SCREENING-LEVEL HAZARD CHARACTERIZATION

Low 1,3-Butadiene C4 Category

SPONSORED CHEMICALS

C4 Raffinate 1 Stream	**No CASRN**
C4 Raffinate 2 Stream	**No CASRN**
C4 Raffinate 3 Stream	**No CASRN**
Catalytic Butylenes Stream	**CASRN 25167-67-3**
***n*-Butane Stream**	**CASRN 106-97-8**
Butene Stream	**CASRN 106-98-9**
Isobutylene Stream	**CASRN 115-11-7**

SUPPORTING CHEMICALS

Isobutylene	**CASRN 115-11-7**
1-Butene	**CASRN 106-98-9**
1,3-Butadiene	**CASRN 106-99-0**
Butane	**CASRN 106-97-8**
2-Butene	**CASRN 107-01-7**

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

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

The evaluation is performed according to established EPA guidance[2,3] and is based primarily on hazard data provided by sponsors; however, in preparing the hazard characterization, EPA

[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.

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

OPPT does not develop HCs for those HPV chemicals which have already been assessed internationally through the HPV program of the Organization for Economic Cooperation and Development (OECD) and for which Screening Initial Data Set (SIDS) Initial Assessment Reports (SIAR) and SIDS Initial Assessment Profiles (SIAP) are available. These documents are presented in an international forum that involves review and endorsement by governmental authorities around the world. OPPT is an active participant in these meetings and accepts these documents as reliable screening-level hazard assessments.

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

Chemical Abstract Service Registry Number (CASRN)	**Sponsored Chemicals** **See Table 1** **Supporting Chemicals** **115-11-7** **106-98-9** **106-99-0** **106-97-8** **107-01-7**
Chemical Abstract Index Name	**Sponsored Chemicals** **See Table 1** **Supporting Chemicals** **1-Propene, 2-methyl-** **1-Butene** **1,3-Butadiene** **Butane** **2-Butene**
Structural Formula	**See Table 12**

Summary

The low 1,3-butadiene C4 category consists of seven process streams that originate from ethylene manufacturing. The substances of this category are gases possessing high vapor pressure and moderate water solubility. All category members are expected to possess high mobility in soil. Volatilization is expected to be high. The rate of hydrolysis is negligible. The rate of atmospheric photooxidation is expected to be rapid to slow for the members of this category. The members of the low 1,3-butadiene C4 category are expected to possess low persistence (P1) and low bioaccumulation potential (B1).

Human Health Hazard

Subcategory I: Streams of Heterogeneous Mixtures Containing 1,3-Butadiene

No data are available for the sponsored streams for the human health endpoints.

The acute inhalation toxicity of the supporting chemical, CASRN 107-01-7, in rats is low. In combined inhalation repeated-dose/reproductive/developmental toxicity screening tests in rats, the supporting chemicals, CASRNs 75-28-5 and 106-98-9, showed no adverse treatment-related effects; the NOAECs for systemic toxicity are 9148 ppm/day and 8000 ppm/day, respectively (highest concentrations tested). In a combined inhalation repeated-dose/reproductive/developmental toxicity screening test in rats, the supporting chemicals CASRNs 106-97-8, 107-01-7 and 115-11-7 showed no toxicologically significant treatment-related effects; the NOAECs for systemic toxicity are 9157 ppm/day, 5009 ppm/day and 8000 ppm/day, respectively (highest concentration tested). The supporting chemical, CASRN

115-11-7, 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, CASRNs 106-97-8, CASRNs 107-01-7 and CASRN 106-98-9 showed no treatment-related effects on reproduction; the NOAECs for reproductive/maternal/developmental toxicity in rats are 9157 ppm/day, 5009 ppm/day and 8000 ppm/day, respectively (highest concentrations tested). Repeated inhalation exposure with CASRN 75-28-5 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). In the 14-week inhalation repeated-dose toxicity study described above, the supporting chemical, CASRN 115-11-7, showed a decrease in sperm motility at 7970 ppm/day; however, no adverse developmental effects were observed in the prenatal developmental toxicity study in rats; NOAEC for maternal/developmental toxicity is 18.4 mg/L/day (highest concentration tested). In an inhalation prenatal developmental toxicity study in rats, the supporting chemical CASRN 115-07-1 showed no treatment-related effects; the NOAEC for maternal/developmental toxicity is 10,000 ppm/day (highest concentration tested). CASRN 115-07-1 induced gene mutations in bacteria, but was equivocal for mutagenicity in mouse lymphoma cells *in vitro*. CASRNs 106-97-8, 115-11-7, 106-98-9 and 107-01-7 did not induce gene mutations in bacteria or mouse lymphoma cells *in vitro*. CASRN 107-01-7 did not induce chromosomal aberrations in rat lymphocytes or Chinese hamster ovary (CHO) cells *in vitro* and CASRNs 115-11-7 and 106-98-9 did not induce micronuclei in rats and/or mice *in vivo*. The supporting chemical, CASRN 106-99-0 was mutagenic in bacteria *in vitro* and induced chromosomal aberrations *in vivo*. CASRN 106-99-0 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 CASRN 106-99-0 carcinogenic to humans. The supporting chemical, CASRN 115-07-1 was not carcinogenic in rats or mice when administered via the inhalation route of exposure. The supporting chemical, CASRN 115-11-7 increased the incidence of tumors in male rats but not female rats, or mice of both sexes.

No data gaps were identified under the HPV Challenge Program.

Subcategory II: High purity streams containing 1,3-butadiene
No data are available for the sponsored streams for the human health endpoints.

Group 1: 1-Butene high purity stream
The acute inhalation toxicity of the supporting chemical, CASRN 107-01-7, in rats is low. In a combined inhalation repeated-dose/reproductive/developmental toxicity screening test in rats, the supporting chemical, CASRN 106-98-9, showed no adverse treatment-related effects; the NOAEC for systemic toxicity is 8000 ppm/day (highest concentration tested). CASRN 106-98-9 showed no treatment-related effects on reproduction; the NOAEC for reproductive/maternal/developmental toxicity in rats is 8000 ppm/day (highest concentration tested). The supporting chemical, CASRN 106-99-0 was mutagenic in bacteria *in vitro* and induced chromosomal aberrations *in vivo*. CASRN 106-99-0 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 CASRN 106-99-0 carcinogenic to humans.

Group 2: Isobutylene high purity stream
The acute inhalation toxicity of the supporting chemical, CASRN 115-11-7, in mice and rats is low. Repeated inhalation exposures of CASRN 115-11-7 (supporting chemical) in rats and mice showed no toxicologically significant treatment-related effects; the NOAEC for systemic toxicity is 7970 ppm/day and 7980 ppm/day(highest concentration tested) in rats and mice, respectively. No specific reproductive toxicity studies are available for the supporting chemical, CASRN 115-11-7. However, no effects were seen on the reproductive organs in mice after 14-week inhalation exposure; rats showed a decrease in sperm motility at 7970 ppm. The supporting chemical, CASRN 106-99-0 was mutagenic in bacteria *in vitro* and induced chromosomal aberrations *in vivo*. CASRN 106-99-0 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 CASRN 106-99-0 carcinogenic to humans. The supporting chemical, CASRN 115-11-7 increased the incidence of tumors in male rats but not female rats, or mice of both sexes.

No data gaps were identified under the HPV Challenge Program.

Subcategory III: Streams that do not contain 1,3-butadiene
No data are available for the sponsored streams for the human health endpoints.

Group 1: C4 Raffinate 3 Stream
The acute inhalation toxicity of the supporting chemical, CASRN 107-01-7 in rats is low. In combined inhalation repeated-dose/reproductive/developmental toxicity screening tests in rats, the supporting chemicals CASRNs 106-97-8 and 107-01-7 showed no toxicologically significant treatment-related effects; the NOAECs for systemic toxicity are 9157 ppm/day and 5009 ppm/day and 8000 ppm/day, respectively (highest concentrations tested). In the combined repeated-dose/reproductive/developmental toxicity screening tests previously mentioned, CASRNs 106-97-8 and 107-01-7 showed no treatment-related effects on reproduction; the NOAECs for reproductive/maternal/developmental toxicity in rats are 9157 ppm/day and 5009 ppm/day, respectively (highest concentrations tested). CASRNs 106-97-8 and 107-01-7 did not induce gene mutations in bacteria or mouse lymphoma cells *in vitro*. CASRN 107-01-7 did not induce chromosomal aberrations in rat lymphocytes or Chinese hamster ovary (CHO) cells *in vitro*.

