years (estimated)[3]	2.7–39 days (estimated)[3]	2.7 days to 4.3 years (estimated)[3]	2.0 days to 4.3 years (estimated)[3]	2.7 days to 4.3 years (estimated)[3]	2.7 days to 4.3 years (estimated)[3]
Hydrolysis Half-life	Stable						
Biodegradation	No data	No data	No data	No data	No data	No data	No data
Bioaccumulation Factor	BAF = 1.9–150 (estimated)[3]	BAF = 1.9–150 (estimated)[3]	BAF = 6.9–150 (estimated)[3]	BAF = 1.9–150 (estimated)[3]	BAF = 1.9–307 (estimated)[3]	BAF = 1.9–150 (estimated)[3]	BAF = 1.9–150 (estimated)[3]
Log K_{oc}	0.60–1.86 (estimated)[3]	0.60–1.86 (estimated)[3]	1.12–1.86 (estimated)[3]	0.60–1.86 (estimated)[3]	0.60–2.1 (estimated)[3]	0.60–1.86 (estimated)[3]	0.60–1.86 (estimated)[3]
Fugacity (Level III Model)[3]							
Air (%)	43–57	43–57	43–55	43–57	38.5–57	43–57	43–57
Water (%)	42–56	42–56	44–56	42–56	42–60.1	42–56	42–56
Soil (%)	0.50–0.91	0.50–0.91	0.56–0.91	0.50–0.91	0.50–1.0	0.50–0.91	0.50–0.91
Sediment (%)	<0.1–0.23	<0.1–0.23	0.11–0.23	<0.1–0.23	<0.1–0.4	<0.1–0.23	<0.1–0.23
Persistence[4]	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)
Bioaccumulation[4]	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.

[2] Data range is based upon the representative structures; 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/episuitedl.htm as of November 18, 2010.

[4] 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 Characteristics of Refinery Gases[1]				
Subcategory IX: Refinery Gases, C1 – C6 with Ammonia, Hydrogen Sulfide, and Carbon Monoxide (continued)			***Subcategory X: Refinery Gases, Ammonia and Hydrogen Sulfide***	***Subcategory XI: Refinery Gases, Ammonia, Hydrogen Sulfide and Carbon Monoxide***
Property	**SPONSORED CHEMICAL Gases (petroleum), hydrotreated sour kerosine depentanizer stabilizer off[2]**	**SPONSORED CHEMICAL Gases (petroleum), crude distn. and catalytic cracking[2]**	**SPONSORED CHEMICAL Gases, (petroleum), ammonia-hydrogen sulfide, water-satd.[2]**	**SPONSORED CHEMICAL Gases, (petroleum), acid, ethanolamine scrubber**
CASRN	68911-58-0	68989-88-8	68783-05-1	68527-13-9
Photodegradation Half-life	2.0–2.7 days (estimated)[3]	2.0 days to 4.3 years (estimated)[3]	Stable. The primary chemical transformation of hydrogen sulfide in the atmosphere is oxidation by oxygen-containing radicals to sulfur dioxide and sulfates[3].	Stable. The primary chemical transformation of hydrogen sulfide in the atmosphere is oxidation by oxygen-containing radicals to sulfur dioxide and sulfates[3].
Hydrolysis Half-life	Stable			
Biodegradation	No data	No data	Bacteria convert ammonia to nitrate under environmental conditions[4;] microorganisms in soil and water are involved in oxidation-reduction reactions which oxidize hydrogen sulfide to elemental sulfur[3].	Bacteria convert ammonia to nitrate under environmental conditions[3;] microorganisms in soil and water are involved in oxidation-reduction reactions which oxidize hydrogen sulfide to elemental sulfur[3].
Bioaccumulation Factor	BAF = 61–150 (estimated)[3]	BAF = 1.9–307 (estimated)[3]	BAF = 1 (estimated)[4,5]	BAF = 1 (estimated)[4,5]
Log K_{oc}	1.60–1.86 (estimated)[3]	0.60–2.1 (estimated)[3]	1.1 (estimated)[4,5]	1.1 (estimated)[4,5]
Fugacity (Level III Model)[3]				
Air (%)	43–48	38.5–57	27.1–56.7	27.1–56.7
Water (%)	51–56	42–60.1	35.9–42.6	35.9–42.6
Soil (%)	0.80–0.91	0.50–1.0	0.7–36.9	0.7–36.9
Sediment (%)	0.16–0.23	<0.1–0.4	0.1	0.1

Table 4. Environmental Fate Characteristics of Refinery Gases[1]				
Subcategory IX: Refinery Gases, C1 – C6 with Ammonia, Hydrogen Sulfide, and Carbon Monoxide (continued)			***Subcategory X: Refinery Gases, Ammonia and Hydrogen Sulfide***	***Subcategory XI: Refinery Gases, Ammonia, Hydrogen Sulfide and Carbon Monoxide***
Property	**SPONSORED CHEMICAL Gases (petroleum), hydrotreated sour kerosine depentanizer stabilizer off[2]**	**SPONSORED CHEMICAL Gases (petroleum), crude distn. and catalytic cracking[2]**	**SPONSORED CHEMICAL Gases, (petroleum), ammonia-hydrogen sulfide, water-satd.[2]**	**SPONSORED CHEMICAL Gases, (petroleum), acid, ethanolamine scrubber**
Persistence[6]	P1 (low)	P1 (low)	P1 (low)	P1 (low)
Bioaccumulation[6]	B1 (low)	B1 (low)	B1 (low)	B1 (low)

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.

[2] Data range is based upon the representative structures; 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/episuitedl.htm as of November 18, 2010.

[4] Solano-Serena, F; Marchal, R; Huet, T; et al. 2000. Biodegradability of volatile hydrocarbons of gasoline. Appl Microbiol Biotech 54(1):121–125.

[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 November 22, 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.

Table 4. Environmental Fate Characteristics of Refinery Gases[1]					
Property	**SUPPORTING CHEMICAL Methane**	**SUPPORTING CHEMICAL Ethane**	**SUPPORTING CHEMICAL Ethylene**	**SUPPORTING CHEMICAL Propane**	**SUPPORTING CHEMICAL 1-Propene**
CASRN	74-82-8	74-84-0	74-85-1	74-98-6	115-07-1
Photodegradation Half-life	4.3 years (estimated)[3]	39 days (estimated)[3]	15 hours (estimated)[3]	8.4 days (estimated)[3]	4.9 hours (estimated)[2]
Hydrolysis Half-life	Stable				
Biodegradation	-182.4°C (measured)[3]	-182.8°C (measured)[3]	-169°C (measured)[3]	-187.6°C (measured)[3]	-185°C (measured)[3]
Bioaccumulation Factor	-161.5°C (measured)[3]	-88.6°C (measured)[3]	-103.7°C (measured)[3]	-42.1°C (measured)[3]	-48°C (measured)[3]
Log K_{oc}	4.66×10^{5} mm Hg at 25°C (measured)[3]	3.15×10^{4} mm Hg at 25°C (measured)[3]	5.21×10^{4} mm Hg at 25°C (measured)[3]	7,150 mm Hg at 25°C (measured)[3]	8,690 mm Hg at 25°C (measured)[3]
Fugacity (Level III Model)[2]					
Air (%)	57	55	26	50	11
Water (%)	42	44	72	49	87
Soil (%)	0.50	0.56	1.0	0.61	1.4
Sediment (%)	<0.1	0.11	0.17	0.14	0.24
Persistence[7]	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)
Bioaccumulation[7]	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.
[2] Data range is based upon the representative structures; 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/episuitedl.htm as of November 18, 2010.
[4] European Commission – European Chemicals Bureau. 2000. IUCLID Dataset on n-Butane. Available online at http://ecb.jrc.ec.europa.eu/IUCLID-DataSheets/106978.pdf as of November 18, 2010.
[5] Solano-Serena, F; Marchal, R; Huet, T; et al. 2000. Biodegradability of volatile hydrocarbons of gasoline. Appl Microbiol Biotech 54(1):121–125.
[6] 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 November 22, 2010.
[7] Low biodegradability may be a result of the test substance residing in the vessel headspace, rather than in the aqueous medium. Hence, the substance will be less bioavailable for degradation by microbes during the test period. However, alkane- and alkene-utilizing bacteria found in soil are likely to transform these hydrocarbons through various oxidation processes. See: Van Ginkel, CG; Welten, HG; de Bont, JA. 1987. Oxidation of gaseous and volatile hydrocarbons by selected alkene-utilizing bacteria. Appl Env Microbiol 53(12):2903–2907.
[8] 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 Characteristics of Refinery Gases[1]							
Property	**SUPPORTING CHEMICAL Butane**	**SUPPORTING CHEMICAL Propane, 2 methyl-**	**SUPPORTING CHEMICAL 1-Propene, 2-methyl-**	**SUPPORTING CHEMICAL 1-Butene**	**SUPPORTING CHEMICAL 2-Butene**	**SUPPORTING CHEMICAL Butane, 2-methyl-**	**SUPPORTING CHEMICAL Pentane**
CASRN	106-97-8	75-28-5	115-11-7	106-98-9	107-01-7	78-78-4	109-66-0
Photodegradation Half-life	4.1 days (estimated)[2]	4.4 days (estimated)[2]	2.5 hours (estimated)[2]	4.7 hours (estimated)[2]	2.1 hours (estimated)[2]	2.7 days (estimated)[2]	2.7 days (estimated)[2]
Hydrolysis Half-life	Stable						
Biodegradation	No data	49% in 30 days (not readily biodegradable)[3]	No data	1% in 28 days (not readily biodegradable)[4,5]	No data	Readily biodegradable[6]	96% in 28 days (readily biodegradable)[4]
Bioaccumulation Factor	BAF = 61 (estimated)[2]	BAF = 47 (estimated)[2]	BAF = 2.1 (estimated)[2]	BAF = 24 (estimated)[2]	BAF = 21 (estimated)[2]	BAF = 44 (estimated)[2]	BAF = 150 (estimated)[2]
Log K_{oc}	1.60 (estimated)[2]	1.50 (estimated)[2]	1.12 (estimated)[2]	1.60 (estimated)[2]	1.60 (estimated)[2]	1.78 (estimated)[2]	1.86 (estimated)[2]
Fugacity (Level III Model)[2]							
Air (%)	48	44	26	11	3.0	39	43
Water (%)	51	55	72	86	94	60	56
Soil (%)	0.80	0.66	1.0	2.0	2.1	0.75	0.91
Sediment (%)	0.16	0.17	0.17	0.27	0.30	0.25	0.23
Persistence[7]	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)
Bioaccumulation[7]	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.

[2] 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/episuitedl.htm as of November 18, 2010.

[3] Solano-Serena, F; Marchal, R; Huet, T; et al. 2000. Biodegradability of volatile hydrocarbons of gasoline. Appl Microbiol Biotech 54(1):121–125.

[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 September 27, 2010.

[5] Low biodegradability may be a result of the test substance residing in the vessel headspace, rather than in the aqueous medium. Hence, the substance will be less bioavailable for degradation by microbes during the test period. However, alkane- and alkene-utilizing bacteria found in soil are likely to transform these hydrocarbons through various oxidation processes. See: Van Ginkel, CG; Welten, HG; de Bont, JA. 1987. Oxidation of gaseous and volatile hydrocarbons by selected alkene-utilizing bacteria. Appl Env Microbiol 53(12):2903–2907.

[6] OECD. 2008. SIDS Initial Assessment Profile for C5 Aliphatic Hydrocarbon Solvents Category. SIAM 26, 16 April. Organisation for Economic Co-operation and Development. Available online at http://webnet.oecd.org/hpv/ui/handler.axd?id=b2243087-cb08-4f47-bd24-9df8ca840c7d as of November 15, 2010. [SIDS dataset not available online]

[7] 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 Characteristics of Refinery Gases[1]								
Property	**SUPPORTING CHEMICAL Cyclopentane**	**SUPPORTING CHEMICAL 2-Butene, 2-methyl-**	**SUPPORTING CHEMICAL Naphtha (petroleum), light catalytic cracked[2]**	**SUPPORTING CHEMICAL Naphtha (petroleum), sweetened[2]**	**SUPPORTING CHEMICAL Gasoline[2]**	**SUPPORTING CHEMICAL Ammonia**	**SUPPORTING CHEMICAL Hydrogen sulfide**	**SUPPORTING CHEMICAL Carbon monoxide**
CASRN	287-92-3	513-35-9	64741-55-5	64741-87-3	86290-81-5 or no CASRN specified	7664-41-7	7783-06-4	630-08-0
Photodegradation Half-life	38.4 hours (estimated)[3]	1.5 hours (estimated)[3]	1.4-32 hours (estimated)[3]	4.2-32 hours (estimated)[3]	32–48.8 hours (estimated)[3]	Stable[4]	Stable. The primary chemical transformation of hydrogen sulfide in the atmosphere is oxidation by oxygen containing radicals to sulfur dioxide and sulfates[4].	Generally stable but reacts with hydroxyl radicals to form CO_2 and atomic oxygen which reacts rapidly with O_2 to form peroxy radicals[5].
Hydrolysis Half-life	Stable							
Biodegradation	Inherently biodegradable[6]	7% in 28 days (not readily biodegradable)[7]	74% in 28 days (inherently biodegradable)[8]	Biodegradable	Biodegradable	Bacteria convert ammonia to nitrate under environmental conditions[4].	Microorganisms in soil and water are involved in oxidation-reduction reactions which oxidize hydrogen sulfide to elemental sulfur[4].	Soils and water are a net source of carbon monoxide in the environment; however, various microorganisms may degrade carbon monoxide in soil and the water column[5].
Bioaccumulation Factor	BAF = 69 (estimated)[3]	BAF = 44 (estimated)[3]	BAF = 44–577 (estimated)[3]	BAF = 44–307 (estimated)[3]	BAF = 44–61 (estimated)[3]	BAF = 1 (estimated)[3,9]	BAF = 1 (estimated)[3,9]	BAF = 6 (estimated)[3,9]
Log K_{oc}	1.9 (estimated)[3]	1.78 (estimated)[3]	1.8–2.6 (estimated)[3]	1.8–2.1 (estimated)[3]	1.6–1.8 (estimated)[3]	1.1 (estimated)[3,9]	1.1 (estimated)[3,9]	0.6 (estimated)[3,9]

Table 4. Environmental Fate Characteristics of Refinery Gases[1]								
Property	**SUPPORTING CHEMICAL Cyclopentane**	**SUPPORTING CHEMICAL 2-Butene, 2-methyl-**	**SUPPORTING CHEMICAL Naphtha (petroleum), light catalytic cracked[2]**	**SUPPORTING CHEMICAL Naphtha (petroleum), sweetened[2]**	**SUPPORTING CHEMICAL Gasoline[2]**	**SUPPORTING CHEMICAL Ammonia**	**SUPPORTING CHEMICAL Hydrogen sulfide**	**SUPPORTING CHEMICAL Carbon monoxide**
Fugacity (Level III Model)[3]								
Air (%)	34.9	0.98	0.95–39	10–43	39–48	27.1	56.7	56.8
Water (%)	62.8	96	41–97	56–87	51–60	35.9	42.6	42.7
Soil (%)	1.9	2.0	0.75–52	0.75–2.4	0.7–0.8	36.9	0.7	0.5
Sediment (%)	0.3	0.42	0.26–1.5	0.23–0.52	0.2	0.1	0.1	0.1
Persistence[10]	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)
Bioaccumulation[10]	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)

[1] American Petroleum Institute, Petroleum HPV Testing Group. 2009. Revised Test Plan and Robust Summary for Petroleum Gas. Available online at http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm as of November 18, 2010.
[2] Data range is based upon the representative structures; 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/episuitedl.htm as of November 18, 2010.
[4] Hazardous Substance Databank. 2010. Available online at http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB as of November 18, 2010.
[5] Agency for Toxic Substances and Disease Registry. 2009. Toxicological profile for carbon monoxide. Available online at http://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=1145&tid=253 as of November 17, 2010.
[6] OECD. 2008. SIDS Initial Assessment Profile for C5 Aliphatic Hydrocarbon Solvents Category. SIAM 26, 16 April. Organisation for Economic Co-operation and Development. Available online at http://webnet.oecd.org/hpv/ui/handler.axd?id=b2243087-cb08-4f47-bd24-9df8ca840c7d as of November 15, 2010. [SIDS dataset not available online]
[7] OECD. 2004. SIDS Initial Assessment Report on 2-methyl-2-butene. SIAM 19, 19-22 October. Organisation for Economic Co-operation and Development. Available online at http://www.chem.unep.ch/irptc/sids/OECDSIDS/513359.pdf as of November 15, 2010.
[8] American Petroleum Institute, Petroleum HPV Testing Group. 2008. Revised Test Plan and Robust Summary for the Gasoline Blending Streams Category. Available online at http://www.epa.gov/hpv/pubs/summaries/gasnecat/c13409tc.htm as of November 18, 2010.
[9] Inorganic compounds are outside the estimated domain.
[10] 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 refinery gases category consists of 62 refinery gases primarily produced in petroleum refineries as the light end fractions of numerous distillation and cracking processes or in gas plants that separate natural gas and natural gas liquids. These mixtures largely consist of C1 to C5 hydrocarbons, together with significant concentrations of other gases, such as hydrogen, nitrogen, hydrogen sulfide and carbon monoxide. The components of this category are gases or volatile liquids with high vapor pressure and moderate to high water solubility. They are expected to have moderate to high mobility in soil. Volatilization from water is expected to be high given their Henry's Law constants. The rate of hydrolysis is expected to be negligible. The rate of atmospheric photooxidation is expected to be negligible to rapid for the members of this category. The members of the refinery gases category are expected to have low persistence (P1) and low bioaccumulation potential (B1).

3. Human Health Hazard

A summary of the human health toxicity data submitted for SIDS endpoint is provided in Table 5.

Acute Oral Toxicity

Subcategory II: Refinery gases, C1 – C4 with ammonia and hydrogen sulfide
Ammonia (CASRN 7664-41-7, supporting chemical)
See human health data at: http://webnet.oecd.org/hpv/ui/Search.aspx
Rat LD_{50} = 350 mg/kg

Subcategory IV: Refinery gases, C1 – C6
Group 1
Cyclopentane (CASRN 287-92-3)
(1) Sprague-Dawley rats (5/sex/dose) were administered cyclopentane via gavage at 5000 mg/kg and observed for 14 days following dosing. No mortality was observed. TSCATS (OTS0556745)
LD_{50} > 5000 mg/kg

(2) See human health data at http://webnet.oecd.org/hpv/ui/Search.aspx

Naphtha (petroleum), light catalytic cracked (CASRN 64741-55-5, supporting chemical)
Paraffins: 30.6% (v/v), Olefins: 45.6%, Naphthenes: 10.4%, Aromatics: 13.1%
Sprague-Dawley rats (5/sex/dose) were administered naphtha (petroleum), light catalytic cracked (API 83-20) via gavage at 5000 mg/kg-bw and observed for 14 days following dosing. No mortalities occurred.
LD_{50} > 5000 mg/kg

Naphtha (petroleum), sweetened (CASRN 64741-87-3, supporting chemical)
Paraffins: 72.1% (v/v), Olefins: < 0.1%, Naphthenes: 20.9%, Aromatics: 4.1%

Sprague-Dawley rats (5/sex/dose) were administered naphtha (petroleum), sweetened (API 81-08) via gavage at 5000 mg/kg-bw and observed for 14 days following dosing. No mortalities occurred.
LD_{50} > 5000 mg/kg

Unleaded gasoline (no CASRN, supporting chemical)
Paraffins: 57.8% (v/v), Olefins: 9.9%, Naphthenes: 3.9%, Aromatics: 28.1%
Sprague-Dawley rats (5/sex/dose) were administered unleaded gasoline (API PS-6) via gavage at 10, 15, 17.5, 20 or 25 mL/kg-bw (~ 13,875 mg/kg-bw)[7] and observed for 14 days following dosing. Mortality occurred at doses ≥ 15 mL/kg-bw.
LD_{50} ~ 13,875 mg/kg

Group 2
See data for Group 1

2-Butene, 2-methyl- (CASRN 513-35-9)
See human health data at http://webnet.oecd.org/hpv/UI/handler.axd?id=db117c7c-460a-4361-8a85-507f4da63012.
1059 mg/kg < Rat LD_{50} < 1655 mg/kg

Group 3
See data for Groups 1 and 2
Benzene (CASRN 71-43-2, supporting chemical)
See human health data at: http://ecb.jrc.ec.europa.eu/DOCUMENTS/Existing-Chemicals/RISK_ASSESSMENT/REPORT/benzenereport063.pdf)
Rat LD_{50} > 810-10,000 mg/kg

Subcategories V to IX
See appropriate data for subcategory IV above.

Acute Inhalation Toxicity

Subcategory I: Refinery gases, C1 – C4
Group 1
Propane (CASRN 74-98-6, supporting chemical)
Rats of unspecified strain (six males or females) were exposed whole-body to propane at 800,000 ppm for 15 minutes. They were observed for CNS effects over a 10 minute exposure period. Mortality was observed during exposure only: recovery from non-lethal exposure was rapid and the rats appeared normal within 10 minutes of exposure.
EC_{50} (CNS depression; 10 min) = 280,000 ppm
LC_{50} (15 min) > 800,000 ppm

[7] Gasoline units were converted from volume to mass using a density of 0.74 g/mL, which was calculated using the specific gravity provided in the robust summaries for the gasoline sample API 94-01. Density of API PS-6 was not provided.

1-Propene (CASRN 115-07-1, supporting chemical)
Sprague-Dawley rats exposed to 65,000 ppm 1-propene via inhalation for four hours. No mortalities were observed. See human health data at: http://webnet.oecd.org/hpv/ui/Search.aspx
Rat LC_{50} > 65,000 ppm (highest concentration tested)

1-Propene, 2-methyl- (CASRN 115-11-7, supporting chemical)
See human health data at: http://www.chem.unep.ch/irptc/sids/oecdsids/115117.pdf.
LC_{50} (mouse) = 180,000 ppm
LC_{50} (rat) = 270,000 ppm

2-Butene (CASRN 107-01-7, supporting chemical)
(1) Wistar Crl:WI(WU)BR rats (5/sex/test concentration) were exposed whole-body to 2-butene (42.4% cis, 55.3% trans) as a vapor at a mean measured concentration of 23.1 mg/L for 4 hours and observed for 14 days following dosing. No mortality was observed.
LC_{50} > 23.1 mg/L

(2) See human health data at http://webnet.oecd.org/hpv/UI/handler.axd?id=db117c7c-460a-4361-8a85-507f4da63012.

Group 2
See data for Group 1

1,3-Butadiene (CASRN 106-99-0, supporting chemical)
(1) In the rat, 4-hour LC_{50} value was reported to be 285 mg/L (129,000 ppm). Information is not available on the strain, age, number and sex, number of exposure concentrations or post observation period.
LC_{50} = 285 mg/L

(2) See human health data at http://ecb.jrc.ec.europa.eu/DOCUMENTS/Existing-Chemicals/RISK_ASSESSMENT/REPORT/butadienereport019.pdf.

Subcategory II: Refinery gases, C1 – C4 with ammonia and hydrogen sulfide
See data for C1-C4 hydrocarbons (excepting 1,3-butadiene) in subcategory I above.

Ammonia (CASRN 7664-41-7, supporting chemical)
See human health data at: http://webnet.oecd.org/hpv/ui/Search.aspx
Rat 1h-LC_{50} = 9.85 – 13.8 mg/L
Mouse 1h-LC_{50} = 2.94 mg/L

Hydrogen sulfide (CASRN 7783-06-4, supporting chemical)
(1) Male and female rats (Sprague-Dawley, Fischer-344 and Long Evans rats used in the study) were exposed to hydrogen sulfide by inhalation for 4 hours at one of eight exposure concentrations ranging from approximately 0.3 to 0.8 mg/L and observed for up to 14 days following exposure. A total of 72 males and 72 females were used, but the study did not specify the number in each exposure group (HPV Challenge submission and Prior et al. 1988).
LC_{50} = 0.70 mg/L

(2) Male and female Sprague-Dawley rats (5/sex/concentration) were exposed to hydrogen sulfide via inhalation at 0, 400, 440, 475, 500, 525, 554 or 600 ppm for 4 hours and were observed for 14 days following exposure. Mortalities were 0/10, 3/10, 3/10, 7/10, 8/10, 8/10, 9/10 and 10/10 in 0, 400, 440, 475, 500, 525, 544 and 600 ppm exposure groups, respectively; all deaths occurred during the first 24 hours following exposure.
LC_{50} = 440 ppm

Ethanethiol (CASRN 75-08-1, supporting chemical)
(1) Male rats and mice (5 rats/concentration, 10 mice/concentration, strain not specified) were exposed via inhalation in a customized chamber to ethanethiol. Rats were exposed to 2600, 3150 3573, 4438, 4432, 4868 or 5100 ppm (approximately 6.6, 8.0, 9.1, 11 or 13 mg/L) and mice were exposed to 2600, 3150, 3573, 4438 or 4832 ppm (approximately 6.6, 8.0, 9.1, 11 or 12 mg/L) for 4 hours and were observed for 14 days following dosing. Mortalities were observed at all dose levels in mice and in rats starting at 4438 ppm (~11 mg/L). Characteristic symptoms of toxicity included increased respiration and restlessness, uncoordinated movement and staggering gait, muscular weakness, partial skeletal muscle paralysis beginning in hind limbs, light to severe cyanosis, tolerance of prone position and mild to heavy sedation. Fatal exposure to the test substance usually resulted in a semi-conscious condition of sedation and lethargy 4 – 6 hours post-exposure before showing signs of toxicity. General signs of acute thiol poisoning exhibited by rats (as well as mice and rabbits) were uniform and were indicative of CNS depression and respiratory paralysis with death ensuing from respiratory failure.
Rat LC_{50} ~ 11 mg/L
Mouse LC_{50} ~ 7.0 mg/L

(2) See human health data at: http://webnet.oecd.org/hpv/ui/Search.aspx

Subcategory III: Refinery gases, C1 – C4 with carbon monoxide
See data for C1-C4 hydrocarbons (excepting 1,3-butadiene) in subcategory I above.

Carbon monoxide (CASRN 630-08-0, supporting chemical)
(1) Male Sprague-Dawley rats, NIH/NMRI Swiss Albino mice and FTD Hartley guinea pigs (4 – 12 /concentration) were exposed to carbon monoxide at 1600, 1800, 2000 or 2200 ppm for 4 hours. Mortalities were observed at all exposure levels. All animals lost consciousness during the first 1 – 2 hours of exposure.
LC_{50} = 1800 ppm

(2) Male Sprague-Dawley rats (4 –12/concentration) were exposed to carbon monoxide via inhalation at concentrations of 1600, 1800, 2000 or 2200 ppm for 4 hours. The exposed rats lost consciousness during the first 1 – 2 hours of exposure. Mortality was observed at all doses and appeared to be dependent on exposure concentration. Mortalities were 1/4, 2/4, 4/8 and 11/12 at the 1600, 1800, 2000 and 2200 ppm, respectively.
LC_{50} = 1800 ppm

Subcategory IV: Refinery gases, C1 – C6
Group 1

See data for C1-C4 hydrocarbons (excepting 1,3-butadiene) in subcategory I above.

Butane, 2-methyl- (CASRN 78-78-4)
See human health data for C5 aliphatic hydrocarbon solvents category - http://webnet.oecd.org/hpv/ui/Search.aspx
Rat LC_{50} > 12.1 mg/L

Pentane (CASRN 109-66-0)
See human health data for pentane: http://webnet.oecd.org/hpv/UI/SIDS_Details.aspx?Key=0af02fa3-f3ef-4df9-b050-43116efd8ef1&idx=0 and C5 aliphatic hydrocarbon solvents category - http://webnet.oecd.org/hpv/ui/Search.aspx.
Rat LC_{50} > 18.0 mg/L

Cyclopentane (CASRN 287-92-3)
In two studies, Sprague-Dawley rats (5/sex/test concentration) were exposed whole-body to cyclopentane as a vapor at mean measured concentrations of 0, 25.3 or 72 mg/L for 4 hours and observed for 14 days following dosing. One male died at 72 mg/L on day 14 post-exposure. TSCATS (OTS0556746 and OTS0558772).
LC_{50} > 72 mg/L

2-Butene, 2-methyl- (CASRN 513-35-9)
See human health data at http://webnet.oecd.org/hpv/UI/handler.axd?id=db117c7c-460a-4361-8a85-507f4da63012.
Rat LC_{50} > 175 mg/L

Light catalytic cracked naphtha (CASRN 64741-55-5, supporting chemical)
Sprague-Dawley rats (5/sex/test concentration) were exposed whole-body to light catalytic cracked naphtha (API 83-20) via inhalation at a nominal concentration of 5 mg/L for 4 hours and observed for 14 days following dosing. The mean measured concentration was 5.28 mg/L. No mortality was observed.
LC_{50} > 5.28 mg/L

Groups 2 and 3
See data for Group 1 and 1,3-butadiene above.

Subcategory V: Refinery gases, C1 – C6 with hydrogen sulfide
See data for C1-C6 hydrocarbons in subcategory IV above. See data for hydrogen sulfide in subcategory II above.

Subcategory VI: Refinery gases, C1 – C6 with carbon monoxide
See appropriate data for C1-C6 hydrocarbons in subcategory IV above. See data for carbon monoxide in subcategory III above.

Subcategory VII: Refinery gases, C1 – C6 with carbon monoxide and hydrogen sulfide

See appropriate data for C1-C6 hydrocarbons in subcategory IV above. See data for hydrogen sulfide and CO in subcategories II and III above, respectively.

Subcategory VIII: Refinery gases, C1 – C6 with ammonia and hydrogen sulfide
See appropriate data for subcategories II and IV above.

Subcategory IX: Refinery gases, C1 – C6 with ammonia, hydrogen sulfide and carbon monoxide
See appropriate data for subcategories II to VIII above.

Subcategory X: Refinery gases, ammonia and hydrogen sulfide
See data for ammonia (CASRN 7664-41-7) and hydrogen sulfide in subcategory II above.

Subcategory XI: Refinery gases, ammonia, hydrogen sulfide and carbon monoxide
See data for ammonia (CASRN 7664-41-7) and hydrogen sulfide in subcategory II above, and for CO in subcategory III above.

Acute Dermal Toxicity

Subcategory IV: Refinery gases, C1 – C6
Groups 1, 2 and 3
2-Butene, 2-methyl- (CASRN 513-35-9)
See human health data at http://webnet.oecd.org/hpv/UI/handler.axd?id=db117c7c-460a-4361-8a85-507f4da63012.
Rat LD_{50} > 2000 mg/kg

Naphtha (petroleum), light catalytic cracked (CASRN 64741-55-5, supporting chemical)
Paraffins: 30.6% (v/v), Olefins: 45.6%, Naphthenes: 10.4%, Aromatics: 13.1%
New Zealand White rabbits (4/sex/dose) were administered naphtha (petroleum), light catalytic cracked (API 83-20) via the dermal route at 2000 or 3000 mg/kg under occluded conditions for 24 hours and observed for 14 days following dosing. Mortality was limited to one male and one female at 2000 mg/kg.
LD_{50} > 3000 mg/kg

Naphtha (petroleum), sweetened (CASRN 64741-87-3, supporting chemical)
Paraffins: 72.1% (v/v), Olefins: < 0.1%, Naphthenes: 20.9%, Aromatics: 4.1%
New Zealand White rabbits (4/sex/dose) were administered naphtha (petroleum), sweetened (API 81-08) via the dermal route at 2000 mg/kg-bw on either abraded or intact skin under occluded conditions for 24 hours and observed for 14 days following dosing. No mortalities occurred.
LD_{50} > 2000 mg/kg

Unleaded gasoline (no CASRN, supporting chemical)
Paraffins: 57.8% (v/v), Olefins: 9.9%, Naphthenes: 3.9%, Aromatics: 28.1%

New Zealand White rabbits (4/sex/dose) were administered unleaded gasoline (API PS-6) via the dermal route at 5 mL/kg-bw (~ 3700 mg/kg-bw)[8] to intact or abraded skin under occluded conditions for 24 hours and observed for 14 days following dosing. Mortality occurred in one female.
LD_{50} > 3700 mg/kg

Subcategories V to IX
See appropriate data for subcategory IV above.

Repeated-Dose Toxicity

Subcategory I: Refinery gases, C1 – C4
Group 1
Ethane (CASRN 74-84-0, supporting chemical)
In a combined repeated-dose/reproductive/developmental toxicity screening test, Sprague-Dawley CD rats (12 males and 24 females/test concentration) were exposed whole-body to ethane as a gas at nominal concentrations of 0, 1600, 5000 or 16,000 ppm, 6 hours/day, 7 days/week for at least 4 weeks. One half of the females were evaluated for subchronic effects after 28 days of exposure. The other half was allowed to mate to assess effects of ethane on reproduction and development. Subchronic effect endpoints included body weight, feed consumption, functional observational battery, motor activity, clinical observations, organ weights, histopathology, macroscopic observations, hematology and clinical chemistry. The mean measured concentrations were 0, 1703, 4762 or 15,502 ppm. No treatment-related effects on survival or evaluated endpoints were observed.
NOAEC = 15,502 ppm/day (highest concentration tested)

Propane (CASRN 74-98-6, supporting chemical)
In a combined repeated-dose/reproductive/developmental toxicity screening test, Sprague-Dawley CD rats (12 males and 24 females/test concentration) were exposed whole-body to propane as a gas at nominal concentrations of 0, 1200, 4000 or 12,000 ppm, 6 hours/day, 7 days/week for at least 4 weeks. One half of the females were evaluated for subchronic effects after 28 days of exposure. The other half was allowed to mate to assess effects of propane on reproduction and development. Subchronic effect endpoints included body weight, feed consumption, functional observational battery, motor activity, clinical observations, organ weights, histopathology, macroscopic observations, hematology and clinical chemistry. The mean measured concentrations were 0, 1230, 3990 or 12,168 ppm. There were no treatment-related effects on survival. Male rats exposed to 12,168 ppm exhibited a decrease in weight gain. Small, but significant increases were observed in hemoglobin concentration, hematocrit, erythrocytes and absolute eosinophils in females exposed to 12,168 ppm. Decreases in absolute and relative kidney weights were observed in males exposed to 1230 and 12,168 ppm. Decreases in absolute liver weights were observed in males at 12,168 ppm and decreases in relative liver weights were observed in females exposed to 3990 and 12,168 ppm. In the absence

[8] Gasoline units were converted from volume to mass using a density of 0.74 g/mL, which was calculated using the specific gravity provided in the robust summaries for the gasoline sample API 94-01. Density of API PS-6 was not provided.

of kidney or liver pathological findings, the changes in organ weights were not considered to be treatment-related.
LOAEC = 12,168 ppm/day (based on decreased weight gain in males and increases in hemoglobin concentration, hematocrit, erythrocytes and absolute eosinophils in females)
NOAEC = 3990 ppm/day

1-Propene (CASRN 115-01-1, supporting chemical)
In a 14-week inhalation study, rats were exposed up to 10,000 ppm 1-propene via the inhalation route of exposure. See human health data at: http://webnet.oecd.org/hpv/ui/Search.aspx
Rat NOAEC = 10,000 ppm/day (highest concentration tested)

Propane, 2-methyl- (CASRN 75-28-5, supporting chemical)
In a combined repeated-dose/reproductive/developmental toxicity screening test, Sprague-Dawley CD rats (12 males and 24 females/test concentration) were exposed whole-body to 2-Methylpropane gas at nominal concentrations of 0, 900, 3000 or 9000 ppm, 6 hours/day, 7 days/week. Subchronic effect endpoints included body weight, feed consumption, functional observational battery, motor activity, clinical observations, organ weights, histopathology, macroscopic observations, hematology and clinical chemistry. The mean measured concentrations were 0, 930, 3122 and 9148 ppm. No mortality was observed. Hematological changes included significant increases in hemoglobin and mean corpuscular hemoglobin in males at 9148 ppm, decreases in platelets in males at 3122 and 9148 ppm, and decreases in monocytes in females at 3122 and 9148 ppm. No other effects on hematological parameters were observed suggesting that the toxicological significance of this observation is unclear. A significant increase in sodium concentration was observed in males at 9148 ppm. Decreases in phosphorus concentration were observed in all exposed females. An increase in spleen weight (relative and absolute) was observed in males at 930 and 3122 ppm, but not at 9148 ppm, and therefore, was not considered to be an effect of exposure.
NOAEC = 9148 ppm/day (highest concentration tested)

Butane (CASRN 106-97-8, supporting chemical)
In a combined repeated-dose/reproductive/developmental toxicity screening test, Sprague-Dawley CD rats (12 males and 24 females/test concentration) were exposed whole-body to butane gas at nominal concentrations of 0, 900, 3000 or 9000 ppm, 6 hours/day, 7 days/week for at least 4 weeks. One half of the females were evaluated for subchronic effects after 28 days of exposure. The other half was allowed to mate to assess effects of butane on reproduction and development. Subchronic effect endpoints included body weight, feed consumption, functional observational battery, motor activity, clinical observations, organ weights, histopathology, macroscopic observations, hematology and clinical chemistry. The mean measured concentrations were 0, 931, 3022 and 9157 ppm. There was a low incidence of chromodacryorrhea or transient red nasal discharge among males exposed to 9157 ppm. A small, significant decrease in male forelimb grip strength was observed in males at 9157 ppm, but an increase in forelimb grip strength was observed in females at the same dose level. A decrease in total bilirubin concentration was observed in males at 3022 and 9157 ppm.
NOAEC = 9157 ppm/day (highest concentration tested)

1-Butene (CASRN 106-98-9, supporting chemical)

(1) In a combined repeated-exposure/reproductive/developmental toxicity study, Sprague-Dawley Crl:CD IGS BR rats (12/sex/dose) were exposed to 1-butene as a gas at 0, 500, 2000 or 8000 ppm, 6 hours/day. The mean measured concentrations were 0, 524, 2062 or 8271 ppm. There were no treatment-related effects on body weight, body weight change, food consumption, motor activity, functional observational battery, hematology, clinical chemistry, organ weights or histopathology. (Low 1,3-butadiene category HPV submission: http://www.epa.gov/chemrtk/pubs/summaries/lowbutd/c13122tc.htm)
NOAEC = 8271 ppm/day (highest concentration tested)

(2) See human health data at: http://webnet.oecd.org/hpv/UI/handler.axd?id=db117c7c-460a-4361-8a85-507f4da63012.
NOAEC = 8000 ppm/day (highest concentration tested)

2-Butene (CASRN 107-01-7, supporting chemical)
(1) In a combined repeated-dose/reproductive/developmental toxicity screening study, Wistar (Hsd/Cpd:WU) rats (12/sex/concentration) were exposed whole-body to 2-butene (cis/trans mixture) gas at nominal concentrations of 0, 2500 or 5000 ppm, 6 hours/day for 7 days/week. Males were exposed for 39 – 46 days and females were exposed for 2 weeks (pre-mating), during mating (up to 1 week) and through gestation day 19. Mean measured concentrations were 0, 2476 and 5009 ppm. Endpoints included clinical signs, body weight, food consumption, hematology, clinical chemistry, organ weights and histopathology. A significant reduction in mean body weight changes was observed in males at 2476 ppm during the first and fourth weeks of exposure and at 5009 ppm during the first week of exposure. Significant decreases in mean body weight were observed in females at 2476 on day 14 and at 5009 on days 7, 14 and lactation day 1; however, body weight changes in dams were comparable to controls throughout the study. Total white blood cell (WBC) count and number of lymphocytes were elevated in males at ≥ 2476 ppm, but the effects were not dose-dependent and values were within historical control ranges. Plasma calcium concentrations were slightly decreased in males at 5009 ppm, but the change was not considered to be toxicologically significant.
NOAEC = 5009 ppm/day (highest concentration tested)

(2) See human health data at: http://webnet.oecd.org/hpv/UI/handler.axd?id=db117c7c-460a-4361-8a85-507f4da63012.
NOAEC = 5000 ppm/day (highest concentration tested)

Ethylene (CASRN 74-85-1, supporting chemical)
(1) In a 13-week study, rats (15/sex/dose, strain not specified) were exposed to ethylene as a gas at 300, 1000, 3000 or 10,000 ppm, 6 hours/day, 5 days/week. There were no effects observed on body weight, body weight change, food consumption, hematology, clinical chemistry, gross pathology or histopathology. Red deposits were observed around the eyes or nose of rats in several dose groups, including the control group. Liver weights were reduced in several dose groups, but the response was not dose-related (http://www.chem.unep.ch/irptc/sids/OECDSIDS/74851.pdf).
NOAEC = 10,000 ppm/day (highest concentration tested)

(2) In a 24-month study, Fischer 344 rats (120/sex/test concentration) were exposed to ethylene as a gas at 0, 300, 1000 or 3000 ppm, 6 hours/day, 5 days/week. There were no treatment-related effects on survival, body weight, body weight change, hematology, blood chemistry or histology (http://www.chem.unep.ch/irptc/sids/OECDSIDS/74851.pdf).
NOAEC = 3000 ppm/day (highest concentration tested)

1-Propene, 2-methyl- (CASRN 115-11-7, supporting chemical)
(1) In a 28-day study, Sprague-Dawley CD(SR)BR rats (5/sex/dose) were administered 2-methyl-1-propene in corn oil via gavage at 0, 1.49, 14.86 or 148.55 mg/kg/day. Endpoints included clinical signs, body weights, hematology, clinical chemistry and histopathology. The total WBC count (predominantly leucocytes and monocytes) was significantly reduced by 11 and 44% in males and females, respectively, at 148.55 mg/kg/day; however, these values were within the historical background range of the laboratory. No other significant effects were observed. (Low 1,3-butadiene category HPV submission: http://www.epa.gov/chemrtk/pubs/summaries/lowbutd/c13122tc.htm and http://www.chem.unep.ch/irptc/sids/OECDSIDS/115117.pdf)
NOAEL = 148.6 mg/kg/day (highest dose tested)

(2) In a 13-week study, Sprague-Dawley Crl:CD(SR)BR rats (10/sex/dose) were exposed whole-body to 2-methyl-1-propene as a gas at 0, 250, 1000 or 8000 ppm, 6 hours/day, 5 days/week. The 8000 ppm concentration level was the highest chamber concentration that could be tested below the explosive limit. Endpoints included body weight, body weight gain, food consumption, hematology, clinical chemistry, organ weights, urinalysis and histopathology. No biologically significant treatment-related effects were observed. (Low 1,3-butadiene category HPV submission: http://www.epa.gov/chemrtk/pubs/summaries/lowbutd/c13122tc.htm)
NOAEC = 8000 ppm/day (highest concentration tested)

(3) In a 14-week National Toxicology Program (NTP) study, Fischer 344 rats (10/sex/test concentration) were exposed whole-body to 1-propene, 2-methyl gas at nominal concentrations of 0, 500, 1000, 2000, 4000 or 8000 ppm, 6 hours/day, 5 days/week. Mean measured concentrations were 0, 495, 1010, 1990, 4010 or 7970 ppm. Endpoints included clinical signs, body weights, organ weights, hematology, clinical chemistry, histopathology, sperm count and motility, estrus cycle length and relative frequency of estrus stages. No mortality was observed. Relative right kidney weights were elevated in all exposed males. Absolute kidney weights in males were increased at $\geq$ 4000 ppm. Increases were observed in the relative liver weight of females at $\geq$ 500 ppm and in the absolute liver weight of females at $\geq$ 1000 ppm, but the increases did not occur in a concentration-dependent manner. In the absence of kidney or liver pathological findings, the changes in organ weights were not considered to be treatment-related. Minimal hypertrophy of goblet cells lining the nasopharyngeal duct in the most caudal section of the nasal cavity was observed in all groups of exposed males and females. A significant decrease in sperm motility was observed at 8000 ppm (NTP Technical Report No. 487).
NOAEC = 7970 ppm/day (highest concentration tested)

(4) In a 14-week NTP study, B6C3F1 mice (10/sex/test concentration) were exposed whole-body to 1-propene, 2-methyl gas at nominal concentrations of 0, 500, 1000, 2000, 4000 or 8000 ppm, 6 hours/day, 5 days/week. Mean measured concentrations were 0, 495, 1010, 1990, 4010 or

7980. Endpoints included clinical signs, body weights, organ weights, hematology, clinical chemistry, histopathology, sperm count and motility, estrus cycle length and relative frequency of estrus stages. No mortality was observed. Relative and absolute right kidney weights were elevated in all exposed females and in males exposed to 7980 ppm. In the absence of kidney pathological findings, the changes in organ weights were not considered to be treatment-related. In females exposed to 1990 or 4010 ppm, time spent in diestrus was increased with a concurrent decrease in the time spent in estrus, although the length of the average estrus cycle was not altered; these effects did not occur in a dose-related manner (NTP Technical Report No. 487).
NOAEC = 7980 ppm/day (highest concentration tested)

(5) See human health data at: http://www.chem.unep.ch/irptc/sids/OECDSIDS/115117.pdf and http://webnet.oecd.org/hpv/UI/handler.axd?id=db117c7c-460a-4361-8a85-507f4da63012.

Group 2
See data for Group 1

1,3-Butadiene (CASRN 106-99-0, supporting chemical)
(1) In a 52-week study, Sprague-Dawley rats (10/sex/test concentration) were exposed whole-body to 1,3-butadiene as a gas at nominal concentrations of 0, 1000 or 8000 ppm, 6 hours/day, 5 days/week. Mean measured concentrations were 0.7, 999 and 7886 ppm. Endpoints included clinical signs, body weight, hematology, clinical chemistry, urinalysis, neuromuscular function, organ weights and histopathology. Clinical signs at 7886 ppm included wet and ruffled fur and slight limb weakness or incoordination from the second to the fifth month of exposure. An increase in liver weight was observed at doses ≥ 999 ppm, but there was no associated liver pathology. There were no other treatment-related effects observed at the end of exposure. (Additional details were obtained from Owen and Glaister, 1990, Environmental Health Perspectives 86:19-25)
NOAEC = 7886 ppm/day (highest concentration tested)

(2) In a 14-week NTP study, B6C3F1 mice (10/sex/test concentration) were exposed to 1,3-butadiene (rubber grade, containing 0.02% t-butyl catechol)as a gas at 0, 625, 1250, 2500, 5000 or 8000, 6 hours/day, 5 days/week (64 exposures). Because four male mice in the high-exposure group died by day 4, another two groups of 10 male mice each were restarted (control and 8000 ppm). At the end of the 95- or 93-day (restart) studies, surviving mice were sacrificed. Endpoints included clinical signs, body weights and histopathology. Mortalities and/or morbidities occurred at 1250 ppm and above. Body weight gains were reduced at concentrations ≥ 2500 ppm in males and ≥ 5000 ppm in females. There were no histopathological effects observed (NTP Technical Report No. 288).
LOAEC = 1250 ppm/day (based on mortalities)
NOAEC = 625 ppm/day

(3) In a 13-week study, Sprague-Dawley rats (40/sex/dose) were exposed to 1,3-butadiene as a gas at 0, 1000, 2000, 4000 or 8000 ppm, 6 hours/day, 5 days/week. Endpoints included clinical signs, body weight, food consumption, urinalysis, hematology, clinical chemistry, brain cholinesterase activity, organ weights, histopathology and neuromuscular function. No

significant treatment-related adverse effects were observed (crude butadiene C4 category; http://www.epa.gov/chemrtk/pubs/summaries/olefins/c12064tc.htm).
NOAEL =8000 ppm/day (highest concentration tested)

(4) See human health data at: http://ecb.jrc.ec.europa.eu/DOCUMENTS/Existing-Chemicals/RISK_ASSESSMENT/REPORT/butadienereport019.pdf

Subcategory II: Refinery gases, C1-C4 with ammonia and hydrogen sulfide
See data for subcategory I (excepting 1,3-butadiene) above.