Group 2: Butane stream
The acute inhalation toxicity of the supporting chemical, CASRN 107-01-7, in rats is low. In a combined inhalation repeated-dose/reproductive/developmental toxicity screening test in rats, the supporting chemicals, CASRN 75-28-5 and 106-97-8, showed no adverse treatment-related effects; the NOAECs for systemic toxicity are 9148 ppm/day and 9157 ppm/day (highest concentrations tested). In the combined repeated-dose/reproductive/developmental screening tests previously mentioned, CASRN 106-97-8 showed no treatment-related effects on reproduction; the NOAEC for reproductive/maternal/developmental toxicity in rats is 9157 ppm/day (highest concentrations tested). Repeated inhalation exposure with CASRN 75-28-5 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). CASRN 106-97-8 did not induce gene

mutations in bacteria or mouse lymphoma cells *in vitro*.

No data gaps were identified under the HPV Challenge Program.

Hazard to the Environment

Based on the supporting chemical, CASRN 109-66-0, the 96-h LC_{50} for fish is 4.26 mg/L and the 48-h EC_{50} for aquatic invertebrates is 2.7 mg/L. The 72-h EC_{50} for aquatic plants ranges from 7.5 to 40 mg/L (supporting chemicals, CASRNs 109-66-0 and 74-85-1, respectively) for biomass and 10.7 to 72 mg/L (supporting chemicals, CASRNs 109-66-0 and 74-85-1, respectively) for growth rate.

No data gaps were identified under the HPV Challenge Program.

The sponsor, American Chemistry Council Olefins Panel, submitted a Test Plan and Robust Summaries to EPA for the low 1,3-butadiene C4 category on July 13, 2001. EPA posted the submission on the ChemRTK HPV Challenge website on September 27, 2001 (http://www.epa.gov/oppt/chemrtk/pubs/summaries/lowbutd/c13122tc.htm). EPA comments on the original submission were posted to the website on May 3, 2002. Public comments were also received and posted to the website. The sponsor submitted updated/revised documents on December 9, 2003 and September 10, 2004, which were posted to the ChemRTK website on February 26, 2004 and September 22, 2004, respectively.

Category Justification

The low 1,3-butadiene C4 category contains 7 ethylene process streams that originate from either a butadiene extraction process unit (C4 Raffinate 1 stream) or the C4 cut of a catalytic cracker (catalytic butylenes stream). In addition to these two streams, the category contains C4 Raffinates 2 and 3, 1-propene, 2-methyl-, 1-butene and butane, all of which are obtained from C4 Raffinate 1. Nearly all of these are mixtures primarily composed of C4, are process-related, and are low in 1,3-butadiene [CASRN 106-99-0 ($\leq$5%)]. The process is outlined in the Appendix. Four of these process streams, Catalytic Butylenes and C4 Raffinates 1, 2 and 3, are complex mixtures and contain varying percentages of propane, propylene, propadiene, n-butane, isobutane, 1-propene, 2-methyl-, 1-butene, *cis/trans* isomers of 2-butene, 1,3-butadiene and other butenes. The other three process streams consist of the purified compounds, *n*-butane (88%), 1-propene, 2-methyl- (99%) and 1-butene (99%). The sponsored streams, and the stream components with their typical concentrations, as presented in the test plan (http://www.epa.gov/oppt/chemrtk/pubs/summaries/lowbutd/c13122tc.htm), are shown in Table 1 and the Appendix (Table 10), respectively.

Table 1. Production Streams, CAS RNs, and CAS RN Names in the Low 1,3-Butadiene C4 Category[1]

Production Streams	CAS RN	CAS RN Name
C4 Raffinate 1	68477-42-9	Gases, petroleum, extractive, C3-5, butene-isobutylene-rich
	25167-67-3	Butene
	68477-83-8	Gases, petroleum, C3-5 olefinic-paraffinic alkylation feed
	68527-19-5	Hydrocarbons, C1-4, debutanizer fraction
	68606-31-5	Hydrocarbons, C3-5, butadiene purifn by-product
C4 Raffinate 2	68606-31-5	Hydrocarbons, C3-5, butadiene purifn by-product
	25167-67-3	Butene
C4 Raffinate 3	68606-24-6[2]	Hydrocarbons, C4, butene concentrator by-product
	25167-67-3	Butene
Catalytic Butylenes	25167-67-3	Butene
Butane	106-97-8	Butane
Butene-1	106-98-9	1-Butene
Isobutylene	115-11-7[3]	1-Propene, 2- methyl

1 The definitions found in the TSCA Chemical Substance Inventory for the CAS RNs in this category are vague with respect to composition. Therefore, it is not uncommon to find that one CAS RN is correctly used to describe different streams (different compositions) or that two or more CAS RNs are used to describe one stream (similar composition). CAS RNs associated with corresponding production streams are shown in the above table. The Olefins Industry or others may use these same CAS RNs to represent substances that may, in various degrees, be dissimilar to the category streams.

2 This CAS RN was not included in the list of CAS RNs originally sponsored under this category. It has been added to this summary report because it is an additional CAS RN that is sometimes used to represent the C4 Raffinate 3 stream.

3 Although this CAS RN was listed in the Low 1,3-Butadiene C4 Category test plan submitted by the Olefins Panel, HPV Implementation Task Group, it was not sponsored under this category because adequate data were summarized for this substance under the OECD (Organization for Economic Co-operation and Development) SIDS (Screening Information Data Set) HPV (High Production Volume) Program. Data for this substance is being used to support the characterization of selected category endpoints.

For the purposes of human health hazard characterization, EPA used CASRN 106-99-0, a genotoxicant and carcinogen, as the chemical around which streams in this category are grouped. EPA also considered CASRN 106-99-0 and the relative purity/relative heterogeneity of individual mixtures as the principal criteria for subdividing the streams containing CASRN 106-99-0. Therefore, the low 1,3-butadiene C4 category is divided into 3 subcategories, with two of the subcategories being further divided into 2 groups (see Table 2). For aquatic toxicity, the category is evaluated without subdivision.

Table 2. Low 1,3-Butadiene Subcategories for Human Health Endpoints

I	Streams of Heterogeneous Mixtures that Contain 1,3-Butadiene	C4 Raffinate stream 1
		C4 Raffinate stream 2
		Catalytic Butylene stream
II	High purity streams containing 1,3-butadiene	Group 1: 1-Butene high purity stream
		Group 2: Isobutylene high purity stream
III	Streams that do not contain 1,3-butadiene	Group 1: C4 Raffinate stream 3
		Group 2: Butane stream

Note: 1,3-Butadiene may be present in all of the category's streams, depending on the refiner and any process changes.

Justification of Supporting Chemicals

No toxicity testing was performed on any of the streams. Therefore, the health hazard assessment relied entirely on toxicology findings from supporting chemicals. The supporting chemicals that EPA used for the assessment of human health hazard and ecotoxicity are presented in Table 3. The selection of supporting chemicals was based on one or more of the following criteria:
1) The chemical is a principal constituent of the stream,
2) The chemical is structurally similar to a principal component of the sponsored stream,
3) The chemical is a minor constituent of a stream, but it is an established genotoxicant and therefore presents risks at low concentrations,
4) The chemical has a unique CASRN, and
5) Toxicity information is available for at least one endpoint.

Table 10 in the Appendix identifies the streams' constituents in terms of wt% or ppm. Data for 1,3-butadiene (CASRN 106-99-0), which is present in many of the streams at $\leq$ 5%, was used as a supporting chemical for genotoxicity and carcinogenicity endpoints, as appropriate.

Many of the supporting chemicals have been assessed in the OECD HPV program, by EPA's IRIS program, or in EPA's hazard characterization documents. The informational source for each supporting chemical that was used for this hazard characterization is presented in Table 13 in the Appendix.

For aquatic toxicity, the sponsor submitted ECOSAR data on the chemical constituents in the category. However, EPA determined that the measured data from ethylene (CASRN 74-85-1), pentane (CASRN 109-66-0) and 2-butene, 2-methyl- (CASRN 513-35-9) are appropriate to support this category based on their similar physico-chemical properties, environmental fate and mode of toxic action (narcosis). In addition, these chemicals are used to set boundaries and cover the low and high carbon numbers in the category (C3-C5). Therefore, data from these supporting chemicals can adequately characterize the aquatic toxicity hazard for this category.

Table 3. Subcategories in the Low 1,3-Butadiene C4 Category: Sponsored Streams and their Supporting Chemicals

CASRN	Stream
SPONSORED CHEMICALS – HUMAN HEALTH HAZARD	
Subcategory I – Streams of heterogeneous mixtures containing 1,3-butadiene	
No CASRN	C4 Raffinate 1 Stream
No CASRN	C4 Raffinate 2 Stream
25167-67-3	Catalytic Butylene Stream
Supporting Chemicals	
75-28-5	Isobutane
115-11-7	Isobutylene
106-98-9	1-Butene
106-99-0	1,3-Butadiene
106-97-8	Butane
107-01-7	2-Butene (isomer mix)
Subcategory II - High purity streams containing 1,3-butadiene	
Group 1	
106-98-9	1-Butene High Purity Stream
Group 2	
115-11-7	Isobutylene High Purity Stream
Supporting Chemicals	
115-11-7	Isobutylene
106-98-9	1-Butene
106-99-0	1,3-Butadiene
107-01-7	2-Butene (isomer mix)
Subcategory III – Streams not containing 1,3-butadiene	
Group 1	
No CASRN	C4 Raffinate 3 Stream
Group 2	
106-97-8	Butane stream
Supporting Chemicals	
106-98-9	1-Butene
107-01-7	2-Butene (isomer mix)
106-97-8	Butane
78-78-4	Isopentane
SPONSORED CHEMICALS – ECOTOXICITY	
No CASRN	C4 Raffinate 1 Stream
No CASRN	C4 Raffinate 2 Stream
No CASRN	C4 Raffinate 3 Stream
25167-67-3	Catalytic Butylene Stream
106-98-9	1-Butene High Purity Stream
115-11-7	Isobutylene High Purity Stream
106-97-8	Butane Streams

Table 3. Subcategories in the Low 1,3-Butadiene C4 Category: Sponsored Streams and their Supporting Chemicals	
CASRN	**Stream**
Supporting Chemicals	
74-85-1	Ethylene
109-66-0	Pentane
513-35-9	2-Butene, 2-methyl-

1. Chemical Identity

1.1 Identification and Purity

A description of the complex mixtures used for this category and the chemical structures of the specific compounds is provided in the Appendix. These selected constituents represent all substances defined by this category and as such, this report represents the entire distribution range based on constituent data. Since 1,3-butadiene makes up no more than 5% of the production streams, no physicochemical data were provided for that specific compound.

1.2 Physical-Chemical Properties

The components of this category are gases that possess high vapor pressure and moderate water solubility. The physical-chemical properties of the sponsored substances contained in the low 1,3-butadiene category and its supporting chemicals are summarized in Tables 4 and 5.

Table 4. Physical-Chemical Properties of the Low 1,3-Butadiene C4 category[1]							
Property	**SPONSORED CHEMICAL C4 Raffinate 1[2]**	**SPONSORED CHEMICAL C4 Raffinate 2[3]**	**SPONSORED CHEMICAL C4 Raffinate 3[4]**	**SPONSORED CHEMICAL Catalytic Butylenes[5]**	**SPONSORED CHEMICAL Butane Stream**	**SPONSORED CHEMICAL Butene-1 Stream**	**SPONSORED CHEMICAL Isobutylene Stream**
CASRN	68477-42-9; 25167-67-3; 68477-83-8; 68527-19-5; 68606-31-5	68606-31-5; 25167-67-3	68606-24-6; 25167-67-3	25167-67-3	106-97-8	106-98-9	115-11-7
Molecular Weight	Complex mixture	Complex mixture	Complex mixture	Complex mixture	58.12	56.11	56.11
Physical State	Gas	Gas	Gas	Gas	Gas	Gas	Gas
Melting Point	-185.3 to -105.5 °C (measured)[6]	-185.3 to -105.5 °C (measured)[6]	-138.9 to -105.5 °C (measured)[6]	185.3 to -105.5 °C (measured)[6]	-138.2 °C (measured)[6]	-185.3 °C (measured)[6]	-140.4 °C (measured)[6]
Boiling Point	-11.7 to 0.8°C (measured)[2]	-6.9 to 3.7°C (measured)[6]	-0.5 to 3.7°C (measured)[6]	-6.9 to 3.7°C (measured)[6]	-0.5°C (measured)[6]	-6.2°C (measured)[6]	-6.9°C (measured)[6]
Vapor Pressure	1,820 to 2,610 mm Hg at 25°C (measured)[2]	1,600 to 2,610 mm Hg at 25°C (measured)[6]	1,600 to 1,820 mm Hg at 25°C (measured)[6]	1,600 to 2,310 mm Hg at 25°C (measured)[6]	1,820 Hg at 25°C (measured)[6]	2,250 mm Hg at 25°C (measured)[6]	2,310 mm Hg at 25°C (measured)[6]
Dissociation Constant (pK_a)	Not applicable						
Henry's Law Constant	0.218 to 1.19 atm-m^3/mol (measured)[6]	0.224 to 0.95 m^3/mol (measured)[6]	0.224 to 0.95 m^3/mol (measured)[6]	0.218 to 0.234 m^3/mol (measured)[6]	0.95 atm-m^3/mol (measured)[6]	0.233 atm-m^3/mol (measured)[6]	0.218 atm-m^3/mol (measured)[6]
Water Solubility	48.8 to 659 mg/L at 25°C (measured)[6]	48.8 to 659 mg/L at 25°C (measured)[6]	61.2 to 659 mg/L at 25°C (measured)[6]	263 to 659 mg/L at 25°C (measured)[6]	61.2 mg/L at 25°C (measured)[6]	221 mg/L at 25°C (measured)[6]	263 mg/L at 25°C (measured)[6]
Log K_{ow}	2.31–2.89 (measured)[6]	2.31– 2.89 (measured)[6]	2.31– 2.89 (measured)[6]	2.31– 2.40 (measured)[6]	2.89 (measured)[6]	2.40 (measured)[6]	2.34 (measured)[6]

[1] Chemicals Manufacturing Association Olefins Panel, HPV Implementation Task Group. 2004. Revised Test Plan and Robust Summary for the low 1,3-Butadiene C4 Category. Available online at http://www.epa.gov/chemrtk/pubs/summaries/lowbutd/c13122tc.htm as of August 18, 2010.

[2] Range of values were derived from data for 1-butene (CASRN 106-98-9); 2-butene, (2Z)- (CASRN 590-18-1); 2-butene, (2E)- (CASRN 624-64-6); 1-propene, 2-methyl- (CASRN 115-11-7); butane (CASRN 106-97-8); and propane, 2-methyl- (CASRN 75-28-5).

[3] Range of values were derived from data for 1-butene (CASRN 106-98-9); 2-butene, (2Z)- (CASRN 590-18-1); 2-butene, (2E)- (CASRN 624-64-6); butane (CASRN 106-97-8); and propane, 2-methyl- (CASRN 75-28-5).

[4] Range of values were derived from data for 2-butene, (2Z)- (CASRN 590-18-1); 2-butene, (2E)- (CASRN 624-64-6); and butane (CASRN 106-97-8).

[5] Range of values were derived from data for 2-butene, (2Z)- (CASRN 590-18-1); 2-butene, (2E)- (CASRN 624-64-6); 1-propene, 2-methyl- (CASRN 115-11-7) ; and 1-butene (CASRN 106-98-9).