Ammonia (CASRN 7664-41-7, supporting chemical)
(1) An Integrated Risk Information System (IRIS) review (1991) by EPA on ammonia is available at http://www.epa.gov/iris/subst/0422.htm.

Based on increased severity of rhinitis and pneumonia with respiratory lesions in rats at 17.4 mg/m^3 (~ 0.017 mg/L), the NOAEC is not established. Based on occupational studies, the inhalation reference concentration (RfC) is 0.1 mg/m^3 (~0.0001 mg/L).

(2) Ten guinea pigs (unspecified strain and sex) and 20 Swiss Albino mice (unspecified strain and sex) were exposed to ammonia continuously via inhalation at 20 ppm (~ 0.014 mg/L) for up to 6 weeks. In a separate test, 6 guinea pigs were similarly exposed to ammonia at 50 ppm (~ 0.035 mg/L) for 6 weeks and 21 Leghorn chickens were exposed to 20 ppm (~ 0.014 mg/L) for up to 12 weeks. No treatment-related effects were observed in animals in the first 4 weeks, but at 6 weeks darkening/reddening, edema, congestion and hemorrhage were seen in the lungs of all three species at necropsy. Effects noted in guinea pigs at 50 ppm include grossly enlarged and congested spleens, congested livers and lungs and pulmonary edema (EPA IRIS: http://cfpub.epa.gov/ncea/iris/index.cfm?fuseaction=iris.showKeywordResults&maxrows=15&startrow=1&textfield=7664-41-7&x=10&y=11&searchtype=irisdata).
LOAEC ~ 0.014 mg/L/day (based on darkening/reddening, edema, congestion and hemorrhage in the lungs)
NOAEC ~ Not established

(3) Guinea pigs were exposed to ammonia via inhalation at 0 or 170 ppm (0.12 mg/L) for 6 hours/day, 5 days/week for up to 18 weeks. No adverse effects were observed in animals exposed to ammonia for 6 – 12 weeks. Guinea pigs exposed for 18 weeks displayed mild changes in the spleen, kidney suprarenal glands and livers. No effects on the lungs were observed and the upper respiratory tract was not examined (EPA IRIS: http://cfpub.epa.gov/ncea/iris/index.cfm?fuseaction=iris.showKeywordResults&maxrows=15&startrow=1&textfield=7664-41-7&x=10&y=11&searchtype=irisdata).
NOAEC = 0.12 mg/L/day (highest concentration tested)

(4) Sherman rats were exposed via inhalation to unspecified concentrations of ammonia for 24 hours/day for 4 weeks. No additional study information is provided (ATSDR: http://www.atsdr.cdc.gov/ToxProfiles/tp126.pdf).
LOAEC = 0.018 mg/L/day (based on increased severity of infection by mycoplasma)
NOAEC = Not established

(5) Sherman rats were exposed via inhalation to unspecified concentrations of ammonia for 24 hours/day for 5 – 10 weeks. No additional study information is provided (ATSDR: http://www.atsdr.cdc.gov/ToxProfiles/tp126.pdf
LOAEC = 0.17 mg/L/day (based on nasal lesions and epithelial hyperplasia)
NOAEC = Not established

(6) See human health data for CASRN 7664-41-7 in OECD HPV Ammonia Category at: http://webnet.oecd.org/hpv/UI/SIDS_Details.aspx?Key=fe91d2d5-0d37-4594-969b-bef63b572ebc&idx=0

Hydrogen sulfide (CASRN 7783-06-4, supporting chemical)
(1) A recent (2003) Integrated Risk Information System (IRIS) review by EPA on hydrogen sulfide is available at http://www.epa.gov/iris/toxreviews/0061tr.pdf.

Based on nasal lesions of the olfactory mucosa in an inhalation study in rats, the inhalation reference concentration (RfC) is 0.002 mg/m^3 (~10 ppm).
(2) Sprague-Dawley rats, Fischer rats and B6C3F1 mice (15/sex/dose) were exposed to hydrogen sulfide at concentrations of 0, 10.1, 30.5 or 80.0 ppm for 6 hours/day, 5 days/week for 90 days. A 10-day observation period followed exposure. In addition, control groups (15/sex) were exposed to clean air only and were handled in a similar manner to that of the test animals. Two female control mice and one male (30.5 ppm) died prior to study termination. No mortalities were observed with Fischer or Sprague-Dawley rat studies. Clinical observations included crustiness associated with the animal's ear tag, crusty nose, eyes and muzzle, lacrimation, rales, yellow/brown stained fur and red stained fur. A decrease in body weight gains of all treatment groups of both sexes was noted after the first week of exposure. Body weights of the treated groups continued to lag behind the control group over the next 12 weeks. No significant changes were noted with respect to food consumption, ophthalmology, neurological function, clinical pathology and organ weight. Gross histopathology revealed no lesions that could be attributed to treatment and there no neuropathologic changes were evident.
Mouse LOAEC = 80 ppm/day (based on inflammation of the nasal mucosa)
Mouse NOAEC = 30.5 ppm/day

Rat LOAEC = 80 ppm/day [based on decreased body weight gain in female rats (Fischer 344 and decreased absolute brain weight in males (Sprague-Dawley)]
Rat NOAEC = 30.5 ppm/day

(2) CD-1 male rats (12/dose) were exposed to hydrogen sulfide via inhalation at concentrations of 0, 10, 30 or 80 ppm for 6 hours/day, 7 days/week for 10 weeks. Noses were dissected and nasal cavities were examined for lesions at six cross-sectional levels and graded for severity (0 = normal to 4 = severe). Mild to severe nasal lesions of the olfactory mucosa, consisting of multifocal, bilaterally-symmetrical olfactory neuron loss and basal cell hyperplasia in lining of the dorsal medial meatus and dorsal and medial region of the ethmoid recess were observed in rats exposed to 30 and 80 ppm. There were no treatment related effects observed in rats exposed to 10 ppm (EPA IRIS: http://www.epa.gov/iris/toxreviews/0061tr.pdf).
LOAEC = 30 ppm/day (based on mild to severe nasal lesions of the olfactory mucosa)
NOAEC = 10 ppm/day

Methanethiol (CASRN 74-93-1, supporting chemical)
(1) Sprague-Dawley rats (31/sex/dose) were exposed via inhalation (whole-body) to methanethiol at concentrations of 0, 2, 17 or 57 ppm (approximately 0, 0.004, 0.033 or 0.11 mg/L) for 7 hours/day, 5 days/week for an overall period of 13 weeks. A negative control group not receiving treatment was also included. No mortality was observed in any of the test groups. Clinical signs of toxicity (huddling into groups of five or six with noses pointed outward from the vertical axis of the exposure chamber) was noted at 57 ppm (0.11 mg/L). Average terminal body weights were lower than those of sham controls for all rats in the exposed groups and showed a dose-related trend at 57 ppm (0.11 mg/L). There was no significant change in food intake or wet/dry fecal weight in comparison with controls. Changes were observed in serum components of terminal blood samples from animals of all exposure groups. Some evidence of pathological changes was noted in liver sections from 31 rats each in each dose group. In all cases, there was evidence of inflammatory cells and possibly enlarged bile ducts.
LOAEC = 0.11 mg/L/day (based on clinical signs of toxicity and decreased body weight)
NOAEC= 0.033 mg/L/day

(2) See human health data at: http://webnet.oecd.org/hpv/ui/Search.aspx

Subcategory III: Refinery gases, C1-C4 with carbon monoxide
See data for subcategory I (excepting 1,3-butadiene) above.

The mechanism of toxicity of carbon monoxide poisoning is well studied (ATSDR: http://www.atsdr.cdc.gov/ToxProfiles/tp201.pdf). Carbon monoxide (CO) binds to hemoglobin (Hb), forming carboxyhemoglobin (COHb), and thereby rendering the hemoglobin molecule less able to bind oxygen. Oxygen transportation by the blood and the release of bound oxygen in the tissues are decreased. Tissue damage results from local hypoxia. Organs with a high oxygen requirement, such as the heart and the brain, are especially sensitive to this effect (EPA AEGL: http://www.epa.gov/opptintr/aegl/pubs/carbon_monoxide_final_volume8_2010.pdf)

Fischer 344 rats (12/sex) were exposed to carbon monoxide as a vapor at 135 ppm (~ 0.15 mg/L) for 6 hours/day, 5 days/week for 13 weeks. Animals were examined clinically at weekly intervals and were tested at the end of the exposure period by functional observational battery, grip strength, body weight and temperature and by sensory evoked potentials. Gross pathological observations were made; however, no tissues were examined microscopically. There were no treatment-related effects observed in this study (TSCATS OTS0516701).
NOAEC = 0.15 mg/L/day (highest concentration tested)

Subcategory IV: Refinery gases, C1-C6
Group 1
See data for subcategory I (excepting 1,3-butadiene) above.

Pentane (CASRN 109-66-0)
(1) In a 90-day study, rats were exposed to pentane via inhalation at concentrations ranging from 5 to 20 mg/L. No adverse effects were observed (C5 aliphatic hydrocarbon solvents category - http://webnet.oecd.org/hpv/ui/Search.aspx).
NOAEC = 20 mg/L/day (highest concentration tested)

(2) See human health data for pentane:
http://webnet.oecd.org/hpv/UI/SIDS_Details.aspx?Key=0af02fa3-f3ef-4df9-b050-43116efd8ef1&idx=0 and C5 aliphatic hydrocarbon solvents category - http://webnet.oecd.org/hpv/ui/Search.aspx.

Cyclopentane (CASRN 287-92-3)
(1) In a 28-day inhalation study in rats, hematological changes (decreased erythrocyte count, decreased mean corpuscular hemoglobin and increased mean corpuscular volume) were observed in male rats at 5.3 mg/L (C5 aliphatic hydrocarbon solvents category - http://webnet.oecd.org/hpv/ui/Search.aspx).
LOAEC (males) =5.3 mg/L/day (based on hematological changes)
NOAEC (males) =1.12 mg/L/day
NOAEC (females) =5.3 mg/L/day (highest concentration tested)

(2) In a 90-day inhalation study in rats, no adverse effects were observed up to the highest concentration tested (C5 aliphatic hydrocarbon solvents category - http://webnet.oecd.org/hpv/ui/Search.aspx).
NOAEC = 30 mg/L/day (highest concentration tested)

(3) See human health data at C5 aliphatic hydrocarbon solvents category:
http://webnet.oecd.org/hpv/ui/Search.aspx

2-Butene, 2-methyl- (CASRN 513-35-9)
(1) In a combined repeated-dose/reproductive/developmental toxicity screening test, Sprague-Dawley Crl:CD rats (12 males and 24 females/test concentration) were exposed to 2-methyl-2-butene gas at 0, 580, 2000 or 7000 ppm, 6 hours/day, 7 days/week for at least 28 days. One half of the females were allowed to mate to assess effects of 2-methyl-2-butene on reproduction and development. The other half was evaluated for subchronic effects. Endpoints (for both sexes) included body weight, feed consumption, motor activity, hematology, clinical chemistry, organ weights and macroscopic and microscopic pathology. The mean measured concentrations were 0, 584, 2026 and 7097 ppm. Effects observed at 7097 ppm included decreased body weight gain, longer clotting time, increased cholesterol in females, increased liver weight, mild centrilobular hepatocyte hypertrophy in females, decreased extramedullary hematopoiesis of the spleen and increased goblet cell hyperplasia in the nasal passages of males. At $\geq$ 2026 ppm, effects included increased myocardial inflammatory heart lesions and cortical/medullary tubular basophilia in the kidneys of males and longer clotting time in females. [This study was reported in the TSCA 8(e)/FYI Initial Screen Database (FYI-0105-1485A)]
LOAEC = 2026 ppm/day (based on increased myocardial inflammatory heart lesions and cortical/medullary tubular basophilia in the kidneys of males and longer clotting time in females)
NOAEC = 584 ppm/day

(2) See human health data at: http://www.chem.unep.ch/irptc/sids/OECDSIDS/513359.pdf

Gasoline (CASRN 86290-81-5, supporting chemical)
In a 13-week study, Sprague-Dawley Crl:CD IGS BR rats (10/sex/test concentration) were exposed whole-body to gasoline (API 99-01) as a vapor at nominal concentrations of 0, 2, 10 or 20 mg/L, 6 hours/day, 5 days/week. Mean measured concentrations were 0, 2.1, 10.1 and 20.3 mg/L. Endpoints included body weight, feed consumption, functional observational battery, motor activity, clinical observations, organ weights, histopathology, macroscopic observations, hematology, clinical chemistry, ophthalmoscopy and neuropathology. An increase in red nasal discharge was observed in animals exposed to 20.3 mg/L, which correlated with eosinophilic material within the nasolacrimal duct lumen at terminal sacrifice in treated animals. Renal histopathological changes observed in males at concentrations ≥ 2.1 mg/L consisted of hyaline droplet nephropathy attributable to the accumulation of alpha-2-microglobulin within renal tubular epithelial cells.[9]
NOAEC = 20.3 mg/L/day (based on no adverse effects observed at the highest dose tested)

Unleaded gasoline (no CASRN, supporting chemical)
(1) Paraffins + Naphthenes: 61.7% (units not specified), Olefins: 8.2%, Aromatics: 30.1%
Sprague-Dawley rats (20/sex/dose) were exposed whole-body to unleaded gasoline as a vapor at nominal concentrations of 0, 400 or 1500 ppm (~ 0, 1.6 or 5.9 mg/L)[10], 6 hours/day, 5 days/week for 13 weeks. Mean measured concentrations were 0, 384 and 1552 ppm (0, 1.57 and 6.35 mg/L). Endpoints measured in the control and high-dose animals included hematology and histopathology. Endpoints measured at all doses included urinalysis and organ weights. No treatment-related mortality was observed. Increases were observed in thrombocytes in males and in reticulocytes in females at 6.35 mg/L. An increase in absolute liver weight was observed at 1.57 mg/L. Decreases in relative adrenal (females only) and brain (males only) weights were observed at 6.35 and ≥ 1.57 mg/L, respectively. No evidence of treatment-related histopathology was observed, with the exception of kidney lesions in males at all doses, which were characterized by subtle, but discernible increases in the incidence and severity of regenerative epithelium and dilated tubules. The latter were seen to contain protein in their lumens.
LOAEC ~ 1.57 mg/L/day (based on decrease in brain weight in males)
NOAEC ~ Not established

(2) Paraffins + Naphthenes: 61.7% (units not specified), Olefins: 8.2%, Aromatics: 30.1%
Squirrel monkeys (4/sex/dose) were exposed whole-body to unleaded gasoline as a vapor at nominal concentrations of 0, 400 or 1500 ppm (~ 0, 1.6 or 5.9 mg/L)[11], 6 hours/day, 5 days/week for 13 weeks. Mean measured concentrations were 0, 384 and 1552 ppm (0, 1.57 and 6.35 mg/L). Endpoints measured in the control and high-dose animals included hematology, central nervous system evaluation, pulmonary function and histopathology. Endpoints measured at all doses included urinalysis and organ weights. No treatment-related mortality was observed. One female exhibited emesis at 6.35 mg/L after 13 days of exposure. Decreases in respiratory rate

[9] Nephropathy seen in male rats may be occurring by an alpha 2µ-globulin-mediated mechanism (which is male rat-specific and not considered relevant to humans). EPA's Risk Assessment Forum has outlined key events and data that are necessary to demonstrate this mode of action (Alpha 2µ-Globulin: Association with Chemically Induced Renal Toxicity and Neoplasia in the Rat, EPA/625/3-91/019F).
[10] Units were converted from ppm to mg/L using the molecular weight of 96.2 g/mole provided by the sponsor for unleaded gasoline sample API 99-01.
[11] Units were converted from ppm to mg/L using the molecular weight of 96.2 g/mole provided by the sponsor for unleaded gasoline sample API 99-01.

(males only) and tidal volume (females only) and an increase in minute volume (males only) were observed at 6.35 mg/L. An increase in absolute thyroid weight was observed in males at concentrations ≥ 1.57 mg/L. A decrease in relative kidney weight was observed in males at 1.57 mg/L. No evidence of treatment-related histopathology was observed.
LOAEL ~ 6.35 mg/L (based on reduced respiratory rate in males, reduced tidal volume in females and elevated minute volume in males)
NOAEL ~ 1.57 mg/L

(3) Paraffins + Naphthenes: 45% (units not specified), Olefins: 12%, Aromatics: 43%
Sprague-Dawley rats (10/sex/dose) were exposed whole-body to an unleaded gasoline blend as a vapor at 0, 0.15, 1.44 or 14.7 mg/L, 6 hours/day, 5 days/week for 90 days. General toxicity and kidney effects were evaluated. No treatment-related mortalities were noted. Irreversible tubular dilatation and necrosis at the corticomedullary junction were observed in male rats at all dose levels, with dose-related severity. No effects were observed in females.
LOAEL (male) = 0.15 mg/L (based on nephropathy)
NOAEL (male) = Not established
NOAEL (female) = 14.7 mg/L (based on no effects at the highest dose tested)

Leaded gasoline (No CASRN, supporting chemical)
(1) Paraffins + Naphthenes: 64.8% (units not specified), Olefins: 7.8%, Aromatics: 27.4%
Sprague-Dawley rats (20/sex/dose) were exposed whole-body to leaded gasoline as a vapor at nominal concentrations of 0, 100 or 400 ppm (~ 0, 0.4 or 1.6 mg/L),[12] 6 hours/day, 5 days/week for 13 weeks. Mean measured concentrations were 0, 0.42 and 1.53 mg/L. Endpoints measured in the control and high-dose animals included hematology and histopathology. Endpoints measured at all doses included urinalysis and organ weights. No treatment-related mortality was observed. Hematological changes at 1.53 mg/L included a decrease in mean corpuscular hemoglobin concentration in males, increases in hematocrit and mean corpuscular volume in females and a decrease in WBC count in females. Decreases in absolute and relative liver weights were observed in females at 1.53 mg/L. Increases in absolute liver and kidney weights were observed at 0.42 mg/L in males and females, respectively. Decreased relative heart weight was observed in males at ≥ 0.42 mg/L. No evidence of treatment-related histopathology was observed, with the exception of kidney lesions in males at all doses, which were characterized by subtle, but discernible increases in the incidence and severity of regenerative epithelium and dilated tubules. Affected tubules contained protein in their lumens (HPV submission for Gasoline Blending streams: http://www.epa.gov/oppt/chemrtk/pubs/summaries/gasnecat/c13409tc.htm).
LOAEC ~ 1.53 mg/L (based on decreased mean corpuscular hemoglobin concentration in males, increased hematocrit and mean corpuscular volume in females and decreased WBC count in females)
NOAEC ~ 0.42 mg/L

(2) Paraffins + Naphthenes: 64.8% (units not specified), Olefins: 7.8%, Aromatics: 27.4%

[12] Units were converted from ppm to mg/L using the molecular weight of 96.2 g/mole provided by the sponsor for unleaded gasoline sample API 99-01.

Squirrel monkeys (4/sex/dose) were exposed whole-body to leaded gasoline as a vapor at nominal concentrations of 0, 100 or 400 ppm (~ 0, 0.4 or 1.6 mg/L),[13] 6 hours/day, 5 days/week for 13 weeks. Mean measured concentrations were 0, 0.42 and 1.53 mg/L. Endpoints measured in the control and high-dose animals included hematology, central nervous system evaluation, pulmonary function and histopathology. Endpoints measured at all doses included urinalysis and organ weights. No treatment-related mortality was observed. One female exhibited emesis after 17 days of exposure at 1.53 mg/L. An increase in minute volume was observed in males at 1.53 mg/L. A decrease in absolute kidney weight was observed in males at 1.53 mg/L. No evidence of treatment-related histopathology was observed (HPV submission for Gasoline Blending streams: http://www.epa.gov/oppt/chemrtk/pubs/summaries/gasnecat/c13409tc.htm).
LOAEC (male) ~ 1.53 mg/L (based on an increase in minute volume)
NOAEC (male) ~ 0.42 mg/L
NOAEC (female) ~ 1.53 mg/L (based on no observed systemic effects at the highest concentration tested)

Naphtha (petroleum), light catalytic cracked (CASRN 64741-55-5)
(1) Paraffins: 43.6% (w/w), Olefins: 22.7%, Naphthenes: 9.7%, Aromatics: 24.0%
Sprague-Dawley rats (15/sex/dose) were administered naphtha (petroleum), light catalytic cracked (MEHSL CRU #84152) via the dermal route at 0, 30, 125 or 300 mg/kg-bw/day under open conditions, 5 days/week for 90 days. There were no treatment-related effects on mortality, body weight, hematologic parameters or any indication of systemic toxicity at any dose level. No organs were directly affected as determined by serum chemistry, clinical observations, organ weights, gross necropsy or microscopic evaluation of organ structures. There were no differences seen in sperm morphology. Moderate erythema and slight edema was observed in males at all dose groups. Histopathological examination revealed mild to moderate epidermal hyperplasia, mild inflammation of the superficial dermis and ulceration in all dose groups (HPV Challenge submission for gasoline blending streams: http://www.epa.gov/oppt/chemrtk/pubs/summaries/gasnecat/c13409tc.htm).
NOAEL = 300 mg/kg-bw/day (based on no systemic effects observed at the highest dose tested)

(2) Paraffins: 37.7% (v/v), Olefins: 53.7%, Naphthenes: 4.3%, Aromatics: 4.4%
Sprague-Dawley rats (16/sex/dose) were exposed whole-body to a distillate of naphtha (petroleum), light catalytic cracked distillate (LCCN-D) as a vapor at nominal concentrations of 0, 2.3, 7.7 and 23.4 mg/L, 6 hours/day, 5 days/week for 15 weeks and observed for 4 weeks after the exposure ended. Mean measured concentrations were within 0.8% of nominal concentrations. Endpoints included clinical signs, body weight, food consumption, hematology, clinical chemistry, organ weights, histopathology, neurobehavior and ophthalmoscopy. Body weight gain was lower in females at 23.4 mg/L. During the recovery period, the high-dose males and females exhibited greater food consumption than controls. Decreases in hematocrit and hemoglobin concentration were observed in males at 23.4 mg/L. Reductions in mean corpuscular hemoglobin concentration were observed in males at 7.7 mg/L and in females at 23.4 mg/L. Increases were observed in absolute kidney weight (males only), relative kidney weight (females only) and relative liver weight (both sexes) at 23.4 mg/L. Elevated relative kidney weights were observed in males at $\geq$ 7.7 mg/L. A dose-related increase in nasal mucosa

[13] Units were converted from ppm to mg/L using the molecular weight of 96.2 g/mole provided by the sponsor for unleaded gasoline sample API 99-01.

hyperplasia, indicative of exposure to a mild irritant, was observed (dose spread not reported). An increase in hyaline droplet accumulation was observed in treated males at all doses (protein measurement unspecified but assumed).[13] Renal inflammation and tubular dilatation were observed in males at ≥ 7.7 mg/L. No other treatment-related effects were observed (HPV Challenge submission for gasoline blending streams: http://www.epa.gov/oppt/chemrtk/pubs/summaries/gasnecat/c13409tc.htm).
LOAEC (males) = 7.7 mg/L/day (increases in relative kidney weight, renal inflammation and tubular dilatation)
NOAEC (males) = 2.3 mg/L/day
LOAEC (females) = 23.4 mg/L/day (based on reductions in mean corpuscular hemoglobin concentration)
NOAEC (females) = 7.7 mg/L/day

(3) Paraffins: 33.2% (v/v), Olefins: 40.0%, Naphthenes: 10.1%, Aromatics: 16.8%
CD-1 mice (10/sex/dose) were exposed whole-body to naphtha (petroleum), light catalytic cracked (LCCN) as a vapor at nominal concentrations of 0, 0.5, 2 and 8 mg/L, 6 hours/day, 5 days/week for 13 weeks. Mean measured concentrations were 0, 0.53, 2.06 and 7.69 mg/L. Endpoints included clinical signs, body weight, hematology, clinical chemistry, organ weights and histopathology. No treatment-related effects were observed (HPV Challenge submission for gasoline blending streams: http://www.epa.gov/oppt/chemrtk/pubs/summaries/gasnecat/c13409tc.htm).
NOAEC = 7.69 mg/L/day (based on no effects observed at the hdt)

(4) Paraffins: 33.2% (v/v), Olefins: 40.0%, Naphthenes: 10.1%, Aromatics: 16.8%
Sprague-Dawley rats (10/sex/dose) were exposed whole-body to naphtha (petroleum), light catalytic cracked (LCCN) as a vapor at nominal concentrations of 0.5, 2 and 8 mg/L, 6 hours/day, 5 days/week for 13 weeks. Sham controls were included, but no specific details reagarding the sham controls were located in the robust summary for this study. Mean measured concentrations were 0.53, 2.06 and 7.69 mg/L. Endpoints included clinical signs, body weight, hematology, clinical chemistry, organ weights and histopathology. Lesions on the skin in the scrotal area were observed in four male rats in the high-dose group. Uterine weights were less than untreated controls at all exposure levels, but not less than the sham controls, and the difference was not dose-related. The number of sperm per gram of cauda epididymis was lower at 7.69 mg/L, compared to the sham controls, but not the untreated controls. No other effects were observed. The decreases in sperm number compared to sham controls were not considered to be treatment-related given the lack of effects on sperm number compared with untreated controls (HPV Challenge submission for gasoline blending streams: http://www.epa.gov/oppt/chemrtk/pubs/summaries/gasnecat/c13409tc.htm).

[13] The presence of nephropathy in association with the hyaline droplet accumulation in male rats suggests that the nephropathy in the males may be occurring by an $alpha_{2u}$-globulin-mediated mechanism, which appears to be unique to male rats and the response is probably not relevant to humans for purposes of risk assessment. EPA's Risk Assessment Forum has outlined the key events and the data that are necessary to demonstrate this mode of action ($Alpha_{2u}$-Globulin: Association with Chemically Induced Renal Toxicity and Neoplasia in the Rat, EPA/625/3-91/019F). One of the key events, $alpha_{2u}$-globulin accumulation, has not been demonstrated. Therefore, the nephropathy is assumed to be relevant to human health and it is concluded that a NOAEL for nephropathy in male rats was not established.

NOAEC (males/females) = 7.69 mg/L/day (based on no effects at the hdt)

(5) Paraffins: 42.8% (v/v), Olefins: 36.5%, Naphthenes: 10.2%, Aromatics: 10.2%
Sprague-Dawley rats (20/sex/dose) were exposed whole-body to naphtha (petroleum), light catalytic cracked (API 81-03) as a vapor at 0, 5.5, 9.5 and 16.4 mg/L, 6 hours/day, 5 days/week for 13 weeks. Endpoints included clinical signs, body weight, hematology, clinical chemistry, urinalysis, organ weights and histopathology. No mortalities were observed. Exposure-related redness with "red material" around the nose was observed at 16.4 mg/L. Body weights of males at 16.4 mg/L were lower than those of controls. Increased kidney weights (relative or absolute unspecified) were observed in treated males at all dose levels (dose-response not indicated), accompanied by histopathological changes in the renal tubules consistent with light hydrocarbon-induced nephropathy (male-rat specific). Liver weights (relative or absolute unspecified) were increased in males at ≥ 9.5 mg/L and in females at 16.4 mg/L, accompanied by centrilobular hepatocellular hypertrophy, which was compatible with non-specific hepatic enzyme induction (HPV Challenge submission for gasoline blending streams: http://www.epa.gov/oppt/chemrtk/pubs/summaries/gasnecat/c13409tc.htm).
LOAEC (males) = 9.5 mg/L/day (based on increased liver weights and centrilobular hepatocellular hypertrophy)
NOAEC (males) = 5.5 mg/L/day
LOAEC (females) = 16.4 mg/L/day (based on increased liver weights and centrilobular hepatocellular hypertrophy)
NOAEC (females) = 9.5 mg/L/day

Group 2
See data for subcategory I and Group 1 above.

Group 3
See data for Groups 1 and 2 above.

Benzene (CASRN 71-43-2, supporting chemical)
(1) A recent (2002) Integrated Risk Information System (IRIS) review by EPA on benzene is available at http://www.epa.gov/iris/subst/0276.htm.

Based on occupational studies in which decreased lymphocyte counts were observed, the oral reference dose (RfD) is 0.0004 mg/kg/day and the inhalation reference concentration (RfC) is 0.03 mg/m^3 (~0.00003 mg/L).

(2) In a 10-week study, CD-1 mice (11 – 12 males/test concentration) were exposed to benzene via inhalation at 0 or 9.6 ppm (0 or 0.03 mg/L), 6 hours/day, 5 days/week. Hematological parameters were evaluated at the end of exposure. No mortality was observed. Increases were observed in spleen weight, total nucleated cells per spleen and nucleated red blood cells (RBCs) at 0.03 mg/L.
LOAEC ~ 0.03 mg/L/day (based on increases in spleen weight, total nucleated cells per spleen and nucleated RBCs)
NOAEC = Not established

(3) In a 13-week study, CD-1 mice (40/sex/test concentration) were exposed whole-body to benzene as a vapor at 0, 1, 10, 30 or 300 ppm (approximately 0, 0.003, 0.03, 0.10 or 0.96 mg/L), 6 hours/day, 5 days/week. Endpoints included behavior, body weights, organ weights, clinical pathology, gross pathology, histopathology, hematology and clinical chemistry. At ~0.96 mg/L, hematological effects included decreases in RBC counts, WBC counts, platelets, hemoglobin, myeloid/erythroid ratios and hematocrit. Other effects at ~0.96 mg/L included femoral myeloid hypoplasia, extramedullary hemotopoiesis in the spleen, thymic atrophy, decreases in absolute and relative testis weights, minimal to moderately severe bilateral atrophy/degeneration of testes, moderate to moderately severe decreases in spermatozoa and a minimal to moderate increase in abnormal sperm morphology. Bilateral ovarian cysts were observed in four females at 0.96 mg/L. Histopathological changes were also observed in mesenteric and mandibular lymph nodes, as well as in the liver at ~0.96 mg/L.
LOAEC ~ 0.96 mg/L/day (based on decreases in RBC counts, WBC counts, platelets, hemoglobin, myeloid/erythroid ratios and hematocrit, femoral myeloid hypoplasia, extramedullary hemotopoiesis in the spleen, thymic atrophy, decreases in absolute and relative testis weights, minimal to moderately severe bilateral atrophy/degeneration of testes, moderate to moderately severe decreases in spermatozoa, a minimal to moderate increase in abnormal sperm morphology, bilateral ovarian cysts and unspecified histopathological changes in the liver and mesenteric and mandibular lymph nodes)
NOAEC ~ 0.10 mg/L/day

(4) Several studies are described in the OECD SIDS documents at: http://ecb.jrc.ec.europa.eu/DOCUMENTS/Existing-Chemicals/RISK_ASSESSMENT/REPORT/benzenereport063.pdf.

Subcategories V to XI
See appropriate data in subcategories I to IV.

Reproductive Toxicity

Subcategory I: Refinery gases, C1 – C4
Group 1

Ethane (CASRN 74-84-0, supporting chemical)
In the combined repeated-dose/reproductive/developmental toxicity screening test described previously, Sprague-Dawley CD female rats (12/test concentration) were exposed to up to 15,502 ppm ethane as a gas for 2 weeks prior to mating, during mating and on gestation days 0 – 19. Males were exposed during mating and post-mating periods for at least 28 days. The dams were allowed to deliver their litters, which were retained until lactation day 4. Reproductive endpoints included mating success, time to mating, number of females pregnant, male fertility, gestation duration, numbers of corpora lutea and implantation sites, number of stillborn pups, number of pups delivered and pup sex ratio. No effects were observed on reproductive organs or any reproductive parameter.
NOAEC (reproductive toxicity) = 15,502 ppm/day (highest concentration tested)

Propane (CASRN 74-98-6, supporting chemical)
In the combined repeated-dose/reproductive/developmental toxicity screening test described previously, Sprague-Dawley CD female rats (12/dose) were exposed to 12,168 ppm propane gas for 2 weeks prior to mating, during mating and on gestation days 0 – 19. Males were exposed during mating and post-mating periods for at least 28 days. The dams were allowed to deliver their litters, which were retained until lactation day 4. Reproductive endpoints included mating success, time to mating, number of females pregnant, male fertility, gestation duration, numbers of corpora lutea and implantation sites, number of stillborn pups, number of pups delivered and pup sex ratio. A statistically significant decrease in the number of live born pups, in combination with an increase in the number of stillborn pups, was observed at concentrations ≥ 3990 ppm. These effects were attributable to the loss of a single total litter at each of the two highest doses (3990 and 12,168 ppm); the losses were preceded by severely reduced body weight gain in the last week of gestation for two particular dams.
LOAEC (reproductive toxicity) = 3990 ppm/day (based on a decrease in the number of live pups and increase in the number of stillborn pups)
NOAEC (reproductive toxicity) = 1230 ppm/day

Propane, 2-methyl- (CASRN 75-28-5, supporting chemical)
In the combined repeated-dose/reproductive/developmental toxicity screening test described previously, Sprague-Dawley CD female rats (12/concentration) were exposed to up to 9148 ppm 2-Methylpropane gas for 2 weeks prior to mating, during mating and on gestation days 0 – 19. Males were exposed during mating and post-mating periods for at least 28 days. The dams were allowed to deliver their litters, which were retained until lactation day 4. Reproductive endpoints included mating success, time to mating, number of females pregnant, gestation duration, number of stillborn pups, pre- and post-implantation loss, number of pups delivered and pup sex ratio. At 9148 ppm, the fertility index (percent of mated females that became pregnant) was reduced by 25% compared to the control. An increase in post-implantation loss was also observed at 9148 ppm.
LOAEC (reproductive toxicity) = 9148 ppm/day (based on a reduction in fertility index and an increase in post-implantation loss)
NOAEC (reproductive toxicity) = 3122 ppm/day

Butane (CASRN 106-97-8, supporting chemical)
In the combined repeated-dose/reproductive/developmental toxicity screening test described previously, Sprague-Dawley CD female rats (12/concentration) were exposed to up to 9157 ppm butane gas for 2 weeks prior to mating, during mating and on gestation days 0 – 19. Males were exposed during mating and post-mating periods for at least 28 days. The dams were allowed to deliver their litters, which were retained until lactation day 4. Reproductive endpoints included mating success, time to mating, number of females pregnant, male fertility, gestation duration, numbers of corpora lutea and implantation sites, number of stillborn pups, number of pups delivered and pup sex ratio. No treatment-related effects were observed on reproductive organs or any reproductive parameter.
NOAEC (reproductive toxicity) = 9157 ppm/day (highest concentration tested)

1-Butene (CASRN 106-98-9, supporting chemical)
In the combined inhalation repeated-exposure/reproductive/developmental toxicity study in rats, described previously, no mortality or treatment related changes in body weights or feed consumption were observed. No treatment-related effects were observed on any of the reproductive parameters that were evaluated, including mating, conception and fertility, time to mating, gestation length, and litter size, as well as offspring gestation and postnatal survival, postnatal survival, pre- and post-implantation loss, pup body weight and pup sex ratio (Low 1,3-butadiene category HPV submission: http://www.epa.gov/chemrtk/pubs/summaries/lowbutd/c13122tc.htm).
NOAEC (reproductive toxicity) = 8000 ppm/day (highest concentration tested)

2-Butene (CASRN 107-01-7, supporting chemical)
(1) In the combined repeated-dose/reproductive/developmental inhalation toxicity screening study in Wistar rats described previously, reproductive endpoints included mating success, time to mate, fecundity index, gestation duration, litter size, number of pups per sex, number of stillbirths, pup malformations, pup body weight, number of implantation sites and corpora lutea and reproductive organ weights and histopathology. No treatment-related reproductive effects were observed up to 5009 ppm.
NOAEC (reproductive toxicity) = 5009 ppm/day (highest concentration tested)

(2) See human health data at: http://webnet.oecd.org/hpv/UI/handler.axd?id=db117c7c-460a-4361-8a85-507f4da63012.
NOAEC (reproductive toxicity) = 5000 ppm/day (highest concentration tested)

Ethylene (CASRN 74-85-1, supporting chemical)
(1) In a combined reproductive/developmental toxicity screening test [OECD TG 421], rats (10/sex/dose, strain not specified) were exposed head-only to ethylene via inhalation at 0, 200, 1000 or 5000 ppm for 6 hours/day. Males received ethylene for 2 weeks prior to mating and during the mating period for at least 28 days. Exposure of females continued until day 20 of gestation; the females were allowed to litter and rear their offspring until day 4 post-partum. Parental endpoints included mortality, clinical condition, body weight, food intake and histopathology of ovaries, testes and epididymides. Reproductive endpoints included litter size, pup sex ratio, pup weight and clinical condition. No adverse effects were observed (http://www.chem.unep.ch/irptc/sids/OECDSIDS/74851.pdf).
NOAEC (reproductive toxicity) = 5000 ppm/day (highest concentration tested)

(2) See human health data at: http://www.chem.unep.ch/irptc/sids/OECDSIDS/74851.pdf

1-Propene, 2-methyl- (CASRN 115-11-7, supporting chemical)
(1) No specific reproductive toxicity study is available. However, in the 14-week inhalation repeated-dose NTP study described previously, male Fischer 344 rats exposed to 1-propene, 2-methyl at 8000 ppm exhibited a decrease in sperm motility (NTP Technical Report No. 487).

(2) See human health data at: http://www.chem.unep.ch/irptc/sids/OECDSIDS/115117.pdf and http://webnet.oecd.org/hpv/UI/handler.axd?id=db117c7c-460a-4361-8a85-507f4da63012.

Group 2
See data for Group 1

1,3-Butadiene (CASRN 106-99-0, supporting chemical)
(1) A recent (2002) Integrated Risk Information System (IRIS) review by EPA on 1,3-butadiene is available at http://www.epa.gov/ncea/iris/subst/0139.htm.

The most sensitive reproductive endpoint observed in subchronic studies with 1,3-butadiene was fetal deaths in dominant lethal studies in mice exposed for 28-days at 65 ppm (see *Other* section for details); the NOAEC was 12.5 ppm. In two-year bioassays, the most sensitive reproductive effects were ovarian atrophy in female mice at 6.25 ppm and testicular atrophy in male mice at 625 ppm. The NOAEC for reproductive toxicity in female mice was not established and in male mice was 200 ppm (see *Carcinogenicity* section for details).

(2) In a combined reproductive/developmental toxicity screening test (OECD TG 421), Sprague-Dawley rats (12/sex/concentration) were exposed whole-body to 1,3-butadiene as a vapor at 0, 300, 1500 or 6000 ppm (approximately 0, 0.66, 3.3 or 13.3 mg/L) for 6 hours/day. Animals of both sexes were exposed for 2 weeks prior to mating and 2 weeks during mating. Males continued to be exposed after mating for a total of 70 days. Females were exposed on gestation days 0 – 19 and postnatal days 5 – 18. After weaning on postnatal day 21, one male and one female from each litter were exposed for 7 days to the same concentration of 1,3-butadiene as its dam. Beginning on postnatal day 28, previously unexposed weanlings (1/sex/litter) were exposed for 7 days to the same concentration of 1,3-butadiene as their dams. Reproductive endpoints included assessments of gonadal function, mating behavior, conception, gestation and parturition (details not specified). Reductions in body weight parameters (details not specified) were observed in the parental generation and offspring at concentrations $\geq$ 3.3 mg/L. Transient reductions in food consumption were observed in the parental generation during the first week of exposure. Clinical signs at 13.3 mg/L included chromodacryorrhea, chromorhinorrhea and salivation in the parental generation and infrequent occurrences of dried red material in the perioral and perinasal regions of four exposed pups. No reproductive effects were observed. **NOAEC (reproductive toxicity) ~ 13.3 mg/L/day** (highest concentration tested)

(3) See human health data at: http://ecb.jrc.ec.europa.eu/DOCUMENTS/Existing-Chemicals/RISK_ASSESSMENT/REPORT/butadienereport019.pdf

Subcategory II: Refinery gases, C1 – C4 with ammonia and hydrogen sulfide
See data for subcategory I (excepting 1,3 butadiene) above.

Ammonia (CASRN 7664-41-7, supporting chemical)
No specific reproductive toxicity studies are available. However, no effects on the reproductive organs were observed in repeated-dose studies of 90-days or longer in several species.
See EPA IRIS (http://www.epa.gov/iris/subst/0422.htm) and human health data for CASRN 7664-41-7 in OECD HPV Ammonia Category at:
http://webnet.oecd.org/hpv/UI/SIDS_Details.aspx?Key=fe91d2d5-0d37-4594-969b-bef63b572ebc&idx=0

Hydrogen sulfide (CASRN 7783-06-4, supporting chemical)
In a combined reproductive/developmental toxicity study, male and female Sprague-Dawley rats (12 /sex/dose) were exposed to hydrogen sulfide at concentrations of 0, 10, 30 or 80 ppm for 6 hours/day, 7 days/week for 2 weeks prior to breeding and during mating and from gestation day 0 through gestation day 19. No mortalities and no adverse physical signs were observed in F0 male and female rats during the study. A decrease in feed consumption was observed in F0 male rats from the 80 ppm exposure group during the first week. There were no effects on reproductive performance of the F0 rats as assessed by the number of females with live pups, litter size, average length of gestation and the average number of implants per pregnant female. Exposure did not affect pup growth, development or performance of any of the behavioral tests.
NOAEC (reproductive toxicity) = 80 ppm/day (highest concentration tested)

Subcategory III: Refinery gases, C1 – C4 with carbon monoxide
See data for subcategory I above (excepting data for 1,3-butadiene)

Carbon monoxide (CASRN 630-08-0, supporting chemical)
No specific reproductive toxicity studies are available. However, no effects on the reproductive organs were observed in repeated-dose studies of 90-days duration in rats.

Subcategory IV: Refinery gases, C1 – C6
Group 1
See also data for subcategory I (excepting 1,3 butadiene) above.

Pentane (CASRN 109-66-0, supporting chemical)
No specific reproductive toxicity study is available. However, in the 90-day inhalation repeated-dose inhalation study with rats described previously, no effects on the reproductive organs were observed: http://webnet.oecd.org/hpv/UI/SIDS_Details.aspx?Key=0af02fa3-f3ef-4df9-b050-43116efd8ef1&idx=0 and C5 aliphatic hydrocarbon solvents category - http://webnet.oecd.org/hpv/ui/Search.aspx).

Cyclopentane (CASRN 287-92-3, supporting chemical)
In the OECD HPV program, the reproductive toxicity endpoint for cyclopentane was addressed using data from a 2-generation reproductive toxicity study in rats with cyclohexane (CASRN 110-82-7: http://webnet.oecd.org/hpv/UI/SIDS_Details.aspx?Key=8e1c6169-bdfd-49e5-872c-f721963cb2d8&idx=0 and C5 aliphatic hydrocarbon solvents category - http://webnet.oecd.org/hpv/ui/Search.aspx). No effects on reproductive parameters were observed up to the highest concentration tested.
NOAEC (reproductive toxicity) ~ 24.1 mg/L/day (highest concentration tested).