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

Table 5. Physical-Chemical Properties of the Low 1,3-Butadiene C4 category[1]			
Property	**SUPPORTING CHEMICAL 2-Butene**	**SUPPORTING CHEMICAL 2-Butene, (2Z)-**	**SUPPORTING CHEMICAL 2-Butene, (2E)-**
CASRN	107-01-7	590-18-1	624-64-6
Molecular Weight	56.11	56.11	56.11
Physical State	Gas	Gas	Gas
Melting Point	-138.9 to -105.5°C (measured)[2]	-138.9°C (measured)[2]	-105.5°C (measured)[2]
Boiling Point	0.8 to 3.7°C (measured)[2]	3.7°C (measured)[2]	0.8°C (measured)[2]
Vapor Pressure	1,600 to 1,760 mm Hg at 25°C (measured)[2]	1,600 mm Hg at 25°C (measured)[2]	1,760 mm Hg at 25°C (measured)[2]
Dissociation Constant (pK_a)	Not applicable		
Henry's Law Constant	0.224 to 0.231 atm-m^3/mol (measured)[2]	0.231 atm-m^3/mol (measured)[2]	0.224 atm-m^3/mol (measured)[2]
Water Solubility	511–659 mg/L (measured)[2]	659 mg/L (measured)[2]	511 mg/L (measured)[2]
Log K_{ow}	2.31–2.33 (measured)[2]	2.33 (measured)[2]	2.31 (measured)[2]

[1] Chemicals Manufacturing Association Olefins Panel, HPV Implementation Task Group. 2004. Revised Test Plan and Robust Summary for the low 1,3-Butadiene C4 Category. Available online at http://www.epa.gov/chemrtk/pubs/summaries/lowbutd/c13122tc.htm as of August 18, 2010.
[2] SRC. The Physical Properties Database (PHYSPROP). SRC, Inc., Syracuse, NY. Available online at http://www.syrres.com/esc/physprop.htm as of August 18, 2010.

2. General Information on Exposure

2.1 Production Volume and Use Pattern

The C low butadiene C4 category chemicals had an aggregated production and/or import volume in the United States greater than 7 billion 50 million pounds in calendar year 2005.

- CASRN 68606-31-5: 50 to < 100 million pounds;
- CASRN 106-97-8: 1 billion pounds and greater;
- CASRN 25167-67-3: 1 billion pounds and greater;
- CASRN 106-98-9: 500 million to < 1 billion pounds;
- CASRN 115-11-7: 1 billion pounds and greater;
- CASRN 68527-19-5: 1 billion pounds and greater;
- CASRN 68606-24-6: 500 million to < 1 billion pounds;
- CASRN 68477-42-9: 1 billion pounds and greater;
- CASRN 68477-83-8: 1 billion pounds and greater;

CASRN 68606-31-5, CASRN 68527-19-5, CASRN 68606-24-6 and CASRN 68477-83-8: No industrial processing and uses, and commercial and consumer uses were reported for these chemicals.

CASRN 106-97-8:
Non-confidential information in the IUR indicated that the industrial processing and uses of the chemical include fuel dealers, gasoline stations with convenience stores, natural gas distribution, oil and gas extraction, petrochemical manufacturing, petroleum bulk stations and terminals, and petroleum refinery as fuels; oil and gas extraction, petrochemical manufacturing and petroleum refinery as intermediates; oil and gas extraction, petroleum refinery, and pipeline transportation of refined petroleum products as not otherwise obtainable (NRO); oil and gas extraction, other basic organic chemical manufacturing, petroleum refinery, and pipeline transportation of refined petroleum products as "other"; petroleum refinery as processing aid, not otherwise listed. Non-confidential commercial and consumer uses of this chemical include lubricants, greases and fuel additives; rubber and plastic products; "other"; not otherwise obtainable (NRO); and transportation products.

CASRN 25167-67-3:
Non-confidential information in the IUR indicated that the industrial processing and uses of the chemical include petroleum refineries as intermediates. Non-confidential commercial and consumer uses of this chemical include lubricants, greases and fuel additives.

CASRN 106-98-9:
Non-confidential information in the IUR indicated that the industrial processing and uses of the chemical include petrochemical manufacturing, all other chemical product and preparation manufacturing, other petroleum and coal products manufacturing, plastic packaging materials and unlaminated film and sheet manufacturing, and resin and synthetic rubber manufacturing as intermediates; other basic organic chemical manufacturing as lubricants. Non-confidential commercial and consumer uses of this chemical include lubricants, greases and fuel additives.

CASRN 115-11-7:
Non-confidential information in the IUR indicated that the industrial processing and uses of the chemical include petrochemical manufacturing as intermediates. Non-confidential commercial and consumer uses of this chemical include lubricants, greases and fuel additives; rubber and plastic products; and "others."

CASRN 68477-42-9:
Industrial processing and uses were claimed confidential. No commercial and consumer uses were reported for this chemical.

2.2 Environmental Exposure and Fate

The components of the low 1,3-butadiene C4 category are expected to possess high mobility in soil. No biodegradation studies were available for the complex mixtures in this category. 1-Butene was not readily biodegradable, achieving less than 5% biodegradation within 28 days in a closed bottle test (OECD 301D); however, several individual components of these complex mixtures have been shown to degrade by mixed microbial or pure cultures isolated from various sources. Propane, 2-methyl- achieved 49% mineralization in 20 days following a 6-day lag period, using mixed microbial cultures isolated from municipal sewage sludge. Butane was

completely degraded after 34 days using the same set of cultures. Volatilization of these substances is expected to be high based on the Henry's Law constants of these substances. The rate of hydrolysis is expected to be negligible since the substances in this category do not possess functional groups that hydrolyze under environmental conditions. The overall weight of evidence suggests that the members of the low 1,3-butadiene C4 category are expected to possess low persistence (P1) and low bioaccumulation potential (B1). The environmental fate properties are provided in Tables 6 and 7.

Table 6. Environmental Fate Properties of the Low 1,3-Butadiene C4 category[1]

Property	SPONSORED CHEMICAL C4 Raffinate 1[2]	SPONSORED CHEMICAL C4 Raffinate 2[3]	SPONSORED CHEMICAL C4 Raffinate 3[4]	SPONSORED CHEMICAL Catalytic Butylenes[5]	SPONSORED CHEMICAL Butane Stream	SPONSORED CHEMICAL Butene-1 Stream	SPONSORED CHEMICAL Isobutylene Stream
CASRN	68477-42-9; 25167-67-3; 68477-83-8; 68527-19-5; 68606-31-5	68606-31-5; 25167-67-3	68606-24-6; 25167-67-3	25167-67-3	106-97-8	106-98-9	115-11-7
Photo-degradation Half-life	2.3–52.6 hours (estimated)[6]	2.3–52.6 hours (estimated)[6]	2.3–48.8 hours (estimated)[6]	2.4–4.7 hours (estimated)	48.8 hours (estimated)[6]	4.7 hours (estimated)[6]	2.4 hours (estimated)[6]
Hydrolysis Half-life	Stable						
Bio-degradation	No data	No data	No data	No data	100% after 34 days[7]	3% after 28 days (not readily bio-degradable)[8]	No data
Bio-accumulation Factor	BAF = 20–61 (estimated)[6]	BAF = 20–61 (estimated)[6]	BAF = 20–61 (estimated)[6]	BAF = 20–23 (estimated)[6]	BAF = 61 (estimated)[6]	BAF = 23 (estimated)[6]	BAF = 21 (estimated)[6]
Log K_{oc}	1.5–1.6 (estimated)[6]	1.5–1.6 (estimated)[6]	1.5–1.6 (estimated)[6]	1.5–1.6 (estimated)[6]	1.6 (estimated)[6]	1.6 (estimated)[6]	1.5 (estimated)[6]
Fugacity (Level III Model)[6]							
Air %	3.0–48.4	3.0–48.4	3.0–48.4	3.0–11.4	48.4	11.4	6.8
Water %	50.6–94.6	50.6–94.6	50.6–94.6	86.4–94.6	50.6	86.4	91.2
Soil %	0.7–2.1	0.7–2.1	0.8–2.1	1.6-2.1	0.8	2.0	1.6
Sediment %	0.2–0.3	0.2–0.3	0.2–0.3	0.3	0.2	0.3	0.3
Persistence[9]	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)	P1 (low)

Table 6. Environmental Fate Properties of the Low 1,3-Butadiene C4 category[1]							
Property	**SPONSORED CHEMICAL C4 Raffinate 1[2]**	**SPONSORED CHEMICAL C4 Raffinate 2[3]**	**SPONSORED CHEMICAL C4 Raffinate 3[4]**	**SPONSORED CHEMICAL Catalytic Butylenes[5]**	**SPONSORED CHEMICAL Butane Stream**	**SPONSORED CHEMICAL Butene-1 Stream**	**SPONSORED CHEMICAL Isobutylene Stream**
Bio-accumulation[9]	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)	B1 (low)

[1] Chemicals Manufacturing Association Olefins Panel, HPV Implementation Task Group. 2004. Revised Test Plan and Robust Summary for the low 1,3-Butadiene C4 Category. Available online at http://www.epa.gov/chemrtk/pubs/summaries/lowbutd/c13122tc.htm as of August 18, 2010.