2-Butene, 2-methyl- (CASRN 513-35-9, supporting chemical)
(1) In the combined repeated-dose/reproductive/developmental toxicity screening test described previously, Sprague-Dawley Crl:CD female rats (12/concentration) were exposed to up to 7097 ppm 2-methyl-2-butene gas for 2 weeks prior to mating, during mating and on gestation days 0 – 19. The dams were allowed to deliver their litters, which were retained until lactation day 4. Males were exposed simultaneously. Reproductive endpoints included estrus cycles, mating

performance, fertility indices, gestation length, organ weights, macroscopic pathology, number of live and dead offspring, pup weight and sex ratio. There were no effects observed on any of the reproductive parameters. [This study was reported in the TSCA 8(e)/FYI Initial Screen Database (FYI-0105-1485A)].
NOAEC (reproductive toxicity) = 7097 ppm/day (highest concentration tested)

(2) See human health data at: http://www.chem.unep.ch/irptc/sids/OECDSIDS/513359.pdf

Gasoline (CASRN 86290-81-5, supporting chemical)
In a 2-generation reproductive toxicity study, Sprague-Dawley Crl:CD IGS BR rats (26/sex/test concentration) were exposed whole-body to gasoline (API 99-01) as a vapor at nominal concentrations of 0, 2, 10 or 20 mg/L, 6 hours/day, 7 days/week. Each of the two generations was exposed for 10 weeks prior to mating, 2 weeks during mating, 3 weeks during gestation and 4 weeks during lactation, with the exception of the time between gestation day 19 and lactation day 5 for females. Mean measured concentrations were 0, 20.1, 10.1 and 20.0 mg/L. Endpoints included physical observations, body weights, feed consumption, organ weights, histopathology and neuropathology. Reproductive organs evaluated included ovaries, uterus, testes, seminal vesicles, prostate and epididymides. Sperm evaluations included motility, sperm count and morphology. Ovary histopathology included evaluation of the primordial follicle population, number of growing follicles and corpora lutea. Reproductive endpoints included number of live and dead pups per litter, sex ratio, pup weight, abnormalities, viability (4-day survival), survival through lactation (day 28) and organ weights of pups. Decreases in body weight gain were observed at 20.0 mg/L in the first parental generation (P0) females during the last 3 weeks of the pre-mating period and in the first filial generation (F1) males during the initial 8 weeks of the pre-mating period. Significant increases in kidney weights (absolute and relative) were observed at concentrations ≥ 10.1 mg/L in P0 and F1 males and at 20.0 mg/L in P0 females. Hyaline droplet nephropathy was observed only in males at 20.0 mg/L. No evidence of neuropathology was observed. No adverse effects were observed on any reproductive parameter.
LOAEC (parental toxicity) = 20.0 mg/L/day (based on decreases in body weight gain in both sexes)
NOAEC (parental toxicity) = 10.1 mg/L/day
NOAEC (reproductive toxicity) = 20.0 mg/L/day (highest concentration tested)

Unleaded gasoline (no CASRN, supporting chemical)
(1) Paraffins: 48.7% (v/v), Olefins: 9.0%, Naphthenes: 6.3%, Aromatics: 36.0%
In a two-generation study, Sprague-Dawley rats (26/sex/dose) were exposed whole-body to unleaded gasoline (API 99-01) vapor condensate at nominal concentrations of 0, 2, 10 or 20 mg/L as a vapor for 6 hours/day, 7 days/week for 10 weeks prior to mating, 2 weeks during mating, 3 weeks during gestation and 4 weeks during lactation. Exposure was suspended on gestation day 19 and resumed on lactation day 5. Mean measured concentrations were 0, 2.01, 10.1 and 20 mg/L. No treatment-related mortalities were observed. Decreases were observed in body weight gain in P0 females and F1 males at 20 mg/L. No effects were observed on the following parameters in adults: clinical condition, feed consumption, estrous cycle data, mating, fertility and gestation indices, pregnancy rate, gestation duration, primordial and growing follicle counts and sperm motility, count and morphology. An increase in kidney weight was observed in P0 and F1 males at ≥ 10.1 mg/L and in P0 females at 20 mg/L. Males exhibited hyaline

droplet nephropathy1at 20 mg/L. There were no effects observed on the number of pups delivered, number of pups dying, number of implantation sites per litter, sex ratio and number of live pups per litter. There were no exposure-related differences in measured parameters in pups, including body weight and body weight gain, macroscopic postmortem evaluations, viability and lactation survival indices, organ weights or neuropathological findings.
NOAEC (reproductive toxicity) = 20 mg/L/day (based on no effects observed at the highest concentration tested)

(2) PONA (Paraffinic, Olefinic, Naphthenic and Aromatic) composition not specified
In a two-generation study, Sprague-Dawley rats (30/sex/dose) were exposed via inhalation to unleaded gasoline vapor condensate (~ 98.8% C3 – C8 non-aromatic hydrocarbons and ~ 1.4% aromatic hydrocarbons) at nominal concentrations of 0, 5, 10 or 20 mg/L for 6 hours/day, 7 days/week for 10 (P0) or 13 (F1) weeks prior to mating, 3 weeks during mating, during gestation until day 20 and resuming on postpartum day 5. Mean measured concentrations were 0, 5.08, 10.3 and 20.2 mg/L. No treatment-related mortality was observed. Increases were observed in liver, kidney and testis weights in males and lung weights in females (doses not specified), but no dose-response relationship was observed. Relative kidney weights in males were elevated at 20.2 mg/L in the F1 generation. Hyaline droplets were observed in the kidneys of males at 20.2 mg/L. No treatment-related effects were observed on clinical condition, body weight of pups and adults, food consumption, mating index, fecundity, fertility index, length of gestation, litter size, live birth index, numbers of live and dead pups, sex ratio, pup survival, pup body weight gain, sperm count, motility and morphology, estrous cycle data, number of corpora lutea and pup maturation rate.
NOAEC (reproductive toxicity) = 20.2 mg/L/day (based on no effects observed at the highest dose tested)

Naphtha (petroleum), light catalytic cracked (CASRN 64741-55-5)
(1) Paraffins: 37.7% (v/v), Olefins: 53.7%, Naphthenes: 4.3%, Aromatics: 4.4%
In a combined reproductive/developmental toxicity screening test, Sprague-Dawley rats (10/sex/dose) were exposed whole-body to a distillate of naphtha (petroleum), light catalytic cracked (LCCN-D) at nominal concentrations of 0, 750, 2500 or 7500 ppm (~ 0, 2.4, 7.9 and 23.8 mg/L) as a vapor, 6 hours/day, 7 days/week for 30 – 47 days, starting 14 days prior to mating and extending through gestation day 19. Dams and their litters were sacrificed on postpartum day 4. Mean measured concentrations were 0, 752, 2512 and 7518 ppm (0, 2.4, 8.0 and 23.9 mg/L). No treatment-related mortalities were observed. Red staining of the snout was observed at concentrations ≥ 8.0 mg/L. At 23.9 mg/L, organ weight changes included increases in absolute and relative kidney weights and relative liver weights in males and increases in absolute and relative spleen weights in females. Hyaline droplet formation and dilatation of tubules in the cortico-medullary junction were observed in males at 23.9 mg/L.[14] There were no effects on parental body weight, food consumption, histology (including testes, epididymides and ovaries), fertility index, live birth index, number of litters, numbers of live and dead pups, number of implantation sites, pup viability, sex ratio and pup body weight.

[14] Nephropathy seen in male rats may be occurring by an alpha 2µ-globulin-mediated mechanism (which is male rat-specific and not considered relevant to humans). EPA's Risk Assessment Forum has outlined key events and data that are necessary to demonstrate this mode of action (Alpha 2µ-Globulin: Association with Chemically Induced Renal Toxicity and Neoplasia in the Rat, EPA/625/3-91/019F).

NOAEC (reproductive toxicity) ~ 23.9 mg/L/day (based on no effects observed at the highest concentration tested)

(2) Paraffins: 33.2% (v/v), Olefins: 40.0%, Naphthenes: 10.1%, Aromatics: 16.8%
In the repeated-dose inhalation study in described previously, Sprague-Dawley rats exposed to naphtha (petroleum), light catalytic cracked (LCCN) as a vapor at a measured concentration of 7.69 mg/L for 13 weeks had a lower number of sperm per gram of cauda epididymis compared to the sham controls, but not the untreated controls.

Group 2
See data for subcategory I and Group 1.

Group 3
See data for Groups 1 and 2.

Benzene (CASRN 71-43-2, supporting chemical)
(1) In the 13-week inhalation study in CD-1 mice described previously, effects on male reproductive organs at 0.96 mg/L included decreases in absolute and relative testes weights, minimal to moderately severe bilateral atrophy/degeneration of testes, moderate to moderately severe decreases in spermatozoa and a minimal to moderate increase in abnormal sperm morphology. In addition, bilateral ovarian cysts were observed in four females at 0.96 mg/L.

(2) See human health data at: http://ecb.jrc.ec.europa.eu/DOCUMENTS/Existing-Chemicals/RISK_ASSESSMENT/REPORT/benzenereport063.pdf.

Subcategories V to XI
See appropriate data in subcategories I to IV.

Developmental Toxicity

Subcategory I: Refinery gases, C1 – C4
Group 1
Ethane (CASRN 74-84-0, supporting chemical)
In the combined repeated-dose/reproductive/developmental toxicity screening test described previously, Sprague-Dawley CD female rats (12/test concentration) were exposed to up to 15,502 ppm ethane gas for 2 weeks prior to mating, during mating and on gestation days 0 – 19. The dams were allowed to deliver their litters, which were retained until lactation day 4. Developmental endpoints included number of stillborn pups, number of live pups per litter, pre- and post-implantation loss, pup sex ratio, pup body weight and weight gain, macroscopic postmortem evaluations of pups and pup viability (4-day survival after birth). No effects were observed on any developmental parameter.
NOAEC (maternal/developmental toxicity) = 15,502 ppm/day (highest concentration tested)

Propane (CASRN 74-98-6, supporting chemical)
In the combined repeated-dose/reproductive/developmental toxicity screening test described previously, Sprague-Dawley CD female rats (12/test concentration) were exposed to up to

12,168 ppm propane gas for 2 weeks prior to mating, during mating and on gestation days 0 – 19. The dams were allowed to deliver their litters, which were retained until lactation day 4. Developmental endpoints included number of stillborn pups, number of live pups per litter, pre- and post-implantation loss, pup sex ratio, pup body weight and weight gain, macroscopic postmortem evaluations of pups and pup viability (4-day survival after birth). A statistically significant decrease in the number of live born pups, in combination with an increase in the number of stillborn pups, was observed at concentrations ≥ 3990 ppm. These effects were attributable to the loss of a single total litter at each of the two highest doses (3990 and 12,168 ppm); the losses were preceded by severely reduced body weight gain in the last week of gestation for two particular dams.
LOAEC (maternal toxicity) = 12,168 ppm/day (based on increases in hemoglobin concentration, hematocrit, erythrocytes and absolute eosinophils)
NOAEC (maternal toxicity) = 3990 ppm/day
LOAEC (developmental toxicity) = 3990 ppm/day (based on a decrease in the number of live pups and increase in the number of stillborn pups)
NOAEC (developmental toxicity) = 1230 ppm/day

1-Propene (CASRN 115-07-1, supporting chemical)
(1) In a prenatal developmental toxicity study, pregnant Wistar rats (25/test concentration) were exposed whole-body to 1-propene as a gas at 0, 200, 1000 or 10,000 ppm for 6 hours/day on gestation days 6 – 19. Measured endpoints included clinical signs, food and water consumption, body weight, numbers of corpora lutea, implantation sites, resorptions and live and dead fetuses, fetus sex and weight and visceral and skeletal abnormalities. No systemic or developmental effects were observed (Propylene streams category: http://www.epa.gov/chemrtk/pubs/summaries/prplstrm/c13281tc.htm).
NOAEC (maternal/developmental toxicity) = 10,000 ppm/day (highest concentration tested)

(2) See human health data at: http://webnet.oecd.org/hpv/ui/Search.aspx

Propane, 2-methyl- (CASRN 75-28-5, supporting chemical)
In the combined repeated-dose/reproductive/developmental toxicity screening test described previously, developmental endpoints included number of stillborn pups, number of live pups per litter, pre- and post-implantation loss, pup sex ratio, pup body weight, macroscopic postmortem evaluations of pups and pup viability (4-day survival after birth). At 9148 ppm, an increase in post-implantation loss was observed.
NOAEC (maternal toxicity/developmental toxicity) = 9148 ppm/day (highest concentration tested)

Butane (CASRN 106-97-8, supporting chemical)
In the combined repeated-dose/reproductive/developmental toxicity screening test described previously, developmental endpoints included number of stillborn pups, number of live pups per litter, pre- and post-implantation loss, pup sex ratio, pup body weight and weight gain, macroscopic postmortem evaluations of pups and pup viability (4-day survival after birth). No treatment-related effects were observed on any developmental parameter.
NOAEC (maternal/developmental toxicity) = 9157 ppm/day (highest concentration tested)

1-Butene (CASRN 106-98-9, supporting chemical)
In the combined inhalation repeated-exposure/reproductive/developmental toxicity study in rats, described previously, no mortality or treatment related changes in body weights or feed consumption were observed. There were no treatment-related effects on any of the developmental parameters evaluated, including pup body weights or weight gains in pups or macroscopic postmortem evaluations of pups. No quantitative information on findings was submitted.
NOAEC (maternal/developmental toxicity) = 8000 ppm/day (highest concentration tested)

2-Butene (CASRN 107-01-7, supporting chemical)
(1) In the combined repeated-dose/reproductive/developmental inhalation toxicity screening study in rats described previously, developmental endpoints included litter size, number of pups per sex, number of stillbirths, pup malformations, pup body weight and pup body weight gain and survival until lactation day 4. No treatment-related developmental effects were observed.
NOAEC (maternal/developmental toxicity) = 5009 ppm/day (highest concentration tested)

(2) See human health data at: http://webnet.oecd.org/hpv/UI/handler.axd?id=db117c7c-460a-4361-8a85-507f4da63012.
NOAEC (maternal/developmental toxicity) = 5000 ppm/day (highest concentration tested)

Ethylene (CASRN 74-85-1, supporting chemical)
(1) In the combined reproductive/developmental inhalation toxicity screening test in rats described previously, developmental endpoints included litter size, sex ratio, pup weight, growth and survival. No adverse effects were observed (http://www.chem.unep.ch/irptc/sids/OECDSIDS/74851.pdf).
NOAEC (maternal/developmental toxicity) = 10,000 ppm/day (highest concentration tested)
(2) See human health data at: http://www.chem.unep.ch/irptc/sids/OECDSIDS/74851.pdf

1-Propene, 2-methyl- (CASRN 115-11-7, supporting chemical)
(1) Pregnant Wistar rats (24/test concentration) were exposed whole-body to 2-methyl-1-propene as a vapor at 0, 500, 2000 or 8000 ppm (approximately 0, 1.1, 4.6 or 18.4 mg/L) for 6 hours/day on gestation days 5 – 21. Endpoints included clinical signs, maternal body weight, food and water consumption, numbers of corpora lutea and implantation sites, sex and weight of fetuses and visceral and skeletal abnormalities. There were no treatment-related effects observed. (Low 1,3-butadiene category HPV submission: http://www.epa.gov/chemrtk/pubs/summaries/lowbutd/c13122tc.htm)
NOAEC (maternal/developmental toxicity) ~ 18.4 mg/L/day (highest concentration tested)

(2) See human health data at: http://www.chem.unep.ch/irptc/sids/OECDSIDS/115117.pdf and http://webnet.oecd.org/hpv/UI/handler.axd?id=db117c7c-460a-4361-8a85-507f4da63012.

Group 2
See data in Group 1.

1,3-Butadiene (CASRN 106-99-0, supportingchemical)
(1) A recent (2002) Integrated Risk Information System (IRIS) review by EPA on 1,3-butadiene is available at http://www.epa.gov/ncea/iris/subst/0139.htm.

The most sensitive reproductive endpoint observed in subchronic studies with 1,3-butadiene was fetal deaths in dominant lethal studies in mice exposed for 28-days at 65 ppm (see *Other* section for details); the NOAEC was 12.5 ppm and testicular atrophy in male mice at 625 ppm. The NOAEC for reproductive toxicity in female mice was not established and in male mice was 200 ppm (see *Carcinogenicity* section for details).

(2) In the combined inhalation reproductive/developmental toxicity screening test in Sprague-Dawley rats described previously, developmental endpoints included assessments of conception, parturition, lactation and development of offspring (details not specified). No developmental effects were observed.
LOAEC (maternal toxicity) = 3.3 mg/L/day (based on reductions in body weight parameters)
NOAEC (maternal toxicity) = 0.66 mg/L/day
NOAEC (developmental toxicity) = 13.3 mg/L/day (highest concentration tested)

(3) In a prenatal developmental toxicity study, pregnant Sprague-Dawley rats (24 – 28/dose) were exposed to 1,3-butadiene gas at 0, 40, 200 or 1000 ppm, 6 hours/day on gestation days 6 – 15. Dams were examined for mortality, morbidity, signs of toxicity, body weight, gross tissue abnormalities and uterus and placental weights. Developmental endpoints included numbers of implantations sites, resorptions, live and dead fetuses, fetal weight and external, visceral and skeletal abnormalities. A decrease in body weight gain was observed in dams at 1000 ppm. No developmental effects were observed.
LOAEC (maternal toxicity) = 1000 ppm/day (based on a decrease in body weight gain)
NOAEC (maternal toxicity) = 200 ppm/day
NOAEC (developmental toxicity) = 1000 ppm/day (highest concentration tested)

(4) In a prenatal developmental toxicity study, pregnant Swiss (CD-1) mice (18 – 22/dose) were exposed to 1,3-butadiene gas at 0, 40, 200 or 1000 ppm, 6 hours/day on gestation days 6 – 15. Dams were examined for mortality, morbidity, signs of toxicity, body weight, gross tissue abnormalities and uterus and placental weights. Developmental endpoints included numbers of implantations sites, resorptions, live and dead fetuses, fetal weight and external, visceral and skeletal abnormalities. A decrease in maternal body weight was observed at 2.2 mg/L. Reduced maternal body weight gain was observed at concentrations $\geq$ 0.44 mg/L. Placental weights were reduced for male fetuses at $\geq$ 0.44 mg/L and for females at 2.2 mg/L. Fetal body weights were significantly reduced in males at $\geq$ 0.088 mg/L and in females at $\geq$ 0.44 mg/L. There was no treatment-related increase in malformations, but there was an increase in fetal variations (supernumary ribs and reduced ossification of sternebrae) at concentrations $\geq$ 0.44 mg/L. (Crude butadiene C4 category; http://www.epa.gov/chemrtk/pubs/summaries/olefins/c12064tc.htm. Additional details were obtained from Morrissey et al., 1990, Environmental Health Perspectives 86:79-84).

LOAEC (maternal toxicity) = 200 ppm/day (based on a decrease in body weight gain)
NOAEC (maternal toxicity) = 40 ppm/day
LOAEC (developmental toxicity) = 40 ppm/day (based on reduced male fetal body weights)
NOAEC (developmental toxicity) = Not established

(5) In a prenatal developmental toxicity study, pregnant Sprague-Dawley CD rats (24/dose) were exposed whole-body to 1,3-butadiene gas at 0, 200, 1000 or 8000 ppm, 6 hours/day on gestation days 6 – 15; dams were sacrificed on gestation day 20. Endpoints included clinical signs, maternal body weight and body weight gain, numbers of implantations and pre- and post-implantation losses, gravid uterine weight, fetal weight, crown/rump length, sex ratio and abnormalities. A significant decrease in maternal body weight gain during the exposure period was observed at concentrations ≥ 200 pppm. Mean fetal weight and crown/rump length were reduced at 8000 ppm. A significantly higher incidence of bipartite thoracic centra was observed at concentrations ≥ 200 ppm. Significantly higher incidences of incomplete and irregular ossification, as well as lens opacity, were observed at 8000 ppm. A significant increase in the incidence of major skeletal defects was observed at concentrations ≥ 1000 ppm; skeletal defects included wavy ribs and abnormalities of the skull, spine, sternum and long bones (TSCATS (OTS0505459).
LOAEC (maternal toxicity) = 200 ppm/day (based on reduced body weight gain)
NOAEC (maternal toxicity) = Not established
LOAEC (developmental toxicity) = 200 ppm/day (based on a higher incidence of bipartite thoracic centra)
NOAEC (developmental toxicity) = Not established

(6) See human health data at: http://ecb.jrc.ec.europa.eu/DOCUMENTS/Existing-Chemicals/RISK_ASSESSMENT/REPORT/butadienereport019.pdf

Subcategory II: Refinery gases, C1 – C4 with ammonia and hydrogen sulfide
See data for subcategory I (excepting 1,3-butadiene) above.

Ammonia (CASRN 7664-41-7, supporting chemical)
(1) See human health data for ammonia category at: http://webnet.oecd.org/hpv/ui/Search.aspx
NOAEL[15] (maternal/developmental toxicity) = 1500 mg/kg/day (highest dose tested)

Hydrogen sulfide (CASRN 7783-06-4, supporting chemical)
(1) In a combined reproductive/developmental toxicity study described above, male and female Sprague-Dawley rats (12 /sex/dose) were exposed to hydrogen sulfide at concentrations of 0, 10, 30 or 80 ppm for 6 hours/day, 7 days/week for 2 weeks prior to breeding and during mating and from gestation day 0 through gestation day 19. No mortalities were observed. Exposure to the test substance did not affect pup growth, development or performance of any of the behavioral tests.
NOAEC (maternal/developmental toxicity) = 80 ppm/day (highest concentration tested)

(2) Sprague-Dawley rats were exposed to hydrogen sulfide at concentrations of 0, 20, 50 or

[15] Based on data for supporting chemical diammonium phosphate (DAP; CASRN 7783-28-0) used as supporting chemical in the OECD HPV Ammonia Category: http://webnet.oecd.org/hpv/ui/Search.aspx

75 ppm for 7 hours/day from gestation day 1 to postnatal day 21. There was an increased glucose levels in 50% of dams in all exposure groups on postnatal day 21. No effects on serum protein, LDH, SGOT or alkaline phosphatase activities were noted in offspring [ATSDR (2006): http://www.atsdr.cdc.gov/ToxProfiles/tp114.pdf].
NOAEC (maternal/developmental toxicity) = 75 ppm/day (highest concentration tested)

(3) Sprague-Dawley rats were exposed to hydrogen sulfide at concentrations of 0, 10, 30 or 80 ppm (~ 0, 0.01, 0.04 or 0.11 mg/L**)** for 6 hours/day, 7 days/week on gestation days 0 – 19 and continued on postnatal days 5 – 18. Developmental delays (pinnae detachment, surface righting, incisor eruption, negative geotaxis and eyelid detachment), developmental neurobehavioral performance (motor activity, passive avoidance, acoustic startle and functional observation battery), brain histopathology and structural anomalies were examined. There were no effects in offspring. Maternal effects were not provided [ATSDR (2006): http://www.atsdr.cdc.gov/ToxProfiles/tp114.pdf].
NOAEL (maternal/developmental toxicity) = 80 ppm/day (highest concentration tested)

(4) Sprague-Dawley rats were exposed to hydrogen sulfide at concentrations of 0, 20 or 75 ppm for 7 hours/day from gestation day 5 to postpartum day 21. Developmental neurological effects were assessed. In the low-exposure group (20 ppm), an increase in serotonin levels in the frontal cortex was seen in offspring on postpartum day 21. There was a transient decrease in norepinephrine levels in the cerebellum; however, the levels were normal by day 21. In the high-dose group (75 ppm), an increase in serotonin levels in the cerebellum and cortex was seen on postpartum days 14 and 21 and norepinephrine levels in the cerebellum and frontal cortex were increased. Maternal effects were not provided [ATSDR (2006): http://www.atsdr.cdc.gov/ToxProfiles/tp114.pdf].
LOAEC (maternal/developmental toxicity) = 75 ppm/day (highest concentration tested

Subcategory III: Refinery gases, C1 – C4 with carbon monoxide
See data for subcategory I above (excepting data for 1,3-butadiene)

Carbon monoxide (CASRN 630-08-0, supporting chemical)
(1) Pregnant female CD-1 mice (number of animals/dose level not specified) were exposed continuously to carbon monoxide via inhalation at concentrations of 0, 65, 125, 250 or 500 ppm for 7 days/week on gestation days 7 – 18. No sign of maternal toxicity was observed under the conditions of the exposure. However, effects were observed in the offspring. The mean number of dead or resorbed fetuses per litter in the high-dose group was greater than control. Weights of fetuses from 125, 250 and 500 ppm carbon monoxide-exposed mothers were decreased when compared to weights of controls. Data suggest that maternal carbon monoxide exposure as low as 125 ppm can affect fetal growth and that higher levels impair variability. The fetus appears to be sensitive to chronic carbon monoxide exposure and this sensitivity is dose-dependent.
NOAEC (maternal toxicity) = 500 ppm/day (highest concentration tested)
LOAEC (developmental toxicity) = 125 ppm/day (based on reduced fetal weight)
NOAEC (developmental toxicity) = 65 ppm/day

(2) Female Albino CD-1 mice were exposed continuously to carbon monoxide at concentrations of 0, 65 or 125 ppm for 7 days/week on gestation days 7 – 18. No sign of maternal toxicity was

observed under the conditions of exposure. However, effects were observed in the offspring. At 125 ppm, there was an increase in the time required by the pups for righting reflexes on day 1 of birth and negative geotaxis on day 10 of birth were observed. Furthermore, these pups took 3 times longer for righting reflex and 2 times longer for negative geotaxis than the control pups. Prenatal carbon monoxide exposure at both 65 and 125 ppm (0.074 or 0.14 mg/L, respectively) decreased the mean aerial righting score of the pups on day 14 of birth when compared to the controls. It is suggested that at low concentrations, prenatal carbon monoxide exposure may lead to retarded reflex development in neonates in a dose dependent manner.
NOAEC (maternal toxicity) = 125 ppm/day (highest concentration tested)
LOAEC (developmental toxicity) = 65 ppm/day (based on reduced aerial righting score)
NOAEC (developmental toxicity) = Not established

(3) Pregnant Long-Evans rats (12 – 16/group) were exposed to carbon monoxide via inhalation at exposures of 0, 30 or 90 ppm for 7 days/week from gestation day 3 to 20. Treatment-related effects included a marked reduction in the number of successful pregnancies in all doses and increased brain weight in the high-dose group, which was believed to be a result of brain edema.
LOAEC (maternal toxicity) = 90 ppm/day (based on increased brain weight and brain edema)
NOAEC (maternal toxicity) = 30 ppm/day
LOAEC (developmental toxicity) = 30 ppm/day (based on decreased percent of pregnant females)
NOAEC (developmental toxicity) = Not established

(4) Pregnant CF-1 mice (39 animals) were exposed to carbon monoxide (99.9% pure) via inhalation at 250 ppm for 24 hours/day on days 6 – 17 of gestation. Additionally, ethanol was administered in drinking water at a concentration of 10 volume percent on days 6 – 16 of gestation. In the teratologic portion of the study, 13 dams underwent a cesarean section on day 18 of gestation. On the same days of gestation, the 11 animals for the postnatal study delivered their fetuses naturally. The absolute and relative weights of the livers from pregnant mice were not affected by exposure. Body weights of exposed mice were comparable to controls during gestation; however, exposed mice gained less weight during days 6 – 9 of gestation. There were no effects on the incidence or distribution of fetal resorptions, number of implantation sites, average size of the litters or sex ratio of the fetuses. However, the fetal body weight and crown-rump length were lower among litters of exposed mice. There was no effect on pregnancy rates of exposed mice after accounting for early resorptions. There were no treatment-related effects on the incidence of external or soft tissue alterations among litters. Increases in the incidences of delayed ossification of the bones of the skull and of the sternebrae and an unfused occipital bone were observed among litters of exposed mice. A slight increase in the incidence of an unfused fifth sternebrae was observed among litters of the exposed mice. The postnatal portion of the study showed no treatment-related effects on pup survival, sex ratio of neonates on day 21, number of days from delivery until all of the eyes of the neonates were open, number of days from mating to parturition among the dams, body weights of neonates, size of litters or gross pathologic changes in neonates and dams (TSCATS OTS0539254).
LOAEC (maternal/developmental toxicity) = 250 ppm/day (based on reduced maternal body weight, fetal weight and crown-rump length and delayed ossification)
NOAEC (maternal/developmental toxicity) = Not established

(5) Pregnant New Zealand White rabbits (21 animals) were exposed to carbon monoxide (99.9% pure) via inhalation at 250 ppm for 24 hours/day on days 6 through 28 of gestation. In the teratologic portion of the study, 10 dams underwent a cesarean section on day 29 of gestation. On the same days of gestation, the seven animals for the postnatal study delivered their fetuses naturally. Additionally, ethanol was administered in drinking water to mice at a concentration of 10 volume percent on days 6 through 27 of gestation. There were no treatment-related effects on body weight. Both the absolute and relative weights of the livers of exposed rabbits were higher than control on day 29 of gestation. There were no treatment-related effects on the number of implantation sites, average size of litters or sex ratio of the fetuses. Neither the apparent nor the total percentage of pregnancy among exposed rabbits was different from that of the control group. Exposure to carbon monoxide and ethanol resulted in an increased incidence of fetal resorptions. Fetal body measurements of the exposed litters were slightly, lower than the control litters. No external of soft tissue alterations were observed. The incidences of delayed ossification of the second sternebrae, extra ribs and of a bone island on the parietal bone were slightly higher than among control litters. The postnatal portion of the study showed no treatment-related effects on kit survival, sex ratio on day 28 of lactation, the number of days from mating to parturition, maternal body weight and gross pathologic changes (in neonates and does). The number of days from delivery until all of the eyes of the neonates were open was reduced among litters of exposed rabbits. The body weights of neonates of exposed rabbits were slightly lower throughout lactation than those of concurrent control litters. The size of the litters was slightly higher among litters of exposed rabbits. The incidence of splay leg or legs was slightly lower among neonates from exposed rabbits compared to the control litters (TSCATS OTS0539254).
NOAEC (maternal toxicity) = 250 ppm/day (highest concentration tested)
LOAEC (developmental toxicity) = 250 ppm/day (based on increased incidence of fetal resorptions and delayed development)
NOAEC (developmental toxicity) = Not established

(6) Pregnant Long-Evans rats were continuously exposed to carbon monoxide via inhalation at 0 (control) or 150 ppm from day 0 to 21 of gestation. Offspring of exposed dams showed slightly (5%) but not lower birth weights than offspring of unexposed mothers. Differences in body weight became progressively greater throughout the pre-weaning period and did reach statistical significance at 4 days of age ($p < 0.01$). Effects observed on the central nervous system (CNS) included decreased brain dopamine content by 45 and 25% on postnatal days 1 and 4, respectively. No treatment-related effects were observed on number of pups per litter or mortality rate on day 1; no cases of gross teratogenesis were observed in either group [draft ATSDR profile for carbon monoxide (2009); additional details are from the primary source (Fechter and Annau, 1977)].
NOAEC (maternal toxicity) = 150 ppm/day (highest concentration tested)
LOAEC (developmental toxicity) = 150 ppm/day (based on decreased body weight in pups)
NOAEC (developmental toxicity) = Not established

(7) Pregnant Long-Evans rats were continuously exposed to carbon monoxide via inhalation at 0 (control) or 150 ppm from day 0 to 20 of gestation. Treatment-related effects on offspring included decreased birth weight (7.6%), a significantly negative effect on growth ($p < 0.01$) and delayed behavioral development as assessed by the negative geotaxis test and the homing test.

There were no treatment-related effects on forebrain and hindbrain levels of dopamine or norepinephrine in pups on postnatal day 1 [draft ATSDR profile for carbon monoxide (2009); additional details are from the primary source (Fechter and Annau, 1980)].
NOAEC (maternal toxicity) = 150 ppm/day (highest concentration tested)
LOAEC (developmental toxicity) = 150 ppm/day (based on decreased birth weight and delayed behavioral development)
NOAEC (developmental toxicity) = Not established

(8) Pregnant rabbits were continuously exposed to carbon monoxide via inhalation at 0 (control), 90 or 180 ppm throughout gestation. Treatment-related effects on offspring included increased fetal death during the first 24 hours of the postnatal period and a concentration-dependent decrease in birth weight (ATSDR: http://www.atsdr.cdc.gov/ToxProfiles/tp201.pdf).
NOAEC (maternal toxicity) = 180 ppm/day (highest concentration tested)
LOAEC (developmental toxicity) = 90 ppm/day (based on increased fetal death and decreased birth weight)
NOAEC (developmental toxicity) = Not established

(9) Data for several additional animal studies are available (ATSDR: http://www.atsdr.cdc.gov/ToxProfiles/tp201.pdf).

Subcategory IV: Refinery gases, C1 – C6
Group 1
See also data for subcategory I (excepting 1,3 butadiene) above.

Pentane (CASRN 109-66-0, supporting chemical)
In a prenatal oral developmental toxicity study, pregnant Crl:CDBR rats were treated with 100, 500 or 1000 mg/kg/day *n*-pentane on days 6-15 of gestation. There was no mortality or statistically significant differences in mean body weight, body weight change, uterine weight, corrected body weight, or uterine implantation data between treated and control dams at any dose. There was no evidence of growth retardation or increased fetal death at any dose. There were no statistically significant differences in total or individual variations or malformations: http://webnet.oecd.org/hpv/UI/SIDS_Details.aspx?Key=0af02fa3-f3ef-4df9-b050-43116efd8ef1&idx=0 and C5 aliphatic hydrocarbon solvents category - http://webnet.oecd.org/hpv/ui/Search.aspx).
NOAEL (maternal toxicity) = 1000 mg/kg/day (highest dose tested)
NOAEL (developmental toxicity) = 1000 mg/kg/day (highest dose tested)

Cyclopentane (CASRN 287-92-3, supporting chemical)
(1) In the OECD HPV program, the devlopmental toxicity endpoint for cyclopentane was addressed using data from a 2-generation reproductive toxicity study in rats with cyclohexane (CASRN 110-82-7: http://webnet.oecd.org/hpv/UI/SIDS_Details.aspx?Key=8e1c6169-bdfd-49e5-872c-f721963cb2d8&idx=0 and C5 aliphatic hydrocarbon solvents category - http://webnet.oecd.org/hpv/ui/Search.aspx). A slight decrease (significance not stated) in pup body weight was observed at 24.1 mg/L/day and maternal toxicity (narcotic effects) was observed at 6.88 mg/L/day.

LOAEC (maternal toxicity) = 6.88 mg/L/day (based on narcotic effects)
NOAEC (maternal toxicity) = 1.72 mg/L/day
LOAEC (developmental toxicity) = 24.1 mg/L/day (based on decreased pup weights)
NOAEC (developmental toxicity) = 6.88 mg/L/day

(2) See human health data for cyclohexane at:
http://webnet.oecd.org/hpv/UI/SIDS_Details.aspx?Key=8e1c6169-bdfd-49e5-872c-f721963cb2d8&idx=0

2-Butene, 2-methyl- (CASRN 513-35-9, supporting chemical)
(1) In the combined inhalation repeated-dose/reproductive/developmental toxicity screening test in Sprague-Dawley rats described previously, developmental endpoints included number of live and dead offspring, pup weight, sex ratio and pup growth and survival. There were no effects observed on any of the developmental parameters. [This study was reported in the TSCA 8(e)/FYI Initial Screen Database (FYI-0105-1485A)].
LOAEC (maternal toxicity) = 2026 ppm/day (based on increased myocardial inflammatory heart lesions and cortical/medullary tubular basophilia in the kidneys of males and longer clotting time in females)
NOAEC (maternal toxicity) = 584 ppm/day
NOAEC (developmental toxicity) = 7097 ppm/day (highest concentration tested)

(2) See human health data at: http://www.chem.unep.ch/irptc/sids/OECDSIDS/513359.pdf

Gasoline (CASRN 86290-81-5, supporting chemical)
(1) Pregnant Crl:CD-1(ICR)BR mice (25/dose) were exposed whole-body to gasoline (API 99-01) as a vapor at nominal concentrations of 0, 2, 10 or 20 mg/L, 6 hours/day on gestation days 5 – 17. Mean measured concentrations were 0, 2.9, 10.6 and 20.9 mg/L. Endpoints included clinical signs, maternal body weight, food consumption, uterine weights, numbers of live, dead and resorbed fetuses, number of corpora lutea, fetal weights and sex ratio and visceral and skeletal abnormalities. Significant decreases in body weight and body weight change were observed in dams at 20.9 mg/L. A significant reduction in fetal body weight was observed at 10.6 and 20.9 mg/L. A significant decrease in the number of live fetuses was observed at 20.9 mg/L, in combination with an increase in the ratio of resorptions to implantation sites.
LOAEC (maternal toxicity) = 20.9 mg/L/day (based on decreases in body weight and body weight change)
NOAEC (maternal toxicity) = 10.6 mg/L/day
LOAEC (developmental toxicity) = 10.6 mg/L/day (based on reduced fetal body weight)
NOAEC (developmental toxicity) = 2.9 mg/L/day

(2) Sprague-Dawley Crl:CD(SD)IGSBR rats (25/dose) were exposed whole-body to gasoline (API 99-01) as a vapor at nominal concentrations of 0, 2, 10 or 20 mg/L, 6 hours/day on gestation days 5 – 20. Mean measured concentrations were 0, 2.0, 10.7 and 20.6 mg/L. Endpoints included clinical signs, maternal body weight, food consumption, uterine weights, numbers of live, dead and resorbed fetuses, number of corpora lutea, fetal weights and sex ratio and visceral and skeletal abnormalities. No treatment-related effects were observed.
NOAEC (maternal/developmental toxicity) = 20.6 mg/L (highest concentration tested)

Gasoline (CASRN 86290-81-5, supporting chemical)

(1) **Paraffins: 79.5% (units not specified), Olefins: 14.1%, Naphthenes: 2.3%, Aromatics: 4.0%**

Pregnant female Sprague-Dawley (CD) [CDBR] rats (21 – 24/dose) were exposed to unleaded gasoline vapor condensate (API 94-02) as a vapor at 0, 2.7, 8 or 24 mg/L for 6 hours/day on gestation days 6 – 19. No maternal toxicity was observed. There were no differences between treated and control groups in developmental malformations, total variations, number of resorptions, fetal body weight and viability. Further details were not provided.

NOAEC (maternal and developmental toxicity) = 24 mg/L/day (based on no effects observed at the highest dose tested)

(2) **PONA composition not specified**

Pregnant female Sprague-Dawley rats (25/dose) were exposed to unleaded gasoline as a vapor at nominal concentrations of 0, 400 or 1600 ppm (~ 0, 1.6 or 6.3 mg/L) for 6 hours/day on gestation days 6 – 15. Mean measured concentrations were 0, 442 and 1573 ppm (~ 0, 1.7 and 6.2 mg/L). There were no treatment-related effects on maternal body weight, food consumption, number of implantation sites, number of resorptions, numbers of live and dead fetuses, fetal weight or incidence of visceral abnormalities. An increase in the number of fetuses with skeletal variations was observed at ~ 6.2 mg/L and consisted mainly of changes related to retarded ossification.

NOAEC (maternal toxicity) ~ 6.2 mg/L/day (based on no effects observed at the highest dose tested)

LOAEC (developmental toxicity) ~ 6.2 mg/L/day (based on an increase in skeletal variations)

NOAEC (developmental toxicity) ~ 1.7 mg/L/day

(3) **PONA composition not specified**

Pregnant Crl:CD-1(ICR)BR mice (25/dose) were exposed whole-body to gasoline (API 99-01) as a vapor at nominal concentrations of 0, 2, 10 or 20 mg/L, 6 hours/day on gestation days 5 – 17. Mean measured concentrations were 0, 2.9, 10.6 and 20.9 mg/L. Endpoints included clinical signs, maternal body weight, food consumption, uterine weights, numbers of live, dead and resorbed fetuses, number of corpora lutea, fetal weights and sex ratio and visceral and skeletal abnormalities. Decreases in body weight and body weight change were observed in dams at 20.9 mg/L. A reduction in fetal body weight was observed at 10.6 and 20.9 mg/L. A decrease in the number of live fetuses was observed at 20.9 mg/L, in combination with an increase in the ratio of resorptions to implantation sites.

LOAEC (maternal toxicity) = 20.9 mg/L/day (based on decreases in body weight and body weight change)

NOAEC (maternal toxicity) = 10.6 mg/L/day

LOAEC (developmental toxicity) = 10.6 mg/L/day (based on reduced fetal body weight)

NOAEC (developmental toxicity) = 2.9 mg/L/day

Group 2
See data for Subcategory I and Group 1.

Group 3
See data for Groups 1 and 2.

Benzene (CASRN 71-43-2, supporting chemical)
(1) Pregnant Swiss-Webster Crl:CFW(SW)Br mice (15/dose) were exposed to benzene as a vapor at 0, 5, 10 or 20 ppm (approximately 0, 0.016, 0.032 or 0.064 mg/L), 6 hours/day on gestation days 6 – 15. Mice (5/dose) were sacrificed on gestation day 16. Endpoints included the numbers of live, dead and resorbed fetuses, fetal weights and external gross morphological malformations, RBC and WBC counts and hemoglobin analysis of fetal blood and numbers of cells in the hematopoietic differentiating proliferating pool (DPP) of fetal livers. Additional mice (5/dose) were allowed to proceed through normal parturition and on day 2 postpartum, pups were subjected to hematological examination, as above. The remaining mice (5/dose) were allowed to proceed through normal parturition and after 6 weeks postpartum, peripheral blood samples were removed from offspring for RBC and WBC counts; additionally, cells of the DPP were enumerated in the spleen and femoral bone marrow. No mortality, morbidity or weight loss of dams was observed during the exposure. No effects of exposure were observed on litter sizes, sex ratios, pup weights and numbers of dead, resorbed or malformed fetuses. Reduced counts of erythroid precursor cells (early nucleated cells) were observed in the peripheral blood of 2-day old pups exposed to benzene (concentrations not specified). Depressed numbers of late nucleated red cells and elevated numbers of granulocytic precursor cells (non-dividing granulocytes) were observed in the peripheral blood of 2-day old pups exposed to 0.064 mg/L. Lower numbers of early and late nucleated RBCs were observed in the livers of 2-day old pups at 0.064 mg/L. Elevated numbers of blasts, dividing/non-dividing granulocytes and lymphocytes were observed in the livers of 2-day old pups and spleens and femurs of 6-week old offspring of dams exposed to 0.064 mg/L.
NOAEC (maternal toxicity) ~ 0.064 mg/L/day (highest concentration tested)
LOAEC (developmental toxicity) ~ 0.064 mg/L/day (based on effects on the hematopoietic system)
NOAEC (developmental toxicity) ~ 0.032 mg/L/day

(2) In a modified prenatal developmental toxicity study, female Sprague-Dawley rats (26 /dose) were exposed to benzene as a vapor at 0, 1, 30 or 300 ppm (approximately 0, 0.0032, 0.096 or 0.96 mg/L), 6 hours/day, 5 days/week for a 10-week pre-mating and mating period and daily on gestation days 0 – 20 and lactation days 5 – 20. Endpoints included maternal body weight, pregnancy rate, length of gestation, numbers of live and dead pups, sex ratio, pup survival, pup body weight change and pup organ weights. Reduced body and liver weights were observed in female pups at 0.96 mg/L. [EPA's Toxicological Review of Benzene, 2002 (EPA/635/R-02/001F)].
NOAEC (maternal toxicity) ~ 0.96 mg/L/day (highest concentration tested)
LOAEC (developmental toxicity) ~ 0.96 mg/L/day (based on reduced body and liver weights in female pups)
NOAEC (developmental toxicity) ~ 0.096 mg/L/day

(3) See human health data at: http://ecb.jrc.ec.europa.eu/DOCUMENTS/Existing-Chemicals/RISK_ASSESSMENT/REPORT/benzenereport063.pdf.

Subcategories V to XI
See appropriate data in subcategories I to IV.

Genetic Toxicity – Gene Mutation

In vitro

Subcategory I: Refinery gases, C1 – C4
Group 1
Methane (CASRN 74-82-8, supporting chemical)
In a reverse-mutation assay, *Salmonella typhimurium* strains TA97, TA98, TA100 and TA1535 were exposed to methane gas at 0, 0.001, 0.002, 0.007, 0.013 or 0.027 µg/plate in a gas chamber with and without metabolic activation. No cytotoxicity was observed. Positive and negative controls were used and responded appropriately. No increase in mutation frequency was observed.
(NTP study 297396: http://ntp-apps.niehs.nih.gov/ntp_tox/index.cfm?fuseaction=ntpsearch.searchhome).
Methane was not mutagenic in this assay.

Propane (CASRN 74-98-6, supporting)
Salmonella typhimurium strains TA98, TA100, TA1535, TA1537 and TA1538 were exposed to propane at concentrations ranging from 10,000 to 500,000 ppm/plate (~ 17.21 – 860.5 mg/L) with and without metabolic activation for 6 hours. Positive and negative controls were included and responded appropriately (Propylene streams category: http://www.epa.gov/chemrtk/pubs/summaries/prplstrm/c13281tc.htm).
CASRN 74-98-6 was not mutagenic in this assay

1-Propene (CASRN 115-07-1, supporting chemical)
(1) In a reverse-mutation assay, *Salmonella typhimurium* strains TA97, TA98, TA100 and TA1535 were exposed to 1-propene gas at concentrations of 0.001 – 0.027 µg/plate with and without metabolic activation. Positive and negative controls were tested concurrently and responded appropriately. No cytotoxicity was reported. In the presence of activation, mutagenicity was observed in strains TA1535 and TA100. Without activation, mutagenicity was noted in strain TA1535 only. (NTP study 779144: http://ntp-apps.niehs.nih.gov/ntp_tox/index.cfm?fuseaction=ntpsearch.searchhome).
1-Propene was mutagenic in this assay.

(2) *Salmonella typhimurium* strains TA98, TA100, TA1535 and TA1537 and *Escherichia coli* strain WP2uvrA (pKM101) were exposed to 1-propene gas at concentrations of 0, 0.031, 0.063, 0.125, 0.25, 0.5 and 1% with and without metabolic activation. Negative controls responded appropriately. Positive controls were tested concurrently, but the responses were not specified. Mutagenic activity was observed only in TA1535 with activation (Propylene streams category: http://www.epa.gov/chemrtk/pubs/summaries/prplstrm/c13281tc.htm).

1-Propene was mutagenic in this assay.

(3) L5178Y mouse lymphoma cells were exposed to 1-propene gas at concentrations of 20 – 50% for 4 hours with and without metabolic activation. The use and response of controls were not specified. 1-Propene did not induce mutations without activation, but results were equivocal with activation (http://ecb.jrc.ec.europa.eu/esis/).
1-Propene was equivocal for mutagenicity in this assay.

(4) Mouse lymphoma cells were exposed to 1-propene at concentrations of 0, 2.5, 5, 10, 20 or 30 µg/mL with and without metabolic activation. An increase in mutation frequency was observed with activation; however, this result was not reproducible. Positive and negative controls were tested concurrently and responded appropriately. No cytotoxicity was observed. (NTP study 537921: http://ntp-apps.niehs.nih.gov/ntp_tox/index.cfm?fuseaction=ntpsearch.searchhome).
1-Propene was not mutagenic in this assay.

(5) See human health data at: http://webnet.oecd.org/hpv/ui/Search.aspx

Butane (CASRN 106-97-8, supporting chemical)
In an NTP assay, *Salmonella typhimurium* strains TA97, TA98, TA100 and TA1535 were exposed to butane as a gas at concentrations of 0, 0.001, 0.002, 0.007, 0.013 and 0.027 µg/plate, with and without metabolic activation. Positive and negative controls were used and responded appropriately. No cytotoxicity was observed. Butane did not induce an increase in mutation frequency. (NTP study 295295: http://ntp-apps.niehs.nih.gov/ntp_tox/index.cfm?fuseaction=ntpsearch.searchhome).
Butane was not mutagenic in this assay.

1-Butene (CASRN 106-98-9, supporting chemical)
Salmonella typhimurium strains TA98, TA100, TA1535 and TA1537 and *Escherichia coli* strain WP2 uvrA were exposed to 1-butene as a gas at concentrations up to 50% with and without metabolic activation. The use of positive and negative controls was not specified. 1-Butene did not increase the mutation frequency (Low 1,3-butadiene category HPV submission: http://www.epa.gov/chemrtk/pubs/summaries/lowbutd/c13122tc.htm).
1-Butene was not mutagenic in this assay.

2-Butene (CASRN 107-01-7, supporting chemical)
(1) *Salmonella typhimurium* strains TA98, TA100, TA1535 and TA1537 and *Escherichia coli* strain WP2 uvrA were exposed to 2-butene as a gas at concentrations up to 50% with and without metabolic activation. The use and responses of controls were not specified. 2-Butene did not increase the mutation frequency (Low 1,3-butadiene category HPV submission: http://www.epa.gov/chemrtk/pubs/summaries/lowbutd/c13122tc.htm).
2-Butene was not mutagenic in this assay.

(2) *Salmonella typhimurium* strains TA98, TA100, TA1535 and TA1537 were exposed to 2-butene (42.4% *cis*, 55.3% *trans*) as a gas at 0, 10, 20, 40, 60 or 80% with and without metabolic

activation. Positive and negative controls were used and responded appropriately. Cytotoxicity was observed at concentrations ≥ 60%. 2-Butene did not increase the mutation frequency.
2-Butene was not mutagenic in this assay.

Ethylene (CASRN 74-85-1, supporting chemical)
In a reverse-mutation assay, *Salmonella typhimurium* strains TA97, TA98, TA100 and TA1535 were exposed to ethylene in an unspecified solvent as a vapor from a liquid at levels up to 4.7 mL/chamber. Positive and negative controls were used and responded appropriately. No cytotoxicity was reported. Ethylene did not increase the mutation frequency.
Ethylene was not mutagenic in this assay.

1-Propene, 2-methyl- (CASRN 115-11-7, supporting chemical)
(1) *Salmonella typhimurium* strains TA98, TA100, TA1535, TA1537 and TA1538 and *Escherichia coli* strain WP2 uvrA (pKM101) were exposed to 2-methyl-1-propene as a gas at concentrations up to 100% with and without metabolic activation. Positive and negative controls were tested concurrently and responded appropriately. 2-Methyl-1-propene did not increase the mutation frequency in any strain. Cytotoxicity was observed at concentrations ≥ 80% (Low 1,3-butadiene category HPV submission: http://www.epa.gov/chemrtk/pubs/summaries/lowbutd/c13122tc.htm).
2-Methyl-1-propene was not mutagenic in this assay.

(2) In a reverse-mutation assay, *Salmonella typhimurium* strains TA97, TA98, TA100 and TA1535 were exposed to 2-methyl-1-propene as a gas at concentrations up to 0.027 moles/dessicator with and without metabolic activation. Positive and negative controls responded appropriately. Exposure to 2-methyl-1-propene did not increase the mutation frequency in any strain (NTP Technical Report No. 272).
2-Methyl-1-propene was not mutagenic in this assay.

(3) L5178Y TK^+/TK^- mouse lymphoma cells were exposed to 2-methyl-1-propene as a gas at concentrations of 0, 6.25, 12.5, 25, 50 or 100% with or without metabolic activation. Positive and negative controls responded appropriately. Cytotoxicity was observed at concentrations≥ 12.5%. 2-Methyl-1-propene did not increase the mutation frequency (Low 1,3-butadiene category HPV submission: http://www.epa.gov/chemrtk/pubs/summaries/lowbutd/c13122tc.htm).
2-Methyl-1-propene was not mutagenic in this assay.

Group 2
See data from Group 1

1,3-Butadiene (CASRN 106-99-0, supporting chemical)
(1) *Salmonella typhimurium* strains TA97, TA98, TA100 and TA1535 were exposed to 1,3-butadiene as a gas at concentrations of 0, 30, 40, 50 or 60% with and without metabolic activation. The use of a positive control was not specified. An increase in mutation frequency was observed only in TA1535 in the presence of rat or mouse activation, but not human activation.
1,3-Butadiene was mutagenic in this assay.

(2) See human health data at: http://ecb.jrc.ec.europa.eu/DOCUMENTS/Existing-Chemicals/RISK_ASSESSMENT/REPORT/butadienereport019.pdf

Subcategory II: Refinery gase, C1-C4 with ammonia and hydrogen sulfide
See data for subcategory I (except 1,3-butadiene) above.

Ammonia (CASRN 7664-41-7, supporting chemical)
(1) In a bacterial reverse mutation assay, *Salmonella typhimurium* strains TA98, TA100, TA1535, TA1537 and TA1538 and *Escherichia coli* WP2 uvrA were exposed to ammonia at 0, 500, 1000, 2500, 5000, 10,000 or 25,000 ppm (0, 0.35, 0.70, 1.7, 7.0 or 17.0 mg/L) with and without activation. Positive and negative controls were tested concurrently and responded appropriately. Cytotoxic concentrations were not indicated. Ammonia did not induce any significant increase in the revertant number with or without S9 mix in any of the five strains of *Salmonella typhimurium* or *Escherichia coli*.
Ammonia was not mutagenic in this assay.

(2) *Escherichia coli* were exposed to ammonia at unspecified concentrations without activation in a reverse mutation assay. No additional study details provided. Positive effects were only observed with treatment levels that were toxic [ATSDR (2004): http://www.atsdr.cdc.gov/ToxProfiles/tp126.pdf].
Ammonia was mutagenic in this assay.

(3) See human health data at: http://webnet.oecd.org/hpv/ui/Search.aspx

Hydrogen sulfide (CASRN 7783-06-4, supporting chemical)
In a bacterial reverse mutation assay, *Salmonella typhimurium* strains TA97, TA98 and TA100 were exposed to hydrogen sulfide at concentrations of 0, 17, 57, 175, 582 or 1750 µg/plate with or without activation. Positive and negative controls were tested concurrently and responded appropriately. Cytotoxic concentrations were not identified. Hydrogen sulfide did not induce any significant increase in the revertant number with or without S9 mix in any of the three strains (either rat or hamster activation system).
Hydrogen sulfide was not mutagenic in this assay.

Methanethiol, sodium salt (CASRN 5188-07-8, supporting chemical)
(1) In a bacterial reverse mutation assay, *Salmonella typhimurium* strains TA98, TA100, TA102, TA1535 and TA1537 were exposed to sodium methyl mercaptide at 312.5, 625, 1250, 2500 and 5000 µg/plate or 125, 250, 500, 1000 and 2000 µg/plate with and without activation. Positive and negative controls were tested concurrently and responded appropriately. Methanethiol, sodium salt did not induce any increase in the revertant number with or without S9 mix in any of the five strains. Cytotoxic concentrations were ≥ 1000 µg/plate without S9 and ≥ 2500 µg/plate with S9. Methanethiol, sodium salt did not induce an increase in mutation frequency.
Methanethiol, sodium salt was not mutagenic in this assay.

(2) See human health data at: http://webnet.oecd.org/hpv/UI/Search.aspx

Ethanethiol (CASRN 75-08-1, supporting chemical)
(1) In a bacterial reverse mutation assay, *Salmonella typhimurium* strains TA98, TA100, TA1535, TA1537 and TA1538 were exposed to ethanethiol in DMSO at concentrations of 0, 123.5, 370.40, 1111.0, 3333.0 or 10,000 µg/plate with and without activation. The cytotoxic concentration was 10,000 µg/plate. Ethanethiol did not induce an increase in the revertant number with or without S9 mix in any of the five strains.
Ethanethiol was not mutagenic in this assay.

(2) L5178Y mouse lymphoma cells were exposed to eight graded doses (maximum dose of 1000 µg/mL) of ethanethiol (purity 100%) with and without metabolic activation. An increase in the induction of forward mutations at the T/K locus in the absence of activation was noted. Ethanethiol did not induce any forward mutations in the presence of metabolic activation [TSCATS (OTS0571884)].
Ethanethiol was mutagenic in this assay.

(3) See human health data at: http://webnet.oecd.org/hpv/UI/Search.aspx.

Subcategory III: Refinery gases, C1 – C4 with carbon monoxide
See also data for Subcategory I (except 1,3-butadiene) above.

No adequate data: see discussion in ATSDR (2009):
http://www.atsdr.cdc.gov/ToxProfiles/tp201.pdf

Subcategory IV: Refinery gases, C1 – C6
Group 1
See data for subcategory I (excepting CASRN 1,3-butadiene) above.

Butane, 2-methyl- (CASRN 78-78-4, supporting chemical)
In a reverse-mutation assay, *Salmonella typhimurium* strains TA97, TA98, TA100 and TA1535 were exposed to vapor from liquid 2-Methylbutane at concentrations of 0, 0.05, 0.1, 0.5, 1, 2, 2.5 and 5 mL/chamber with and without metabolic activation. Positive and negative controls were used and responded appropriately. No cytotoxicity was observed. No increase in mutation frequency was observed (NTP study 211868: http://ntp-apps.niehs.nih.gov/ntp_tox/index.cfm?fuseaction=ntpsearch.searchhome).
2-Methylbutane was not mutagenic in this assay.

Pentane (CASRN 109-66-0, supporting chemical)
(1) In a reverse-mutation assay, *Salmonella typhimurium* strains TA97, TA98, TA100 and TA1535 were exposed to pentane in dimethylsulfoxide (DMSO) at concentrations up to 6667 µg/plate with and without metabolic activation. Positive and negative controls were tested concurrently and responded appropriately. Cytotoxicity was observed at concentrations ≥ 100 µg/plate for all strains with and without activation. Pentane did not cause an increase in mutation frequency in any strain with or without activation (NTP study 502864: http://ntp-apps.niehs.nih.gov/ntp_tox/index.cfm?fuseaction=ntpsearch.searchhome).
Pentane was not mutagenic in this assay.

(2) See human health data for pentane: http://webnet.oecd.org/hpv/UI/SIDS_Details.aspx?Key=0af02fa3-f3ef-4df9-b050-43116efd8ef1&idx=0 and C5 aliphatic hydrocarbon solvents category - http://webnet.oecd.org/hpv/ui/Search.aspx.

Cyclopentane (CASRN 287-92-3, supporting chemical)
In a reverse-mutation assay, *Salmonella typhimurium* strains TA97, TA98, TA100 and TA1535 were exposed to cyclopentane in DMSO at concentrations of 0, 100, 333, 1000, 3333 or 10,000 µg/plate with and without metabolic activation. Positive and negative controls were tested concurrently and responded appropriately. Cytotoxicity was observed in all strains at concentrations ≥ 10,000 µg/plate with and without activation. Cyclopentane did not increase the mutation frequency in any strain (NTP study A90637: http://ntp-apps.niehs.nih.gov/ntp_tox/index.cfm?fuseaction=ntpsearch.searchhome).
Cyclopentane was not mutagenic in this assay.

2-Butene, 2-methyl- (CASRN 513-35-9, supporting chemical)
(1) *Salmonella typhimurium* strains TA98, TA100, TA1535, TA1537 and TA1538 and *Escherichia coli* strains WP2 and WP7 uvrA were exposed to 2-methyl-2-butene in ethanol at concentrations of 0, 0.2, 2, 20, 500 or 2000 µg/plate with and without metabolic activation. Positive and negative controls were used but the results were not specified. 2-methyl-2-butene did not increase the mutation frequency in any strain (http://www.chem.unep.ch/irptc/sids/OECDSIDS/513359.pdf).
2-Methyl-2-butene was not mutagenic in this assay.

(2) In a gene conversion assay, *Saccharomyces cerevisiae* were exposed to 2-methyl-2-butene in ethanol at concentrations of 0.01, 0.1, 0.5, 1 or 5 mg/mL with and without metabolic activation. No treatment-related increase in mitotic gene conversion was observed (http://www.chem.unep.ch/irptc/sids/OECDSIDS/513359.pdf).
2-Methyl-2-butene was not mutagenic in this assay.

Gasoline (CASRN 86290-81-5, supporting chemical)
(1) Mouse lymphoma L5178Y TK+/- cells were exposed to unleaded gasoline (wholly vaporized) in acetone at 0, 0.065, 0.13, 0.26, 0.52 or 1.04 µg/mL with and without metabolic activation. Positive controls were used and responded appropriately. Little cytotoxicity was observed. No increase in the mutation frequency was observed.
Gasoline was not mutagenic in this assay.

(2) *Salmonella typhimurium* strains TA98, TA100, TA1535, TA1537 and TA1538 and *Saccharomyces cerevisiae* strain D4 were exposed to unleaded gasoline (wholly vaporized) in DMSO at concentrations of 0, 0.375, 0.75, 1.5 and 3% for bacteria and 0, 0.625, 1.25, 2.5 and 5% for yeast with and without metabolic activation. Positive and negative controls responded appropriately. No dose-dependent, reproducible increases in mutation frequency were observed.
Gasoline was not mutagenic in this assay.

Naphtha (petroleum), light catalytic cracked (CASRN 64741-55-5, supporting chemical)
Paraffins: 30.6% (v/v), Olefins: 45.6%, Naphthenes: 10.4%, Aromatics: 13.1%

Mouse lymphoma cells were exposed to naphtha (petroleum), light catalytic cracked (API 83-20) in ethanol at concentrations of 50 – 800 nL/mL without metabolic activation and 25 – 500 nL/mL with activation. Positive control and negative controls responded appropriately. Cytotoxicity was observed at 175 nL/mL. Naphtha (petroleum), light catalytic cracked (API 83-20) did not cause an increase in mutation frequency.
Naphtha (petroleum), light catalytic cracked was not mutagenic in this assay.

Naphtha (petroleum), sweetened (CASRN 64741-87-3, supporting chemical)
Paraffins: 72.1% (v/v), Olefins: <0.1%, Naphthenes: 20.9%, Aromatics: 6.9%
Mouse lymphoma L5178Y TK+/- cells were exposed to naphtha (petroleum), sweetened (API 81-08) in ethanol at concentrations of 12.5 – 300 μL/mL with and without metabolic activation. Positive and negative controls responded appropriately. Naphtha (petroleum), sweetened (API 81-08) did not cause a reproducible increase in mutation frequency.
Naphtha (petroleum), sweetened was not mutagenic in this assay.

Unleaded gasoline (no CASRN, supporting chemical)
(1) **PONA composition not specified**
Salmonella typhimurium strains TA98, TA100, TA1535, TA1537 and TA1538 and *Saccharomyces cerevisiae* strain D4 were exposed to unleaded gasoline in DMSO at concentrations of 0.375 to 3% for Salmonella typhimurium and of 0.625 to 5% for Saccharomyces cerevisiae, with and without metabolic activation. Positive and negative controls responded appropriately. Unleaded gasoline did not cause a reproducible increase in mutation frequency.
Unleaded gasoline was not mutagenic in this assay.

(2) **PONA composition not specified**
Mouse lymphoma L5178Y TK+/- cells were exposed to unleaded gasoline in acetone at concentrations of 0.065 – 1.04 μL/mL with and without metabolic activation. Positive and negative controls responded appropriately. Unleaded gasoline did not cause an increase in mutation frequency.
Unleaded gasoline was not mutagenic in this assay.

Naphtha (petroleum), light catalytic cracked (CASRN 64741-55-5)
(1) **Paraffins: 30.6% (v/v), Olefins: 45.6%, Naphthenes: 10.4%, Aromatics: 13.1%**
Mouse lymphoma cells were exposed to naphtha (petroleum), light catalytic cracked (API 83-20) in ethanol at concentrations of 50 – 800 nL/mL without metabolic activation and 25 – 500 nL/mL with activation. Positive control and negative controls responded appropriately. Cytotoxicity was observed at 175 nL/mL. Naphtha (petroleum), light catalytic cracked (API 83-20) did not cause an increase in mutation frequency (HPV Challenge submission for gasoline blending streams: http://www.epa.gov/oppt/chemrtk/pubs/summaries/gasnecat/c13409tc.htm).
Naphtha (petroleum), light catalytic cracked was not mutagenic in this assay.

(2) **Paraffins: 42.8% (v/v), Olefins: 36.5%, Naphthenes: 10.2%, Aromatics: 10.2%**
Mouse lymphoma cells were exposed to naphtha (petroleum), light catalytic cracked (API 81-03) at unspecified concentrations with and without metabolic activation. Naphtha (petroleum), light catalytic cracked (API 81-03) was not mutagenic with or without activation. No other details

were provided (HPV Challenge submission for gasoline blending streams: http://www.epa.gov/oppt/chemrtk/pubs/summaries/gasnecat/c13409tc.htm).
Naphtha (petroleum), light catalytic cracked was not mutagenic in this assay.

(3) **Paraffins: 34.6% (v/v), Olefins: 29.2%, Naphthenes: 14.5%, Aromatics: 21.1%**
Mouse lymphoma cells were exposed to naphtha (petroleum), light catalytic cracked (API 81-04) at unspecified concentrations with and without metabolic activation. Naphtha (petroleum), light catalytic cracked (API 81-04) was not mutagenic without activation, but the results were equivocal with activation. No other details were provided (HPV Challenge submission for gasoline blending streams: http://www.epa.gov/oppt/chemrtk/pubs/summaries/gasnecat/c13409tc.htm).
Naphtha (petroleum), light catalytic cracked was equivocal for the induction of mutations in this assay.

Group 2
See data for subcategory I and Group 1 above.

Group 3
See data for Groups 1 and 2.

Benzene (CASRN 71-43-2, supporting chemical)
(1) *Salmonella typhimurium* strains TA98, TA100, TA104 and TA1535 were exposed to benzene as a vapor at concentrations of 0, 3, 6, 15, 30, 100, 300 or 1000 ppm with and without metabolic activation. A positive control was not used. Exposure to benzene increased the mutation frequency in TA100, TA104 and TA1535 with activation. Cytotoxicity was not specified.
Benzene was mutagenic in this assay.

(2) See human health data at: http://ecb.jrc.ec.europa.eu/DOCUMENTS/Existing-Chemicals/RISK_ASSESSMENT/REPORT/benzenereport063.pdf.

Subcategory V - XI
See appropriate data for Subcategories I to IV above.

In vivo

Subcategory I: Refinery gases, C1 – C4
1-Propene (CASRN 115-07-1, supporting chemical)
Fischer 344 rats (8 males/dose) were exposed to 1-propene via inhalation at 0, 200, 2000 or 10,000 ppm for 6 hours/day for a total of 20 exposures. After sacrifice, spleens were removed and cultured to select for Hprt mutant T-lymphocytes. Exposure to 1-propene did not increase the mutation frequency at the Hprt locus (Propylene streams category: http://www.epa.gov/chemrtk/pubs/summaries/prplstrm/c13281tc.htm).
1-Propene was not mutagenic in this assay.

Genetic Toxicity – Chromosomal Aberrations

In vitro

Subcategory I: Refinery gases, C1 – C4
Group 1
2-Butene (CASRN 107-01-7, supporting chemical)
Sprague-Dawley rat lymphocytes were exposed to 2-butene (42.4% cis, 55.3% trans) as a gas at 0, 10, 20, 40, 50, 60, 80 or 100% with and without metabolic activation. Positive and negative controls were used and responded appropriately. Cytotoxicity was observed at concentrations ≥ 50%. 2-Butene did not induce significant dose-related increases in frequency of structural chromosome aberrations or polyploid cells.
2-Butene did not induce chromosomal aberrations in this assay.

Ethylene (CASRN 74-85-1, supporting chemical)
CHO cells were exposed to ethylene at concentrations up to ~25% in a nitrogen atmosphere in 3-hour pulse treatments for 20 hours with and without metabolic activation. Positive and negative controls responded appropriately. The frequency of chromosomal aberrations was not significantly affected by exposure to ethylene (http://www.chem.unep.ch/irptc/sids/OECDSIDS/74851.pdf).
Ethylene did not induce chromosomal aberrations in this assay.

Group 2
See data for Group 1.

1,3-Butadiene (CASRN 106-99-0, supporting chemical)
(1) CHO cells were exposed to 1,3-butadiene in ethanol at 0, 24, 30 or 200 µM with or without metabolic activation. A positive control was used but results were not specified. 1,3-Butadiene was weakly positive for the induction of sister chromatid exchange in the presence of activation. 1,3-Butadiene induced sister chromatid exchange in this assay.(2) See human health data at: http://ecb.jrc.ec.europa.eu/DOCUMENTS/Existing-Chemicals/RISK_ASSESSMENT/REPORT/butadienereport019.pdf

Subcategory II: Refinery gases, C1-C4 with ammonia and hydrogen sulfide
See data for subcategory I (excepting 1,3-butadiene) above.

Methanethiol, sodium salt (CASRN 5188-07-8, supporting chemical)
(1) In a chromosomal aberration test, human lymphocytes were exposed to 21.21% sodium mercaptide solution in water at concentrations of 30, 60, 90, 120, 240 or 480 µg/mL with and without S9 mix. The frequencies of cells with structural chromosome aberrations of the vehicle and positive controls were as specified in acceptance criteria and within the range of the historical data for both tests. Cytotoxic concentrations were ≥ 240 µg/mL without S9 and 480 µg/mL with S9. Sodium methylmercaptide did not induce structural chromosome aberrations but could induce numerical aberrations (polyploidy) in cultured human lymphocytes.
Methanethiol was equivocal in this assay.

(2) See human health data at: http://webnet.oecd.org/hpv/UI/Search.aspx

Ethanethiol (CASRN 75-08-1, supporting chemical)
(1) In a sister chromosome exchange assay, CHO cells were exposed to ethanethiol (ethyl mercaptan) at concentrations of 25, 84, 250, 840 and 2500 µg/mL with and without activation. In the absence of S9 mix, an increase of SCEs was observed at 840 and 2500 µg/mL with and without metabolic activation and a > 2-fold increase in SCEs was seen both with and without activation.
Ethanethiol induced sister chromatid exchange in this assay.

(2) See human health data at: http://webnet.oecd.org/hpv/UI/Search.aspx.

Subcategory III: Refinery gases, C1-C4 with carbon monoxide
See data for subcategory I (excepting 1,3-butadiene) above.

Carbon monoxide (CASRN 630-08-0, supporting chemical)
(1) ICR mice (64 pregnant females/dose) were exposed to carbon monoxide via inhalation at 0 (control), 1500, 2500 or 3500 ppm for 10 minutes on gestation day 5, 11 or 16. Fetal blood and maternal bone marrow was examined on gestation day 21 for evidence of sister chromatid exchange (SCE) [ATSDR (2009): http://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=1145&tid=253].
Carbon monoxide induced sister chromatid exchange in this assay.

(2) ICR mice (50 pregnant females/dose) were exposed to carbon monoxide via inhalation at 0 (control) or 500 ppm (~ 0 and 0.57 mg/L, respectively) for 1 hour on gestation days 0 – 6, 7 – 13 or 14 – 20. Fetal blood and maternal bone marrow were examined on gestation day 21 for evidence of SCE [ATSDR (2009): http://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=1145&tid=253].
Carbon monoxide induced sister chromatid exchange in this assay.

Subcategory IV: Refinery gases, C1 – C6
Group 1
See also data for subcategory I (excepting 1,3-butadiene) above.

Pentane (CASRN 109-66-0, supporting chemical)
Chinese hamster ovary cells were treated with pentane with and without metabolic activation. The results obtained were inconclusive (See human health data for pentane: http://webnet.oecd.org/hpv/UI/SIDS_Details.aspx?Key=0af02fa3-f3ef-4df9-b050-43116efd8ef1&idx=0 and C5 aliphatic hydrocarbon solvents category - http://webnet.oecd.org/hpv/ui/Search.aspx).
Pentane was equivocal for chromosomal aberrations in this assay.

Cyclopentane (CASRN 287-92-3, supporting chemical)
Human lymphocytes were treated with cyclopentane with and without metabolic activation. Negative results were obtained with activation and positive results were obtained without

activation. (See human health data from C5 aliphatic hydrocarbon solvents category - http://webnet.oecd.org/hpv/ui/Search.aspx).
Cyclopentane was induced chromosomal aberrations without activation and did not induce chromosomal aberrations with activation in this assay.

2- Butene, 2-methyl- (CASRN 513-35-9, supporting chemical)
In a cytogenetics assay, rat hepatocytes were exposed to 2-methyl-2-butene at 12.5, 25 or 50 mL/mL. Exposure to 2-butene did not increase the frequency of chromatid gaps, breaks or aberrations (http://www.chem.unep.ch/irptc/sids/OECDSIDS/513359.pdf).
2-Methyl-2-butene- did not induce chromosomal aberrations in this assay.

Group 2
See data for subcategory I and Group 1.

Group 3
See data for Groups 1 and 2.
Benzene (CASRN 71-43-2, supporting chemical)
(1) Human lymphocytes were exposed to benzene at concentrations of 16, 78 or 391 mg/L with or without metabolic activation. Increases in the frequency of sister chromatid exchange and cytotoxicity were observed with activation. No positive control was used.
Benzene induced sister chromatid exchange in this assay.

(2) See human health data at: http://ecb.jrc.ec.europa.eu/DOCUMENTS/Existing-Chemicals/RISK_ASSESSMENT/REPORT/benzenereport063.pdf.

Subcategories V to XI
See appropriate data for subcategories I to IV above.

In vivo

Subcategory I: Refinery gases, C1 – C4
Group 1
1-Propene (CASRN 115-07-1, supporting chemical)
In a micronucleus assay, male Fischer 344 rats (8/dose) were exposed to 1-propene via inhalation at 0, 200, 2000 or 10,000 ppm, 6 hours/day, 5 days/week for 4 weeks. Positive and negative controls were tested and responded appropriately. No treatment-related increase in micronuclei was observed (Propylene streams category: http://www.epa.gov/chemrtk/pubs/summaries/prplstrm/c13281tc.htm).
1-Propene did not induce micronuclei in this assay.

1-Butene (CASRN 106-98-9, supporting chemical)
In a micronucleus assay, Crl:CDR(ICR)Br Swiss mice (10 – 15/sex/dose) were exposed to 1-butene whole-body via inhalation at 0, 1000, 9000 or 22,000 ppm, 2 hours/day for 1 – 2 days. A positive control was used, but the response was not specified. Exposure to 1-butene did not

increase the frequency of micronuclei formation in polychromatic erythrocytes (PCEs) or mature erythrocytes.
1-Butene did not induce micronuclei in this assay.

Ethylene (CASRN 74-85-1, supporting chemical)
In two micronucleus assays, rats and mice (10/dose, strain and sex not specified) were exposed to ethylene via inhalation at concentrations of 0, 40, 1000 or 3000 ppm, 6 hours/day, 5 days/week for 4 weeks. The positive control responded appropriately. Exposure to ethylene did not result in an increase in the frequency of micronuclei in either species (http://www.chem.unep.ch/irptc/sids/OECDSIDS/74851.pdf).
Ethylene did not induce micronuclei in this assay.

1-Propene, 2-methyl- (CASRN 115-11-7, supporting chemical)
(1) In a micronucleus assay, B6C3F1 mice (10 males/dose) were exposed to 2-methyl-1-propene whole-body via inhalation at 0, 1000, 3260 or 10,000 ppm, 6 hours/day for 2 days. Positive and negative controls responded appropriately. Exposure to 2-methyl-1-propene did not increase the number of micronuclei in PCEs (Low 1,3-butadiene C4 category HPV submission: http://www.epa.gov/chemrtk/pubs/summaries/lowbutd/c13122tc.htm).
2-Methyl-1-propene did not induce micronuclei in this assay.

(2) In a micronucleus assay conducted by the NTP, mice (5/sex/dose) were exposed to 2-methyl-1-propene via inhalation at 0, 500, 1000, 2000, 4000 or 8000 ppm for 14 weeks. Negative controls responded appropriately. There was not a significant increase in the frequency of micronuclei (NTP Technical Report No. 272).
2-Methyl-1-propene did not induce micronuclei in this assay.

Group 2
See data for Group 1.

1,3-Butadiene (CASRN 106-99-0, supporting chemical)
(1) In a micronucleus assay, male Wistar rats (10/dose) were exposed to 1,3-butadiene as a gas at 0, 50, 200 or 500 ppm, 6 hours/day for 5 days. The use of a positive control was not specified. No increase in the frequency of micronuclei was observed. A slight toxic effect was observed in rat bone marrow cells at 500 ppm.
1,3-Butadiene did not induce micronuclei in this assay.

(2) In a micronucleus assay, female CB6F1 mice (20/dose) were exposed to 1,3-butadiene as a gas at 0, 50, 200, 500 or 1300 ppm, 6 hours/day for 5 days. The use of a positive control was not specified. A dose-dependent increase in micronuclei frequency was observed in both blood and bone marrow cells at all exposure levels.
1,3-Butadiene induced micronuclei in this assay.

Subcategory III: Refinery gases C1-C4 with carbon dioxide
See data for subcategories I and II above (excepting 1,3-butadiene).

Carbon monoxide (CASRN 630-08-0, supporting chemical)
(1) In a micronucleus assay, ICR mice (64 pregnant females/dose) were exposed to carbon monoxide via inhalation at 0 (control), 1500, 2500 or 3500 ppm (~ 0, 1.7, 2.9 and 4.0 mg/L, respectively) for 10 minutes on gestation day 5, 11 or 16. Fetal blood and maternal bone marrow were examined on gestation day 21 for evidence of chromosomal aberrations [ATSDR (2009): http://www.atsdr.cdc.gov/ToxProfiles/tp201.pdf].
Carbon monoxide induced micronuclei in this assay.

(2) In a micronucleus assay, ICR mice (50 pregnant females/dose) were exposed to carbon monoxide via inhalation at 0 (control) or 500 ppm (~ 0 and 0.57 mg/L, respectively) for 1 hour on gestation days 0 – 6, 7 – 13 or 14 – 20. Fetal blood and maternal bone marrow were examined on gestation day 21 for evidence of chromosomal aberrations [ATSDR (2009): http://www.atsdr.cdc.gov/ToxProfiles/tp201.pdf].
Carbon monoxide induced micronuclei in this assay.

Subcategory IV: Refinery gases, C1 – C6
Group 1
See also data for Subcategory I (excepting CASRN 1,3-butadiene) above.

Pentane (CASRN 109-66-0, supporting chemical)
In a micronecleus assay, rats were treated with pentane via inhalation and bone marrow micronuclei examined (See human health data for pentane: http://webnet.oecd.org/hpv/UI/SIDS_Details.aspx?Key=0af02fa3-f3ef-4df9-b050-43116efd8ef1&idx=0 and C5 aliphatic hydrocarbon solvents category - http://webnet.oecd.org/hpv/ui/Search.aspx).
Pentane did not induce micronuclei in this assay.

Cyclopentane (CASRN 287-92-3, supporting chemical)
In two micronucleus assays, different strains of mice were treated with cyclopentane via inhalation and erythrocyte micronuclei examined. (See human health data from C5 aliphatic hydrocarbon solvents category - http://webnet.oecd.org/hpv/ui/Search.aspx).
Cyclopentane did not induce micronuclei in this assay.

2-Butene, 2-methyl- (CASRN 513-35-9, supporting chemical)
(1) In a micronucleus assay, male and female NMRI mice were exposed to 2-methyl-2-butene via inhalation at 1000, 3000 or 10,000 ppm for two 6-hour exposures. Male and female B6C3F1 mice were similarly exposed at 10,000 ppm only. Animals were sacrificed 24 hours following the second exposure period. A dose-related biologically relevant increase in PCEs containing micronuclei was observed at ≥ 1000 ppm in male NMRI mice and at ≥ 3000 ppm in female NMRI mice. Increased numbers of micronuclei were also observed in B6C3F1 mice at 10,000 ppm [This study was reported in the TSCA 8(e)/FYI Initial Screen Database (8EHQ-0409-17500A)].
2-Methyl-2-butene induced micronuclei in this assay.

(2) In a micronucleus assay, male Crl:CD BR rats (10/group) were exposed whole-body to 2-methyl-2-butene as a vapor at target concentrations of 0, 1000, 3260 and 10,000 ppm in air, 6

hours/day for 2 consecutive days. Actual mean exposure concentrations were 0, 1005, 3207 and 9956 ppm, respectively. Bone marrow samples were collected and prepared for evaluation of micronucleus formation approximately 24 hours after dosing. A small but statistically significant increase in micronucleus formation was observed at 3260 and 10,000 ppm. In addition, a dose-related increase was noted for the mean number of micronucleated PCEs. A statistically significant decrease in the mean percent of PCEs was observed at ≥ 1000 ppm [TSCATS (OTS0524006-2 and OTS0524006-3].
2-Methyl-2-butene induced micronuclei in this assay.

(3) In a micronucleus assay, Syrian hamsters were exposed to 2-methyl-2-butene via inhalation at 1000 ppm, 6 hours/day for 2 days. A marginal increase in bone marrow micronuclei was observed (http://www.chem.unep.ch/irptc/sids/OECDSIDS/513359.pdf).
2-Butene, 2-methyl was equivocal for the induction of micronuclei in this assay.

(4) In a micronucleus assay, B6C3F1 mice were exposed to 2-methyl-2-butene via inhalation at 1000, 3260 or 10,000 ppm, 6 hours/day for 2 days. A dose-related increase in the number of micronuclei was observed at ≥ 3260 ppm
(http://www.chem.unep.ch/irptc/sids/OECDSIDS/513359.pdf)
2-Butene, 2-methyl induced micronuclei in this assay.

Gasoline (CASRN 86290-81-5, supporting chemical)
(1) In a sister chromatid exchange assay, Sprague-Dawley Crl:CD IGS BR rats (5/sex/dose) were exposed whole-body to gasoline (API 99-01) as a vapor at nominal concentrations of 0, 2, 10 or 20 mg/L, 6 hours/day, 5 days/week for 4 weeks. Mean measured concentrations were 0, 2.1, 10.1 and 20.3 mg/L. A positive control was used and responded appropriately. Increases in sister chromatid exchange were observed in females at all exposure levels and in males at doses ≥ 10 mg/L.
Gasoline induced sister chromatid exchange in this assay.

(2) In a micronucleus assay, Sprague-Dawley Crl:CD IGS BR rats (5/sex/dose) were exposed whole-body to gasoline (API 99-01) as a vapor at nominal concentrations of 0, 2, 10 or 20 mg/L, 6 hours/day, 5 days/week for 4 weeks. Mean measured concentrations were 0, 2.1, 10.1 and 20.3 mg/L. A positive control was used and responded appropriately. No increase in the frequency of micronuclei or cytotoxicity was observed in exposed mice.
Gasoline did not induce micronuclei in this assay.

Naphtha (petroleum), sweetened (CASRN 64741-87-3, supporting chemical)
Paraffins: 72.1% (v/v), Olefins: <0.1%, Naphthenes: 20.9%, Aromatics: 6.9%
In a bone marrow chromosomal aberration assay, Sprague-Dawley rats (10/sex/dose) were exposed whole-body to naphtha (petroleum), sweetened (API 81-08) as a vapor at nominal concentrations of 0, 65, 300 or 2050 ppm (0, 0.21, 0.99 or 6.8 mg/L) for 6 hours/day for 5 days. Mean measured concentrations were 0, 69, 293 and 2012 ppm (0, 0.23, 0.97 and 6.7 mg/L). Positive and negative controls responded appropriately. There were no treatment-related increases in chromosomal aberrations.
Naphtha (petroleum), sweetened did not induce chromosomal aberrations in this assay.

Unleaded gasoline (no CASRN, supporting chemical)

(1) **Paraffins: 48.7% (v/v), Olefins: 9.0%, Naphthenes: 6.3%, Aromatics: 36.0%**

In a sister chromatid exchange assay, Sprague-Dawley rats (5/sex/dose) were exposed whole-body to unleaded gasoline (API 99-01) vapor condensate via inhalation at nominal concentrations of 0, 2, 10 or 20 mg/L for 6 hours/day, 5 days/week for 4 weeks. Mean measured concentrations were 0, 2.05, 10.2 and 20.3 mg/L. Positive and negative controls responded appropriately. A statistically significant ($p < 0.05$) increase in the frequency of sister chromatid exchange was observed at all dose levels.

Unleaded gasoline induced sister chromatid exchange in this assay.

(2) **Paraffins: 48.7% (v/v), Olefins: 9.0%, Naphthenes: 6.3%, Aromatics: 36.0%**

In a micronucleus assay, Sprague-Dawley rats (5/sex/dose) were exposed whole-body to unleaded gasoline (API 99-01) vapor condensate via inhalation at nominal concentrations of 0, 2, 10 or 20 mg/L for 6 hours/day, 5 days/week for 4 weeks. Mean measured concentrations were 0, 2.05, 10.2 and 20.3 mg/L. Positive and negative controls responded appropriately. Unleaded gasoline (API 99-01) caused neither an increase in micronucleated immature erythrocytes nor bone marrow cell toxicity.

Unleaded gasoline did not induce micronuclei in this assay.

(3) **Paraffins: 57.8% (v/v), Olefins: 9.9%, Naphthenes: 3.9%, Aromatics: 28.1%**

In a bone marrow chromosomal aberrations assay, male rats (3 – 5/dose) were administered unleaded gasoline (API PS-6) in acetone at concentrations of 0, 0.01, 0.024, 0.03, 0.08, 0.1 or 0.24 mL via intraperitoneal injection for 5 days. Positive and negative controls responded appropriately. There were no dose-related increases in chromosomal aberrations.

Unleaded gasoline did not induce chromosomal aberrations in this assay.

Group 2

See data for subcategory I and Group 1.

Group3

See data for Groups 1 and 2.

Benzene (CASRN 71-43-2, supporting chemical)

(1) In a sister chromatid exchange assay, male Sprague-Dawley rats (5/dose) were exposed to benzene as a vapor at 0, 0.1, 0.3, 1, 3, 10 or 30 ppm for 6 hours. Upon sacrifice, lymphocytes were assayed for sister chromatid exchange. The use of a positive control was not specified. At doses $\geq$ 3 ppm, a dose-dependent increase in the frequency of sister chromatid exchange was observed.

Benzene induced sister chromatid exchange in this assay.

(2) In a micronucleus assay, male Sprague-Dawley rats (5/dose) were exposed to benzene as a vapor at 0, 0.1, 0.3, 1, 3, 10 or 30 ppm for 6 hours. The use of a positive control was not specified. Significant increases in the frequency of micronuclei were observed at doses $\geq$ 1 ppm.

Benzene induced micronuclei in this assay.

(3) In a sister chromatid exchange assay, male DBA/2 mice (5/dose) were exposed to benzene as a vapor at 0, 10, 100 or 1000 ppm for 6 hours; upon sacrifice, lymphocytes were assayed for sister chromatid exchange. The use of a positive control was not specified. Increases in the frequency of sister chromatid exchange were observed at all doses.
Benzene induced sister chromatid exchange in this assay.

(4) In a micronucleus assay, male DBA/2 mice (5/dose) were exposed to benzene as a vapor at 0, 10, 100 or 1000 ppm for 6 hours. The use of a positive control was not specified. Significant increases in the frequency of micronuclei were observed at all doses.
Benzene induced micronuclei in this assay.

Subcategories V to XI
See data for subcategories I to IV above.

Additional Information

Skin Irritation

Subcategory II: Refinery gases, C1-C4 with ammonia and hydrogen sulfide
Ammonia (CASRN 7664-41-7, supporting chemical)
Ammonia as a gas or aqueous solution is a skin irritant. Aqueous ammonia is corrosive to skin and eyes in animals. See human health data for ammonia category at:
http://webnet.oecd.org/hpv/ui/Search.aspx

Subcategory IV: Refinery gases, C1 – C6
Pentane (CASRN 109-66-0, supporting chemical)
See human health data for pentane:
http://webnet.oecd.org/hpv/UI/SIDS_Details.aspx?Key=0af02fa3-f3ef-4df9-b050-43116efd8ef1&idx=0 and C5 aliphatic hydrocarbon solvents category - http://webnet.oecd.org/hpv/ui/Search.aspx.
Pentane was not a skin irritant in rabbits in this study.

Cyclopentane (CASRN 287-92-3, supporting chemical)
New Zealand White rabbits (3/sex) were administered 0.5 mL of cyclopentane via the dermal route to both intact and abraded skin under occlusive conditions for 24 hours and were observed for up to 72 hours following exposure. No erythema, edema or other dermal effects were noted at 24 hours post-exposure; therefore, the primary irritation score was 0 [TSCATS (OTS0556742)].
Cyclopentane was not irritating to rabbit skin in this study.

2-Butene, 2-methyl- (CASRN 513-35-9, supporting chemical)
New Zealand White rabbits (3/sex) were administered 0.5 mL of 2-methyl-2-butene via the dermal route to both intact and abraded skin under occlusive conditions for 24 hours and were observed for 7 days following exposure. Mild irritation was observed, including erythema and

edema. The primary irritation index was 1.79 (http://www.chem.unep.ch/irptc/sids/OECDSIDS/513359.pdf).
2-Butene, 2-methyl was slightly irritating to rabbit skin in this study.

Naphtha (petroleum), light catalytic cracked (CASRN 64741-55-5, supporting chemical)
Paraffins: 30.6% (v/v), Olefins: 45.6%, Naphthenes: 10.4%, Aromatics: 13.1%
Six rabbits (strain and sex not specified) were administered 0.5 mL of naphtha (petroleum), light catalytic cracked (API 83-20) to intact or abraded skin under occluded conditions for 24 hours and observed for 14 days following dosing. Edema and erythema were observed on both intact and abraded skin. The primary dermal irritation score was 3.7.
Naphtha (petroleum), light catalytic cracked was moderately irritating to rabbit skin in this study.

Naphtha (petroleum), sweetened (CASRN 64741-87-3, supporting chemical)
Paraffins: 72.1% (v/v), Olefins: <0.1%, Naphthenes: 20.9%, Aromatics: 4.1%
Six rabbits (strain and sex not specified) were administered 0.5 mL of naphtha (petroleum), sweetened (API 81-08) to intact or abraded skin under occluded conditions for 24 hours and observed for 14 days following dosing. Slight edema and erythema were observed on both intact and abraded skin. The primary dermal irritation score was 1.2.
Naphtha (petroleum), sweetened was slightly irritating to rabbit skin in this study.

Gasoline (no CASRN, supporting chemical)
Paraffins: 57.8% (v/v), Olefins: 9.9%, Naphthenes: 3.9%, Aromatics: 28.1%
Rabbits (3/sex, strain not specified) were administered 0.5 mL of unleaded gasoline (API PS-6) to intact or abraded skin under occluded conditions for 24 hours and observed for 14 days following dosing. Edema and erythema were noted at 72 hours on both intact and abraded skin. The primary dermal irritation score was 0.98.
Gasoline was slightly irritating to rabbit skin in this study.

Eye Irritation

Subcategory II: Refinery gases, C1-C4 with ammonia and hydrogen sulfide
Ammonia (CASRN 7664-41-7, supporting chemical)
Aqueous ammonia is corrosive to skin and eyes in animals. See human health data for ammonia category at: http://webnet.oecd.org/hpv/ui/Search.aspx

Subcategory IV: Refinery gases, C1 – C6
Pentane (CASRN 109-66-0, supporting chemical)
See human health data for pentane: http://webnet.oecd.org/hpv/UI/SIDS_Details.aspx?Key=0af02fa3-f3ef-4df9-b050-43116efd8ef1&idx=0 and C5 aliphatic hydrocarbon solvents category - http://webnet.oecd.org/hpv/ui/Search.aspx.
Pentane was minimally irritating to rabbit eyes in this study.

Cyclopentane (CASRN 287-92-3, supporting chemical)
In two studies, New Zealand White rabbits (6/sex) were administered 0.1 mL of cyclopentane in the left eye. Treated eyes were either left unwashed or washed with tap water (40 mL) 4 seconds after treatment. Untreated eyes served as controls. Animals were observed for 7 days following administration. Excessive blinking and rubbing were observed upon instillation. In washed eyes, conjunctival redness was noted in all six rabbits at the 1-hour observation and was characterized by inflamed, more diffuse and deeper crimson red blood vessels, with individual vessels not easily discernible. Redness persisted in two rabbits up to 24 hours and in another rabbit up to 48 hours. No corneal opacity, iritis, conjunctival chemosis or discharge was noted in any of the washed eyes. In unwashed eyes, iritis and chemosis were noted in one rabbit, and conjunctival redness was noted in all six rabbits. No corneal opacity or conjunctival discharge was noted in any of the unwashed eyes. All ocular lesions had cleared by day 4 [TSCATS (OTS0556743 and OTS0556744)].
Cyclopentane was moderately irritating to rabbit eyes in these studies.

2-Butene, 2-methyl- (CASRN 513-35-9, supporting chemical)
New Zealand White rabbits (6/dose) were administered 0.2 mL of 2-methyl-2-butene in one eye and were observed for 7 days following exposure. A moderate initial pain response was observed (scored as a 4 on a scale of 1 – 6). No significant irritation was observed (http://www.chem.unep.ch/irptc/sids/OECDSIDS/513359.pdf).
2-Butene, 2-methyl was not irritating to rabbit eyes in this study.

Naphtha (petroleum), light catalytic cracked (CASRN 64741-55-5, supporting chemical)
Paraffins: 30.6% (v/v), Olefins: 45.6%, Naphthenes: 10.4%, Aromatics: 13.1%
Rabbits (9/dose; strain and sex not specified) were administered 0.1 mL of naphtha (petroleum), light catalytic cracked (API 83-20) to one eye; the other eye served as a control. After 20 – 30 seconds, the treated eyes of three rabbits were rinsed with water for 1 minute. Animals were observed for 7 days after treatment. After 1 hour, primary eye irritation scores were 1.0 and 3.3 for unwashed and washed eyes, respectively. An irritation score of zero was recorded at all other times.
Naphtha (petroleum), light catalytic cracked was not irritating to rabbit eyes in this study.

Naphtha (petroleum), sweetened (CASRN 64741-87-3, supporting chemical)
Paraffins: 72.1% (v/v), Olefins: <0.1%, Naphthenes: 20.9%, Aromatics: 6.9%
Four male and five female rabbits (strain not specified) were administered 0.1 mL of naphtha (petroleum), sweetened (API 81-08) to one eye; the other eye served as a control. After 20 – 30 seconds, the treated eyes of three rabbits were rinsed with water for 1 minute. Animals were observed for 7 days after treatment. After 1 hour, primary eye irritation scores were 2.0 and 0.7 for unwashed and washed eyes, respectively. No irritation remained after 24 hours.
Naphtha (petroleum), sweetened was not irritating to rabbit eyes in this study.

Respiratory Tract Irritation

Subcategory IV: Refinery gases, C1 – C6
Butane, 2-methyl- (CASRN 78-78-4, supporting chemical)

See human health data at: http://webnet.oecd.org/hpv/ui/Search.aspx
2-Methylbutane was not a respiratory tract irritant in mice in this study.

Pentane (CASRN 109-66-0, supporting chemical)
See human health data for pentane: http://webnet.oecd.org/hpv/UI/SIDS_Details.aspx?Key=0af02fa3-f3ef-4df9-b050-43116efd8ef1&idx=0 and C5 aliphatic hydrocarbon solvents category - http://webnet.oecd.org/hpv/ui/Search.aspx.
Pentane was not a respiratory tract irritant in mice in this study.

Skin Sensitization

Subcategory IV: Refinery gases, C1 – C6
Butane, 2-methyl- (CASRN 78-78-4, supporting chemical)
See human health data at: http://webnet.oecd.org/hpv/ui/Search.aspx
2-Methylbutane was not sensitizing to guinea pig skin in this study.

Pentane (CASRN 109-66-0, supporting chemical)
See human health data for pentane: http://webnet.oecd.org/hpv/UI/SIDS_Details.aspx?Key=0af02fa3-f3ef-4df9-b050-43116efd8ef1&idx=0 and C5 aliphatic hydrocarbon solvents category - http://webnet.oecd.org/hpv/ui/Search.aspx.
Pentane was not sensitizing to guinea pig skin in this study.

2-Butene, 2-methyl- (CASRN 513-35-9, supporting chemical)
Guinea pigs (20/dose) were administered 2-methyl-2-butene as a 0.1% solution in corn oil intradermally and then as a 50% solution in corn oil topically in the induction phase. The topical challenge consisted of a 25% solution in corn oil. No positive reactions were observed after the challenge phase (http://www.chem.unep.ch/irptc/sids/OECDSIDS/513359.pdf).
2-Methyl-2-butene was not sensitizing to guinea pig skin in this study.

Naphtha (petroleum), light catalytic cracked (CASRN 64741-55-5, supporting chemical)
Paraffins: 30.6% (v/v), Olefins: 45.6%, Naphthenes: 10.4%, Aromatics: 13.1%
Guinea pigs (10/sex, strain not specified) were administered 0.4 mL of naphtha (petroleum), light catalytic cracked (API 83-20) to shorn skin under occluded conditions for 6 hours once per week for 3 weeks. After a 2-week resting period, a challenge dose of 0.4 mL of 25% test substance in paraffin oil was applied to a previously untreated site and animals were observed for 48 hours following treatment. No skin reactions were observed following application of the challenge dose.
Naphtha (petroleum), light catalytic cracked was not sensitizing to guinea pig skin in this study.