[2] Range of values were derived from data for 1-butene (CASRN 106-98-9); 2-butene, (2Z)- (CASRN 590-18-1); 2-butene, (2E)- (CASRN 624-64-6); 1-propene, 2-methyl- (CASRN 115-11-7); butane (CASRN 106-97-8); and propane, 2-methyl- (CASRN 75-28-5).

[3] Range of values were derived from data for 1-butene (CASRN 106-98-9); 2-butene, (2Z)- (CASRN 590-18-1); 2-butene, (2E)- (CASRN 624-64-6); butane (CASRN 106-97-8); and propane, 2-methyl- (CASRN 75-28-5).

[4] Range of values were derived from data for 2-butene, (2Z)- (CASRN 590-18-1); 2-butene, (2E)- (CASRN 624-64-6); and butane (CASRN 106-97-8).

[5] Range of values were derived from data for 2-butene, (2Z)- (CASRN 590-18-1); 2-butene, (2E)- (CASRN 624-64-6); butane (CASRN 106-97-8); propane, 2-methyl- (CASRN 75-28-5); and 1-butene (CASRN 106-98-9).

[6] 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 August 18, 2010.

[7] Solano-Serena, F; Huet, N; Lebeault, J; et al. 2000. Biodegradability of volatile hydrocarbons of gasoline. Appl Microbiol Biotechnol 54:121–125.

[8] National Institute of Technology and Evaluation. 2002. Biodegradation and bioaccumulation of the existing chemical substances under the Chemical Substances Control Law. Available online at http://www.safe.nite.go.jp/english/kizon/KIZON_start_hazkizon.html as of October 1, 2010.

[9] Federal Register. 1999. Category for persistent, bioaccumulative, and toxic new chemical substances. *Federal Register* 64, Number 213 (November 4, 1999) pp. 60194–60204.

Table 7. Environmental Fate Properties of the Low 1,3-Butadiene C4 category[1]			
Property	**SUPPORTING CHEMICAL 2-Butene**	**SUPPORTING CHEMICAL 2-Butene, (2Z)-**	**SUPPORTING CHEMICAL 2-Butene, (2E)-**
CASRN	107-01-7	590-18-1	624-64-6
Photodegradation Half-life	2.3 hours (estimated)[2]	2.3 hours (estimated)[2]	2.3 hours (estimated)[2]
Hydrolysis Half-life	Stable		
Biodegradation	Degraded by pure cultures[3]	Degraded by pure cultures[3]	Degraded by pure cultures[3]
Bioaccumulation Factor	BAF = 20–21	BAF = 21 (estimated)[2]	BAF = 20 (estimated)[2]
Log K_{oc}	1.6 (estimated)[2]	1.6 (estimated)[2]	1.6 (estimated)[2]
Fugacity (Level III Model)[2]			
Air %	3.0	3.0	3.0
Water %	94.6	94.6	94.6
Soil %	2.1	2.1	2.1
Sediment %	0.3	0.3	0.3
Persistence[4]	P1 (low)	P1 (low)	P1 (low)
Bioaccumulation[4]	B1 (low)	B1 (low)	B1 (low)

[1] Chemicals Manufacturing Association Olefins Panel, HPV Implementation Task Group. 2004. Revised Test Plan and Robust Summary for the low 1,3-Butadiene C4 Category. Available online at http://www.epa.gov/chemrtk/pubs/summaries/lowbutd/c13122tc.htm as of August 18, 2010.
[2] SRC. The Physical Properties Database (PHYSPROP). SRC, Inc., Syracuse, NY. Available online at http://www.syrres.com/esc/physprop.htm as of August 18, 2010.
[3] Chemicals Manufacturing Association Olefins Panel, HPV Implementation Task Group. 2004. Revised Test Plan and Robust Summary for the Crude Butadiene C4 Category. Available online at http://www.epa.gov/chemrtk/pubs/summaries/olefins/c12064tc.htm as of August 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.

3. Human Health Hazard

A summary of toxicity data submitted for SIDS endpoints is provided in Table 8. The Table also indicates where data for tested category members are read-across (RA) to untested members of the category. The sponsor did not provide testing information for any of its streams. As a result, this section addresses SIDS toxicity data on supporting chemicals only.

Acute Inhalation Toxicity

Subcategory I: Streams of Heterogeneous Mixtures Containing 1,3-Butadiene Isobutylene (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.

Subcategory II: High purity streams containing 1,3-butadiene
Group 1: 1-Butene high purity stream
2-Butene (CASRN 107-01-7, supporting chemical)
See summary for this chemical under Subcategory I above.

Group 2: Isobutylene high purity stream
Isobutylene (CASRN 115-11-7, supporting chemical)
See summary for this chemical under Subcategory I above.

Subcategory III: Streams that do not contain 1,3-butadiene
2-Butene (CASRN 107-01-7, supporting chemical)
See summary for this chemical under Subcategory I above.

Isopentane (CASRN 78-78-4, supporting chemical)
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

Repeated-Dose Toxicity

Subcategory I: Streams of Heterogeneous Mixtures Containing 1,3-Butadiene
1-Butene (CASRN 106-98-9, supporting chemical)
In a combined inhalation repeated-dose/reproductive/developmental toxicity study, Sprague-Dawley rats (12/sex/concentration) were exposed whole-body to 0, 500, 2000 or 8000 ppm CASRN 106-98-9 (as a gas) via inhalation for 6 hrs/day, 7 days/week. The mean measured concentrations were 0, 524, 2062 or 8271 ppm. No deaths or treatment-related observations were noted, including changes in body weight or feed consumption changes, motor activity and functional observation battery changes, or clinical chemistry parameters. At exposure concentrations >2000 ppm, exposed rats exhibited increased incidence of mixed inflammatory cells in the caecal mucosa. Control animals also exhibited increased numbers of inflammatory cells in the caecal mucosa. The response was not considered treatment-related. Other microscopic findings showed similar incidences in controls and 1-butene-treated animals. No quantitative information on findings was provided.
NOAEC = 8000 ppm/day (the highest concentration tested)

Isobutylene (CASRN 115-11-7, supporting chemical)

(1) Sprague-Dawley rats (10/sex/concentration) were exposed to 0, 250, 1000 or 8000 ppm CASRN 115-11-7 (as a gas) via inhalation for 6 hrs/day, 5 days/week for 13 weeks. The 8000 ppm concentration level was the highest chamber concentration that could be tested below the explosive limit for isobutylene. There were no treatment-related effects on mortality or body weight. No biologically significant, other treatment-related effects were observed at any level. Elevated ketones were detected in the urine of the intermediate and high exposure animals of both sexes; the toxicological significance of this finding is unknown. Histopathological examination of organs did not reveal any treatment-related changes. No quantitative information was submitted.
NOAEC = 8000 ppm/day (highest concentration tested)

(2) Sprague-Dawley rats (5/sex/dose) were treated with nominally 0, 1.49, 14.86 or 148.55 mg/kg-bw/day CASRN 115-11-7 in corn oil via oral gavage for 28 days. There was no treatment-related mortality and no changes in body weight or food consumption. At the highest dose tested, there was a significant decrease in total white blood cell count (44% in females, $p<0.01$; 11% in males, $p<0.01$), predominantly in leucocytes and monocytes. No biologically significant treatment-related effects were observed at any level. In the intermediate and high dose animals of both sexes, elevated ketones were detected in the urine. The toxicological significance of this finding is unknown. Histopathological examination of organs did not reveal any treatment-related changes.
LOAEL = 148.6 mg/kg-bw/day (based on significant decrease in white blood cell count)
NOAEL = 14.9 mg/kg-bw/day

(3) In a 14-week National Toxicology Program (NTP) study, Fischer 344 rats (10/sex/test concentration) were exposed whole-body to isobutylene 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 ≥ 4000 ppm. Increases were observed in the relative liver weight of females at ≥ 500 ppm and in the absolute liver weight of females at ≥ 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 isobutylene 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.