Gasoline (no CASRN, supporting chemical)
Paraffins: 57.8% (v/v), Olefins: 9.9%, Naphthenes: 3.9%, Aromatics: 28.1%
Guinea pigs (10/sex, strain not specified) were administered 0.5 mL of unleaded gasoline (API PS-6) to shorn skin under occluded conditions for 6 hours, 3 times/week, for 3 weeks. The first

application consisted of undiluted test substance; the remaining applications were 50% dilutions in mineral oil. After a 2-week resting period, a challenge dose of 0.5 mL of 50% unleaded gasoline in mineral oil was applied to a previously untreated site and animals were observed for 48 hours following treatment. On the basis of edema and erythema scores, the challenge dose did not appear to be more reactive than the sensitizing treatments.
Gasoline was not sensitizing to guinea pig skin in this study.

Carcinogenicity

Subcategory I: Refinery gases, C1 – C4
1-Propene (CASRN 115-07-1, supporting chemical)
(1) In multiple studies, Sprague-Dawley rats (≥ 100/sex/dose) were exposed to 1-propene via inhalation at 0, 200, 1000 or 5000 ppm, 7 hours/day, 5 days/week for 24 months. No treatment-related effects on survival, body weight or tumor incidence were observed {http://ecb.jrc.ec.europa.eu/esis/ and TSCATS (OTS0000116-0)}.
1-Propene did not increase the incidence of tumors in rats in this study.

(2) In a National Toxicology Program study, F344 rats (50/sex/group) were exposed whole-body to 1-propene as a gas at 0, 5000 or 10,000 ppm, 6 hours/day, 5 days/week for 103 weeks. No significant effects on survival were observed. No changes in body weight were noted and no clinical signs of toxicity were observed. An increased incidence of squamous metaplasia of the respiratory epithelium was noted in exposed rats at ≥ 5000 ppm. Epithelial hyperplasia of the nasal cavity occurred at an increased incidence in females at 10,000 ppm (9/50) and at a slightly increased incidence in males at 10,000 ppm (5/50). Inflammation of the nasal cavity was found in both males and females, at ≥ 5000 and 10,000 ppm, respectively. Inflammation was characterized by an influx of lymphocytes, macrophages and granulocytes into the submucosa and an influx of granulocytes into the lumen. An elevated incidence of hyperplasia of parafollicular (C-cell) cells in the thyroid was found in exposed male and female rats. C-cell adenomas and C-cell adenomas or carcinomas (combined) occurred in females with a significant negative trend. The incidence of C-cell adenomas at 10,000 ppm was significantly lower than that in the controls. The incidences of C-cell adenomas or carcinomas (combined) in males were not significantly different in exposed groups [NTP Technical Report No. 272].
1-Propene did not increase the incidence of tumors in rats in this study.

(3) In multiple studies, Swiss mice (≥ 100/sex/dose) were exposed to 1-propene via inhalation at 0, 200, 1000 or 5000 ppm, 7 hours/day, 5 days/week for 18 months. No treatment-related changes in survival, body weight or tumor incidence were observed {http://ecb.jrc.ec.europa.eu/esis/ and TSCATS (OTS0000116-0)}.
1-Propene did not increase the incidence of tumors in mice in this study.

(4) In an NTP study, B6C3F1 mice (49 – 50/sex/group) were exposed whole-body to 1-propene as a gas at 0, 5000 or 10,000 ppm, 6 hours/day, 5 days/week for 103 weeks. After week 59, mean body weights of males at 10,000 ppm were ~ 5% lower than those of the controls. No compound-related effects were observed on clinical signs or survival. Chronic focal inflammation of the kidneys occurred at increased incidence in exposed mice of both sexes. The incidence of alveolar/bronchiolar carcinomas in males at 5000 ppm was significantly lower than

in the controls. There was a dose-dependent decrease in alveolar/bronchiolar adenomas or carcinomas (combined) in male mice. The incidence of endometrial stromal polyps in female mice increased in a dose-dependent manner, but the incidences in the exposed groups were not significantly higher than that of the controls [NTP Technical Report No. 272].
1-Propene did not increase the incidence of tumors in mice in this study.

1-Propene, 2-methyl- (CASRN 115-11-7, supporting chemical)
F344/N rats (50/sex/group) and B63F1 mice (50/sex/group) were exposed to 0, 500, 2000, or 8000 ppm 2-methylpropene gas by whole body exposure for 6 hours/day, 5 days/week for two years. Survival of controls and exposed groups were comparable, as were body weights, with the exception of the female mice exposed to 2000 and 8000 ppm isobutylene. Nonneoplastic effects included increased incidences and/or severities of nasal lesions, including hyaline degeneration of olfactory epithelium, in male and female rats and mice, and hyaline degeneration of the respiratory epithelium in male and female mice. There was some evidence of carcinogenic activity in male F344/N rats exposed to 8000 ppm 2-methylpropene gas, based on an increased incidence of follicular cell carcinoma of the thyroid gland. There was no evidence of carcinogenic activity in female rats or mice of both sexes up to the highest concentration tested. National Toxicology Program, NTP TR 487, December 1998:
http://ntp.niehs.nih.gov/ntp/htdocs/LT_rpts/tr487.pdf
2-Methylpropene increased the incidence of tumors in male rats in this study.

1,3-Butadiene (CASRN 106-99-0, supporting chemical)
(1) In an NTP study, B6C3F1 mice (50/sex/concentration) were exposed to 1,3-butadiene gas via inhalation at 0, 625 or 1250 ppm, 6 hours/day, 5 days/week. The study was scheduled to last 2 years but, was terminated at 60 (males) and 61 weeks (females) because of high mortality in both exposure groups. Survival was markedly reduced in exposed animals due primarily to malignant tumors. Increased incidences and early induction of hemangiosarcomas of the heart, malignant lymphomas, alveolar/bronchiolar adenomas and carcinomas, and pappilomas of the stomach in males and females were seen. In addition, in females, acinar cell carcinomas of the mammary gland, granulose cell tumors of the ovary, hepatocellular adenomas and adenomas or carcinomas (combined) were seen. 1,3-Butadiene was associated with nonneoplastic lesions in the respiratory epithelium, liver necrosis, and testicular or ovarian atrophy.
(http://ntp-apps.niehs.nih.gov/ntp_tox/index.cfm?fuseaction=ntpsearch.searchhome)
1,3-Butadiene increased incidences of various tumors at multiple sites in this assay.

(2) Sprague-Dawley rats (100/sex/dose) were exposed whole-body to 1,3-butadiene as a gas at nominal concentrations of 0, 1000 or 8000 ppm, 6 hours/day, 5 days/week for 105 weeks for females or 111 weeks for males. Mean measured concentrations were 0.7, 999 and 7886 ppm (0.001, 2.2 and 17.4 mg/L). At concentrations $\geq$ 999 ppm, significant increases were observed in uterine sarcomas, total mammary gland tumors (adenomas and carcinomas combined) and thyroid follicular cell adenomas in females, as well as Leydig cell tumors in males. At 7886 ppm, significant increases were observed in the incidences of pancreatic exocrine adenomas in males and Zymbal gland carcinomas in females. [Additional details were obtained from Owen and Glaister, 1990, Environmental Health Perspectives 86:19-25.]
1.3-Butadiene was carcinogenic to rats in this study.

(3) In two NTP studies, B6C3F1 mice (50 – 70/sex/dose) were exposed to 1,3-butadiene as a gas at concentrations of 6.25 – 1250 ppm for 6 hours/day, 5 days/week for up to 2 years. Treatment-related effects included increased incidences and early induction of hemangiosarcomas of the heart, malignant lymphomas, alveolar/bronchiolar carcinomas, squamous cell carcinomas of the stomach, acinar cell carcinomas of the mammary gland, malignant granulosa cell tumors of the ovary, hepatocellular adenomas and carcinomas (combined), histiocytic sarcomas and adenoacanthomas. [Details were obtained from NTP studies C50602A and C50602C. See NTP TR-434].
1,3-Butadiene was carcinogenic to mice in these studies.

(4) There is "sufficient evidence" from epidemiologic studies of exposed workers to consider 1,3-butadiene carcinogenic to humans (http://www.epa.gov/iris/subst/0139.htm).

Subcategory IV: Refinery gases, C1 – C6
See data for subcategory I above.

Benzene (CASRN 71-43-2, supporting chemical)
(1) In a NTP study, haploinsufficient $p16^{Ink4a}/p19^{Arf}$ mice (15/sex/dose) were administered benzene in corn oil via gavage at 0, 25, 50, 100 or 200 mg/kg-bw, 5 days/week for 27 weeks. The incidence of malignant lymphoma was significantly increased in males at 200 mg/kg-bw. [Details were obtained from NTP study C99034: http://ntp-apps.niehs.nih.gov/ntp_tox/index.cfm?fuseaction=ntpsearch.searchhome].
Benzene was carcinogenic to mice in this study.

(2) In an NTP study, F344/N rats (50/sex/dose) were administered benzene in corn oil via gavage at 0, 25, 50 or 100 mg/kg-bw, 5 days/week for 103 weeks. Treatment-related increases were observed in the incidences of Zymbal gland carcinomas, squamous cell papillomas and carcinomas of the oral cavity and squamous cell papillomas and carcinomas of the skin (males only). [Details were obtained from NTP study C55276: http://ntp-apps.niehs.nih.gov/ntp_tox/index.cfm?fuseaction=ntpsearch.searchhome].
Benzene was carcinogenic to rats in this study.

(3) In an NTP study, B6C3F1 mice (50/sex/dose) were administered benzene in corn oil via gavage at 0, 25 (females only), 50, 100 or 200 (males only) mg/kg-bw, 5 days/week for 103 weeks. Exposure to benzene increased the incidences of Zymbal gland squamous cell carcinomas, malignant lymphomas, alveolar/bronchiolar carcinomas, squamous cell carcinomas of the preputial gland, ovarian granulosa cell tumors and carcinomas and carcinosarcomas of the mammary gland. [Details were obtained from NTP study C55276: http://ntp-apps.niehs.nih.gov/ntp_tox/index.cfm?fuseaction=ntpsearch.searchhome].
Benzene was carcinogenic to mice in this study.

(4) Benzene is characterized as a known human carcinogen for all routes of exposure based upon convincing human evidence as well as supporting evidence from animal studies (http://www.epa.gov/ncea/iris/subst/0276.htm).

Naphtha (petroleum), sweetened (CASRN 64741-87-3, supporting chemical)
Paraffins: 72.1% (v/v), Olefins: <0.1%, Naphthenes: 20.9%, Aromatics: 6.9%
Male C3H mice (47 – 50/dose) were administered 0.05 mL of naphtha (petroleum), sweetened (API 81-08) to shorn skin 2 times/week for 139 weeks. No adverse effects were observed on body weight or survival. There was no treatment-related effect on the incidence of non-neoplastic or neoplastic lesions.
Naphtha (petroleum), sweetened was not carcinogenic to mice in this study.

Gasoline (no CASRN, supporting chemical)
(1) **Paraffins: 57.8% (v/v), Olefins: 9.9%, Naphthenes: 3.9%, Aromatics: 28.1%**
Fischer 344 rats (100/sex/dose) were exposed whole-body to gasoline (API PS-6) as a vapor at nominal concentrations of 0, 50, 275 or 1500 ppm (~ 0, 0.2, 1.1 or 5.9 mg/L)[16] for up to 113 weeks. Mean measured concentrations were 0, 67, 292 and 2056 ppm (0, 0.3, 1.1 or 8.1 mg/L). Increases were observed in the incidence of renal carcinomas, sarcomas and adenomas in males.
Gasoline was carcinogenic to rats in this study.

(2) **Paraffins: 57.8% (v/v), Olefins: 9.9%, Naphthenes: 3.9%, Aromatics: 28.1%**
B6C3F1 mice (100/sex/dose) were exposed whole-body to gasoline (API PS-6) as a vapor at nominal concentrations of 0, 50, 275 or 1500 ppm (~ 0, 0.2, 1.1 or 5.9 mg/L)[16] for up to 113 weeks. Mean measured concentrations were 0, 67, 292 and 2056 ppm (0, 0.3, 1.1 or 8.1 mg/L). Increases were observed in the incidence of hepatocellular carcinomas and adenomas.
Gasoline was carcinogenic to mice in this study.

(3) **Paraffins: 57.8% (v/v), Olefins: 9.9%, Naphthenes: 3.9%, Aromatics: 28.1%**
C3H/HeJ mice (50 males) were administered 0.05 mL of gasoline (API PS-6) via the dermal route 2 times/week to clipped skin for 131 weeks. There was no treatment-related effect on the incidence of systemic or dermal tumors.
Gasoline was not carcinogenic to mice in this study.

Neurotoxicity

Subcategory II: Refinery gases, C1-C4 with ammonia and hydrogen sulfide
Hydrogen sulfide (CASRN 7783-06-4, supporting chemical)
(1) Rats (strain not specified) were exposed to hydrogen sulfide at a concentration of 125 ppm 4 hours/day, 5 days/week in several tests for 5 – 11 weeks. In one test, rats were trained on a radial arm maze and then exposed to hydrogen sulfide for 5 weeks. Following exposure, performance on the maze was assessed. There were no adverse effects on maze performance after 5 weeks of exposure. In another test, rats were simultaneously exposed to hydrogen sulfide and trained on the maze for 11 weeks. Rats were able to do the maze task, but performance was adversely affected. Rats from this test had difficulty re-learning the maze task after they were retrained on the maze without additional exposure [ATSDR (2006): http://www.atsdr.cdc.gov/ToxProfiles/tp114.pdf].
Hydrogen sulfide was neurotoxic to rats in this study.

[16] Units were converted from ppm to mg/L using the molecular weight of 96.2 g/mole provided by the sponsor for unleaded gasoline sample API 99-01.

(2) Male Sprague-Dawley rats were exposed to hydrogen sulfide at concentrations of 0 or 50 ppm (0.07 mg/L) 5 days/week for 25 weeks. Neurological function was assessed using measurements of motor and sensory nerve conduction velocities of the tail nerve and the morphology of the sciatic nerve. There were no treatment-related neurotoxic effects noted [ATSDR (2006): http://www.atsdr.cdc.gov/ToxProfiles/tp114.pdf].
Hydrogen sulfide was neurotoxic to rats in this study.

Subcategory IV: Refinery gases, C1 – C6
Gasoline (no CASRN, supporting chemical)
(1) **Paraffins: 77.4% (v/v), Olefins: 15.2% , Naphthenes: 3.3% , Aromatics: 4.2%**
Sprague-Dawley rats (5/sex/dose) were administered unleaded gasoline (API 99-01) vapor condensate via whole-body inhalation as a vapor at nominal concentrations of 0, 2, 10 or 20 mg/L for 6 hours/day, 7 days/week. Mean measured concentrations were 0, 2.0, 10.1 and 20.0 mg/L. The parental generation was exposed for 10 weeks prior to mating, 2 weeks during mating, 3 weeks during gestation and 4 weeks postpartum. Exposure of pregnant females was suspended between gestation day 19 and postpartum day 5. Pups were not exposed directly to unleaded gasoline (API 99-01). F1 pup brains were evaluated for glial fibrillary acidic protein (GFAP) levels on postpartum day 28. Exposure of the parental generation did not elevate GFAP levels in any assessed brain region, indicating that unleaded gasoline (API 99-01) did not cause gliosis.
Gasoline was not neurotoxic to rats in this study.

(2) **Paraffins: 77.4% (v/v), Olefins: 15.2% , Naphthenes: 3.3%, Aromatics: 4.2%**
Sprague-Dawley rats (5/sex/dose) were administered unleaded gasoline (API 99-01) vapor condensate via whole-body inhalation as a vapor at nominal concentrations of 0, 2, 10 or 20 mg/L, 6 hours/day, 5 days/week for 13 weeks. Mean measured concentrations were 0, 2.1, 10.2 and 20.3 mg/L. Adult brains were evaluated for GFAP levels at the end of exposure. Exposure to unleaded gasoline did not elevate GFAP levels in any assessed brain region, indicating that unleaded gasoline did not cause gliosis.
Gasoline was not neurotoxic to rats in this study.

(3) Although gasoline did not demonstrate neurotoxicity in the studies provided by the sponsor, the neurotoxicity of gasoline is well-established in humans. Information on the human neurotoxicity of gasoline may be found in the ATSDR Toxicological Profile for Automotive Gasoline, http://www.atsdr.cdc.gov/toxprofiles/tp72.pdf.

Other

1,3-Butadiene (CASRN 106-99-0, supporting chemical)
(1) Male B6C3F1 mice (20 mice/concentration) were exposed to 1,3-butadiene gas at 0, 200, 1000 or 5000 ppm, 6 hours/day for 5 days and sacrificed 5 weeks after the end of exposure. Mice were examined for lesions of the reproductive tract and other gross abnormalities. Sperm from the cauda of the right epididymis were examined for morphological abnormalities. A significant, dose-related increase in the frequency of abnormal sperm heads was observed at ≥

1000 ppm. This study was designed to assess the effects of 1,3-butadiene on sperm head morphology and did not include all of the endpoints necessary to assess the reproductive toxicity of a substance (Crude butadiene C4 category; http://www.epa.gov/chemrtk/pubs/summaries/olefins/c12064tc.htm).

(2) In a dominant lethal mutation assay, male CD-1 mice (50/dose) were exposed to 1,3-butadiene gas at 0, 12.5, 65 or 130 ppm (0, 0.028, 0.14 or 0.29 mg/L), 6 hours/day, 5 days/week for 4 weeks, and then mated with unexposed females. Females were sacrificed on gestation day 17 and uterine contents were examined. An increase in early embryonic deaths was observed at concentrations ≥ 0.14 mg/L. An increased frequency of runts (fetuses with weight reduced by 75%) was observed at 0.29 mg/L; runts exhibited an increased frequency of skeletal abnormalities, including macroscopic changes in the sternum, vertebrae, pelvic girdle and forelimbs [TSCATS (OTS0559090)].
1,3-Butadiene induced dominant lethal mutations in this assay.

Unleaded gasoline (no CASRN, supporting chemical)
Paraffins: 57.8% (v/v), Olefins: 9.9%, Naphthenes: 3.9%, Aromatics: 28.1%
In a dominant lethal assay, CD-1 mice (10 males/dose) were exposed to unleaded gasoline (API PS-6) as a vapor at nominal concentrations of 0, 400 or 1600 ppm (0, 1.5 or 6 mg/L) for 6 hours/day, 5 days/week for 8 weeks. Exposed males were mated with unexposed females and the numbers of live and dead implants were counted. Mean measured concentrations were 0, 396 and 1525 ppm (~ 0, 1.6 and 6.0 mg/L)[17]. Positive and negative controls responded appropriately. There were no treatment-related increases in post-implantation deaths.
Unleaded gasoline did not induce dominant lethal mutations in this assay.

Conclusion: No data are available for the sponsored substances of the refinery gases category. Supporting chemical data are used to address the human health endpoints.

Subcategory I: Refinery gases, C1 – C4
Group 1. No data are available for the sponsored substances for the human health endpoints. The acute inhalation toxicity of propene and 2-butene in rats is low. Rats repeatedly exposed via inhalation to propene for up to 14-weeks showed no adverse treatment-related effects; the NOAEC for systemic toxicity is 10,000 ppm/day (highest concentration tested). In combined inhalation repeated-dose/reproductive/developmental toxicity screening tests in rats, ethane, 75-28-5, 106-97-8 and 1-butene showed no adverse treatment-related effects; the NOAECs for systemic toxicity are 15,502 ppm/day, 9148 ppm/day, 9157 ppm/day and 8000 ppm/day, respectively (highest concentrations tested). In a combined inhalation repeated-dose/reproductive/developmental toxicity screening test in rats, CASRN 74-98-6 showed decreased body weight gain in males, and hematological effects in females at 12,168 ppm/day; the NOAEC for systemic toxicity is 3990 ppm/day. Ethene, 2-butene and 2-methylpropene showed no treatment-related effects with repeated inhalation exposure in rats; the NOAECs for systemic toxicity range from 5009 ppm/day 2-butene) to 10,000 ppm/day (ethene, highest concentrations tested). 2-Methylpropene, showed no treatment-related effects after 14 weeks of repeated inhalation exposure in mice; the NOAEC for systemic

[17] Units were converted from ppm to mg/L using the molecular weight of 96.2 g/mole provided by the sponsor for unleaded gasoline sample API 99-01.

toxicity is 7980 ppm/day (highest concentration tested). In the combined repeated-dose/reproductive/developmental screening tests previously mentioned, ethane, 106-97-8, 2-butene and 1-butene showed no treatment-related effects on reproduction; the NOAECs for reproductive/maternal/developmental toxicity in rats are15,502 ppm/day, 9157 ppm/day, 5009 ppm/day and 8000 ppm/day, respectively (highest concentrations tested). Repeated inhalation exposure with isobutane in rats showed decreased fertility and increased post-implantation loss at 9148 ppm; the NOAEC for reproductive toxicity is 3122 ppm/day and the NOAEC for maternal/developmental toxicity is 9148 ppm/day (highest concentration tested). The combined repeated-dose/reproductive/developmental screening test with propane in rats, showed a decrease in the number of live pups and an increase in the number of stillborn pups after inhalation exposure at 3990 ppm/day; the NOAEC for reproductive/developmental toxicity is 1230 ppm/day. Based on the systemic effects observed at 12,168 ppm/day (decreased body weight gain and hematological effects), the NOAEC for maternal toxicity is 3990 ppm/day. No specific reproductive toxicity studies are available for 2-methylpropene; however, in the 14-week inhalation repeated-dose toxicity study described above, there was a decrease in sperm motility at 7970 ppm/day. However, no adverse developmental effects were observed in the prenatal developmental toxicity study in rats; for 2-methylpropene the NOAEC for maternal/developmental toxicity is 18.4 mg/L/day (highest concentration tested). In a combined inhalation reproductive/developmental toxicity screening test in rats, ethene showed no adverse effects; the NOAEC for reproductive/maternal/developmental toxicity is 10,000 ppm/day (highest concentration tested). In an inhalation prenatal developmental toxicity study in rats, propene showed no treatment-related effects; the NOAEC for maternal/developmental toxicity is 10,000 ppm/day (highest concentration tested). Propene induced gene mutations in bacteria, but was equivocal for mutagenicity in mouse lymphoma cells *in vitro*. CASRNs 74-82-8, 106-97-8, ethene, 2-methylpropene, 1-butene and 2-butene did not induce gene mutations in bacteria or mouse lymphoma cells *in vitro*. Ethene and 2-butene did not induce chromosomal aberrations in rat lymphocytes or Chinese hamster ovary (CHO) cells *in vitro* and propene, ethene, 2-methylpropene and 1-butene did not induce micronuclei in rats and/or mice *in vivo*. Propene was not carcinogenic in rats or mice when administered via the inhalation route of exposure. 2-Methylpropene increased the incidence of tumors in male rats but not female rats, or mice of both sexes.

Group 2. See also data for Group 1. The acute inhalation toxicity of 1,3-butadiene is low in rats. Repeated-dose studies show the mouse to be more sensitive to CASRN 1,3-butadiene exposure than the rat. Several studies of inhalation exposure for up to two-years showed minimal effects in rats; the NOAEC for systemic toxicity is 7886 ppm/day. In a 14-week inhalation repeated-dose toxicity study in mice, 1,3-butadiene showed mortality at 1250 ppm/day; the NOAEC for systemic toxicity is 625 ppm/day. The most sensitive reproductive endpoint observed in subchronic studies with CASRN 1,3-butadiene was fetal deaths in dominant lethal studies in mice exposed by inhalation for 28-days at 65 ppm/day; the NOAEC for dominant lethal effects is 12.5 ppm/day. In two-year bioassays, the most sensitive reproductive effects were ovarian atrophy in female mice at 6.25 ppm/day and testicular atrophy in male mice at 625 ppm/day. The NOAEC for reproductive toxicity in female mice is not established and in male mice is 200 ppm/day. In a combined reproductive/developmental toxicity screening test, rats exposed to 1,3-butadiene by vapor inhalation showed no effects on reproduction; the NOAEC for reproductive/developmental toxicity is 13.3 mg/L/day (highest concentration tested). Maternal

toxicity, as evidenced by decreased body weight, was observed in dams treated at 3.3 mg/L; the NOAEC for maternal toxicity is 0.66 mg/L/day. Prenatal developmental toxicity studies in rats and mice showed decreased body weight gains in treated dams following inhalation exposure to CASRN 1,3-butadiene at 200 and 1000 ppm/day, in mice and rats, respectively. No effects on developmental parameters were observed in rats; the NOAECs for maternal and developmental toxicity are 200 ppm/day and 1000 ppm/day (highest concentration tested), respectively. Reduced fetal body weight was observed in male mice at 40 ppm/day; the NOAECs for maternal and developmental toxicity are not established. 1,3-Butadiene was mutagenic in bacteria *in vitro* and induced chromosomal aberrations *in vivo*. 1,3-Butadiene increased incidences of various tumors at multiple sites in rats and mice and there is "sufficient evidence" from epidemiologic studies of exposed workers to consider 1,3-butadiene carcinogenic to humans.

Subcategory II: Refinery gases, C1 – C4 with ammonia and hydrogen sulfide

No data are available for the sponsored substances for the human health endpoints. The data in subcategory I (excepting data for 1,3-butadiene) can also be used to address the human health endpoints for subcategory II. Please see the human health summary for subcategory I above.

The acute inhalation toxicity for CASRN 7664-41-7 is moderate in rats and mice. In repeated-dose inhalation studies in guinea pigs, chickens and mice, darkening/reddening, edema, congestion and hemorrhage were seen in the lungs of all three species at 0.014 mg/L/day. Guinea pigs also showed grossly enlarged and congested spleens and livers; the NOAEC is not established. No specific reproductive toxicity studies are available for CASRN 7664-41-7; however, no effects on reproductive organs were observed in animals in repeated-dose studies. CASRN 7664-41-7 did not induce gene mutations in bacteria *in vitro*. CASRN 7664-41-7 is a skin and eye irritant and is corrosive in the aqueous form.

The acute inhalation toxicity of hydrogen sulfide is moderate in rats. In inhalation repeated-dose studies in rats and mice, the olfactory nasal mucosa is the principal target site. Local effects are observed at 80 ppm in mice and 30 ppm in rats; the NOAEC for local effects is 10 ppm/day in rats and 30.5 ppm/day in mice. In different strains of rats, females showed decreased body weights and males showed increased absolute brain weights at 80 ppm; the NOAEC for systemic toxicity is 30.5 ppm/day. In a combined inhalation reproductive/developmental toxicity screening test in rats, no effects on reproduction were observed; the NOAEC for reproductive/maternal/developmental toxicity is 80 ppm/day (highest concentration tested). Hydrogen sulfide did not induce gene mutations in bacteria *in vitro*.

Subcategory III: Refinery gases, C1-C4 with carbon monoxide

No data are available for the sponsored substances for the human health endpoints. The data in subcategory I (excepting 1,3-butadiene) can also be used to address the human health endpoints for subcategory III. Please see human health summary for subcategory I above.

The acute inhalation toxicity of CO is moderate in rats. The mechanism of toxicity of carbon monoxide poisoning is well studied. CO binds to hemoglobin (Hb), forming carboxyhemoglobin (COHb), and thereby rendering the hemoglobin molecule less able to bind oxygen. Oxygen transportation by the blood and the release of bound oxygen in the tissues are decreased. Tissue damage results from local hypoxia. Organs with a high oxygen requirement, such as the heart

and the brain, are especially sensitive to this effect. Rats exposed via inhalation to CO for up to 13 weeks showed no adverse effects up to 0.15 mg/L/day; the NOAEC for systemic effects is 0.15 mg/L/day (highest concentration tested). No specific reproductive toxicity studies are available; however, no effects were observed on the reproductive organs in repeated-dose studies. Prenatal developmental toxicity studies are available in several species. The NOAEC for developmental toxicity is not established based on effects such as mortality, decreased pregnancies and decreased fetal weights at 90 ppm and 30 ppm in rabbits and rats, respectively. The NOAEC for maternal toxicity ranges from 30 ppm/day in rats (increased brain weight and brain edema at 90 ppm/day) to 180 ppm/day in rabbits (no effects at highest concentration tested). CO induces chromosomal aberrations in mammalian cells *in vitro*.

Subcategory IV: Refinery gases, C1-C6

No data are available for the sponsored substances for the human health endpoints. The data in subcategory I can also be used to address the human health endpoints for subcategory IV. Please see human health summary for subcategory I above.

Groups 1 and 2 (includes 1,3-butadiene). The acute oral, inhalation and dermal toxicity of subcategory IV in rats is low. In 90-day vapor inhalation repeated-dose studies in rats, pentane and cyclopentane showed no adverse treatment-related effects; the NOAECs for systemic toxicity are 20 mg/L/day and 30 mg/L/day (highest concentrations tested), respectively. Rats exposed to CASRN 86290-81-5 by inhalation for 13 weeks, showed no adverse treatment-related effects; the NOAEC for systemic toxicity is 20.3 mg/L/day (highest concentration tested). Several representative studies in gasoline are available. In unleaded gasoline (no CASRN), a decrease in brain weight in males was observed at 1.57 mg/L/day, the lowest dose tested in a repeated-dose toxicity study by the inhalation route in rats; the NOAEC for systemic toxicity was not be established. Effects on pulmonary function were observed at 6.35 mg/L/day in a repeated-dose toxicity study by the inhalation route in monkeys; the NOAEC for systemic toxicity is 1.57 mg/L/day. In unleaded gasoline blend (no CASRN), signs of kidney toxicity in males were reported at 0.15 mg/L/day in a repeated-dose toxicity study by the inhalation route in rats; the NOAEC for systemic toxicity is 14.7 mg/L/day in females (highest dose tested). The NOAEC is not established in males. In leaded gasoline (no CASRN), signs of blood toxicity and effects on pulmonary function were reported at 1.53 mg/L/day in repeated-dose toxicity studies by the inhalation route in rats and monkeys; the NOAEC for systemic toxicity is 0.42 mg/L/day in rats and in male monkeys, and 1.53 mg/L/day in female monkeys (highest dose tested).

In an inhalation combined repeated-dose/reproductive/developmental toxicity screening test in rats, 2-methyl-2-butene showed heart lesions in males and longer clotting times in females at 2026 ppm/day; the NOAEC for systemic toxicity is 584 ppm/day. No effects on reproduction were observed; the NOAEC for reproductive/developmental toxicity is 7097 ppm/day (highest concentration tested). Based on the systemic effects described above, the NOAEC for maternal toxicity is 584 ppm/day. No specific reproductive toxicity studies are available for pentane; however no effects were observed on the reproductive organs in rats following 90-day inhalation exposure. In an oral prenatal developmental toxicity study in rats, pentane showed no maternal or developmental effects; the NOAEC for maternal/developmental toxicity is 1000 mg/kg/day (highest dose tested). A prenatal developmental toxicity study by the inhalation route in rats with CASRN 64741-55-5 showed no signs of maternal toxicity, but an increase in the number of

resorptions was observed at 7.7 mg/L/day; the NOAEC for maternal and developmental toxicity are 7.7 mg/L/day and 2.2 mg/L/day, respectively. A prenatal developmental toxicity study by the inhalation route in rats with unleaded gasoline (PONA composition not specified) showed no signs of maternal toxicity, but increases in delayed ossification in offspring were observed at 6.2 mg/L/day; the NOAECs for maternal and developmental toxicity are 6.2 mg/L/day and 1.7 mg/L/day, respectively.

CASRNs 78-78-4, pentane, cyclopentane and 513-35-9 did not induce gene mutations in mouse lymphoma cells and bacteria *in vitro*. Pentane was equivocal for chromosomal aberrations *in vitro* and negative in a rat micronucleus assay *in vivo*. Cyclopentane was positive in the absence, and negative in the presence of metabolic activation, for chromosomal aberrations *in vitro*, and negative in a mouse micronucleus assay *in vivo*. 2-Methyl-2-butene did not induce chromosomal aberrations *in vitro* but induced micronuclei in rats and mice *in vivo*; whereas a micronuclei test of the same chemical was equivocal in hamsters. CASRN 86290-81-5 induced sister chromatid exchange in rats, but not in micronuclei *in vivo*. 2-Methylbutane is not irritating to the respiratory tract in mice and is not a skin sensitizer in guinea pigs. pentane is irritating to rabbit eyes, not irritating to rabbit skin or the respiratory tract of mice and not a skin sensitizer in guinea pigs. cyclopentane is moderately irritating to rabbit eyes and not irritating to rabbit skin. 2-Methyl-2-butene is irritating to rabbit skin, but not to rabbit eyes. cyclopentane is not irritating to rabbit skin, but is irritating to rabbit eyes. 2-methyl-2-butene is not a skin sensitizer in guinea pigs. CASRN 64741-55-5 is irritating to rabbit skin, not irritating to rabbit eye and is not a skin sensitizer in guinea pigs. Unleaded and leaded gasolines are neurotoxic in humans.

Group 3. See also data from groups 1 and 2. The acute oral and inhalation toxicity of benzene in rats is low and moderate, respectively. Repeated-dose studies with benzene show that the hematopoietic system is the most sensitive indicator of toxicity. Mice exposed repeatedly via vapor inhalation to benzene showed hematological effects [e.g. decreases in blood cell counts (RBC and WBC), platelets, hemoglobin, hematocrit], thymic atrophy and testicular effects at 0.96 mg/L/day; the NOAEC for systemic toxicity is 0.1 mg/L/day. In a similar study in mice, designed to assess specific effects on hematology, increases in spleen weight, total nucleated cells per spleen and nucleated RBCs were seen at 0.03 mg/L; the NOAEC is not established. Repeated inhalation exposure of rats to benzene showed a decrease in WBC counts and percentage of lymphocytes at 0.96 mg/L/day; the NOAEC for hematological effects on peripheral blood circulation is 0.096 mg/L/day. Guideline reproductive toxicity studies are not available; however, in the 13-week inhalation exposures with benzene in mice, adverse effects were observed on the male and female reproductive organs. In a modified prenatal developmental toxicity study, female rats exposed to benzene via vapor inhalation pre- and post-mating and through lactation, had female pups with reduced body and liver weights at 0.96 mg/L/day; the NOAECs for maternal and developmental toxicity are 0.96 mg/L/day (highest concentration tested) and 0.096 mg/L/day, respectively. In an inhalation prenatal developmental toxicity study in mice, benzene showed effects on the hematopoietic system in offspring at 0.064 mg/L/day; the NOAECs for maternal and developmental toxicity are 0.064 mg/L/day (highest concentration tested) and 0.032 mg/L/day, respectively. Benzene induced gene mutations in bacteria *in vitro*, sister chromatid exchange in human lymphocytes *in vitro* and in rat and mouse lymphocytes *in vivo*. Benzene induced micronuclei in rats and mice *in vivo*.

Subcategories V: Refinery gases, C1 – C6 with hydrogen sulfide; Subcategory VI: Refinery gases, C1 – C6 with carbon monoxide; Subcategory VII: Refinery gases, C1 – C6 with carbon monoxide and hydrogen sulfide; Subcategory VIII: Refinery gases, C1 – C6 with ammonia and hydrogen sulfide; and Subcategory IX: Refinery gases, C1 – C6 with ammonia, hydrogen sulfide and carbon monoxide

No data are available for the sponsored substances for the human health endpoints. Available data from subcategories I, II, III and IV can also be used to address the human health endpoints for subcategories V to XI. Please see these human health summaries.

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

Subcategory I: Refinery gases, C1 – C4

Group 1

Endpoint	SPONSORED CHEMICAL Gases (petroleum), catalytic reformed naphtha stripper overheads (68477-77-0)	SPONSORED CHEMICAL Tail gas (petroleum), catalytic cracker refractionation absorber (68478-25-1)	SPONSORED CHEMICAL Fuel gases, hydrotreater fractionation, scrubbed (68513-11-1)	SPONSORED CHEMICAL Fuel gases, thermal cracked catalytic cracking residue (68513-13-3)	SPONSORED CHEMICAL Gases (petroleum), catalytic reformed straight-run naphtha stabilizer overheads (68513-14-4)	SPONSORED CHEMICAL Gases (petroleum), reformer effluent high-pressure flash drum off (68513-18-8)	SPONSORED CHEMICAL Gases (petroleum), reformer effluent low-pressure flash drum off (68513-19-9)	SPONSORED CHEMICAL Gases, (petroleum), methane-rich off (68527-14-0)	SPONSORED CHEMICAL Gases (petroleum), secondary absorber off, fluidized catalytic cracker overheads fractionators (68602-84-6)	SPONSORED CHEMICAL Petroleum products, refinery gases (68607-11-4)
Acute Inhalation Toxicity LC_{50} (mg/L)	No Data > 23 (RA)									
Repeated-Dose Toxicity NOAEL/LOAEL Oral (mg/kg-bw/day)	No Data NOAEL = 14.86 LOAEL = 148.55 (RA)									
Repeated-Dose Toxicity NOAEC/LOAEC Inhalation (ppm/day)	No Data NOAEC = 3990 LOAEC = 12,168 (RA)									
Reproductive Toxicity NOAEC/LOAEC Inhalation (ppm/day) Reproductive Toxicity	No Data NOAEC = 1230 LOAEC = 3990 (RA)									
Developmental Toxicity NOAEC/LOAEC Inhalation (ppm/day) Maternal Toxicity	No Data NOAEC = 3990 LOAEC=12,168									

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

Subcategory I: Refinery gases, C1 – C4

Group 1

Endpoint	**SPONSORED CHEMICAL Gases (petroleum), catalytic reformed naphtha stripper overheads (68477-77-0)**	**SPONSORED CHEMICAL Tail gas (petroleum), catalytic cracker refractionation absorber (68478-25-1)**	**SPONSORED CHEMICAL Fuel gases, hydrotreater fractionation, scrubbed (68513-11-1)**	**SPONSORED CHEMICAL Fuel gases, thermal cracked catalytic cracking residue (68513-13-3)**	**SPONSORED CHEMICAL Gases (petroleum), catalytic reformed straight-run naphtha stabilizer overheads (68513-14-4)**	**SPONSORED CHEMICAL Gases (petroleum), reformer effluent high-pressure flash drum off (68513-18-8)**	**SPONSORED CHEMICAL Gases (petroleum), reformer effluent low-pressure flash drum off (68513-19-9)**	**SPONSORED CHEMICAL Gases, (petroleum), methane-rich off (68527-14-0)**	**SPONSORED CHEMICAL Gases (petroleum), secondary absorber off, fluidized catalytic cracker overheads fractionators (68602-84-6)**	**SPONSORED CHEMICAL Petroleum products, refinery gases (68607-11-4)**
Developmental Toxicity	NOAEC = 1230 LOAEC=3990 (RA)									
Genetic Toxicity – Gene Mutation *In vitro*	No Data Negative (RA)									
Genetic Toxicity – Gene Mutation *In vivo*	No Data Negative (RA)									
Genetic Toxicity – Chromosomal Aberrations *In vitro*	No Data Negative (RA)									
Genetic Toxicity – Chromosomal Aberrations *In vivo*	No Data Negative (RA)									

Measured data in bold text; (RA) = Read Across

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

Subcategory I: Refinery gases, C1 – C4 (continued)

	Group 1							*Group 2 (with 1,3 butadiene)**		
Endpoint	**SPONSORED CHEMICAL Gases (petroleum), hydrocracking low-pressure separator (68783-06-2)**	**SPONSORED CHEMICAL Gases (petroleum), refinery (68814-67-5)**	**SPONSORED CHEMICAL Gases (petroleum), platformer products separator off (68814-90-4)**	**SPONSORED CHEMICAL Gases (petroleum), fluidized catalytic cracker scrubbing secondary absorber off (68919-03-9)**	**SPONSORED CHEMICAL Gases (petroleum), platformer stabilizer off, light ends fractionation (68919-07-3)**	**SPONSORED CHEMICAL Gases (petroleum), unifiner stripper off (68919-12-0)**	**SPONSORED CHEMICAL Tail gas (petroleum), catalytic hydrodesulfurized naphtha separator (68952-79-4)**	**SPONSORED CHEMICAL Fuel gases, crude oil distillates (68476-29-9)**	**SPONSORED CHEMICAL Gases (petroleum), hydrocracking depropanizer off, hydrocarbon-rich (68513-16-6)**	**SPONSORED CHEMICAL Gases (petroleum), sponge absorber off, fluidized catalytic cracker and gas oil (68955-33-9)**
Acute Inhalation Toxicity LC_{50} (mg/L)	No Data > 23 (RA)									
Repeated-Dose Toxicity NOAEL/ LOAEL Oral (mg/kg-bw/day)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)									
Repeated-Dose Toxicity NOAEC/ LOAEC Inhalation (ppm/day)	No Data NOAEC = 3990 LOAEC = 12,168 (RA)							No Data NOAEC = 625 LOAEC = 1250 (RA)		
Reproductive Toxicity NOAEC/ LOAEC Inhalation (ppm/day) Reproductive Toxicity	No Data NOAEC = 1230 LOAEC = 3990 (RA)							No Data (rat) NOAEC = 1230 LOAEC = 3990 (mouse) NOAEC = 12.5 LOAEC = 65 (RA)		

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

Subcategory I: Refinery gases, C1 – C4 (continued)

	Group 1							*Group 2 (with 1,3 butadiene)**		
Endpoint	**SPONSORED CHEMICAL Gases (petroleum), hydrocracking low-pressure separator (68783-06-2)**	**SPONSORED CHEMICAL Gases (petroleum), refinery (68814-67-5)**	**SPONSORED CHEMICAL Gases (petroleum), platformer products separator off (68814-90-4)**	**SPONSORED CHEMICAL Gases (petroleum), fluidized catalytic cracker scrubbing secondary absorber off (68919-03-9)**	**SPONSORED CHEMICAL Gases (petroleum), platformer stabilizer off, light ends fractionation (68919-07-3)**	**SPONSORED CHEMICAL Gases (petroleum), unifiner stripper off (68919-12-0)**	**SPONSORED CHEMICAL Tail gas (petroleum), catalytic hydrodesulfurized naphtha separator (68952-79-4)**	**SPONSORED CHEMICAL Fuel gases, crude oil distillates (68476-29-9)**	**SPONSORED CHEMICAL Gases (petroleum), hydrocracking depropanizer off, hydrocarbon-rich (68513-16-6)**	**SPONSORED CHEMICAL Gases (petroleum), sponge absorber off, fluidized catalytic cracker and gas oil (68955-33-9)**
Developmental Toxicity NOAEC/ LOAEC Inhalation (ppm/day) **Maternal Toxicity** **Developmental Toxicity**	No Data NOAEC = 3990 LOAEC=12,168 NOAEC = 1230 LOAEC=3990 (RA)							No Data NOAEC = Not Established LOAEC = 200 NOAEC = Not established LOAEC = 40 (RA)		
Genetic Toxicity – Gene Mutation *In vitro*	No Data Negative (RA)							No Data Positive (RA)		
Genetic Toxicity – Gene Mutation *In vivo*	No Data Negative (RA)							–		
Genetic Toxicity – Chromosomal Aberrations *In vitro*	No Data Negative (RA)							No Data Positive (RA)		
Genetic Toxicity – Chromosomal Aberrations *In vivo*	No Data Negative (RA)							No Data Positive (RA)		

Measured data in bold text; (RA) = Read Across; – indicates endpoint not addressed for this chemical; * contains up to 2% 1,3-butadiene

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

	Subcategory II: Refinery gases, C1 – C4 with ammonia and hydrogen sulfide		*Subcategory III: Refinery gases, C1 – C4 with carbon monoxide*			
Endpoint	**SPONSORED CHEMICAL Gases (petroleum), dry sour, gas-concn.-unit-off (68477-92-9)**	**SPONSORED CHEMICAL Gases (petroleum), distillate unifiner desulfurization stripper off (68919-01-7)**	**SPONSORED CHEMICAL Fuel gases (68476-26-6)**	**SPONSORED CHEMICAL Gases (petroleum), hydrogen-rich (68477-97-4)**	**SPONSORED CHEMICAL Gases (petroleum), oil refinery gas distn. Off (68527-15-1)**	**SPONSORED CHEMICAL Fuel gases, producer gas (8006-20-0)**
Acute Inhalation Toxicity LC_{50} (ppm)	No Data 440 (RA)	No Data 440 (RA)	No Data 1800 (RA)	No Data 1800 (RA)	No Data 1800 (RA)	No Data 1800 (RA)
Repeated-Dose Toxicity NOAEL/LOAEL Inhalation (mg/L)	No Data (rat; local effects) NOAEC = 10 LOAEC = 30 (rat; systemic) NOAEC = 30.5 LOAEC = 80 (RA)	No Data (rat; local effects) NOAEC = 10 LOAEC = 30 (rat; systemic) NOAEC = 30.5 LOAEC = 80 (RA)	No Data NOAEC = 0.15 mg/L/day (RA)	No Data NOAEC = 0.15 mg/L/day (RA)	No Data NOAEC = 0.15 mg/L/day (RA)	No Data NOAEC = 0.15 mg/L/day (RA)
Reproductive Toxicity NOAEC/LOAEC Inhalation (ppm/day) **Reproductive Toxicity**	No Data NOAEC = 80 (RA)	No Data NOAEC = 80 (RA)	No Data No effects were observed in the reproductive organs in repeated-dose study (RA)	No Data No effects were observed in the reproductive organs in repeated-dose study (RA)	No Data No effects were observed in the reproductive organs in repeated-dose study (RA)	No Data No effects were observed in the reproductive organs in repeated-dose study (RA)
Developmental Toxicity NOAEC/LOAEC Inhalation (ppm/day) **Maternal Toxicity** **Developmental Toxicity**	No Data NOAEC = 80 NOAEC = 80 (RA)	No Data NOAEC = 80 NOAEC = 80 (RA)	No Data (Long Evans rat) NOAEC = 30 LOAEC = 90 NOAEC = Not established LOAEC = 30	No Data (Long Evans rat) NOAEC = 30 LOAEC = 90 NOAEC = Not established LOAEC = 30	No Data (Long Evans rat) NOAEC = 30 LOAEC = 90 NOAEC = Not established LOAEC = 30	No Data (Long Evans rat) NOAEC = 30 LOAEC = 90 NOAEC = Not established LOAEC = 30

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

	Subcategory II: Refinery gases, C1 – C4 with ammonia and hydrogen sulfide		***Subcategory III: Refinery gases, C1 – C4 with carbon monoxide***			
Endpoint	**SPONSORED CHEMICAL Gases (petroleum), dry sour, gas-concn.-unit-off (68477-92-9)**	**SPONSORED CHEMICAL Gases (petroleum), distillate unifiner desulfurization stripper off (68919-01-7)**	**SPONSORED CHEMICAL Fuel gases (68476-26-6)**	**SPONSORED CHEMICAL Gases (petroleum), hydrogen-rich (68477-97-4)**	**SPONSORED CHEMICAL Gases (petroleum), oil refinery gas distn. Off (68527-15-1)**	**SPONSORED CHEMICAL Fuel gases, producer gas (8006-20-0)**
Maternal Toxicity			(rabbit) NOAEC = 180	(rabbit) NOAEC = 180	(rabbit) NOAEC = 180	(rabbit) NOAEC = 180
Developmental Toxicity			NOAEC = Not established LOAEC = 90 (RA)	NOAEC = Not established LOAEC = 90 (RA)	NOAEC = Not established LOAEC = 90 (RA)	NOAEC = Not established LOAEC = 90 (RA)
Genetic Toxicity – Gene Mutation *In vitro*	No Data Positive (RA)	No Data Positive (RA)	No Data Negative (RA)	No Data Negative (RA)	No Data Negative (RA)	No Data Negative (RA)
Genetic Toxicity – Chromosomal Aberrations *In vitro*	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)
Genetic Toxicity – Chromosomal Aberrations *In vivo*	–	–	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)

Measured data in bold text; (RA) = Read Across; – indicates endpoint not addressed for this chemical

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

Subcategory IV: Refinery gases, C1 – C6

	Group 1				***Group 2 (with 1,3 butadiene)****		***Group 3 (with benzene and 1,3 butadiene)***		
Endpoint	**SPONSORED CHEMICAL Gases (petroleum), C6 – 8 catalytic reformer (68477-81-6)**	**SPONSORED CHEMICAL Tail gas, (petroleum), cracked distillate hydrotreater separator (68478-29-5)**	**SPONSORED CHEMICAL Tail gas (petroleum), hydrodesulfurized straight-run naphtha separator (68478-30-8)**	**SPONSORED CHEMICAL Gases (petroleum), preflash tower off, crude distn. (68919-08-4)**	**SPONSORED CHEMICAL Fuel gases, refinery (68308-27-0)**	**SPONSORED CHEMICAL Tail gas (petroleum), straight-run naphtha hydrodesulfurizer (68952-80-7)**	**SPONSORED CHEMICAL Tail gas (petroleum), catalytic reformed naphtha separator (68478-27-3)**	**SPONSORED CHEMICAL Tail gas (petroleum), catalytic reformed naphtha stabilizer (68478-28-4)**	**SPONSORED CHEMICAL Residues (petroleum), deethanizer tower** (68513-68-8)**
Acute Oral Toxicity LD_{50} (mg/kg)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)	–	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)
Acute Inhalation Toxicity LC_{50} (mg/L)	No Data > 175 (RA)	No Data > 175 (RA)	No Data > 175 (RA)	No Data 440 ppm (RA)	No Data > 175 (RA)	No Data > 175 (RA)	No Data > 175 (RA)	No Data > 175 (RA)	No Data > 175 (RA)
Acute Dermal Toxicity LD_{50} (mg/kg)	No Data > 2000 (RA)	No Data > 2000 (RA)	No Data > 2000 (RA)	–	No Data > 2000 (RA)	No Data > 2000 (RA)	No Data > 2000 (RA)	No Data > 2000 (RA)	No Data > 2000 (RA)
Repeated-Dose Toxicity NOAEL/LOAEL Oral (mg/kg-bw/day)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)	–	No Data NOAEL = 14.86 LOAEL = 148.55 (RA)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)
Repeated-Dose Toxicity NOAEC/LOAEC Inhalation (ppm/day)	No Data NOAEC = 625 LOAEC =1250 (RA)	No Data NOAEC = 625 LOAEC =1250 (RA)	No Data NOAEC = 625 LOAEC =1250 (RA)	No Data (rat; local effects) NOAEC = 10 LOAEC = 30 (rat; systemic) NOAEC = 30.5 LOAEC = 80 (RA)	No Data NOAEC = 625 LOAEC =1250 (RA)	No Data NOAEC = 625 LOAEC =1250 (RA)	No Data (mg/L) NOAEC = 0.10 LOAEC = 0.96 (RA)	No Data (mg/L) NOAEC = 0.10 LOAEC = 0.96 (RA)	No Data (mg/L) NOAEC = 0.10 LOAEC = 0.96 (RA)

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

Subcategory IV: Refinery gases, C1 – C6									
	Group 1				*Group 2 (with 1,3 butadiene)**		*Group 3 (with benzene and 1,3 butadiene)***		
Endpoint	**SPONSORED CHEMICAL Gases (petroleum), C6 – 8 catalytic reformer (68477-81-6)**	**SPONSORED CHEMICAL Tail gas, (petroleum), cracked distillate hydrotreater separator (68478-29-5)**	**SPONSORED CHEMICAL Tail gas (petroleum), hydrodesulfurized straight-run naphtha separator (68478-30-8)**	**SPONSORED CHEMICAL Gases (petroleum), preflash tower off, crude distn. (68919-08-4)**	**SPONSORED CHEMICAL Fuel gases, refinery (68308-27-0)**	**SPONSORED CHEMICAL Tail gas (petroleum), straight-run naphtha hydrodesulfurizer (68952-80-7)**	**SPONSORED CHEMICAL Tail gas (petroleum), catalytic reformed naphtha separator (68478-27-3)**	**SPONSORED CHEMICAL Tail gas (petroleum), catalytic reformed naphtha stabilizer (68478-28-4)**	**SPONSORED CHEMICAL Residues (petroleum), deethanizer tower** (68513-68-8)**
Reproductive Toxicity NOAEC/LOAEC Inhalation (ppm/day)					No Data (rat) NOAEC = 1230 LOAEC = 3990	No Data (rat) NOAEC = 1230 LOAEC = 3990	No Data (rat) NOAEC = 1230 LOAEC = 3990	No Data (rat) NOAEC = 1230 LOAEC = 3990	No Data (rat) NOAEC = 1230 LOAEC = 3990
Reproductive Toxicity	No Data NOAEC = 7097 (RA)	No Data NOAEC = 7097 (RA)	No Data NOAEC = 7097 (RA)	No Data NOAEC = 80 (RA)	(mouse – 28-day) NOAEC = 12.5 LOAEC = 65 (RA)	(mouse – 28-day) NOAEC = 12.5 LOAEC = 65 (RA)	(mouse – 28-day) NOAEC = 12.5 LOAEC = 65 (RA)	(mouse – 28-day) NOAEC = 12.5 LOAEC = 65 (RA)	(mouse – 28-day) NOAEC = 12.5 LOAEC = 65 (RA)
Developmental Toxicity NOAEC/LOAEC Inhalation (ppm/day)									
Maternal Toxicity	No Data NOAEC = 584 LOAEC = 2026	No Data NOAEC = 584 LOAEC = 2026	No Data NOAEC = 584 LOAEC = 2026	No Data NOAEC = 80	No Data NOAEC = Not Established LOAEC = 200	No Data NOAEC = Not Established LOAEC = 200	No Data NOAEC = Not Established LOAEC = 200	No Data NOAEC = Not Established LOAEC = 200	No Data NOAEC = Not Established LOAEC = 200
Developmental Toxicity	NOAEC = 7097 (RA)	NOAEC = 7097 (RA)	NOAEC = 7097 (RA)	NOAEC = 80 (RA)	NOAEC = Not established LOAEC = 40 (RA)	NOAEC = Not established LOAEC = 40 (RA)	NOAEC = Not established LOAEC = 40 (RA)	NOAEC = Not established LOAEC = 40 (RA)	NOAEC = Not established LOAEC = 40 (RA)
Genetic Toxicity – Gene Mutation *In vitro*	No Data Negative (RA)	No Data Negative (RA)	No Data Negative (RA)	No Data Negative (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)
Genetic Toxicity – Chromosomal Aberrations *In vitro*	No Data Negative (RA)	No Data Negative (RA)	No Data Negative (RA)	No Data Negative (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)

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

Subcategory IV: Refinery gases, C1 – C6									
	Group 1				***Group 2 (with 1,3 butadiene)****		***Group 3 (with benzene and 1,3 butadiene)***		
Endpoint	**SPONSORED CHEMICAL Gases (petroleum), C6 – 8 catalytic reformer (68477-81-6)**	**SPONSORED CHEMICAL Tail gas, (petroleum), cracked distillate hydrotreater separator (68478-29-5)**	**SPONSORED CHEMICAL Tail gas (petroleum), hydrodesulfurized straight-run naphtha separator (68478-30-8)**	**SPONSORED CHEMICAL Gases (petroleum), preflash tower off, crude distn. (68919-08-4)**	**SPONSORED CHEMICAL Fuel gases, refinery (68308-27-0)**	**SPONSORED CHEMICAL Tail gas (petroleum), straight-run naphtha hydrodesulfurizer (68952-80-7)**	**SPONSORED CHEMICAL Tail gas (petroleum), catalytic reformed naphtha separator (68478-27-3)**	**SPONSORED CHEMICAL Tail gas (petroleum), catalytic reformed naphtha stabilizer (68478-28-4)**	**SPONSORED CHEMICAL Residues (petroleum), deethanizer tower** (68513-68-8)**
Genetic Toxicity – Chromosomal Aberrations ***In vivo***	No Data Negative (RA)	No Data Negative (RA)	No Data Negative (RA)	No Data Negative (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)

Measured data in bold text; (RA) = Read Across; – indicates endpoint not addressed for this chemical; * contains up to 2% 1,3-butadiene; **contains up to 2% 1,3-butadiene and benzene (CASRN 71-43-2)

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

	Subcategory V: Refinery gases, C1 – C6 with hydrogen sulfide	***Subcategory VI: Refinery gases, C1 – C6 with carbon monoxide***							
		Group 1						***Group 2 (with benzene)****	
Endpoint	**SPONSORED CHEMICAL Gases (petroleum), dry sour, gas-concn.-unit-off (68477-95-2)**	**SPONSORED CHEMICAL Gases (petroleum), blend oil, hydrogen-nitrogen-rich (68477-68-9)**	**SPONSORED CHEMICAL Gases (petroleum), hydrotreater blend oil recycle, hydrogen-nitrogen-rich (68477-98-5)**	**SPONSORED CHEMICAL Gases (petroleum), reformer make-up, hydrogen-rich (68478-01-3)**	**SPONSORED CHEMICAL Fuel gases, amine system residues (68476-27-7)**	**SPONSORED CHEMICAL Fuel gases, C6 – 8 catalytic reformer (68476-28-8)**	**SPONSORED CHEMICAL Gases (petroleum), hydrotreated sour kerosine flash drum (68911-59-1)**	**SPONSORED CHEMICAL Gases (petroleum), benzene unit recycle, hydrogen-rich (68477-67-8)**	**SPONSORED CHEMICAL Gases (petroleum), C6 – 8 catalytic reformer recycle (68477-80-5)**
Acute Oral Toxicity LD_{50} (mg/kg-bw)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 810-10,000 (RA)	No Data 810-10,000 (RA)
Acute Inhalation Toxicity LC_{50} (mg/L)	No Data 440 ppm (RA)	No Data 1800 ppm (RA)	No Data 1800 ppm (RA)	No Data 1800 ppm (RA)	No Data 1800 ppm (RA)	No Data 1800 ppm (RA)	No Data 1800 ppm (RA)	43.7	43.7
Acute Dermal Toxicity LD_{50} (mg/kg-bw)	No Data > 2000 (RA)	No Data > 2000 (RA)	No Data > 2000 (RA)	No Data > 2000 (RA)	No Data > 2000 (RA)	No Data > 2000 (RA)	No Data > 2000 (RA)	No Data > 2000 (RA)	No Data > 2000 (RA)
Repeated-Dose Toxicity NOAEL/LOAEL Oral (mg/kg-bw/day)	No Data NOAEL = 14.9 LOAEL = 148.9 (RA)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)
Repeated-Dose Toxicity NOAEC/LOAEC Inhalation (ppm/day)	No Data (rat; local effects) NOAEC = 10 LOAEC = 30 (rat; systemic) NOAEC = 30.5 LOAEC = 80 (RA)	No Data NOAEC = 625 LOAEC =1250 (RA)	No Data NOAEC = 625 LOAEC =1250 (RA)	No Data NOAEC = 625 LOAEC =1250 (RA)	No Data NOAEC = 625 LOAEC =1250 (RA)	No Data NOAEC = 625 LOAEC =1250 (RA)	No Data NOAEC = 625 LOAEC =1250 (RA)	No Data; mg/L/day NOAEC = 0.10 LOAEC = 0.96 (RA)	No Data: mg/L/day NOAEC = 0.10 LOAEC = 0.96 (RA)

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

	Subcategory V: Refinery gases, C1 – C6 with hydrogen sulfide	***Subcategory VI: Refinery gases, C1 – C6 with carbon monoxide***							
		Group 1						***Group 2 (with benzene)****	
Endpoint	**SPONSORED CHEMICAL Gases (petroleum), dry sour, gas-concn.-unit-off (68477-95-2)**	**SPONSORED CHEMICAL Gases (petroleum), blend oil, hydrogen-nitrogen-rich (68477-68-9)**	**SPONSORED CHEMICAL Gases (petroleum), hydrotreater blend oil recycle, hydrogen-nitrogen-rich (68477-98-5)**	**SPONSORED CHEMICAL Gases (petroleum), reformer make-up, hydrogen-rich (68478-01-3)**	**SPONSORED CHEMICAL Fuel gases, amine system residues (68476-27-7)**	**SPONSORED CHEMICAL Fuel gases, C6 – 8 catalytic reformer (68476-28-8)**	**SPONSORED CHEMICAL Gases (petroleum), hydrotreated sour kerosine flash drum (68911-59-1)**	**SPONSORED CHEMICAL Gases (petroleum), benzene unit recycle, hydrogen-rich (68477-67-8)**	**SPONSORED CHEMICAL Gases (petroleum), C6 – 8 catalytic reformer recycle (68477-80-5)**
Reproductive Toxicity NOAEC/LOAEC Inhalation (ppm/day)	No Data (rat) NOAEC = 1230 LOAEC = 3990 (mouse – 28-day) NOAEC = 12.5 LOAEC = 65 (mouse – 2-year) NOAEC(f) = Not Established LOAEC(f) = 6.25 NOAEC(m) = 200 LOAEC (m) = 625 (RA)	No Data NOAEC = 7097 (RA)	No Data NOAEC = 7097 (RA)	No Data NOAEC = 7097 (RA)	No Data NOAEC = 7097 (RA)	No Data NOAEC = 7097 (RA)	No Data NOAEC = 7097 (RA)	No Data NOAEC = 1230 LOAEC = 3990 (RA)	No Data NOAEC = 1230 LOAEC = 3990 (RA)
Developmental Toxicity NOAEC/LOAEC Inhalation (ppm/day)	No Data NOAEC = Not Established LOAEC = 200	No Data (Long Evans rat) NOAEC = 30 LOAEC = 90	No Data (Long Evans rat) NOAEC = 30 LOAEC = 90	No Data (Long Evans rat) NOAEC = 30 LOAEC = 90	No Data (Long Evans rat) NOAEC = 30 LOAEC = 90	No Data (Long Evans rat) NOAEC = 30 LOAEC = 90	No Data (Long Evans rat) NOAEC = 30 LOAEC = 90	No Data NOAEC = 0.064	No Data NOAEC = 0.064
Maternal Toxicity		NOAEC = Not established LOAEC = 30	NOAEC = Not established LOAEC = 30	NOAEC = Not established LOAEC = 30	NOAEC = Not established LOAEC = 30	NOAEC = Not established LOAEC = 30	NOAEC = Not established LOAEC = 30	NOAEC = 0.032 LOAEC = 0.064 (RA)	NOAEC = 0.032 LOAEC = 0.064 (RA)
Developmental Toxicity	NOAEC = Not established LOAEC = 40 (RA)	(rabbit) NOAEC = 180	(rabbit) NOAEC = 180	(rabbit) NOAEC = 180	(rabbit) NOAEC = 180	(rabbit) NOAEC = 180	(rabbit) NOAEC = 180		
Maternal Toxicity		NOAEC = Not established LOAEC = 90 (RA)	NOAEC = Not established LOAEC = 90 (RA)	NOAEC = Not established LOAEC = 90 (RA)	NOAEC = Not established LOAEC = 90 (RA)	NOAEC = Not established LOAEC = 90 (RA)	NOAEC = Not established LOAEC = 90 (RA)		
Developmental Toxicity									

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

	Subcategory V: Refinery gases, C1 – C6 with hydrogen sulfide	*Subcategory VI: Refinery gases, C1 – C6 with carbon monoxide*							
		Group 1						*Group 2 (with benzene)**	
Endpoint	**SPONSORED CHEMICAL Gases (petroleum), dry sour, gas-concn.-unit-off (68477-95-2)**	**SPONSORED CHEMICAL Gases (petroleum), blend oil, hydrogen-nitrogen-rich (68477-68-9)**	**SPONSORED CHEMICAL Gases (petroleum), hydrotreater blend oil recycle, hydrogen-nitrogen-rich (68477-98-5)**	**SPONSORED CHEMICAL Gases (petroleum), reformer make-up, hydrogen-rich (68478-01-3)**	**SPONSORED CHEMICAL Fuel gases, amine system residues (68476-27-7)**	**SPONSORED CHEMICAL Fuel gases, C6 – 8 catalytic reformer (68476-28-8)**	**SPONSORED CHEMICAL Gases (petroleum), hydrotreated sour kerosine flash drum (68911-59-1)**	**SPONSORED CHEMICAL Gases (petroleum), benzene unit recycle, hydrogen-rich (68477-67-8)**	**SPONSORED CHEMICAL Gases (petroleum), C6 – 8 catalytic reformer recycle (68477-80-5)**
Genetic Toxicity – Gene Mutation *In vitro*	No Data Positive (RA)	No Data Negative (RA)	No Data Negative (RA)	No Data Negative (RA)	No Data Negative (RA)	No Data Negative (RA)	No Data Negative (RA)	No Data Positive (RA)	No Data Positive (RA)
Genetic Toxicity – Chromosomal Aberrations *In vitro*	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)
Genetic Toxicity – Chromosomal Aberrations *In vivo*	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)

Measured data in bold text; (RA) = Read Across; – indicates endpoint not addressed for this chemical; * contains up to 2% benzene (CASRN 71-43-2)

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

	Subcategory VI: Refinery gases, C1 – C6 with carbon monoxide			*Subcategory VII: Refinery gases, C1 – C6 with carbon monoxide and hydrogen sulfide*	*Subcategory VIII: Refinery gases, C1 – C6 with ammonia and hydrogen sulfide*		
	Group 2 (with benzene) cont.*				*Group 1*	*Group 2 (with 1,3 butadiene)***	
Endpoint	**SPONSORED CHEMICAL Gases (petroleum), C6 – 8 catalytic reformer recycle, hydrogen-rich (68477-82-7)**	**SPONSORED CHEMICAL Gases (petroleum), benzene unit hydrotreater depentanizer overheads (68602-82-4)**	**SPONSORED CHEMICAL Gases (petroleum), benzene unit hydrodesulfurizer off (68477-66-7)**	**SPONSORED CHEMICAL Gases (petroleum), reforming hydrotreater (68478-02-4)**	**SPONSORED CHEMICAL Gases (petroleum), heavy distillate hydrotreater desulfurization stripper off (68919-04-0)**	**SPONSORED CHEMICAL Gases (petroleum), fluidized catalytic cracker fractionation off (68919-02-8)**	**SPONSORED CHEMICAL Waste gases, refinery vent (68814-47-1)**
Acute Oral Toxicity LD_{50} (mg/kg)	No Data 810-10,000 (RA)	No Data 810-10,000 (RA)	No Data 810-10,000 (RA)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)
Acute Inhalation Toxicity LC_{50} (mg/L)	43.7	43.7	43.7	No Data 440 ppm (RA)	No Data 400 ppm (RA)	No Data 400 ppm (RA)	No Data 400 ppm (RA)
Acute Dermal Toxicity LD_{50} (mg/kg)	No Data > 2000 (RA)	No Data > 2000 (RA)	No Data > 2000 (RA)	No Data > 2000 (RA)	No Data > 2000 (RA)	No Data > 2000 (RA)	No Data > 2000 (RA)
Repeated-Dose Toxicity NOAEL/LOAEL Oral (mg/kg-bw/day)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)
Repeated-Dose Toxicity NOAEC/LOAEC Inhalation (ppm/day)	No Data; mg/L/day NOAEC = 0.10 LOAEC = 0.96 (RA)	No Data; mg/L/day NOAEC = 0.10 LOAEC = 0.96 (RA)	No Data; mg/L/day NOAEC = 0.10 LOAEC = 0.96 (RA)	No Data (rat; local effects) NOAEC = 10 LOAEC = 30 (rat; systemic) NOAEC = 30.5 LOAEC = 80 (RA)	No Data (rat; local effects) NOAEC = 10 LOAEC = 30 (rat; systemic) NOAEC = 30.5 LOAEC = 80 (RA)	No Data (rat; local effects) NOAEC = 10 LOAEC = 30 (rat; systemic) NOAEC = 30.5 LOAEC = 80 (RA)	No Data (rat; local effects) NOAEC = 10 LOAEC = 30 (rat; systemic) NOAEC = 30.5 LOAEC = 80 (RA)
Reproductive Toxicity NOAEC/LOAEC Inhalation (ppm/day) Reproductive	No Data NOAEC = 1230 LOAEC = 3990 (RA)	No Data NOAEC = 1230 LOAEC = 3990 (RA)	No Data NOAEC = 1230 LOAEC = 3990 (RA)	No Data NOAEC = 80 (RA)	No Data NOAEC = 80 (RA)	No Data (rat) NOAEC = 1230 LOAEC = 3990	No Data (rat) NOAEC = 1230 LOAEC = 3990

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

	Subcategory VI: Refinery gases, C1 – C6 with carbon monoxide			*Subcategory VII: Refinery gases, C1 – C6 with carbon monoxide and hydrogen sulfide*	*Subcategory VIII: Refinery gases, C1 – C6 with ammonia and hydrogen sulfide*		
	Group 2 (with benzene) cont.*				*Group 1*	*Group 2 (with 1,3 butadiene)***	
Endpoint	**SPONSORED CHEMICAL Gases (petroleum), C6 – 8 catalytic reformer recycle, hydrogen-rich (68477-82-7)**	**SPONSORED CHEMICAL Gases (petroleum), benzene unit hydrotreater depentanizer overheads (68602-82-4)**	**SPONSORED CHEMICAL Gases (petroleum), benzene unit hydrodesulfurizer off (68477-66-7)**	**SPONSORED CHEMICAL Gases (petroleum), reforming hydrotreater (68478-02-4)**	**SPONSORED CHEMICAL Gases (petroleum), heavy distillate hydrotreater desulfurization stripper off (68919-04-0)**	**SPONSORED CHEMICAL Gases (petroleum), fluidized catalytic cracker fractionation off (68919-02-8)**	**SPONSORED CHEMICAL Waste gases, refinery vent (68814-47-1)**
Toxicity						(mouse – 28-day) NOAEC = 12.5 LOAEC = 65 (mouse – 2-year) NOAEC(f) = Not Established LOAEC(f) = 6.25 NOAEC(m) = 200 LOAEC (m) = 625 (RA)	(mouse – 28-day) NOAEC = 12.5 LOAEC = 65 (mouse – 2-year) NOAEC(f) = Not Established LOAEC(f) = 6.25 NOAEC(m) = 200 LOAEC (m) = 625 (RA)
Developmental Toxicity NOAEL/LOAEL Inhalation (ppm/day) **Maternal Toxicity** **Developmental Toxicity** **Maternal Toxicity** **Developmental Toxicity**	No Data NOAEC = 0.064 NOAEC = 0.032 LOAEC = 0.064 (RA)	No Data NOAEC = 0.064 NOAEC = 0.032 LOAEC = 0.064 (RA)	No Data NOAEC = 0.064 NOAEC = 0.032 LOAEC = 0.064 (RA)	No Data (Long Evans rat) NOAEC = 30 LOAEC = 90 NOAEC = Not established LOAEC = 30 (rabbit) NOAEC = 180 NOAEC = Not established LOAEC = 90 (RA)	No Data NOAEC = 80 NOAEC = 80 (RA)	No Data NOAEC = Not Established LOAEC = 200 NOAEC = Not established LOAEC = 40 (RA)	No Data NOAEC = Not Established LOAEC = 200 NOAEC = Not established LOAEC = 40 (RA)

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

	Subcategory VI: Refinery gases, C1 – C6 with carbon monoxide			*Subcategory VII: Refinery gases, C1 – C6 with carbon monoxide and hydrogen sulfide*	*Subcategory VIII: Refinery gases, C1 – C6 with ammonia and hydrogen sulfide*		
	Group 2 (with benzene) cont.*				*Group 1*	*Group 2 (with 1,3 butadiene)***	
Endpoint	**SPONSORED CHEMICAL Gases (petroleum), C6 – 8 catalytic reformer recycle, hydrogen-rich (68477-82-7)**	**SPONSORED CHEMICAL Gases (petroleum), benzene unit hydrotreater depentanizer overheads (68602-82-4)**	**SPONSORED CHEMICAL Gases (petroleum), benzene unit hydrodesulfurizer off (68477-66-7)**	**SPONSORED CHEMICAL Gases (petroleum), reforming hydrotreater (68478-02-4)**	**SPONSORED CHEMICAL Gases (petroleum), heavy distillate hydrotreater desulfurization stripper off (68919-04-0)**	**SPONSORED CHEMICAL Gases (petroleum), fluidized catalytic cracker fractionation off (68919-02-8)**	**SPONSORED CHEMICAL Waste gases, refinery vent (68814-47-1)**
Genetic Toxicity – Gene Mutation *In vitro*	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Negative (RA)	No Data Negative (RA)	No Data Positive (RA)	No Data Positive (RA)
Genetic Toxicity – Chromosomal Aberrations *In vitro*	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Negative (RA)	No Data Positive (RA)	No Data Positive (RA)
Genetic Toxicity – Chromosomal Aberrations *In vivo*	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	–	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)

Measured data in bold text; (RA) = Read Across; – indicates endpoint not addressed for this chemical; *contains up to 2% benzene (CASRN 71-43-2); **contains up to 2% 1,3-butadiene

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

Subcategory IX: Refinery gases, C1 – C6 with ammonia, hydrogen sulfide and carbon monoxide

	Group 1					***Group 2 (with 1,3 butadiene)****		***Group 3 (with 1,3 butadiene and benzene)****	
Endpoint	**SPONSORED CHEMICAL Gases (petroleum), amine system feed (68477-65-6)**	**SPONSORED CHEMICAL Gases (petroleum), recycle, hydrogen-rich (68478-00-2)**	**SPONSORED CHEMICAL Gases (petroleum), reforming hydrotreater, hydrogen-methane-rich (68478-03-5)**	**SPONSORED CHEMICAL Gases (petroleum), reforming hydrotreater make-up, hydrogen-rich (68478-04-6)**	**SPONSORED CHEMICAL Gases (petroleum), hydrotreated sour kerosine depentanizer stabilizer off (68911-58-0)**	**SPONSORED CHEMICAL Gases (petroleum), refinery blend (68783-07-3)**	**SPONSORED CHEMICAL Fuel gases, refinery, unsweetened (68783-62-0)**	**SPONSORED CHEMICAL Gases (petroleum), thermal cracking distn. (68478-05-7)**	**SPONSORED CHEMICAL Gases (petroleum), crude distn. and catalytic cracking (68989-88-8)**
Acute Oral Toxicity LD_{50} (mg/kg)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)	No Data 1059 < LD_{50} < 1655 (RA)
Acute Inhalation Toxicity LC_{50} (ppm)	No Data 400 (RA)								
Acute Dermal Toxicity LD_{50} (mg/kg)	No Data > 2000 (RA)								
Repeated-Dose Toxicity NOAEL/LOAEL Oral (mg/kg-bw/day)	No Data NOAEL = 14.9 LOAEL = 148.6 (RA)								
Repeated-Dose Toxicity NOAEC/LOAEC Inhalation (ppm/day)	No Data (rat; local effects) NOAEC = 10 LOAEC = 30 (rat; systemic) NOAEC = 30.5 LOAEC = 80 (RA)	No Data (rat; local effects) NOAEC = 10 LOAEC = 30 (rat; systemic) NOAEC = 30.5 LOAEC = 80 (RA)	No Data (rat; local effects) NOAEC = 10 LOAEC = 30 (rat; systemic) NOAEC = 30.5 LOAEC = 80 (RA)	No Data (rat; local effects) NOAEC = 10 LOAEC = 30 (rat; systemic) NOAEC = 30.5 LOAEC = 80 (RA)	No Data (rat; local effects) NOAEC = 10 LOAEC = 30 (rat; systemic) NOAEC = 30.5 LOAEC = 80 (RA)	No Data (rat; local effects) NOAEC = 10 LOAEC = 30 (rat; systemic) NOAEC = 30.5 LOAEC = 80 (RA)	No Data (rat; local effects) NOAEC = 10 LOAEC = 30 (rat; systemic) NOAEC = 30.5 LOAEC = 80 (RA)	No Data (rat; local effects) NOAEC = 10 LOAEC = 30 (rat; systemic) NOAEC = 30.5 LOAEC = 80 (RA)	No Data (rat; local effects) NOAEC = 10 LOAEC = 30 (rat; systemic) NOAEC = 30.5 LOAEC = 80 (RA)

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

Subcategory IX: Refinery gases, C1 – C6 with ammonia, hydrogen sulfide and carbon monoxide									
	Group 1					*Group 2 (with 1,3 butadiene)**		*Group 3 (with 1,3 butadiene and benzene)***	
Endpoint	**SPONSORED CHEMICAL Gases (petroleum), amine system feed (68477-65-6)**	**SPONSORED CHEMICAL Gases (petroleum), recycle, hydrogen-rich (68478-00-2)**	**SPONSORED CHEMICAL Gases (petroleum), reforming hydrotreater, hydrogen-methane-rich (68478-03-5)**	**SPONSORED CHEMICAL Gases (petroleum), reforming hydrotreater make-up, hydrogen-rich (68478-04-6)**	**SPONSORED CHEMICAL Gases (petroleum), hydrotreated sour kerosine depentanizer stabilizer off (68911-58-0)**	**SPONSORED CHEMICAL Gases (petroleum), refinery blend (68783-07-3)**	**SPONSORED CHEMICAL Fuel gases, refinery, unsweetened (68783-62-0)**	**SPONSORED CHEMICAL Gases (petroleum), thermal cracking distn. (68478-05-7)**	**SPONSORED CHEMICAL Gases (petroleum), crude distn. and catalytic cracking (68989-88-8)**
Reproductive Toxicity NOAEC/LOAEC Inhalation (ppm/day)	No Data NOAEC = 80 (RA)	No Data NOAEC = 80 (RA)	No Data NOAEC = 80 (RA)	No Data NOAEC = 80 (RA)	No Data NOAEC = 80 (RA)	No Data (rat) NOAEC = 1230 LOAEC = 3990 (mouse – 28-day) NOAEC = 12.5 LOAEC = 65 (mouse – 2-year) NOAEC(f) = Not Established LOAEC(f) = 6.25 NOAEC(m) = 200 LOAEC (m) = 625 (RA)	No Data (rat) NOAEC = 1230 LOAEC = 3990 (mouse – 28-day) NOAEC = 12.5 LOAEC = 65 (mouse – 2-year) NOAEC(f) = Not Established LOAEC(f) = 6.25 NOAEC(m) = 200 LOAEC (m) = 625 (RA)	No Data (rat) NOAEC = 1230 LOAEC = 3990 (mouse – 28-day) NOAEC = 12.5 LOAEC = 65 (RA)	No Data (rat) NOAEC = 1230 LOAEC = 3990 (mouse – 28-day) NOAEC = 12.5 LOAEC = 65 (RA)
Reproductive Toxicity									

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

Subcategory IX: Refinery gases, C1 – C6 with ammonia, hydrogen sulfide and carbon monoxide

	Group 1					***Group 2 (with 1,3 butadiene)****		***Group 3 (with 1,3 butadiene and benzene)*****	
Endpoint	**SPONSORED CHEMICAL Gases (petroleum), amine system feed (68477-65-6)**	**SPONSORED CHEMICAL Gases (petroleum), recycle, hydrogen-rich (68478-00-2)**	**SPONSORED CHEMICAL Gases (petroleum), reforming hydrotreater, hydrogen-methane-rich (68478-03-5)**	**SPONSORED CHEMICAL Gases (petroleum), reforming hydrotreater make-up, hydrogen-rich (68478-04-6)**	**SPONSORED CHEMICAL Gases (petroleum), hydrotreated sour kerosine depentanizer stabilizer off (68911-58-0)**	**SPONSORED CHEMICAL Gases (petroleum), refinery blend (68783-07-3)**	**SPONSORED CHEMICAL Fuel gases, refinery, unsweetened (68783-62-0)**	**SPONSORED CHEMICAL Gases (petroleum), thermal cracking distn. (68478-05-7)**	**SPONSORED CHEMICAL Gases (petroleum), crude distn. and catalytic cracking (68989-88-8)**
Developmental Toxicity NOAEL/LOAEL Inhalation (mg/L)									
Maternal Toxicity	No Data (Long Evans rat) NOAEC = 30 LOAEC = 90	No Data (Long Evans rat) NOAEC = 30 LOAEC = 90	No Data (Long Evans rat) NOAEC = 30 LOAEC = 90	No Data (Long Evans rat) NOAEC = 30 LOAEC = 90	No Data NOAEC = Not Established LOAEC = 200	No Data NOAEC = Not Established LOAEC = 200	No Data NOAEC = Not Established LOAEC = 200	No Data NOAEC = Not Established LOAEC = 200	No Data NOAEC = Not Established LOAEC = 200
Developmental Toxicity	NOAEC = Not established LOAEC = 30 (rabbit)	NOAEC = Not established LOAEC = 30 (rabbit)	NOAEC = Not established LOAEC = 30 (rabbit)	NOAEC = Not established LOAEC = 30 (rabbit)	NOAEC = Not established LOAEC = 40 (RA)	NOAEC = Not established LOAEC = 40 (RA)	NOAEC = Not established LOAEC = 40 (RA)	NOAEC = Not established LOAEC = 40 (RA)	NOAEC = Not established LOAEC = 40 (RA)
Maternal Toxicity	NOAEC = 180	NOAEC = 180	NOAEC = 180	NOAEC = 180					
Developmental Toxicity	NOAEC = Not established LOAEC = 90 (RA)	NOAEC = Not established LOAEC = 90 (RA)	NOAEC = Not established LOAEC = 90 (RA)	NOAEC = Not established LOAEC = 90 (RA)					
Genetic Toxicity – Gene Mutation *In vitro*	No Data Negative (RA)	No Data Negative (RA)	No Data Negative (RA)	No Data Negative (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)
Genetic Toxicity – Chromosomal Aberrations *In vitro*	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)

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

Subcategory IX: Refinery gases, C1 – C6 with ammonia, hydrogen sulfide and carbon monoxide									
	Group 1					***Group 2 (with 1,3 butadiene)****		***Group 3 (with 1,3 butadiene and benzene)*****	
Endpoint	**SPONSORED CHEMICAL Gases (petroleum), amine system feed (68477-65-6)**	**SPONSORED CHEMICAL Gases (petroleum), recycle, hydrogen-rich (68478-00-2)**	**SPONSORED CHEMICAL Gases (petroleum), reforming hydrotreater, hydrogen-methane-rich (68478-03-5)**	**SPONSORED CHEMICAL Gases (petroleum), reforming hydrotreater make-up, hydrogen-rich (68478-04-6)**	**SPONSORED CHEMICAL Gases (petroleum), hydrotreated sour kerosine depentanizer stabilizer off (68911-58-0)**	**SPONSORED CHEMICAL Gases (petroleum), refinery blend (68783-07-3)**	**SPONSORED CHEMICAL Fuel gases, refinery, unsweetened (68783-62-0)**	**SPONSORED CHEMICAL Gases (petroleum), thermal cracking distn. (68478-05-7)**	**SPONSORED CHEMICAL Gases (petroleum), crude distn. and catalytic cracking (68989-88-8)**
Genetic Toxicity – Chromosomal Aberrations ***In vivo***	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)

Measured data in bold text; (RA) = Read Across; – indicates endpoint not addressed for this chemical; * contains up to 2% 1,3-butadiene; **contains up to 2% 1,3-butadiene and benzene (CASRN 71-43-2)

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

	Subcategory X: Refinery gases, ammonia and hydrogen sulfide	***Subcategory XI: Refinery gases, ammonia, hydrogen sulfide and carbon monoxide***
Endpoint	**SPONSORED CHEMICAL** **Gases, (petroleum), ammonia-hydrogen sulfide, water-satd.** **(68783-05-1)**	**SPONSORED CHEMICAL** **Gases, (petroleum), acid, ethanolamine scrubber** **(68527-13-9)**
Acute Inhalation Toxicity **LC_{50} (ppm)**	No Data 400 (RA)	No Data 400 (RA)
Repeated-Dose Toxicity **NOAEC/LOAEC** **Inhalation (ppm/day)**	No Data (rat; local effects) NOAEC = 10 LOAEC = 30 (rat; systemic) NOAEC = 30.5 LOAEC = 80 (RA)	No Data (rat; local effects) NOAEC = 10 LOAEC = 30 (rat; systemic) NOAEC = 30.5 LOAEC = 80 (RA)
Reproductive Toxicity **NOAEC/LOAEC** **Inhalation (ppm/day)** **Reproductive Toxicity**	No Data NOAEC = 80 (RA)	No Data NOAEC = 80 (RA)
Developmental Toxicity **NOAEC/LOAEC** **Inhalation (ppm/day)** **Maternal Toxicity** **Developmental Toxicity** **Maternal Toxicity** **Developmental Toxicity**	No Data NOAEC = 80 NOAEC = 80 (RA)	No Data (Long Evans rat) NOAEC = 30 LOAEC = 90 NOAEC = Not established LOAEC = 30 (rabbit) NOAEC = 180 NOAEC = Not established LOAEC = 90 (RA)
Genetic Toxicity – Gene Mutation ***In vitro***	No Data Negative (RA)	No Data Negative (RA)

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

	Subcategory X: Refinery gases, ammonia and hydrogen sulfide	***Subcategory XI: Refinery gases, ammonia, hydrogen sulfide and carbon monoxide***
Endpoint	**SPONSORED CHEMICAL** **Gases, (petroleum), ammonia-hydrogen sulfide, water-satd.** **(68783-05-1)**	**SPONSORED CHEMICAL** **Gases, (petroleum), acid, ethanolamine scrubber** **(68527-13-9)**
Genetic Toxicity – Chromosomal Aberrations ***In vitro***	No Data Negative* (RA)	No Data Positive (RA)
Genetic Toxicity – Chromosomal Aberrations ***In vivo***	–	No Data Positive (RA)

Measured data in bold text; (RA) = Read Across; – indicates that endpoint was not addressed for this chemical; *Based on read across - see data for OECD HPV Ammonia category at http://webnet.oecd.org/hpv/ui/Search.aspx.

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

Endpoints	SUPPORTING CHEMICAL Methane (C1) (74-82-8)	SUPPORTING CHEMICAL Ethane (C2) (74-84-0)	SUPPORTING CHEMICAL Ethylene (C2) (74-85-1)	SUPPORTING CHEMICAL Propane (C3) (74-98-6)	SUPPORTING CHEMICAL 1-Propene (C4) (115-07-1)	SUPPORTING CHEMICAL Butane (C4) (106-97-8)	SUPPORTING CHEMICAL Propane, 2-methyl (C4) (75-28-5)	SUPPORTING CHEMICAL 1-Propene, 2-methyl (C4) (115-11-7)	SUPPORTING CHEMICAL 1-Butene (C4) (106-98-9)	SUPPORTING CHEMICAL 2-Butene (C4) (107-01-7)
Acute Inhalation Toxicity LC_{50} (ppm)	–	–	–	**>800,000 (15 min)**	**>65,000**	–	–	**180,000 (mouse) 270,000 (rat)**	–	**> 23 mg/L**
Repeated-Dose Toxicity NOAEL/LOAEL Oral (mg/kg-bw/day)	–	–	–	–	–	–	–	**NOAEL = 14.86 LOAEL = 148.6**	–	**–**
Repeated-Dose Toxicity NOAEC/LOAEC Inhalation (ppm/day)	–	**NOAEC = 15,502 (highest concentration tested)**	**NOAEC = 10,000 (highest concentration tested)**	**NOAEC= 3990 LOAEC= 12,168**	**NOAEC = 10,000 (highest concentration tested)**	**NOAEC = 9157 (highest concentration tested)**	**NOAEC = 9148 (highest concentration tested)**	**(rat) NOAEC = 7970 (highest concentration tested) (mouse) NOAEC = 7980 (highest concentration tested**	**NOAEC = 8000 (highest concentration tested)**	**NOAEC = 5009 (highest concentration tested)**
Reproductive Toxicity NOAEC/ LOAEC Inhalation (ppm/day) Reproductive Toxicity	–	**NOAEC = 15,502 (highest concentration tested)**	**NOAEC = 5000 (highest concentration tested)**	**NOAEC = 1230 LOAEC = 3990**	–	**NOAEC = 9157 (highest concentration tested)**	**NOAEC = 3122 LOAEC = 9148**	A decrease in sperm motility was observed at 7970 ppm in a 14-wk inhalation repeated-dose toxicity study in rats.	**NOAEC = 8000 (highest concentration tested)**	**NOAEC = 5009 (highest concentration tested)**
Developmental Toxicity NOAEC/ LOAEC Inhalation (mg/L) Maternal Toxicity Developmental Toxicity	–	**NOAEC = 15,502 (highest concentration tested) NOAEC = 15,502 (highest concentration tested)**	**NOAEC = 5000 (highest concentration tested) NOAEC = 5000 (highest concentration tested)**	**NOAEC = 3990 LOAEC=12,168 NOAEC = 1230 LOAEC=3990**	**NOAEC = 10,000 (highest concentration tested) NOAEC = 10,000 (highest concentration tested)**	**NOAEC = 9157 (highest concentration tested) NOAEC = 9157 (highest concentration tested)**	**NOAEC = 9148 (highest concentration tested) NOAEC = 9148 (highest concentration tested)**	**NOAEC = 18.4 mg/L/day (highest concentration tested) NOAEC = 18.4 mg/L/day (highest concentration tested)**	**NOAEC = 8000 (highest concentration tested) NOAEC = 8000 (highest concentration tested)**	**NOAEC = 5009 (highest concentration tested) NOAEC = 5009 (highest concentration tested)**

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

Endpoints	SUPPORTING CHEMICAL Methane (C1) (74-82-8)	SUPPORTING CHEMICAL Ethane (C2) (74-84-0)	SUPPORTING CHEMICAL Ethylene (C2) (74-85-1)	SUPPORTING CHEMICAL Propane (C3) (74-98-6)	SUPPORTING CHEMICAL 1-Propene (C4) (115-07-1)	SUPPORTING CHEMICAL Butane (C4) (106-97-8)	SUPPORTING CHEMICAL Propane, 2-methyl (C4) (75-28-5)	SUPPORTING CHEMICAL 1-Propene, 2-methyl (C4) (115-11-7)	SUPPORTING CHEMICAL 1-Butene (C4) (106-98-9)	SUPPORTING CHEMICAL 2-Butene (C4) (107-01-7)
Genetic Toxicity – Gene Mutation *In vitro*	**Negative**	–	**Negative**	**Negative**	**Positive**	**Negative**	–	**Negative**	**Negative**	**Negative**
Genetic Toxicity – Gene Mutation *In vivo*	–	–	–	–	**Negative**	–	–	–	–	–
Genetic Toxicity – Chromosomal Aberrations *In vitro*	–	–	**Negative**	–	–	–	–	–	–	**Negative**
Genetic Toxicity – Chromosomal Aberrations *In vivo*	–	–	**Negative**	–	**Negative**	–	–	**Negative**	**Negative**	–
Additional Information										
Skin Irritation	–	–	–	–	–	–	–	–	–	–
Eye Irritation	–	–	–	–	–	–	–	–	–	–
Skin Sensitization	–	–	–	–	–	–	–	–	–	–
Carcinogenicity	–	–	**Equivocal**	–	**Negative**	–	–	**Positive (male rats) Negative (female rats and mice of both sexes)**	–	–
Neurotoxicity	–	–	–	–	–	–	–	–	–	–

Measured data in bold text; – indicates that endpoint was not addressed for this chemical

Table 5. Summary Table of the Screening Information Data Set as Submitted under the U.S. HPV Challenge Program – Human Health Data									
Endpoints	**SUPPORTING CHEMICAL Light catalytic cracked naphtha (C4 – C12) (64741-55-5)**	**SUPPORTING CHEMICAL Sweetened naphtha (C4 – C12) (64741-87-3)**	**SUPPORTING CHEMICAL Gasoline (C4 – C12) (86290-81-5)**	**SUPPORTING CHEMICAL 1,3-Butadiene (C4) (106-99-0)**	**SUPPORTING CHEMICAL Benzene (C6) (71-43-2)**	**SUPPORTING CHEMICAL Pentane (C5) (109-66-0)**	**SUPPORTING CHEMICAL Cyclopentane (C5) (287-92-3)**	**SUPPORTING CHEMICAL 2-Butene, 2-methyl (C5) (513-35-9)**	**SUPPORTING CHEMICAL Butane, 2-methyl- (C5) (78-78-4)**
Acute Oral Toxicity LD_{50} (mg/kg)	**> 5000**	–	–	–	**(rat) 810-10,000**	–	**> 5000**	**1059 < LD_{50} < 1655**	**–**
Acute Inhalation Toxicity Rat LC_{50} (mg/L)	**> 5.3**	**> 5.2**	–	**285**	**43.7**	**>18**	**> 72**	**> 175**	**>12.1**
Acute Dermal Toxicity LD_{50} (mg/kg)	**>3000**	–	–	–	–	–	–	**> 2000**	–
Repeated-Dose Toxicity NOAEC/LOAEC Inhalation (ppm/day)	**(mg/L/day) NOAEL (male) = 2.3 LOAEL (male) = 7.7 NOAEL (female) = 7.7 LOAEL (female) = 23.4**	–	**(rat; mg/L/day) NOAEC = 20.3 (highest concentration tested)**	**(rat) NOAEC=7886 (highest concentration tested) (mouse) NOAEC=625 LOAEC=1250**	**(rat; mg/L) NOAEC = 0.10 LOAEC = 0.96**	**(rat) NOAEC=20 (highest concentration tested)**	**(rat) NOAEC=30 (highest concentration tested)**	**(rat) NOAEC = 625 LOAEC = 1250**	–

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

Endpoints	SUPPORTING CHEMICAL Light catalytic cracked naphtha (C4 – C12) (64741-55-5)	SUPPORTING CHEMICAL Sweetened naphtha (C4 – C12) (64741-87-3)	SUPPORTING CHEMICAL Gasoline (C4 – C12) (86290-81-5)	SUPPORTING CHEMICAL 1,3-Butadiene (C4) (106-99-0)	SUPPORTING CHEMICAL Benzene (C6) (71-43-2)	SUPPORTING CHEMICAL Pentane (C5) (109-66-0)	SUPPORTING CHEMICAL Cyclopentane (C5) (287-92-3)	SUPPORTING CHEMICAL 2-Butene, 2-methyl (C5) (513-35-9)	SUPPORTING CHEMICAL Butane, 2-methyl- (C5) (78-78-4)
Reproductive Toxicity NOAEC/LOAEC Inhalation (ppm/day) **Reproductive Toxicity**	**(mg/L/day) NOAEC = 23.9 (highest concentration tested)** **NOAEC = 23.9 (highest concentration tested)**	–	**(rat; mg/L) NOAEL = 20.0 (highest concentration tested)**	**(mouse – 28-day) NOAEC = 12.5 LOAEC = 65** **(mouse – 2-year) NOAEC(f) = Not Established LOAEC(f) = 6.25 NOAEC(m) = 200 LOAEC (m) = 625** **(rat) NOAEC = 13.3 mg/L/day (highest concentration tested)**	Effects on male and female reproductive organs observed at 0.96 mg/L in 13-week inhalation repeated-dose toxicity study in mice.	No effects on reproductive organs in rats in 90-day repeated-dose study	No Data* (rat – CASRN 110-82-7) 24.1 mg/L	**(rat) NOAEC = 7097 (highest concentration tested)**	–
Developmental Toxicity NOAEC/LOAEC Inhalation (ppm/day) **Maternal Toxicity** **Developmental Toxicity** **Maternal Toxicity** **Developmental Toxicity**	**(mg/L/day) NOAEC = 23.9 (highest concentration tested)** **NOAEC = 23.9 (highest concentration tested)**	– –	**(mouse) NOAEC = 10.6 LOAEC = 20.9** **NOAEC = 2.9 LOAEC = 10.6**	**(rat) NOAEC = Not Established LOAEC = 200** **NOAEC = Not Established LOAEC = 200** **(mouse) NOAEC = Not Established LOAEC = 200** **NOAEC = Not Established LOAEC = 40**	**(rat; mg/L) NOAEC = 0.96 (highest concentration tested)** **NOAEC = 0.096 LOAEC = 0.96** **(mouse; mg/L) NOAEC = 0.064 (highest concentration tested)** **NOAEC = 0.032 LOAEC = 0.064**	–	No Data* (rat – CASRN 110-82-7) NOAEC = 1.72 mg/L/day LOAEC = 6.88 mg/L/day NOAEC = 6.88 mg/L/day LOAEC = 24.1 mg/L/day	**(rat) NOAEC = 584 LOAEC = 2026** **NOAEC = 7097 (highest concentration tested)**	–

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

Endpoints	SUPPORTING CHEMICAL Light catalytic cracked naphtha (C4 – C12) (64741-55-5)	SUPPORTING CHEMICAL Sweetened naphtha (C4 – C12) (64741-87-3)	SUPPORTING CHEMICAL Gasoline (C4 – C12) (86290-81-5)	SUPPORTING CHEMICAL 1,3-Butadiene (C4) (106-99-0)	SUPPORTING CHEMICAL Benzene (C6) (71-43-2)	SUPPORTING CHEMICAL Pentane (C5) (109-66-0)	SUPPORTING CHEMICAL Cyclopentane (C5) (287-92-3)	SUPPORTING CHEMICAL 2-Butene, 2-methyl (C5) (513-35-9)	SUPPORTING CHEMICAL Butane, 2-methyl- (C5) (78-78-4)
Genetic Toxicity – Gene Mutation *In vitro*	**Negative**	–	**Negative**	**Positive**	**Positive**	**Negative**	**Negative**	**Negative**	**Negative**
Genetic Toxicity – Gene Mutation *In vivo*	–	–	**Positive**	**Positive**	**Positive**	–	–	–	–
Genetic Toxicity – Chromosomal Aberrations *In vitro*	–	–	–	–	–	**Equivocal**	**Negative (with activation) Positive (without activation)**	**Negative**	–
Genetic Toxicity – Chromosomal Aberrations *In vivo*	–	–	–	**Positive**	**Positive**	**Negative**	**Negative**	**Positive**	–
Additional Information	**Moderately irritating**			**Slightly Irritating**					
Skin Irritation		–	**Not irritating**		–	**Not irritating**	**Not irritating**	**Slightly irritating**	–
Eye Irritation	**Not irritating**	–	–	–	–	**Minimally irritating**	**Moderately irritating**	**Not irritating**	–
Respiratory Tract Irritation	–	–	–	–	–			–	**Not irritating**
Skin Sensitization	–	–	–	–	–	**Not irritating**	–	**Negative**	**Negative**
Carcinogenicity	**Not sensitizing**	–	–	–	–	**Negative**	–	–	–
Neurotoxicity	–	–	–	–	**Positive**	–	–	–	–
	–	–	**Negative in animals**	–	–	–	–	–	–

Measured data in bold text; **–** indicates that endpoint was not addressed for this chemical; * As read-across in the C5 aliphatic hydrocarbon solvents category in the OECD HPV program - http://webnet.oecd.org/hpv/ui/Search.aspx.