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 (Petroleum Hydrocarbon Gases Category HPV submission: http://www.epa.gov/chemrtk/pubs/summaries/ptrlgas/c13224tc.htm)
NOAEC = 9157 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)

Isobutane (CASRN 75-28-5, supporting chemical)
(1) 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 isobutane gas at nominal concentrations of 0, 900, 3000 or 9000 ppm (actual: 0, 930, 3122, and 9148 ppm, respectively) for 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. No mortality was observed. No biologically significant effects were observed at any of the concentration levels (Petroleum Hydrocarbon Gases Category HPV submission: http://www.epa.gov/chemrtk/pubs/summaries/ptrlgas/c13224tc.htm).
NOAEC = 9148 ppm/day (highest concentration tested)

Subcategory II: High purity streams containing 1,3-butadiene
Group 1: 1-Butene high purity stream
1-Butene (CASRN 106-98-9, supporting chemical)
See summary for this chemical under Subcategory I above.

Group 2: Isobutylene high purity stream
Isobutylene (CASRN 115-11-7, supporting chemical)
See summary for this chemical under Subcategory I above.

Subcategory III: Streams that do not contain 1,3-butadiene
Group 1: C4 Raffinate 3 stream
Butane (CASRN 106-97-8, supporting chemical)
See data for this chemical in Subcategory I above.

2-Butene (CASRN 107-01-7, supporting chemical)
See summary for this chemical under Subcategory I above.

Group 2: Butane stream
Data for the supporting chemical CASRN 78-78-4 are read across from the Petroleum Hydrocarbon Gases Category hazard characterization document: http://iaspub.epa.gov/oppthpv/hpv_hc_characterization.get_report_by_cas?doctype=2 and are presented in Table 8.

Butane (CASRN 106-97-8, supporting chemical)
See summary for this chemical under Subcategory I above.

Isobutane (CASRN 75-28-5, supporting chemical)
See summary for this chemical under Subcategory I above.

Reproductive Toxicity

Subcategory I: Streams of Heterogeneous Mixtures Containing 1,3-Butadiene
1-Butene (CASRN 106-98-9, supporting chemical)
In the combined repeated-exposure/reproductive/developmental rat toxicity inhalation study 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. No quantitative information on findings was submitted.
NOAEC (reproductive toxicity) = 8000 ppm (highest concentration tested)

Isobutane (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 isobutane 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 (Petroleum Hydrocarbon Gases Category HPV submission: http://www.epa.gov/chemrtk/pubs/summaries/ptrlgas/c13224tc.htm).
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

Isobutylene (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 isobutylene at 7970 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.

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 (Petroleum Hydrocarbon Gases Category HPV submission: http://www.epa.gov/chemrtk/pubs/summaries/ptrlgas/c13224tc.htm).
NOAEC (reproductive toxicity) = 9157 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)

Subcategory II: High purity streams containing 1,3-butadiene
Group 1: 1-Butene high purity stream
1-Butene (CASRN 106-98-9, supporting chemical)
See summary for this chemical under Subcategory I above.

Group 2: Isobutylene high purity stream
Isobutylene (CASRN 115-11-7, supporting chemical)
See summary for this chemical under Subcategory I above.

Subcategory III: Streams that do not contain 1,3-butadiene
Group 1: C4 Raffinate stream 3
Butane (CASRN 106-97-8, supporting chemical)
See summary for this chemical under Subcategory I above.

2-Butene (CASRN 107-01-7, supporting chemical)
See summary for this chemical under Subcategory I above.

Group 2: Butane stream
Data for the supporting chemical CASRN 78-78-4 are read across from the Petroleum Hydrocarbon Gases Category hazard characterization document: http://iaspub.epa.gov/oppthpv/hpv_hc_characterization.get_report_by_cas?doctype=2 and are presented in Table 8.

Butane (CASRN 106-97-8, supporting chemical)
See summary for this chemical under Subcategory I above.

Isobutane (CASRN 75-28-5, supporting chemical)
See summary for this chemical under Subcategory I above.

Developmental Toxicity
Subcategory I: Streams of Heterogeneous Mixtures Containing 1,3-Butadiene
1-Butene (CASRN 106-98-9, supporting chemical)
In the inhalation combined repeated-dose/reproductive/developmental toxicity study in rats, described above, 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 (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)

Isobutane (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 (Petroleum Hydrocarbon Gases Category HPV submission: http://www.epa.gov/chemrtk/pubs/summaries/ptrlgas/c13224tc.htm).
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.
(Petroleum Hydrocarbon Gases Category HPV submission: http://www.epa.gov/chemrtk/pubs/summaries/ptrlgas/c13224tc.htm).
NOAEC (maternal/developmental toxicity) = 9157 ppm/day (highest concentration tested)

Subcategory II: High purity streams containing 1,3-butadiene
Group 1: 1-Butene high purity stream
1-Butene (CASRN 106-98-9, supporting chemical)
See data for this chemical under Subcategory I above.

Group 2: Isobutylene high purity stream
Isobutylene (CASRN 115-11-7, supporting chemical)
(1) Pregnant Wistar rats (24/test concentration) were exposed whole-body to isobutylene 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.
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.

Subcategory III: Streams that do not contain 1,3-butadiene
Group 1: C4 Raffinate stream 3
Butane (CASRN 106-97-8, supporting chemical)
See summary for this chemical under Subcategory I above.

2-Butene (CASRN 107-01-7, supporting chemical)
See summary for this chemical under Subcategory I above.

Group 2: Butane stream
Data for the supporting chemical CASRN 78-78-4 are read across from the Petroleum Hydrocarbon Gases Category hazard characterization document: http://iaspub.epa.gov/oppthpv/hpv_hc_characterization.get_report_by_cas?doctype=2 and are presented in Table 8.

Butane (CASRN 106-97-8, supporting chemical)
See summary for this chemical under Subcategory I above.

Isobutane (CASRN 75-28-5, supporting chemical)
See summary for this chemical under Subcategory I above.

Genetic Toxicity - Gene Mutation

In vitro

Subcategory I: Streams of Heterogeneous Mixtures Containing 1,3-Butadiene
1-Butene (CASRN 106-98-9, supporting chemical)
(1) CASRN 106-98-9 was tested in several *Salmonella typhimurium* strains (TA97, TA98 and TA100) in the presence and absence of metabolic activation by a novel method for evaluation of vapor-phase chemicals. The test concentrations were limited by the solubility of 1-butene in ethanol: 0, 1.3, 4.2, 13.0, 43.2 or 130 µg/plate.
CASRN 106-98-9 was not mutagenic in this study.

(2) CASRN 106-98-9 was tested in several *Salmonella typhimurium* strains (TA98, TA100, TA1535, and TA1537) and E. *coli* WP 2uvrA in the presence and absence of metabolic activation, using a novel technique for gas exposure. The use of controls was not specified but other test substances showed a positive response.
CASRN 106-98-9 was not mutagenic in this study.

2-Butene (CASRN 107-01-7, supporting chemical)
(1) CASRN 107-01-7 was tested in several *Salmonella typhimurium* strains (TA98, TA100, TA1535, and TA1537) and E. *coli* WP 2uvrA in the presence and absence of metabolic activation, using a novel technique for gas exposure. The use of controls was not specified but other test substances showed a positive response.
CASRN 107-01-7 was not mutagenic in this study.

(2) *Salmonella typhimurium* strains TA98, TA100, TA1535 and TA1537 were exposed to CASRN 107-01-7 (gas) at 0, 10, 20, 40, 60 or 80%, with and without metabolic activation. Both positive and negative controls were used in each study. Toxicity was evident at 80% concentration, but no increases in the number of revertant colonies of any strain were observed. Positive control responses were not reported.
CASRN 107-01-7 was not mutagenic in these assays.

Isobutylene (*CASRN 115-11-7, *supporting chemical)
(1) CASRN 115-11-7 (gas) was tested twice in an agar overlay assay (with and without metabolic activation) using *Salmonella typhimurium* strains TA98, TA100, TA1535, TA1537 and TA1538, and E. *coli* WP 2uvrA (pKM101). The first test used isobutylene concentrations of 5, 10, 20, 30, 40 and 50%, and the second test used 10, 20, 40, 60, 80 and 100%. Cytotoxicity was observed with and without metabolic activation at 80 and 100% isobutylene. Positive controls responded as expected. No mutagenic activity was observed for isobutylene.
CASRN 115-11-7 was not mutagenic in this study.

(2) L5178Y TK^+/TK^- mouse lymphoma cells were exposed to CASRN 115-11-7 (gas) at 100%, or 50, 25, 12.5 or 6.25% diluted with or without metabolic activation. Both positive and negative controls were used in each study. Toxicity was evident at concentrations > 6.25%. Positive controls responded as expected. No mutagenic activity was observed.
CASRN 115-11-7 was not mutagenic in this assay.

Butane (CASRN 106-97-8)
In an NTP study, *Salmonella typhimurium* strains TA97, TA98, TA100 and TA1535 were incubated with CASRN 106-97-8 (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. CASRN 106-97-8 did not induce an increase in mutation frequency (NTP study 295295: http://ntp-apps.niehs.nih.gov/ntp_tox/index.cfm?fuseaction=ntpsearch.searchhome).
CASRN 106-97-8 was not mutagenic in this assay.

1,3-Butadiene (CASRN 106-99-0, supporting chemical)
(1) *Salmonella typhimurium* strains TA97, TA98, TA100, and TA1535 were exposed to 0, 30, 40, 50, or 60% CASRN 106-99-0 (as a gas) with or without metabolic activation (rat, mouse or human liver S9).
CASRN 106-99-0 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: High purity streams containing 1,3-butadiene
Group 1: 1-Butene high purity stream
1-Butene (CASRN 106-98-9, supporting chemical)
See summary for this chemical under Subcategory I above.

1,3-Butadiene (CASRN 106-99-0, supporting chemical)
See summary for this chemical under Subcategory I above.

Group 2: Isobutylene high purity stream
Isobutylene (CASRN 115-11-7, supporting chemical)
See summary for this chemical under Subcategory I above.

1,3-Butadiene (CASRN 106-99-0, supporting chemical)
See summary for this chemical under Subcategory I above.

Subcategory III: Streams that do not contain 1,3-butadiene
Group 1: C4 Raffinate stream 3
Butane (CASRN 106-97-8, supporting chemical)
See summary for this chemical under Subcategory I above.

2-Butene (CASRN 107-01-7, supporting chemical)
See summary for this chemical under Subcategory I above.

Group 2: Butane stream
Data for the supporting chemicals CASRN 78-78-4 and CASRN 75-28-5 are read across from the Petroleum Hydrocarbon Gases Category hazard characterization document: http://iaspub.epa.gov/oppthpv/hpv_hc_characterization.get_report_by_cas?doctype=2 and are presented in Table 8.

Butane (CASRN 106-97-8, supporting chemical)
See summary for this chemical under Subcategory I above.

Genetic Toxicity – Chromosomal Aberrations

In vitro

Subcategory I: Streams of Heterogeneous Mixtures Containing 1,3-Butadiene

2-Butene (CASRN 107-01-7, supporting chemical)
Sprague-Dawley rat lymphocytes were exposed to 2-butene (42.4% cis, 55.3% trans) 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 (Petroleum Hydrocarbon Gases Category HPV submission: http://www.epa.gov/chemrtk/pubs/summaries/ptrlgas/c13224tc.htm).
CASRN 107-01-7 did not induce chromosomal aberrations in this assay.

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 III: Streams that do not contain 1,3-butadiene
Group 1: C4 Raffinate stream 3
Data for the supporting chemical CASRN 106-97-8 are read across from the Petroleum Hydrocarbon Gases Category hazard characterization document: http://iaspub.epa.gov/oppthpv/hpv_hc_characterization.get_report_by_cas?doctype=2 and are presented in Table 8.

2-Butene (CASRN 107-01-7, supporting chemical)
See data for this chemical under Subcategory I above.

Group 2: Butane stream
Data for the supporting chemicals CASRNs 78-78-4, 75-28-5 and 106-97-8 are read across from the Petroleum Hydrocarbon Gases Category hazard characterization document: http://iaspub.epa.gov/oppthpv/hpv_hc_characterization.get_report_by_cas?doctype=2 and are presented in Table 8.

In vivo

Subcategory I: Streams of Heterogeneous Mixtures Containing 1,3-Butadiene
1-Butene (CASRN 106-98-9, supporting chemical)
CASRN 106-98-9 (gas) was administered by inhalation to male and female Crl:CDR(IRC)Br Swiss mice (10/sex/concentration) at 0, 1000, 9000 or 22,000 ppm for 2 hours/day for 2 days. Slides of bone marrow smears were prepared and examined microscopically. CASRN 106-98-9 did not induce significant changes in micronucleus formation in polychromatic erythrocytes or mature erythrocytes, and did not cause significant changes in the ratio of PCE/NCE (Petroleum Hydrocarbon Gases Category HPV submission: http://www.epa.gov/chemrtk/pubs/summaries/ptrlgas/c13224tc.htm).

CASRN 106-98-9 did not induce micronuclei in this assay.

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 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.
CASRN 106-99-0 did not induce chromosomal aberrations 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.
CASRN 106-99-0 induced chromosomal aberrations in this assay.

Subcategory II: High purity streams containing 1,3-butadiene
Group 1: 1-Butene high purity stream
1-Butene (CASRN 106-98-9, supporting chemical)
See data for this chemical under Subcategory I above.

1,3-Butadiene (CASRN 106-99-0, supporting chemical)
See data for this chemical under Subcategory I above.

Group 2: Isobutylene high purity stream
Isobutylene (CASRN 115-11-7, supporting chemical)
In a micronucleus assay, B6C3F1 mice (10 males/group) were exposed to 0, 1000, 3260 or 10,000 ppm CASRN 115-11-7 (gas) by whole body inhalation for 6 hours/day for two days. Animals were sacrificed at 24 hours, bone marrow was aspirated and slides were prepared, stained and evaluated for the presence of micronuclei. A significant regression coefficient ($p<0.05$) for increased percentage of polychromatic erythrocytes treated with CASRN 115-11-7 was observed; however, the parameters were within historical controls and not considered biologically relevant. Negative control values were within normal range, and the positive controls performed adequately.
CASRN 115-11-7 did not increase micronuclei in this assay.

1,3-Butadiene (CASRN 106-99-0, supporting chemical)
See data for this chemical under Subcategory I above.

Subcategory III: Streams that do not contain 1,3-butadiene
Group 1: C4 Raffinate stream 3
1-Butene (CASRN 106-98-9, supporting chemical)
See data for this chemical under Subcategory I above.

Additional Information

Respiratory Tract Irritation
Subcategory III: Streams that do not contain 1,3-butadiene
Isopentane (CASRN 78-78-4)
See human health data at: http://webnet.oecd.org/hpv/ui/Search.aspx
Isopentane was not a respiratory tract irritant in mice in this study.

Skin Sensitization

Subcategory III: Streams that do not contain 1,3-butadiene
Isopentane (CASRN 78-78-4)
See human health data at: http://webnet.oecd.org/hpv/ui/Search.aspx
Isopentane was not sensitizing to guinea pig skin in this study.

Carcinogenicity

Subcategory I: Streams of Heterogeneous Mixtures Containing 1,3-Butadiene
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 ≥ 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).

Isobutylene (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 CASRN 115-11-7 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 CASRN 115-11-7 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
Isobutylene increased the incidence of tumors in male rats in this study.

Subcategory II: High purity streams containing 1,3-butadiene
Group: 1-Butene high purity stream
1,3-Butadiene (CASRN 106-99-0, supporting chemical)
See data for this chemical under Subcategory I above.

Group 2: Isobutylene high purity stream
Isobutylene (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 isobutylene 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 CASRN 115-11-7 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
CASRN 115-11-7 increased the incidence of tumors in male rats in this study.

1,3-Butadiene (CASRN 106-99-0, supporting chemical)
See data for this chemical under Subcategory I above.