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

Endpoint	SUPPORTING CHEMICAL Ammonia (7664-41-7)	SUPPORTING CHEMICAL Hydrogen sulfide (7783-06-4)	SUPPORTING CHEMICAL Carbon monoxide (630-08-0)	SUPPORTING CHEMICAL Methanethiol (74-93-1)	SUPPORTING CHEMICAL Ethanethiol (75-08-1)
Acute Inhalation Toxicity LC_{50} (ppm)	**(rat) 9.85-13.8 mg/L (mouse) 2.94 mg/L**	**440**	**1800**	**–**	**(rat) 11 mg/L (mouse) 7 mg/L**
Repeated-Dose Toxicity NOAEC/LOAEC Inhalation (ppm/day)	**(several species; mg/L/day) NOAEC = Not established LOAEC = 0.014**	**(mouse; local effects) NOAEC = 30.5 LOAEC = 80 (rat; local effects) NOAEC = 10 LOAEC = 30 (rat; systemic) NOAEC = 30.5 LOAEC = 80**	**NOAEC = 0.15 mg/L/day (highest concentration tested)**	**NOAEC = 0.033 LOAEC = 0.11**	–
Reproductive Toxicity NOAEC/LOAEC Inhalation (ppm/day) **Reproductive Toxicity**	No effects were observed in the reproductive organs in repeated-dose studies.	**NOAEC = 80 (highest concentration tested)**	No effects were observed in the reproductive organs in repeated-dose study	**–**	**–**
Developmental Toxicity NOAEC/LOAEC Inhalation (ppm/day) **Maternal Toxicity** **Developmental Toxicity** **Maternal Toxicity** **Developmental Toxicity**	**–**	**NOAEC = 80 (highest concentration tested)** **NOAEC = 80 (highest concentration tested)**	**(Long Evans rat) NOAEC = 30 LOAEC = 90** **NOAEC = Not established LOAEC = 30** **(rabbit) NOAEC = 180 (highest concentration tested)** **NOAEC = Not established LOAEC = 90**	**–**	**–**

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

Endpoint	SUPPORTING CHEMICAL Ammonia (7664-41-7)	SUPPORTING CHEMICAL Hydrogen sulfide (7783-06-4)	SUPPORTING CHEMICAL Carbon monoxide (630-08-0)	SUPPORTING CHEMICAL Methanethiol (74-93-1)	SUPPORTING CHEMICAL Ethanethiol (75-08-1)
Genetic Toxicity – Gene Mutation *In vitro*	**Negative**	**Negative**	–	–	**Negative**
Genetic Toxicity – Chromosomal Aberrations *In vitro*	–	–	**Positive**	**Equivocal***	**Positive**
Genetic Toxicity – Chromosomal Aberrations *In vivo*	–	–	**Positive**	–	–
Additional Information					
Skin Irritation	–	–	–	–	–
Eye Irritation	–	–	–	–	–
Respiratory Irritation	**Irritating**	–	–	–	–
Skin sensitization	–	–	–	–	–
Carcinogenicity	–	–	–	–	–
Neurotoxicity		**Positive**	–	–	–

Measured data in bold text; **–** indicates that endpoint was not addressed for this chemical; *based on data for sodium salt (CASRN 5188-07-8; see OECD HPV data at: http://webnet.oecd.org/hpv/ui/Search.aspx

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

Methane (CASRN 74-82-8, supporting chemical)
The ECOSAR program was used to estimate the 96-hour LC_{50} for fish exposed to methane.
96-h LC_{50} = 148 mg/L

Ethane (CASRN 74-84-0, supporting chemical)
The ECOSAR program was used to estimate the 96-hour LC_{50} for fish exposed to ethane.
96-h LC_{50} = 91 mg/L

Ethylene (CASRN 74-85-1, supporting chemical)
The ECOSAR program was used to estimate the 96-hour LC_{50} for fish exposed to ethylene.
96-h LC_{50} = 96 mg/L

Propane (CASRN 74-98-6, supporting chemical)
The ECOSAR program was used to estimate the 96-hour LC_{50} for fish exposed to propane.
96-h LC_{50} = 49 mg/L

Butane (CASRN 106-97-8, supporting chemical)
The ECOSAR program was used to estimate the 96-hour LC_{50} for fish exposed to butane.
96-h LC_{50} = 24 mg/L

Pentane (CASRN 109-66-0, supporting chemical)
http://webnet.oecd.org/hpv/UI/handler.axd?id=940b1ed1-84c8-4433-98e9-18b19fc8f99e
96-h LC_{50} = 4.3 mg/L

Hexane (CASRN 110-54-3, supporting chemical)
Fathead minnows (*Pimephales promelas*) were exposed to mean measured concentrations of hexane at 0, 0.9, 1.7, 2.4, 3.8, and 4.7 mg/L (99% purity) for 96 hours
96-h LC_{50} = 2.5 mg/L

Ammonia (CASRN 7664-41-7, supporting chemical)
Bluegill sunfish (*Lepomis macrochirus*) were exposed to ammonia at unspecified concentrations in freshwater for 96 hours under flow-through conditions.
96-h LC_{50} = 0.17 mg/L

Hydrogen sulfide (CASRN 7783-06-4, supporting chemical)
Rainbow trout (*Oncorhynchus mykiss*) were exposed to hydrogen sulfide at unspecified concentrations under flow-through conditions for 96 hours. Water was at a temperature of 20

°C, pH was 8.0, hardness was 104 mg/L $CaCO_3$, alkalinity was 77 mg/L $CaCO_3$ and dissolved oxygen level was 8.9 mg/L.
96-h LC_{50} = 0.007 mg/L

Acute Toxicity to Aquatic Invertebrates

Methane (CASRN 74-82-8, supporting chemical)
The ECOSAR program was used to estimate the 48-hour EC_{50} for daphnids exposed to methane.
48-h EC_{50} = 69 mg/L

Ethane (CASRN 74-84-0, supporting chemical)
The ECOSAR program was used to estimate the 48-hour EC_{50} for daphnids exposed to ethane.
48-h EC_{50} = 47 mg/L

Ethylene (CASRN 74-85-1, supporting chemical)
The ECOSAR program was used to estimate the 48-hour EC_{50} for daphnids exposed to ethylene.
48-h EC_{50} = 48 mg/L

Propane (CASRN 74-98-6, supporting chemical)
The ECOSAR program was used to estimate the 48-hour EC_{50} for daphnids exposed to propane.
48-h EC_{50} = 27 mg/L

Butane (CASRN 106-97-8, supporting chemical)
The ECOSAR program was used to estimate the 48-hour EC_{50} for daphnids exposed to butane.
48-h EC_{50} = 14 mg/L

Pentane (CASRN 109-66-0, supporting chemical)
http://webnet.oecd.org/hpv/UI/handler.axd?id=940b1ed1-84c8-4433-98e9-18b19fc8f99e
48-h EC_{50} = 2.7 mg/L

Hexane (CASRN 110-54-3, supporting chemical)
The ECOSAR program was used to estimate the 48-hour EC_{50} for daphnids exposed to hexane.
48-h EC_{50} = 3.3 mg/L

Ammonia (CASRN 7664-41-7, supporting chemical)
(1) Unspecified invertebrates were exposed to ammonia. No further details were provided.
48-h LC_{50} = 0.53 – 22.8 mg/L

Hydrogen sulfide (CASRN 7783-06-4, supporting chemical)
Unspecified invertebrates were exposed to hydrogen sulfide. No further details were provided.
48-h LC_{50} = 0.022 – 1.07 mg/L

Toxicity to Aquatic Plants

Methane (CASRN 74-82-8, supporting chemical)
The ECOSAR program was used to estimate the 96-hour EC_{50} for green algae exposed to methane.
96-h EC_{50} = 19 mg/L

Ethane (CASRN 74-84-0, supporting chemical)
The ECOSAR program was used to estimate the 96-hour EC_{50} for green algae exposed to ethane.
96-h EC_{50} = 16 mg/L

Ethylene (CASRN 74-85-1, supporting chemical)
Green algae (*Pseudokirchneriella subcapitata*) were exposed to ethylene at mean measured concentrations of 3.3, 7.8, 13.9, 32 and 58 mg/L for 72 hours. Growth inhibition was observed at concentrations ≥ 32 mg/L.
72-h EC_{50} (biomass) = 40 mg/L
72-h EC_{50} (growth) = 72 mg/L

Propane (CASRN 74-98-6, supporting chemical)
The ECOSAR program was used to estimate the 96-hour EC_{50} for green algae exposed to propane.
96-h EC_{50} = 12 mg/L

Butane (CASRN 106-97-8, supporting chemical)
The ECOSAR program was used to estimate the 96-hour EC_{50} for green algae exposed to butane.
96-h EC_{50} = 7.7 mg/L

Pentane (CASRN 109-66-0, supporting chemical)
http://webnet.oecd.org/hpv/UI/handler.axd?id=940b1ed1-84c8-4433-98e9-18b19fc8f99e
96-h EC_{50} (growth rate) = 10.7 mg/L

Hexane (CASRN 110-54-3, supporting chemical)
The ECOSAR program was used to estimate the 96-hour EC_{50} for green algae exposed to hexane.
96-h EC_{50} = 2.8 mg/L

Ammonia (CASRN 7664-41-7, supporting chemical)
http://webnet.oecd.org/hpv/UI/handler.axd?id=7a66b9ff-c0f6-4191-b90b-ea6e1f16b5e8
96-h EC_{50} = <1 mg/L (un-ionized ammonia)

Hydrogen sulfide (CASRN 7783-06-4, supporting chemical)
No data are available.

Conclusion:

Subcategory I: Refinery gases containing C1 – C6 hydrocarbons
Using the supporting chemicals methane, ethane, ethene, propane, butane, pentane, and hexane, the 96-h LC_{50} for fish is ranged from 2.5-148 mg/L. Using the same supporting chemicals, the 48-h EC_{50} for aquatic invertebrates and the 96-h EC_{50} for aquatic plants ranges from 2.7-69 mg/L and 2.8-72 mg/L, respectively

Subcategory II: Refinery gases containing C1 – C6 hydrocarbons, ammonia, and hydrogen sulfide
Using the supporting chemicals methane, ethane, ethene, propane, butane, pentane, hexane, hydrogen sulfide, and ammonia, the 96-h LC_{50} for fish is ranged from 0.007-148 mg/L. Using the same supporting chemicals, the 48-h EC_{50} for aquatic invertebrates and the 96-h EC_{50} for aquatic plants ranges from 0.022-69 mg/L and < 1-72 mg/L, respectively.

Subcategory III: Refinery gases (without hydrocarbons), ammonia and hydrogen sulfide
Using the supporting chemicals, hydrogen sulfide and ammonia, the 96-h LC_{50} for fish is 0.007 mg/L. Using the same supporting chemicals, the 48-h EC_{50} for aquatic invertebrates and the 96-h EC50 for aquatic plants are 0.022 mg/L and < 1 mg/L, respectively.

Subcategory IV: Refinery gases with carbon monoxide
Adequate data are not available for the members of this subcategory.

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

Endpoint	*Subcategory I: Refinery gases, C1 – C6* **SPONSORED CHEMICAL***	*Subcategory II: Refinery gases, C1 – C6 with hydrogen sulfide and ammonia* **SPONSORED CHEMICAL****	*Subcategory III: Refinery gases, hydrogen sulfide and ammonia* **SPONSORED CHEMICAL*****	*Subcategory IV: Refinery gases with carbon monoxide* **SPONSORED CHEMICAL******
Fish **96-h LC_{50} (mg/L)**	No Data 2.5-148 (RA)	No Data 0.007-148 (RA)	No Data 0.007 (RA)	Data Gap
Aquatic Invertebrates **48-h EC_{50} (mg/L)**	No Data 2.7-69 (RA)	No Data 0.022-69 (RA)	No Data 0.022 (RA)	Data Gap
Aquatic Plants **96-h EC_{50} (mg/L)**	No Data 2.8-72 (RA)	No Data <1-72 (RA)	<1 mg/L[1]	Data Gap

* represents CASRNs 68476-29-9, 68477-77-0, 68478-25-1, 68513-11-1, 68513-13-3, 68513-14-4, 68513-16-6, 68513-18-8, 68513-19-9, 68527-14-0, 68602-84-6, 68607-11-4, 68783-06-2, 68814-67-5, 68814-90-4, 68919-03-9, 68919-07-3, 68919-12-0, 68952-79-4, 68955-33-9, , 68308-27-0, 68477-81-6, 68478-27-3, 68478-28-4, 68478-29-5, 68478-30-8, 68919-08-4, 68952-80-7, and 68513-68-8.

** represents CASRNs 68477-92-9, 68919-01-7, 68477-95-2, 68814-47-1, 68919-02-8, and 68919-04-0.

*** represents CASRN 68783-05-1.

**** represents CASRNs 68476-26-6, 68477-97-4, 68527-15-1, 8006-20-0, 68477-68-9, 68477-98-5, 68478-01-3, 68476-27-7, 68476-28-8, 68477-66-7, 68477-67-8, 68477-80-5, 68602-82-4, 68911-59-1, 68911-59-1, 68477-65-6, 68478-00-2, 68478-03-5, 68478-04-6, 68478-05-7, 68783-07-3, 68783-62-0, 68911-58-0, 68989-88-8, and 68527-13-9.

[1] This is from unionized ammonia.; **Measured data in bold text** (i.e. derived from testing); (e) = estimated; (RA) = read across

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

Endpoint	SUPPORTING CHEMICAL Methane (74-82-8)	SUPPORTING CHEMICAL Ethane (74-84-0)	SUPPORTING CHEMICAL Ethylene (74-85-1)	SUPPORTING CHEMICAL Propane (74-98-6)	SUPPORTING CHEMICAL Butane (106-97-8)	SUPPORTING CHEMICAL Pentane (109-66-0)	SUPPORTING CHEMICAL Hexane (110-54-3)	SUPPORTING CHEMICAL Hydrogen sulfide (7783-06-4)	SUPPORTING CHEMICAL Ammonia (7664-41-7)
Fish 96-h LC_{50} (mg/L)	148 (e)	91 (e)	96 (e)	49 (e)	24 (e)	**4.3**	**2.5**	**0.007**	**0.17**
Aquatic Invertebrates 48-h EC_{50} (mg/L)	69 (e)	47 (e)	48 (e)	27 (e)	14 (e)	**2.7**	3.3 (e)	**0.022**	**0.53**
Aquatic Plants 96-h EC_{50} (mg/L)	19 (e)	16 (e)	**40 (biomass) 72 (growth)**	12 (e)	7.7 (e)	**10.7**	2.8 (e)	-	<1 mg/L[1]

* represents CASRNs 68476-29-9, 68477-77-0, 68478-25-1, 68513-11-1, 68513-13-3, 68513-14-4, 68513-16-6, 68513-18-8, 68513-19-9, 68527-14-0, 68602-84-6, 68607-11-4, 68783-06-2, 68814-67-5, 68814-90-4, 68919-03-9, 68919-07-3, 68919-12-0, 68952-79-4, 68955-33-9, , 68308-27-0, 68477-81-6, 68478-27-3, 68478-28-4, 68478-29-5, 68478-30-8, 68919-08-4, 68952-80-7, and 68513-68-8.
** represents CASRNs 68477-92-9, 68919-01-7, 68477-95-2, 68814-47-1, 68919-02-8, and 68919-04-0.
*** represents CASRN 68783-05-1.
**** represents CASRNs 68476-26-6, 68477-97-4, 68527-15-1, 8006-20-0, 68477-68-9, 68477-98-5, 68478-01-3, 68476-27-7, 68476-28-8, 68477-66-7, 68477-67-8, 68477-80-5, 68602-82-4, 68911-59-1, 68911-59-1, 68477-65-6, 68478-00-2, 68478-03-5, 68478-04-6, 68478-05-7, 68783-07-3, 68783-62-0, 68911-58-0, 68989-88-8, and 68527-13-9.
[1] This is from unionized ammonia; **Measured data in bold text** (i.e. derived from testing**)**; (e) = estimated; (RA) = read across

APPENDIX

The following pages show:

- Table 7 with a list of the sponsored substances and the supporting chemicals as subcategorized for the human health endpoints
- Table 8 with a list of the sponsored substances and the supporting chemicals as subcategorized for the ecotoxicity endpoints
- Table 9 with a list of the major constituents in the category streams
- Table 10 with a list of representative structures
- Table 11 with a list of reference sources

Table 7. Refinery Gases Category – Subcategories for Human Health	
CASRN	**CA Index Name**
Subcategory I – Refinery gases, C1-C4	
Sponsored Chemicals	
68476-29-9	Fuel gases, crude oil distillates
68477-77-0	Gases (petroleum), catalytic reformed naphtha stripper overheads
68478-25-1	Tail gas (petroleum), catalytic cracker refractionation absorber
68513-11-1	Fuel gases, hydrotreater fractionation, scrubbed
68513-13-3	Fuel gases, thermal cracked catalytic cracking residue
68513-14-4	Gases (petroleum), catalytic reformed straight-run naphtha stabilizer overheads
68513-16-6	Gases (petroleum), hydrocracking depropanizer off, hydrocarbon-rich
68513-18-8	Gases (petroleum), reformer effluent high-pressure flash drum off
68513-19-9	Gases (petroleum), reformer effluent low-pressure flash drum off
68527-14-0	Gases, (petroleum), methane-rich off
68602-84-6	Gases (petroleum), secondary absorber off, fluidized catalytic cracker overheads fractionator
68607-11-4	Petroleum products, refinery gases
68783-06-2	Gases (petroleum), hydrocracking low-pressure separator
68814-67-5	Gases (petroleum), refinery
68814-90-4	Gases (petroleum), platformer products separator off
68919-03-9	Gases (petroleum), fluidized catalytic cracker scrubbing secondary absorber off
68919-07-3	Gases (petroleum), platformer stabilizer off, light ends fractionation
68919-12-0	Gases (petroleum), unifiner stripper off
68952-79-4	Tail gas (petroleum), catalytic hydrodesulfurized naphtha separator
68955-33-9	Gases (petroleum), sponge absorber off, fluidized catalytic cracker and gas oil desulfurizer overhead fractionation
Supporting Chemicals	
74-82-8	Methane
74-84-0	Ethane
74-85-1	Ethene
74-98-6	Propane
115-07-1	1-Propene
106-97-8	Butane
75-28-5	Isobutane
115-11-7	1-Propene, 2-methyl-
106-98-9	1-Butene
107-01-7	2-Butene
106-99-0	1,3-Butadiene
Subcategory II – Refinery gases, C1-C4 with ammonia and hydrogen sulfide	
Sponsored Chemicals	

Table 7. Refinery Gases Category – Subcategories for Human Health	
CASRN	**CA Index Name**
68477-92-9	Gases (petroleum), dry sour, gas-concn.-unit-off
68919-01-7	Gases (petroleum), distillate unifiner desulfurization stripper off
Supporting Chemicals	
74-82-8	Methane
74-84-0	Ethane
74-85-1	Ethene
74-98-6	Propane
115-07-1	1-Propene
106-97-8	Butane
75-28-5	Isobutane
115-11-7	1-Propene, 2-methyl-
106-98-9	1-Butene
107-01-7	2-Butene
74-93-1	Methanethiol
5188-07-8	Methanethiol, sodium salt (1:1)
75-08-1	Ethanethiol
7664-41-7	Ammonia
7783-06-4	Hydrogen sulfide
Subcategory III – Refinery gases, C1-C4 with carbon monoxide	
Sponsored Chemicals	
68476-26-6	Fuel gases
68477-97-4	Gases (petroleum), hydrogen-rich
68527-15-1	Gases (petroleum), oil refinery gas distn. off
8006-20-0	Fuel gases, producer gas
Supporting Chemicals	
74-82-8	Methane
74-84-0	Ethane
74-85-1	Ethene
74-98-6	Propane
115-07-1	1-Propene
106-97-8	Butane
75-28-5	Isobutane
115-11-7	1-Propene, 2-methyl-
106-98-9	1-Butene
107-01-7	2-Butene
630-08-0	Carbon monoxide
7664-41-7	Ammonia

Table 7. Refinery Gases Category – Subcategories for Human Health	
CASRN	**CA Index Name**
7783-06-4	Hydrogen sulfide
Subcategory IV – Refinery gases, C1-C6	
Sponsored Chemicals	
68308-27-0	Fuel gases, refinery
68477-81-6	Gases (petroleum), C6 – 8 catalytic reformer
68478-27-3	Tail gas (petroleum), catalytic reformed naphtha separator
68478-28-4	Tail gas (petroleum), catalytic reformed naphtha stabilizer
68478-29-5	Tail gas, (petroleum), cracked distillate hydrotreater separator
68478-30-8	Tail gas (petroleum), hydrodesulfurized straight-run naphtha separator
68919-08-4	Gases (petroleum), preflash tower off, crude distn.
68952-80-7	Tail gas (petroleum), straight-run naphtha hydrodesulfurizer
68513-68-8	Residues (petroleum), deethanizer tower
Supporting Chemicals	
74-82-8	Methane
74-84-0	Ethane
74-85-1	Ethene
74-98-6	Propane
115-07-1	1-Propene
106-97-8	Butane
75-28-5	Isobutane
115-11-7	1-Propene, 2-methyl-
106-98-9	1-Butene
107-01-7	2-Butene
78-78-4	2-Methylbutane
109-66-0	Pentane
287-92-3	Cyclopentane
513-35-9	2-Methyl-2-butene-
64741-55-5	Light catalytic cracked naphtha
64741-87-3	Sweetened naphtha
86290-81-5 or no CASRN	Gasoline
106-99-0	1,3-Butadiene
71-43-2	Benzene
7664-41-7	Ammonia
7783-06-4	Hydrogen sulfide
Subcategory V – Refinery gases, C1-C6 with hydrogen sulfide	
Sponsored Chemical	
68477-95-2	Gases (petroleum), dry sour, gas-concn.-unit-off

Table 7. Refinery Gases Category – Subcategories for Human Health	
CASRN	**CA Index Name**
Supporting Chemicals	
74-82-8	Methane
74-84-0	Ethane
74-85-1	Ethene
74-98-6	Propane
115-07-1	1-Propene
106-97-8	Butane
75-28-5	Isobutane
115-11-7	1-Propene, 2-methyl-
106-98-9	1-Butene
107-01-7	2-Butene
78-78-4	2-Methylbutane
109-66-0	Pentane
287-92-3	Cyclopentane
513-35-9	2-Methyl-2-butene-
64741-55-5	Light catalytic cracked naphtha
64741-87-3	Sweetened naphtha
86290-81-5 or no CASRN	Gasoline
106-99-0	1,3-Butadiene
7664-41-7	Ammonia
7783-06-4	Hydrogen sulfide
Subcategory VI – Refinery gases, C1-C6 with carbon monoxide	
Sponsored Chemicals	
68477-68-9	Gases (petroleum), blend oil, hydrogen-nitrogen-rich
68477-98-5	Gases (petroleum), hydrotreater blend oil recycle, hydrogen-nitrogen-rich
68478-01-3	Gases (petroleum), reformer make-up, hydrogen-rich
68476-27-7	Fuel gases, amine system residues
68476-28-8	Fuel gases, C6 – 8 catalytic reformer
68477-66-7	Gases (petroleum), benzene unit hydrodesulfurizer off
68477-67-8	Gases (petroleum), benzene unit recycle, hydrogen-rich
68477-80-5	Gases (petroleum), C6 – 8 catalytic reformer recycle
68477-82-7	Gases (petroleum), C6 – 8 catalytic reformer recycle, hydrogen-rich
68602-82-4	Gases (petroleum), benzene unit hydrotreater depentanizer overheads
68911-59-1	Gases (petroleum), hydrotreated sour kerosine flash drum
Supporting Chemicals	
74-82-8	Methane
74-84-0	Ethane

Table 7. Refinery Gases Category – Subcategories for Human Health	
CASRN	**CA Index Name**
74-85-1	Ethene
74-98-6	Propane
115-07-1	1-Propene
106-97-8	Butane
75-28-5	Isobutane
115-11-7	1-Propene, 2-methyl-
106-98-9	1-Butene
107-01-7	2-Butene
78-78-4	2-Methylbutane
109-66-0	Pentane
287-92-3	Cyclopentane
513-35-9	2-Methyl-2-butene-
64741-55-5	Light catalytic cracked naphtha
64741-87-3	Sweetened naphtha
86290-81-5 or no CASRN	Gasoline
630-08-0	Carbon monoxide
71-43-2	Benzene
Subcategory VII – Refinery gases, C1-C6 with carbon monoxide and hydrogen sulfide	
Sponsored Chemical	
68478-02-4	Gases (petroleum), reforming hydrotreater
Supporting Chemicals	
74-82-8	Methane
74-84-0	Ethane
74-85-1	Ethene
74-98-6	Propane
115-07-1	1-Propene
106-97-8	Butane
75-28-5	Isobutane
115-11-7	1-Propene, 2-methyl-
106-98-9	1-Butene
107-01-7	2-Butene
78-78-4	2-Methylbutane
109-66-0	Pentane
287-92-3	Cyclopentane
513-35-9	2-Methyl-2-butene-
64741-55-5	Light catalytic cracked naphtha
64741-87-3	Sweetened naphtha
86290-81-5 or	Gasoline

Table 7. Refinery Gases Category – Subcategories for Human Health	
CASRN	**CA Index Name**
no CASRN	
630-08-0	Carbon monoxide
7664-41-7	Ammonia
7783-06-4	Hydrogen sulfide
Subcategory VIII – Refinery gases, C1-C6 with ammonia and carbon monoxide	
Sponsored Chemicals	
68814-47-1	Waste gases, refinery vent
68919-02-8	Gases (petroleum), fluidized catalytic cracker fractionation off
68919-04-0	Gases (petroleum), heavy distillate hydrotreater desulfurization stripper off
Supporting Chemicals	
74-82-8	Methane
74-84-0	Ethane
74-85-1	Ethene
74-98-6	Propane
115-07-1	1-Propene
106-97-8	Butane
75-28-5	Isobutane
115-11-7	1-Propene, 2-methyl-
106-98-9	1-Butene
107-01-7	2-Butene
78-78-4	2-Methylbutane
109-66-0	Pentane
287-92-3	Cyclopentane
513-35-9	2-Methyl-2-butene-
64741-55-5	Light catalytic cracked naphtha
64741-87-3	Sweetened naphtha
86290-81-5 or no CASRN	Gasoline
7664-41-7	Ammonia
7783-06-4	Hydrogen sulfide
106-99-0	1,3-Butadiene
Subcategory IX – Refinery gases, C1-C6 with ammonia, hydrogen sulfide and carbon monoxide	
Sponsored Chemicals	
68477-65-6	Gases (petroleum), amine system feed
68478-00-2	Gases (petroleum), recycle, hydrogen-rich
68478-03-5	Gases (petroleum), reforming hydrotreater, hydrogen-methane-rich
68478-04-6	Gases (petroleum), reforming hydrotreater make-up, hydrogen-rich
68478-05-7	Gases (petroleum), thermal cracking distn.

Table 7. Refinery Gases Category – Subcategories for Human Health	
CASRN	**CA Index Name**
68783-07-3	Gases (petroleum), refinery blend
68783-62-0	Fuel gases, refinery, unsweetened
68911-58-0	Gases (petroleum), hydrotreated sour kerosine depentanizer stabilizer off
68989-88-8	Gases (petroleum), crude distn. and catalytic cracking
Supporting Chemicals	
74-82-8	Methane
74-84-0	Ethane
74-85-1	Ethene
74-98-6	Propane
115-07-1	1-Propene
106-97-8	Butane
75-28-5	Isobutane
115-11-7	1-Propene, 2-methyl-
106-98-9	1-Butene
107-01-7	2-Butene
78-78-4	2-Methylbutane
109-66-0	Pentane
287-92-3	Cyclopentane
513-35-9	2-Methyl-2-butene-
64741-55-5	Light catalytic cracked naphtha
64741-87-3	Sweetened naphtha
86290-81-5 or no CASRN	Gasoline
630-08-0	Carbon monoxide
7664-41-7	Ammonia
7783-06-4	Hydrogen sulfide
106-99-0	1,3-Butadiene
71-43-2	Benzene
74-93-1	Methanethiol
5188-07-8	Methanethiol, sodium salt (1:1)
75-08-1	Ethanethiol
Subcategory X – Refinery gases, C1-C6 with ammonia, hydrogen sulfide and carbon monoxide	
Sponsored Chemical	
68783-05-1	Gases, (petroleum), ammonia-hydrogen sulfide, water-satd.
Supporting Chemicals	
7664-41-7	Ammonia
7783-06-4	Hydrogen sulfide
Subcategory XI – Refinery gases, C1-C6 with ammonia, hydrogen sulfide and carbon monoxide	

Table 7. Refinery Gases Category – Subcategories for Human Health	
CASRN	**CA Index Name**
Sponsored Chemicals	
68527-13-9	Gases, (petroleum), acid, ethanolamine scrubber
Supporting Chemicals	
630-08-0	Carbon monoxide
7664-41-7	Ammonia
7783-06-4	Hydrogen sulfide

Table 8. Refinery Gases Category – Subcategories for Ecotoxicity	
CASRN	**CA Index Name**
Subcategory I – Refinery gases, C1-C6	
Sponsored Chemicals	
68476-29-9	Fuel gases, crude oil distillates
68477-77-0	Gases (petroleum), catalytic reformed naphtha stripper overheads
68478-25-1	Tail gas (petroleum), catalytic cracker refractionation absorber
68513-11-1	Fuel gases, hydrotreater fractionation, scrubbed
68513-13-3	Fuel gases, thermal cracked catalytic cracking residue
68513-14-4	Gases (petroleum), catalytic reformed straight-run naphtha stabilizer overheads
68513-16-6	Gases (petroleum), hydrocracking depropanizer off, hydrocarbon-rich
68513-18-8	Gases (petroleum), reformer effluent high-pressure flash drum off
68513-19-9	Gases (petroleum), reformer effluent low-pressure flash drum off
68527-14-0	Gases, (petroleum), methane-rich off
68602-84-6	Gases (petroleum), secondary absorber off, fluidized catalytic cracker overheads fractionator
68607-11-4	Petroleum products, refinery gases
68783-06-2	Gases (petroleum), hydrocracking low-pressure separator
68814-67-5	Gases (petroleum), refinery
68814-90-4	Gases (petroleum), platformer products separator off
68919-03-9	Gases (petroleum), fluidized catalytic cracker scrubbing secondary absorber off
68919-07-3	Gases (petroleum), platformer stabilizer off, light ends fractionation
68919-12-0	Gases (petroleum), unifiner stripper off
68952-79-4	Tail gas (petroleum), catalytic hydrodesulfurized naphtha separator
68955-33-9	Gases (petroleum), sponge absorber off, fluidized catalytic cracker and gas oil desulfurizer overhead fractionation
68308-27-0	Fuel gases, refinery
68477-81-6	Gases (petroleum), C6 – 8 catalytic reformer
68478-27-3	Tail gas (petroleum), catalytic reformed naphtha separator
68478-28-4	Tail gas (petroleum), catalytic reformed naphtha stabilizer
68478-29-5	Tail gas, (petroleum), cracked distillate hydrotreater separator
68478-30-8	Tail gas (petroleum), hydrodesulfurized straight-run naphtha separator
68919-08-4	Gases (petroleum), preflash tower off, crude distn.
68952-80-7	Tail gas (petroleum), straight-run naphtha hydrodesulfurizer
68513-68-8	Residues (petroleum), deethanizer tower
Subcategory II – Refinery gases, C1-C6 with ammonia and hydrogen sulfide	
Sponsored Chemicals	
68477-92-9	Gases (petroleum), dry sour, gas-concn.-unit-off
68919-01-7	Gases (petroleum), distillate unifiner desulfurization stripper off
68477-95-2	Gases (petroleum), dry sour, gas-concn.-unit-off
68814-47-1	Waste gases, refinery vent

Table 8. Refinery Gases Category – Subcategories for Ecotoxicity	
CASRN	**CA Index Name**
68919-02-8	Gases (petroleum), fluidized catalytic cracker fractionation off
68919-04-0	Gases (petroleum), heavy distillate hydrotreater desulfurization stripper off
Subcategory III – Refinery gases (without hydrocarbons), ammonia and hydrogen sulfide	
Sponsored Chemicals	
68783-05-1	Gases, (petroleum), ammonia-hydrogen sulfide, water-satd.
Subcategory IV – Refinery gases with carbon monoxide	
Sponsored Chemicals	
68477-65-6	Gases (petroleum), amine system feed
68478-00-2	Gases (petroleum), recycle, hydrogen-rich
68478-03-5	Gases (petroleum), reforming hydrotreater, hydrogen-methane-rich
68478-04-6	Gases (petroleum), reforming hydrotreater make-up, hydrogen-rich
68478-05-7	Gases (petroleum), thermal cracking distn.
68783-07-3	Gases (petroleum), refinery blend
68783-62-0	Fuel gases, refinery, unsweetened
68911-58-0	Gases (petroleum), hydrotreated sour kerosine depentanizer stabilizer off
68989-88-8	Gases (petroleum), crude distn. and catalytic cracking
68527-13-9	Gases, (petroleum), acid, ethanolamine scrubber
68476-26-6	Fuel gases
68477-97-4	Gases (petroleum), hydrogen-rich
68527-15-1	Gases (petroleum), oil refinery gas distn. off
8006-20-0	Fuel gases, producer gas
68477-68-9	Gases (petroleum), blend oil, hydrogen-nitrogen-rich
68477-98-5	Gases (petroleum), hydrotreater blend oil recycle, hydrogen-nitrogen-rich
68478-01-3	Gases (petroleum), reformer make-up, hydrogen-rich
68476-27-7	Fuel gases, amine system residues
68476-28-8	Fuel gases, C6 – 8 catalytic reformer
68477-66-7	Gases (petroleum), benzene unit hydrodesulfurizer off
68477-67-8	Gases (petroleum), benzene unit recycle, hydrogen-rich
68477-80-5	Gases (petroleum), C6 – 8 catalytic reformer recycle
68477-82-7	Gases (petroleum), C6 – 8 catalytic reformer recycle, hydrogen-rich
68602-82-4	Gases (petroleum), benzene unit hydrotreater depentanizer overheads
68911-59-1	Gases (petroleum), hydrotreated sour kerosine flash drum
68478-02-4	Gases (petroleum), reforming hydrotreater
Supporting Chemicals for the Refinery Gases Category	
7664-41-7	Ammonia
7783-06-4	Hydrogen sulfide
74-82-8	Methane
74-84-0	Ethane

Table 8. Refinery Gases Category – Subcategories for Ecotoxicity

CASRN	CA Index Name
74-85-1	Ethene
74-98-6	Propane
106-97-8	Butane
109-66-0	Pentane
110-54-3	Hexane

Table 9. CHEMICAL COMPOSITION OF SPONSORED SUBSTANCES IN THE REFINERY GAS CATEGORY[12]

Table 9. Component Compositional Ranges (Wt. %)													
Petroleum Refinery Gas Name	**CASRN**	**C1 – C4 HCs**	**C5 – C6 HCs**	**Ammonia**	**Carbon Monoxide**	**Hydrogen Sulfide**	**Methyl Mer-captan**	**Ethyl Mercaptan**	**Benzene**	**1,3-Buta-diene**	**Carbon Dioxide**	**Hydrogen**	**Nitrogen**
Subcategory I: Refinery gases, C1 – C4													
Fuel gases, crude oil distillates	68476-29-9	40–59	–	–	–	–	–	–	–	0.1–2	–	40–59	1–5
Gases (petroleum), catalytic reformed naphtha stripper overheads	68477-77-0	40–60	–	–	–	–	–	–	–	–	–	40–60	–
Tail gas (petroleum), catalytic cracker refractionation absorber	68478-25-1	40–59	–	–	–	–	–	–	–	–	–	40–59	1–5
Fuel gases, hydrotreater fractionation, scrubbed	68513-11-1	40–59	–	–	–	–	–	–	–	–	–	40–59	1–5
Fuel gases, thermal cracked catalytic cracking residue	68513-13-3	40–59	–	–	–	–	–	–	–	–	–	40–59	1–5
Gases (petroleum), catalytic reformed straight-run naphtha stabilizer overheads	68513-14-4	40–59	–	–	–	–	–	–	–	–	–	40–59	1–5
Gases (petroleum), hydrocracking depropanizer off, hydrocarbon-rich	68513-16-6	89–98	–	0.01–0.2	–	0.1–0.5	–	–	–	0.1–2	–	1–10	0.1–0.5
Gases (petroleum), reformer effluent high-pressure flash drum off	68513-18-8	25–49	–	–	–	–	–	–	–	–	–	50–74	1–5
Gases (petroleum), reformer effluent low-pressure flash drum off	68513-19-9	25–49	–	–	–	–	–	–	–	–	–	50–74	1–5
Gases, (petroleum), methane-rich off. C1	68527-14-0	60–80	–	–	–	–	–	–	–	–	–	10–20	10–20

[12] Chemical compositions are based on limited historical (1992 – 2002) data from several U.S. petrochemical and petroleum company refineries in the Gulf Coast and mid-continent areas.

Table 9. Component Compositional Ranges (Wt. %)

Petroleum Refinery Gas Name	CASRN	C1 – C4 HCs	C5 – C6 HCs	Ammonia	Carbon Monoxide	Hydrogen Sulfide	Methyl Mer-captan	Ethyl Mercaptan	Benzene	1,3-Buta-diene	Carbon Dioxide	Hydrogen	Nitrogen
Gases (petroleum), secondary absorber off, fluidized catalytic cracker overheads fractionator	68602-84-6	35–45	–	–	–	–	–	–	–	–	–	35–45	10–30
Petroleum products, refinery gases	68607-11-4	21–44	–	–	–	–	–	–	–	–	–	55–74	1–5
Gases (petroleum), hydrocracking low-pressure separator	68783-06-2	40–59	–	–	–	–	–	–	–	–	–	40–59	1–5
Gases (petroleum), refinery	68814-67-5	40–59	–	–	–	–	–	–	–	–	–	40–59	1–5
Gases (petroleum), platformer products separator off	68814-90-4	40–59	–	–	–	–	–	–	–	–	–	40–59	1–5
Gases (petroleum), fluidized catalytic cracker scrubbing secondary absorber off	68919-03-9	40–54	–	–	–	–	–	–	–	–	–	40–55	1–20
Gases (petroleum), platformer stabilizer off, light ends fractionation	68919-07-3	40–59	–	–	–	–	–	–	–	–	–	40–59	1–5
Gases (petroleum), unifiner stripper off	68919-12-0	40–54	–	–	–	–	–	–	–	–	–	40–55	1–5
Tail gas (petroleum), catalytic hydrodesulfurized naphtha separator	68952-79-4	40–59	–	–	–	–	–	–	–	–	–	40–59	1–5
Gases (petroleum), sponge absorber off, fluidized catalytic cracker and gas oil desulfurizer overhead fractionation	68955-33-9	40–59	–	–	–	–	–	–	–	0.1–2	–	40–59	1–5
Subcategory II: Refinery gases, C1 – C4 with ammonia and hydrogen sulfide													
Gases (petroleum), dry sour, gas-concn.-unit-off	68477-92-9	48–79	–	0.1–5	–	0.5–15	0.1–1	0.01–0.5	–	–	–	20–50	0.5–10
Gases (petroleum), distillate unifiner desulfurization stripper off	68919-01-7	40–55	–	1–15	–	25–45	–	–	–	–	–	1–5	1–5

Table 9. Component Compositional Ranges (Wt. %)

Petroleum Refinery Gas Name	CASRN	C1 – C4 HCs	C5 – C6 HCs	Ammonia	Carbon Monoxide	Hydrogen Sulfide	Methyl Mer-captan	Ethyl Mercaptan	Benzene	1,3-Buta-diene	Carbon Dioxide	Hydrogen	Nitrogen
Subcategory III: Refinery gases, C1 – C4 with carbon monoxide													
Fuel gases	68476-26-6	10–58	–	0.01–0.2	0.5–5	0.01–0.5	–	–	–	–	0.1–3	40–88	1–5
Gases (petroleum), hydrogen-rich	68477-97-4	5–15	–	–	0.5–10	–	–	–	–	–	0.1–3	65–90	1–10
Gases (petroleum), oil refinery gas distn. off	68527-15-1	30–45	–	–	0.5–20	–	–	–	–	–	0.1–10	30–45	5–20
Fuel gases, producer gas	8006-20-0	1–10	–	–	20–30	–	–	–	–	–	20–30	20–30	20–30
Subcategory IV: Refinery gases, C1 – C6													
Fuel gases, refinery	68308-27-0	37–58.5	0.5–3	–	–	–	–	–	–	0.1–2	–	40–59	1–5
Gases (petroleum), C6 – 8 catalytic reformer	68477-81-6	35–58.5	0.5–5	–	–	–	–	–	–	–	–	40–59	1–5
Tail gas (petroleum), catalytic reformed naphtha separator	68478-27-3	30–49	1–10	–	–	–	–	–	0.1–2	0.1–2	–	40–59	1–5
Tail gas (petroleum), catalytic reformed naphtha stabilizer	68478-28-4	25–56	3–15	–	–	–	–	–	0.1–2	0.1–2	–	40–59	1–5
Tail gas, (petroleum), cracked distillate hydrotreater separator	68478-29-5	30–58	1–10	–	–	–	–	–	–	–	–	40–59	1–5
Tail gas (petroleum), hydrodesulfurized straight-run naphtha separator	68478-30-8	25–56	3–15	–	–	–	–	–	–	–	–	40–59	1–5
Gases (petroleum), preflash tower off, crude distn.	68919-08-4	25–54	5–15	0.01–0.5	–	0.05–0.2	–	–	–	–	–	1–10	20–50
Tail gas (petroleum), straight-run naphtha hydrodesulfurizer	68952-80-7	30–58	1–10	–	–	–	–	–	–	0.1–2	–	40–59	1–5
Residues (petroleum), deethanizer tower	68513-68-8	80–95	5–20	–	–	–	–	–	0.05–1	0.01–1	–	–	–
Subcategory V: Refinery gases, C1 – C6 with hydrogen sulfide													
Gases (petroleum), dry sour, gas-concn.-unit-off	68477-95-2	93–99.8	0.1–2	0.01–0.5	–	0.1–4	–	–	–	0.1–2	–	–	–

Table 9. Component Compositional Ranges (Wt. %)

Petroleum Refinery Gas Name	CASRN	C1 – C4 HCs	C5 – C6 HCs	Ammonia	Carbon Monoxide	Hydrogen Sulfide	Methyl Mer-captan	Ethyl Mercaptan	Benzene	1,3-Buta-diene	Carbon Dioxide	Hydrogen	Nitrogen
Subcategory VI: Refinery gases, C1 – C6 with carbon monoxide													
Gases (petroleum), blend oil, hydrogen-nitrogen-rich	68477-68-9	0.9–18	0.1–2	–	0.5–20	–	–	–	–	–	0.1–10	30–50	20–40
Gases (petroleum), hydrotreater blend oil recycle, hydrogen-nitrogen-rich	68477-98-5	0.5–18	0.5–2	–	0.5–20	–	–	–	–	–	0.1–10	30–50	20–40
Gases (petroleum), reformer make-up, hydrogen-rich	68478-01-3	4.9–13.5	0.1–1.5	–	0.5–15	–	–	–	–	–	0.1–5	60–75	0.5–5
Fuel gases, amine system residues	68476-27-7	37–49.5	0.5–3	–	0.5–5	–	–	–	–	–	0.1–3	40–59	0.5–5
Fuel gases, C6 – 8 catalytic reformer	68476-28-8	25–40	5–10	–	0.5–10	–	–	–	–	–	0.1–5	35–45	1–10
Gases (petroleum), benzene unit hydrodesulfurizer off	68477-66-7	0.3–13	0.7–7	–	0.5–20	–	–	–	0.1–2	–	0.1–10	50–75	–
Gases (petroleum), benzene unit recycle, hydrogen-rich	68477-67-8	0.3–13	0.7–7	–	0.5–15	–	–	–	0.1–2	–	0.1–5	60–80	–
Gases (petroleum), C6 – 8 catalytic reformer recycle	68477-80-5	1–29	1–9	–	0.5–15	–	–	–	0.1–2	–	0.1–5	40–60	1–15
Gases (petroleum), C6 – 8 catalytic reformer recycle, hydrogen-rich	68477-82-7	9–20	1–10	–	0.5–10	–	–	–	0.1–2	–	0.1–3	50–75	1–10
Gases (petroleum), benzene unit hydrotreater depentanizer overheads	68602-82-4	27–35	3–15	–	0.5–10	–	–	–	0.1–1	–	0.1–3	40–60	1–10
Gases (petroleum), hydrotreated sour kerosine flash drum	68911-59-1	30–49	1–10	–	0.5–5	–	–	–	–	–	0.1–3	40–50	1–5
Subcategory VII: Refinery gases, C1 – C6 with carbon monoxide and hydrogen sulfide													
Gases (petroleum), reforming hydrotreater	68478-02-4	20–49	1–10	0.05–0.5	0.5–5	0.1–1	–	–	–	–	0.1–3	30–50	0.5–5

Table 9. Component Compositional Ranges (Wt. %)

Petroleum Refinery Gas Name	CASRN	C1 – C4 HCs	C5 – C6 HCs	Ammonia	Carbon Monoxide	Hydrogen Sulfide	Methyl Mer-captan	Ethyl Mercaptan	Benzene	1,3-Buta-diene	Carbon Dioxide	Hydrogen	Nitrogen
Subcategory VIII: Refinery gases, C1 – C6 with ammonia and hydrogen sulfide													
Waste gases, refinery vent	68814-47-1	25–49	1–10	1–15	–	20–35	–	–	–	0.1–2	–	1–5	1–10
Gases (petroleum), fluidized catalytic cracker fractionation off	68919-02-8	25–44	1–10	0.1–5	–	1–15	–	–	–	0.1–2	–	35–45	1–15
Gases (petroleum), heavy distillate hydrotreater desulfurization stripper off	68919-04-0	25–44	1–10	0.1–5	–	1–15	–	–	–	–	–	35–45	1–15
Subcategory IX: Refinery gases, C1 – C6 with ammonia, hydrogen sulfide and carbon monoxide													
Gases (petroleum), amine system feed	68477-65-6	0.9–9	0.1–1	0.1–10	0.5–15	10–25	–	–	–	–	0.1–10	30–50	–
Gases (petroleum), recycle, hydrogen-rich	68478-00-2	4.9–13.5	0.1–1.5	0.1–3	0.5–10	0.5–10	–	–	–	–	0.1–5	50–70	0.5–10
Gases (petroleum), reforming hydrotreater, hydrogen-methane-rich	68478-03-5	27–39.5	0.5–3	0.1–2	0.5–5	0.5–5	–	–	–	–	0.1–2	40–60	0.5–5
Gases (petroleum), reforming hydrotreater make-up, hydrogen-rich	68478-04-6	17–39.5	0.5–3	0.1–1	0.5–3	0.5–3	–	–	–	–	0.1–1	50–75	0.5–3
Gases (petroleum), thermal cracking distn.	68478-05-7	20–39	1–10	0.1–2	0.5–10	0.5–5	–	–	0.1–2	0.1–2	0.1–5	35–50	1–5
Gases (petroleum), refinery blend	68783-07-3	58–80	1–10	0.1–1	0.5–5	0.1–4	0.1–0.5	0.01–0.1		0.1–2	0.1–3	1–15	0.05–5
Fuel gases, refinery, unsweetened	68783-62-0	61–94	1–15	0.1–1	0.5–5	0.1–4	0.1–1	0.01–0.5		0.1–2	0.1–3	0.1–5	0.05–5
Gases (petroleum), hydrotreated sour kerosine depentanizer stabilizer off	68911-58-0	25–44	1–10	0.1–2	0.5–5	0.5–5	–	–	–	–	0.1–3	35–50	1–5
Gases (petroleum), crude distn. and catalytic cracking	68989-88-8	25–44	1–10	0.1–5	0.5–10	0.5–10	–	–	0.1–2	0.1–2	0.1–5	30–45	1–10

Table 9. Component Compositional Ranges (Wt. %)

Petroleum Refinery Gas Name	CASRN	C1 – C4 HCs	C5 – C6 HCs	Ammonia	Carbon Monoxide	Hydrogen Sulfide	Methyl Mer-captan	Ethyl Mercaptan	Benzene	1,3-Buta-diene	Carbon Dioxide	Hydrogen	Nitrogen
Subcategory X: Refinery gases, ammonia and hydrogen sulfide													
Gases, (petroleum), ammonia-hydrogen sulfide, water-satd.	68783-05-1	–	–	45–60	–	20–30	–	–	–	–	–	1–5	1–10
Subcategory XI: Refinery gases, ammonia, hydrogen sulfide and carbon monoxide													
Gases, (petroleum), acid, ethanolamine scrubber	68527-13-9	–	–	1–10	1–10	35–45	–	–	–	–	35–45	1–10	1–10

Note on representative structures: The structures chosen for each category member were largely based on the CAS definition included in the CAS registry name. This was supplemented with any information that could be obtained from the refinery processes included in the CAS registry names and from the limited compositional data provided by the sponsor in the Test Plan. It should be understood that each category member consists of many hydrocarbon substances, well beyond the three or four substances shown in the Appendix for most members. The representative structures are meant to show the range of carbon numbers present in each complex mixture.

Table 10. Representative Structures of the Members of the Refinery Gases Category

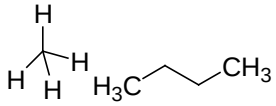
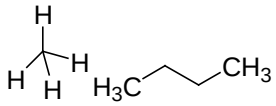
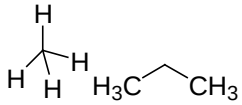
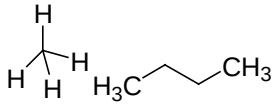
Sponsored Chemicals		
Name	**CASRN**	**Description or Chemical Structure[1]**
SUBCATEGORY I: REFINERY GASES, C1 – C4		
Fuel gases, crude oil distillates	68476-29-9	 A complex combination of light gases produced by distillation of crude oil and by catalytic reforming of naphtha. It consists of hydrogen and hydrocarbons having carbon numbers predominantly in the range of C1 through C4 and boiling in the range of approximately -217 to -12°C.
Gases (petroleum), catalytic reformed naphtha stripper overheads	68477-77-0	 Combination of hydrocarbons obtained from the stabilization of catalytic reformed naphtha. It consists of hydrogen and saturated aliphatic hydrocarbons having carbon numbers predominantly in the range of C1 through C4.
Tail gas (petroleum), catalytic cracker refractionation absorber	68478-25-1	 A complex combination of hydrocarbons obtained from refractionation of products from a catalytic cracking process. It consists of hydrogen and hydrocarbons having carbon numbers predominantly in the range of C1 through C3.
Fuel gases, hydrotreater fractionation, scrubbed	68513-11-1	 A complex combination produced by the fractionation and scrubbing of products from various hydrotreating units. It consists of hydrogen and hydrocarbons having carbon numbers predominantly in the range of C1 through C4.

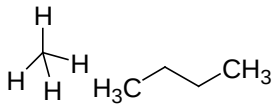
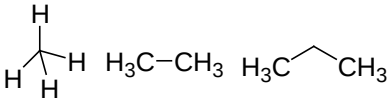
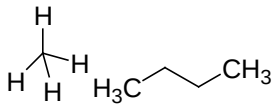
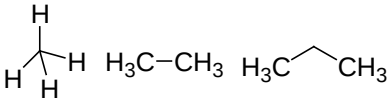
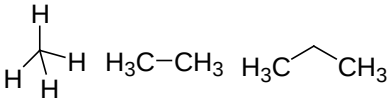
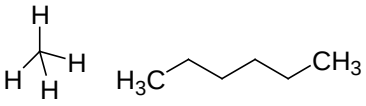
Table 10. Representative Structures of the Members of the Refinery Gases Category		
Sponsored Chemicals		
Name	**CASRN**	**Description or Chemical Structure[1]**
Fuel gases, thermal cracked catalytic cracking residue	68513-13-3	 A complex combination obtained by the thermal cracking of a catalytically cracked residuum. It consists of hydrogen and saturated aliphatic hydrocarbons having carbon numbers predominantly in the range of C1 through C4.
Gases (petroleum), catalytic reformed straight-run naphtha stabilizer overheads	68513-14-4	 A complex combination of hydrocarbons obtained from the catalytic reforming of straight-run naphtha followed by fractionation of the total effluent. It consists of hydrogen, methane, ethane, and propane.
Gases (petroleum), hydrocracking depropanizer off, hydrocarbon-rich	68513-16-6	 A complex combination of hydrocarbon produced by the distillation of products from a hydrocracking process. It consists predominantly of hydrocarbons having carbon numbers predominantly in the range of C1 through C4. It may also contain small amounts of hydrogen and hydrogen sulfide.
Gases (petroleum), reformer effluent high-pressure flash drum off	68513-18-8	 A complex combination produced by the high-pressure flashing of the effluent from the reforming reactor. It consists primarily of hydrogen with various small amounts of methane, ethane, and propane.
Gases (petroleum), reformer effluent low-pressure flash drum off	68513-19-9	 A complex combination produced by low-pressure flashing of the effluent from the reforming reactor. It consists primarily of hydrogen with various small amounts of methane, ethane, and propane.
Gases (petroleum), methane-rich off	68527-14-0	 A complex combination separated by distillation of a gas stream containing hydrogen, carbon monoxide, carbon dioxide, and hydrocarbons having carbon numbers in the range of C1 through C6 or obtained by the cracking of ethane and propane. It consists primarily of methane with various small amounts of hydrogen and nitrogen.

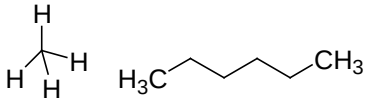
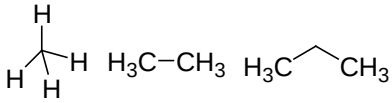
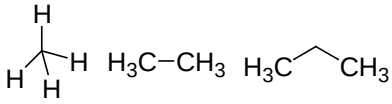
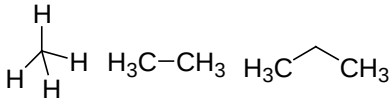
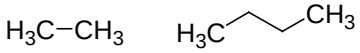
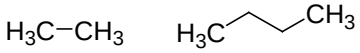
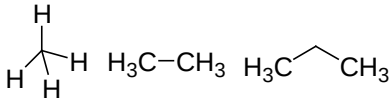
Table 10. Representative Structures of the Members of the Refinery Gases Category		
Sponsored Chemicals		
Name	**CASRN**	**Description or Chemical Structure[1]**
Gases (petroleum), secondary absorber off, fluidized catalytic cracker overheads fractionater	68602-84-6	 A complex combination produced by treating the feed from the benzene unit with hydrogen in the presence of a catalyst followed by depentanizing. It consists primarily of hydrogen, ethane, and propane with various small amounts of nitrogen, carbon monoxide, carbon dioxide, and hydrocarbons having carbon numbers predominantly in the range of C1 through C6.
Petroleum products, refinery gases	68607-11-4	 A complex combination which consists primarily of hydrogen with various small amounts of methane, ethane, and propane.
Gases (petroleum), hydrocracking low-pressure separator	68783-06-2	 A complex combination obtained by the liquid-vapor separation of the hydrocracking process reactor effluent. It consists predominantly of hydrogen and saturated hydrocarbons having carbon numbers predominantly in the range of C1 through C3.
Gases (petroleum), refinery	68814-67-5	 A complex combination obtained from various petroleum refining operations. It consists of hydrogen and hydrocarbons having carbon numbers predominantly in the range of C1 through C3.
Gases (petroleum), platformer products separator off	68814-90-4	 A complex combination obtained from the chemical reforming of naphthenes to aromatics. It consists mainly of hydrogen and saturated hydrocarbons having carbon numbers predominantly in the range of C2 through C4.
Gases (petroleum), fluidized catalytic cracker scrubbing secondary absorber off	68919-03-9	 A complex combination obtained from the chemical reforming of naphthenes to aromatics. It consists mainly of hydrogen and saturated hydrocarbons having carbon numbers predominantly in the range of C2 through C4.
Gases (petroleum), platformer stabilizer off, light ends fractionation	68919-07-3	 A complex combination obtained by the fractionation of the light ends of the

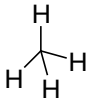
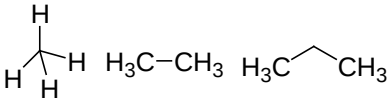
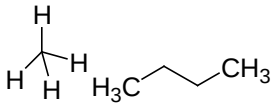
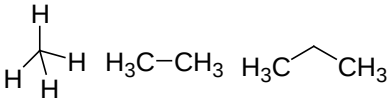
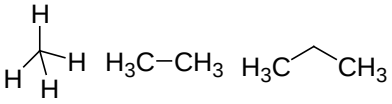
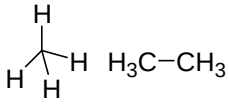
Table 10. Representative Structures of the Members of the Refinery Gases Category		
Sponsored Chemicals		
Name	**CASRN**	**Description or Chemical Structure[1]**
		platinum reactors of the platformer unit. It consists of hydrogen, methane, ethane, and propane.
Gases (petroleum), unifiner stripper off	68919-12-0	 A combination of hydrogen and methane obtained by fractionation of the products from the unifiner unit.
Tail gas (petroleum), catalytic hydrodesulfurized naphtha separator	68952-79-4	 A complex combination of hydrocarbons obtained from the hydrodesulfurization of naphtha. It consists of hydrogen, methane, ethane, and propane.
Gases (petroleum), sponge absorber off, fluidized catalytic cracker and gas oil desulfurizer overhead fractionation	68955-33-9	 A complex combination obtained by the fractionation of products from the fluidized catalytic cracker and gas oil desulfurizer. It consists of hydrogen and hydrocarbons having carbon numbers predominantly in the range of C1 through C4.
SUBCATEGORY II: REFINERY GASES, C1 – C4 WITH AMMONIA AND HYDROGEN SULFIDE		
Gases (petroleum), dry sour, gas-concn.-unit-off	68477-92-9	 The complex combination of dry gases from a gas concentration unit. It consists of hydrogen, hydrogen sulfide, and hydrocarbons having carbon numbers predominantly in the range of C1 through C3.
Gases (petroleum), distillate unifiner desulfurization stripper off	68919-01-7	 A complex combination stripped from the liquid product of the unifiner desulfurization process. It consists of hydrogen sulfide, methane, ethane, and propane.
SUBCATEGORY III: REFINERY GASES, C1 – C4 WITH CARBON MONOXIDE		
Fuel gas	68476-26-6	 A combination of light gases. It consists predominantly of hydrogen and/or

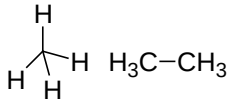
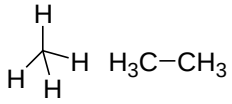
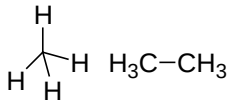
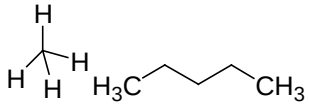
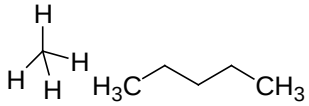
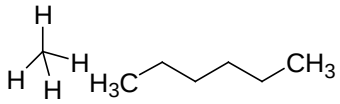
Table 10. Representative Structures of the Members of the Refinery Gases Category		
Sponsored Chemicals		
Name	**CASRN**	**Description or Chemical Structure[1]**
		low molecular weight hydrocarbons.
Gases (petroleum), hydrogen-rich	68477-97-4	 A complex combination separated as a gas from hydrocarbon gases by chilling. It consists primarily of hydrogen with various small amounts of carbon monoxide, nitrogen, methane, and C2 hydrocarbons.
Gases (petroleum), oil refinery gas distn. off	68527-15-1	 A complex combination separated by distillation of a gas containing hydrogen, carbon monoxide, carbon dioxide, and hydrocarbons having carbon numbers in the range of C1 through C6 or obtained by cracking ethane and propane. It consists of hydrocarbons having carbon numbers predominantly in the range of C1 through C2, hydrogen, nitrogen, and carbon monoxide.
Fuel gases, low and medium B.T.U.	8006-20-0	 A complex combination obtained by burning coal or coke with a restricted air or oxygen supply or by blowing air or oxygen and steam through incandescent coke. The combustibles consist primarily of carbon monoxide, carbon dioxide, and hydrogen.
SUBCATEGORY IV: REFINERY GASES, C1 – C6		
Fuel gases, refinery	68308-27-0	 A complex combination of light gases consisting of hydrogen and hydrocarbons having carbon numbers predominantly in the range of C1 through C5.
Gases (petroleum), C6-8 catalytic reformer	68477-81-6	 A complex combination of hydrocarbons produced by distillation of products from catalytic reforming of C6–C8 feed. It consists of hydrogen and hydrocarbons having carbon numbers in the range of C1 through C5.
Tail gas (petroleum), catalytic reformed naphtha separator	68478-27-3	 A complex combination of hydrocarbons obtained from the catalytic reforming

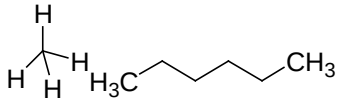
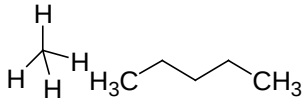
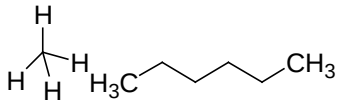
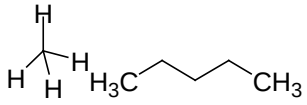
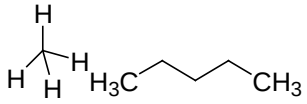
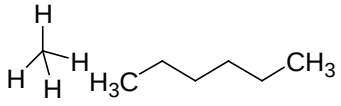
Table 10. Representative Structures of the Members of the Refinery Gases Category		
Sponsored Chemicals		
Name	**CASRN**	**Description or Chemical Structure[1]**
		of straight run naphtha. It consists of hydrogen and hydrocarbons having carbon numbers predominantly in the range of C1 through C6.
Tail gas (petroleum), catalytic reformed naphtha stabilizer	68478-28-4	 A complex combination of hydrocarbons obtained from the stabilization of catalytic reformed naphtha. It consists of hydrogen and hydrocarbons having carbon numbers predominantly in the range of C1 through C6.
Tail gas (petroleum), cracked distillate hydrotreater separator	68478-29-5	 A complex combination of hydrocarbons obtained by treating cracked distillates with hydrogen in the presence of a catalyst. It consists of hydrogen and saturated aliphatic hydrocarbons having carbon numbers predominantly in the range of C1 through C5.
Tail gas (petroleum), hydrodesulfurized straight-run naphtha separator	68478-30-8	 A complex combination of hydrocarbons obtained from hydrodesulfurization of straight-run naphtha. It consists of hydrogen and saturated aliphatic hydrocarbons having carbon numbers predominantly in the range of C1 through C6.
Gases (petroleum), preflash tower off, crude distn.	68919-08-4	 A complex combination produced from the first tower used in the distillation of crude oil. It consists of nitrogen and saturated aliphatic hydrocarbons having carbon numbers predominantly in the range of C1 through C5.
Tail gas (petroleum), straight-run naphtha hydrodesulfurizer	68952-80-7	 A complex combination obtained from the hydrodesulfurization of straight-run naphtha. It consists of hydrogen and hydrocarbons having carbon numbers predominantly in the range of C1 through C5.
Residues (petroleum), deethanizer tower	68513-68-8	 A complex residuum from the distillation of a gas stream containing hydrogen, carbon monoxide, carbon dioxide, and hydrocarbons having carbon numbers in the range of C1 through C6 or from the cracking of ethane and propane. It consists of hydrocarbons having carbon numbers in the range of C2 through

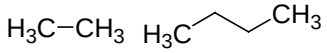
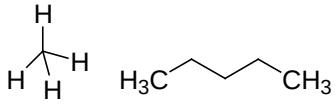
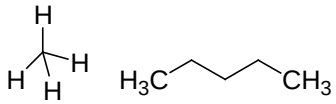
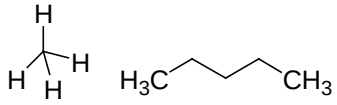
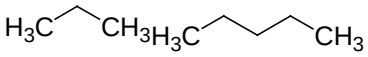
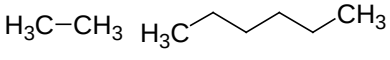
Table 10. Representative Structures of the Members of the Refinery Gases Category		
Sponsored Chemicals		
Name	**CASRN**	**Description or Chemical Structure[1]**
		C6. It may contain small amounts of benzene.
SUBCATEGORY V: REFINERY GASES, C1 – C6 WITH HYDROGEN SULFIDE		
Gases (petroleum), Girbatol unit feed	68477-95-2	 A complex combination of hydrocarbons that is used as the feed into the Girbatol unit to remove hydrogen sulfide. It consists of aliphatic hydrocarbons having carbon numbers predominantly in the range of C2 through C4.
SUBCATEGORY VI: REFINERY GASES, C1 – C6 WITH CARBON MONOXIDE		
Gases (petroleum), blend oil, hydrogen-nitrogen-rich	68477-68-9	 A complex combination of hydrocarbons obtained by distillation of a blend oil. It consists primarily of hydrogen and nitrogen with various small amounts of carbon monoxide, carbon dioxide, and aliphatic hydrocarbons having carbon numbers predominantly in the range of C1 through C5.
Gases (petroleum), hydrotreater blend oil recycle, hydrogen-nitrogen-rich	68477-98-5	 A complex combination obtained from recycled hydrotreated blend oil. It consists primarily of hydrogen and nitrogen with various small amounts of carbon monoxide, carbon dioxide, and hydrocarbons having carbon numbers predominantly in the range of C1 through C5.
Gases (petroleum), reformer make-up, hydrogen-rich	68478-01-3	 A complex combination obtained from the reformers. It consists primarily of hydrogen with various small amounts of carbon monoxide and aliphatic hydrocarbons having carbon numbers predominantly in the range of C1 through C5.
Fuel gases, amine system residues	68476-27-7	 The complex residuum from the amine system for removal of hydrogen sulfide. It consists primarily of hydrogen, methane, and ethane with various small amounts of nitrogen, carbon dioxide, and hydrocarbons having carbon numbers predominantly in the range of C3 through C5.
Fuel gases, C6-8 catalytic reformer	68476-28-8	 A complex combination of gases obtained from a catalytic reforming process using C6–C8 hydrocarbon feed. It consists primarily of hydrogen and methane

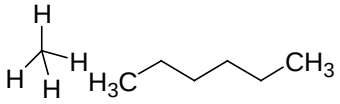
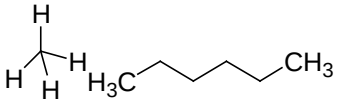
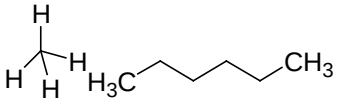
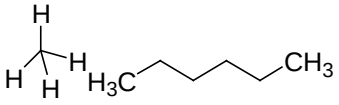
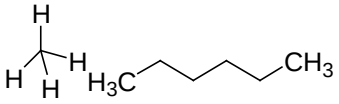
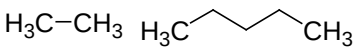
Table 10. Representative Structures of the Members of the Refinery Gases Category		
Sponsored Chemicals		
Name	**CASRN**	**Description or Chemical Structure[1]**
		with various small amounts of nitrogen, carbon monoxide, carbon dioxide, and hydrocarbons having carbon numbers predominantly in the range of C2 through C6.
Gases (petroleum), benzene unit hydrodesulfurizer off	68477-66-7	 Off gases produced by the benzene unit. It consists primarily of hydrogen and carbon monoxide; hydrocarbons having carbon numbers predominantly in the range of C1 through C6, including benzene, may also be present.
Gases (petroleum), benzene unit recycle, hydrogen-rich	68477-67-8	 A complex combination of hydrocarbons obtained by recycling the gases of the benzene unit. It consists primarily of hydrogen with various small amounts of carbon monoxide and hydrocarbons having carbon numbers in the range of C1 through C6.
Gases (petroleum), C6-8 catalytic reformer recycle	68477-80-5	 A complex combination of hydrocarbons produced by distillation of products from catalytic reforming of C6–C8 feed and recycled to conserve hydrogen. It consists primarily of hydrogen. It may also contain various small amounts of carbon monoxide, carbon dioxide, nitrogen, and hydrocarbons having carbon numbers predominantly in the range of C1 through C6.
Gases (petroleum), C6-8 catalytic reformer recycle, hydrogen-rich	68477-82-7	 No definition
Gases (petroleum), benzene unit hydrotreater depentenizer overheads	68602-82-4	 A complex combination produced by treating the feed from the benzene unit with hydrogen in the presence of a catalyst followed by depentanizing. It consists primarily of hydrogen, ethane, and propane with various small amounts of nitrogen, carbon monoxide, carbon dioxide and hydrocarbons having carbon numbers predominantly in the range of C1 through C6. It may contain trace amounts of benzene.
Gases (petroleum), hydrotreated sour kerosine flash drum	68911-59-1	 A complex combination obtained from the flash drum of the unit treating sour kerosene with hydrogen in the presence of a catalyst. It consists primarily of hydrogen and methane with various small amounts of nitrogen, carbon

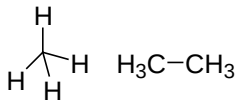
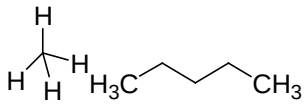
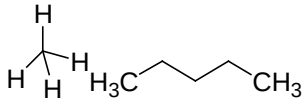
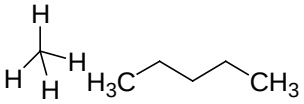
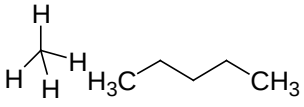
Table 10. Representative Structures of the Members of the Refinery Gases Category		
Sponsored Chemicals		
Name	**CASRN**	**Description or Chemical Structure[1]**
		monoxide, and hydrocarbons having carbon numbers predominantly in the range of C2 through C5.
SUBCATEGORY VII: REFINERY GASES, C1 – C6 WITH CARBON MONOXIDE AND HYDROGEN SULFIDE		
Gases (petroleum), reforming hydrotreater	68478-02-4	 A complex combination obtained from the reforming hydrotreating process. It consists primarily of hydrogen, methane, and ethane with various small amounts of hydrogen sulfide and aliphatic hydrocarbons having carbon numbers predominantly in the range of C3 through C5.
SUBCATEGORY VIII: REFINERY GASES, C1 – C6 WITH AMMONIA AND HYDROGEN SULFIDE		
Waste gases, refinery vent	68814-47-1	 A complex combination obtained from various refinery processes. It consists of hydrocarbons having carbon numbers predominantly in the range of C1 through C5 and hydrogen sulfide.
Gases (petroleum), fluidized catalytic cracker fractionation off	68919-02-8	 A complex combination produced by the fractionation of the overhead product of the fluidized catalytic cracking process. It consists of hydrogen, hydrogen sulfide, nitrogen, and hydrocarbons having carbon numbers predominantly in the range of C1 through C5.
Gases (petroleum), heavy distillate hydrotreater desulfurization stripper off	68919-04-0	 A complex combination stripped from the liquid product of the heavy distillate hydrotreater desulfurization process. It consists of hydrogen, hydrogen sulfide, and saturated aliphatic hydrocarbons having carbon numbers predominantly in the range of Cl through C5.
SUBCATEGORY IX: REFINERY GASES, C1 – C6 WITH AMMONIA, HYDROGEN SULFIDE, AND CARBON MONOXIDE		
Gases (petroleum), amine system feed	68477-65-6	 The feed to the amine system for removal of hydrogen sulfide. It consists of hydrogen, carbon monoxide, carbon dioxide, and hydrogen sulfide; aliphatic hydrocarbons having carbon numbers predominantly in the range of C1 through C5 may also be present.

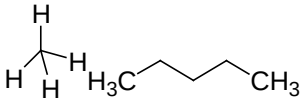
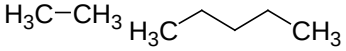
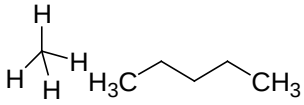
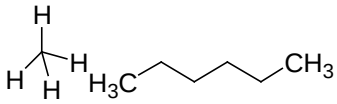
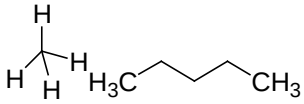
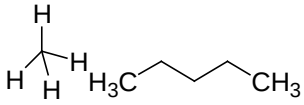
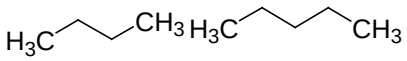
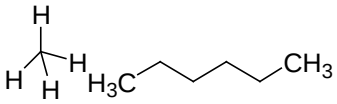
Table 10. Representative Structures of the Members of the Refinery Gases Category		
Sponsored Chemicals		
Name	**CASRN**	**Description or Chemical Structure[1]**
Gases (petroleum), recycle, hydrogen-rich	68478-00-2	 A complex combination obtained from recycled reactor gases. It consists primarily of hydrogen with various small amounts of carbon monoxide, carbon dioxide, nitrogen, hydrogen sulfide, and saturated aliphatic hydrocarbons having carbon numbers in the range of C1 through C5.
Gases (petroleum), reforming hydrotreater, hydrogen-methane-rich	68478-03-5	 A complex combination obtained from the reforming hydrotreating process. It consists primarily of hydrogen and methane with various small amounts of carbon monoxide, carbon dioxide, nitrogen, and saturated aliphatic hydrocarbons having carbon numbers predominantly in the range of C2 through C5.
Gases (petroleum), reforming hydrotreater make-up, hydrogen-rich	68478-04-6	 A complex combination obtained from the reforming hydrotreating process. It consists primarily of hydrogen with various small amounts of carbon monoxide and aliphatic hydrocarbons having carbon numbers predominantly in the range of C1 through C5.
Gases (petroleum), thermal cracking distn.	68478-05-7	 A complex combination produced by distillation of products from a thermal cracking process. It consists of hydrogen, hydrogen sulfide, carbon monoxide, carbon dioxide, and hydrocarbons having carbon numbers predominantly in the range of C1 through C6.
Gases (petroleum), refinery blend	68783-07-3	 A complex combination obtained from various refinery processes. It consists of hydrogen, hydrogen sulfide, and hydrocarbons having carbon numbers predominantly in the range of C1 through C5.
Fuel gases, refinery, unsweetened	68783-62-0	 A complex combination obtained by the fractionation of naphtha and compressed hydrocarbon gas streams from various refinery processes. It consists predominantly of hydrocarbons having carbon numbers in the range of C1 through C5 and boiling in the range of -73° to 65°C.

Table 10. Representative Structures of the Members of the Refinery Gases Category		
Sponsored Chemicals		
Name	**CASRN**	**Description or Chemical Structure[1]**
Gases (petroleum), hydrotreated sour kerosine dependanizer stabilizer off	68911-58-0	 The complex combination obtained from the dependanizer stabilization of hydrotreated kerosene. It consists primarily of hydrogen, methane, ethane, and propane with various small amounts of nitrogen, hydrogen sulfide, carbon monoxide, and hydrocarbons having carbon numbers predominantly in the range of C4 through C5.
Gases (petroleum), crude distn. and catalytic cracking	68989-88-8	 A complex combination produced by crude distillation and catalytic cracking processes. It consists of hydrogen, hydrogen sulfide, nitrogen, carbon monoxide, and paraffinic and olefinic hydrocarbons having carbon numbers predominantly in the range of C1 through C6.
SUBCATEGORY X: REFINERY GASES, AMMONIA AND HYDROGEN SULFIDE		
Gases, (petroleum), ammonia-hydrogen sulfide, water-satd.	68783-05-1	H_2S, NH_3 A water-saturated gas produced by the treatment of waste process water through steam stripping. It consists of up to 30% hydrogen sulfide and up to 60% ammonia.
SUBCATEGORY XI: REFINERY GASES, AMMONIA, HYDROGEN SULFIDE AND CARBON MONOXIDE		
Gases, (petroleum), acid, ethanolamine scrubber	68527-13-9	H_2S, CO_2 A complex mixture separated from refinery gas by scrubbing with ethanolamine. It consists primarily of hydrogen sulfide and carbon dioxide. It may also contain various small amounts of hydrogen, carbon monoxide, and nitrogen.

[1] Hydrogen gas (H_2) is a significant component in most of these streams (see Table A-1).

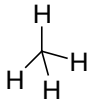
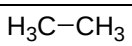
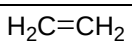
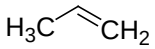
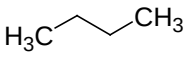
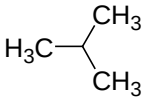
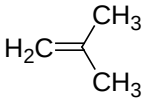
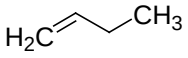
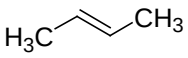
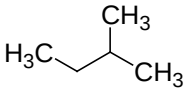
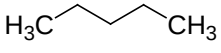
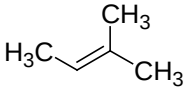
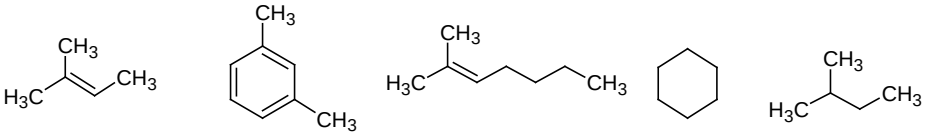
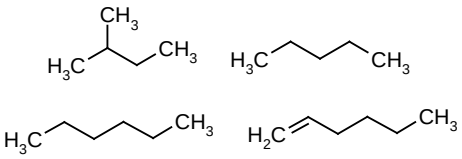
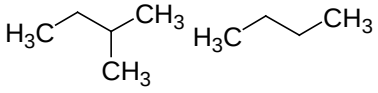
Table 10. Representative Structures of the Members of the Refinery Gases Category		
Supporting Chemicals		
Name	**CASRN**	**Description or Chemical Structure[1]**
Methane	74-82-8	
Ethane	74-84-0	
Ethene	74-85-1	
Propane	74-98-6	
1-Propene	115-07-1	
Butane	106-97-8	
Propane, 2-methyl-	75-28-5	
1-Propene, 2-methyl-	115-11-7	
1-Butene	106-98-9	
2-Butene	107-01-7	
Butane, 2-methyl-	78-78-4	
Pentane	109-66-0	
Cyclopentane	287-92-3	
2-Butene, 2-methyl-	513-35-9	

Table 10. Representative Structures of the Members of the Refinery Gases Category

Supporting Chemicals		
Name	**CASRN**	**Description or Chemical Structure[1]**
Naphtha (petroleum), light catalytic cracked	64741-55-5	 Predominant structures obtained from GC/MS data 34% Paraffin; 40% olefin; 11% naphthene; 15% aromatic A complex combination of hydrocarbons produced by the distillation of products from a catalytic cracking process. It consists of hydrocarbons having carbon numbers predominantly in the range of C4 through C11 and boiling in the range of approximately minus 20°C to 190 °C. It contains a relatively large proportion of unsaturated hydrocarbons.
Naphtha (petroleum), sweetened	64741-87-3	 Predominant structures obtained from GC/MS data 48% Paraffin; 44% olefin; 6% naphthene; 1% aromatic A complex combination of hydrocarbons obtained by subjecting a petroleum naphtha to a sweetening process to convert mercaptans or to remove acidic impurities. It consists of hydrocarbons having carbon numbers predominantly in the range of C4 through C12 and boiling in the range of approximately minus 10 °C to 230 °C
Gasoline	86290-81-5	 Baseline Gasoline Vapor Condensate [BGVC], a 20% light fraction of a whole unleaded gasoline sample was used in various inhalation studies. The main components were isopentane (36.5%) and butane (12.78%). All other components were below 10%.
Ammonia	7664-41-7	NH_3
Hydrogen sulfide (H2S)	7783-06-4	H_2S
Carbon monoxide	630-08-0	CO

[1] Hydrogen gas (H_2) is a significant component in most of these streams (see Table A-1).

Table 11: Reference Sources for Supporting Chemical Data		
CASRN	**CHEMICAL**	**SOURCE**
74-82-8	Methane	Methane is a greenhouse gas whose hazard to the environment is described on the EPA website: http://www.epa.gov/climatechange/emissions/index.html
74-84-0	Ethane	Assessed in HPV Challenge submission for Petroleum Hydrocarbon Gases Category: http://www.epa.gov/chemrtk/pubs/summaries/ptrlgas/c13224tc.htm A hazard characterization for this category is available for viewing at http://iaspub.epa.gov/oppthpv/hpv_hc_characterization.get_report?doctype=2
74-85-1	Ethylene	Assessed as OECD HPV at SIAM 5: http://www.chem.unep.ch/irptc/sids/OECDSIDS/74851.pdf)
74-98-6	Propane	Assessed in HPV Challenge submission for Petroleum Hydrocarbon Gases Category: http://www.epa.gov/chemrtk/pubs/summaries/ptrlgas/c13224tc.htm A hazard characterization for this category is available for viewing at http://iaspub.epa.gov/oppthpv/hpv_hc_characterization.get_report?doctype=2
115-07-1	1-Propene	Assessed as OECD HPV at CASRN 115-07-1: SIAM 16; http://webnet.oecd.org/hpv/ui/Search.aspx
106-97-8	Butane	Assessed in HPV Challenge submission for Petroleum Hydrocarbon Gases Category: http://www.epa.gov/chemrtk/pubs/summaries/ptrlgas/c13224tc.htm A hazard characterization for this category is available for viewing at http://iaspub.epa.gov/oppthpv/hpv_hc_characterization.get_report?doctype=2
75-28-5	Isobutane	Assessed in HPV submission for Petroleum Hydrocarbon Gases Category: http://www.epa.gov/chemrtk/pubs/summaries/ptrlgas/c13224tc.htm A hazard characterization for this category is being prepared and will be available for viewing at http://iaspub.epa.gov/oppthpv/hpv_hc_characterization.get_report?doctype=2
115-11-7	Isobutylene	HPV submission for this Category: http://www.epa.gov/oppt/chemrtk/pubs/summaries/lowbutd/c13122tc.htm Assessed as OECD HPV at SIAM 17 and SIAM 19, butenes category; http://www.chem.unep.ch/irptc/sids/OECDSIDS/115117.pdf and http://webnet.oecd.org/hpv/UI/handler.axd?id=db117c7c-460a-4361-8a85-507f4da63012, respectively.

Table 11: Reference Sources for Supporting Chemical Data		
CASRN	**CHEMICAL**	**SOURCE**
106-98-9	1-Butene	HPV submission for this Category: http://www.epa.gov/oppt/chemrtk/pubs/summaries/lowbutd/c13122tc.htm Assessed as OECD HPV at SIAM 19 in the butenes category: http://webnet.oecd.org/hpv/UI/handler.axd?id=db117c7c-460a-4361-8a85-507f4da63012
107-01-7	2-Butene (isomer mix)	HPV submission for this Category: http://www.epa.gov/oppt/chemrtk/pubs/summaries/lowbutd/c13122tc.htm Assessed as OECD HPV at SIAM 1 and SIAM 19 in butenes category; http://www.chem.unep.ch/irptc/sids/oecdsids/107017.pdf and http://webnet.oecd.org/hpv/UI/handler.axd?id=db117c7c-460a-4361-8a85-507f4da63012, respectively.
78-78-4	Isopentane	HPV submission for Petroleum Gases Category: http://www.epa.gov/chemrtk/pubs/summaries/ptrlgas/c13224tc.htm A hazard characterization for this category is available for viewing at http://iaspub.epa.gov/oppthpv/hpv_hc_characterization.get_report?doctype=2 Assessed as OECD HPV at SIAM 26 in the C5 aliphatic hydrocarbon solvents category: http://webnet.oecd.org/hpv/ui/handler.axd?id=b2243087-cb08-4f47-bd24-9df8ca840c7d
109-66-0	Pentane	Assessed as OECD HPV at SIAM 13 and SIAM 26 in the C5 aliphatic hydrocarbon solvents category: http://ecb.jrc.it/DOCUMENTS/Existing-Chemicals/RISK_ASSESSMENT/REPORT/n-pentanereport043.pdf and http://webnet.oecd.org/hpv/ui/Search.aspx, respectively.
287-92-3	Cyclopentane	Assessed as OECD HPV as part of category at SIAM 26, C5 aliphatic hydrocarbon solvents category; http://webnet.oecd.org/hpv/ui/Search.aspx
513-35-9	2-Butene, 2-methyl-	Assessed as OECD HPV at SIAM 19; http://www.chem.unep.ch/irptc/sids/OECDSIDS/513359.pdf
64741-55-5	Light catalytic cracked naphtha	HPV submission for this category: http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm
64741-87-3	Sweetened naphtha	HPV submission for this category: http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm
86290-81-5 or no CASRN	Gasoline	HPV submission for this category: http://www.epa.gov/hpv/pubs/summaries/ptrlgas/c13224tc.htm

Table 11: Reference Sources for Supporting Chemical Data		
CASRN	**CHEMICAL**	**SOURCE**
7664-41-7	Ammonia	Assessed as OECD HPV at SIAM 24 Ammonia category: http://webnet.oecd.org/hpv/UI/SIDS_Details.aspx?Key=8bdc6f94-afcf-4bd3-87dd-94f82b151637&idx=0 Assessed by EPA, IRIS assessment: http://www.epa.gov/iris/subst/0422.htm 2004 ATSDR Toxicological Profile: http://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=11&tid=2
7783-06-4	Hydrogen sulfide	Assessed by EPA, IRIS assessment: http://www.epa.gov/iris/toxreviews/0061tr.pdf 2006 ATSDR Toxicological Profile: http://www.atsdr.cdc.gov/ToxProfiles/tp114.pdf
630-08-0	Carbon monoxide	2009 DRAFT ATSDR Toxicological Profile: http://www.atsdr.cdc.gov/ToxProfiles/tp201.pdf Carbon monoxide is one of six common air pollutants for which National Ambient Air Quality standards have been set: http://www.epa.gov/air/urbanair/index.html. Additional information can be found on the EPA website at: http://www.epa.gov/air/urbanair/co/index.html EPA acute exposure guidelines: http://www.epa.gov/opptintr/aegl/pubs/carbon_monoxide_final_volume8_2010.pdf
71-43-2	Benzene	2005 EPA IRIS assessment: http://www.epa.gov/ncea/iris/toxreviews/0276tr.pdf (2002, noncancer) http://www.epa.gov/ncea/iris/supdocs/0276index.html (other IRIS benzene documents, including cancer) EPA VCCEP Program: http://www.epa.gov/oppt/vccep/pubs/chem2a.html 2007 ATSDR draft Tox Profile: http://www.atsdr.cdc.gov/ToxProfiles/tp3.pdf Assessed as OECD HPV at SIAM 21: http://ecb.jrc.ec.europa.eu/DOCUMENTS/Existing-Chemicals/RISK_ASSESSMENT/REPORT/benzenereport063.pdf
106-99-0	1,3-Butadiene	2002 EPA IRIS assessment: http://www.epa.gov/ncea/iris/subst/0139.htm 2009 ATSDR draft Tox Profile: http://www.atsdr.cdc.gov/ToxProfiles/tp28.pdf Assessed as OECD HPV at SIAM 4: http://ecb.jrc.ec.europa.eu/DOCUMENTS/Existing-

Table 11: Reference Sources for Supporting Chemical Data		
CASRN	**CHEMICAL**	**SOURCE**
		Chemicals/RISK_ASSESSMENT/REPORT/butadienereport019.pdf
74-93-1	Methyl Mercaptan	Assessed as OECD HPV in methyl mercaptans category at SIAM 27: http://webnet.oecd.org/hpv/UI/SIDS_Details.aspx?Key=bd39ea0f-70f3-4492-bc2c-de8674dabcf5&idx=0
5188-07-8	Sodium Methanethiolate	Assessed as OECD HPV in methyl mercaptans category at SIAM 27: http://webnet.oecd.org/hpv/UI/SIDS_Details.aspx?Key=bd39ea0f-70f3-4492-bc2c-de8674dabcf5&idx=0
75-08-1	Ethyl Mercaptan	Assessed as OECD HPV in C2-C4 aliphatic thiols category at SIAM 30: http://webnet.oecd.org/hpv/UI/SIDS_Details.aspx?Key=08161706-af46-40e8-a333-4f93c771eee7&idx=0
Draft Screening Assessment for Petroleum and Refinery Gases [site-restricted]; Environment Canada (2011): http://www.ec.gc.ca/ese-ees/default.asp?lang=En&n=08D395AD-1		