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 as a 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.

Conclusion:

Subcategory I: Streams of Heterogeneous Mixtures Containing 1,3-Butadiene
No data are available for the sponsored streams for the human health endpoints.

The acute inhalation toxicity of the supporting chemical, CASRN 107-01-7, in rats is low. In combined inhalation repeated-dose/reproductive/developmental toxicity screening tests in rats, the supporting chemicals, CASRNs 75-28-5 and 106-98-9, showed no adverse treatment-related effects; the NOAECs for systemic toxicity are 9148 ppm/day and 8000 ppm/day, respectively (highest concentrations tested). In a combined inhalation repeated-dose/reproductive/developmental toxicity screening test in rats, the supporting chemicals CASRNs 106-97-8, 107-01-7 and 115-11-7 showed no toxicologically significant treatment-related effects; the NOAECs for systemic toxicity are 9157 ppm/day, 5009 ppm/day and 8000 ppm/day, respectively (highest concentration tested). The supporting chemical, CASRN 115-11-7, 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, CASRNs 106-97-8, CASRNs 107-01-7 and CASRN 106-98-9 showed no treatment-related effects on reproduction; the NOAECs for reproductive/maternal/developmental toxicity in rats are 9157 ppm/day, 5009 ppm/day and 8000 ppm/day, respectively (highest concentrations

tested). Repeated inhalation exposure with CASRN 75-28-5 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). In the 14-week inhalation repeated-dose toxicity study described above, the supporting chemical, CASRN 115-11-7, showed a decrease in sperm motility at 7970 ppm/day; however, no adverse developmental effects were observed in the prenatal developmental toxicity study in rats; NOAEC for maternal/developmental toxicity is 18.4 mg/L/day (highest concentration tested). In an inhalation prenatal developmental toxicity study in rats, the supporting chemical CASRN 115-07-1 showed no treatment-related effects; the NOAEC for maternal/developmental toxicity is 10,000 ppm/day (highest concentration tested). CASRN 115-07-1 induced gene mutations in bacteria, but was equivocal for mutagenicity in mouse lymphoma cells *in vitro*. CASRNs 106-97-8, 115-11-7, 106-98-9 and 107-01-7 did not induce gene mutations in bacteria or mouse lymphoma cells *in vitro*. CASRN 107-01-7 did not induce chromosomal aberrations in rat lymphocytes or Chinese hamster ovary (CHO) cells *in vitro* and CASRNs 115-11-7 and 106-98-9 did not induce micronuclei in rats and/or mice *in vivo*. The supporting chemical, CASRN 106-99-0 was mutagenic in bacteria *in vitro* and induced chromosomal aberrations *in vivo*. CASRN 106-99-0 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 CASRN 106-99-0 carcinogenic to humans. The supporting chemical, CASRN 115-07-1 was not carcinogenic in rats or mice when administered via the inhalation route of exposure. The supporting chemical, CASRN 115-11-7 increased the incidence of tumors in male rats but not female rats, or mice of both sexes.

Subcategory II: High purity streams containing 1,3-butadiene

No data are available for the sponsored streams for the human health endpoints.

Group 1: 1-Butene high purity stream

The acute inhalation toxicity of the supporting chemical, CASRN 107-01-7, in rats is low. In a combined inhalation repeated-dose/reproductive/developmental toxicity screening test in rats, the supporting chemical, CASRN 106-98-9, showed no adverse treatment-related effects; the NOAEC for systemic toxicity is 8000 ppm/day (highest concentration tested). CASRN 106-98-9 showed no treatment-related effects on reproduction; the NOAEC for reproductive/maternal/developmental toxicity in rats is 8000 ppm/day (highest concentration tested). The supporting chemical, CASRN 106-99-0 was mutagenic in bacteria *in vitro* and induced chromosomal aberrations *in vivo*. CASRN 106-99-0 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 CASRN 106-99-0 carcinogenic to humans.

Group 2: Isobutylene high purity stream

The acute inhalation toxicity of the supporting chemical, CASRN 115-11-7, in mice and rats is low. Repeated inhalation exposures of CASRN 115-11-7 (supporting chemical) in rats and mice showed no toxicologically significant treatment-related effects; the NOAEC for systemic toxicity is 7970 ppm/day and 7980 ppm/day(highest concentration tested) in rats and mice, respectively. No specific reproductive toxicity studies are available for the supporting chemical, CASRN 115-11-7. However, no effects were seen on the reproductive organs in mice after 14-week inhalation exposure; rats showed a decrease in sperm motility at 7970 ppm. The supporting

chemical, CASRN 106-99-0 was mutagenic in bacteria *in vitro* and induced chromosomal aberrations *in vivo*. CASRN 106-99-0 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 CASRN 106-99-0 carcinogenic to humans. The supporting chemical, CASRN 115-11-7 increased the incidence of tumors in male rats but not female rats, or mice of both sexes.

Subcategory III: Streams that do not contain 1,3-butadiene

No data are available for the sponsored streams for the human health endpoints.

Group 1: C4 Raffinate 3 Stream

The acute inhalation toxicity of the supporting chemical, CASRN 107-01-7 in rats is low. In combined inhalation repeated-dose/reproductive/developmental toxicity screening tests in rats, the supporting chemicals CASRNs 106-97-8 and 107-01-7 showed no toxicologically significant treatment-related effects; the NOAECs for systemic toxicity are 9157 ppm/day and 5009 ppm/day and 8000 ppm/day, respectively (highest concentrations tested). In the combined repeated-dose/reproductive/developmental toxicity screening tests previously mentioned, CASRNs 106-97-8 and 107-01-7 showed no treatment-related effects on reproduction; the NOAECs for reproductive/maternal/developmental toxicity in rats are 9157 ppm/day and 5009 ppm/day, respectively (highest concentrations tested). CASRNs 106-97-8 and 107-01-7 did not induce gene mutations in bacteria or mouse lymphoma cells *in vitro*. CASRN 107-01-7 did not induce chromosomal aberrations in rat lymphocytes or Chinese hamster ovary (CHO) cells *in vitro*.

Group 2: Butane stream

The acute inhalation toxicity of the supporting chemical, CASRN 107-01-7, in rats is low. In a combined inhalation repeated-dose/reproductive/developmental toxicity screening test in rats, the supporting chemicals, CASRN 75-28-5 and 106-97-8, showed no adverse treatment-related effects; the NOAECs for systemic toxicity are 9148 ppm/day and 9157 ppm/day (highest concentrations tested). In the combined repeated-dose/reproductive/developmental screening tests previously mentioned, CASRN 106-97-8 showed no treatment-related effects on reproduction; the NOAEC for reproductive/maternal/developmental toxicity in rats is 9157 ppm/day (highest concentrations tested). Repeated inhalation exposure with CASRN 75-28-5 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). CASRN 106-97-8 did not induce gene mutations in bacteria or mouse lymphoma cells *in vitro*.

Table 8. Summary of the Screening Information Data Set Under the U.S. HPV Challenge Program –Human Health Data							
	Subcategory I: Streams of heterogeneous mixtures containing 1,3-butadiene			***Subcategory II: High purity streams containing 1,3-butadiene***		***Subcategory III: Streams not containing 1,3-butadiene***	
Endpoints	**SPONSORED CHEMICAL C4 Raffinate 1 Stream (No CASRN)**	**SPONSORED CHEMICAL C4 Raffinate 2 Stream (No CASRN)**	**SPONSORED CHEMICAL Catalytic Butylene Stream (25167-67-3)**	**SPONSORED CHEMICAL 1-Butene high purity stream (*Group 1*) (106-98-9)**	**SPONSORED CHEMICAL Isobutylene high purity stream (*Group 2*) (115-11-7)**	**SPONSORED CHEMICAL C4 Raffinate 3 Stream (*Group 1*) (No CASRN)**	**SPONSORED CHEMICAL High Purity Butane Stream (*Group 2*) (106-97-8)**
Acute Inhalation Toxicity LC_{50} (ppm)	No Data >23.1 mg/L (RA)	No Data >23.1 mg/L (RA)	No Data >23.1 mg/L (RA)	No Data >23.1 mg/L (RA)	No Data (mouse) 180,000 (rat) 270,000 (RA)	No Data >23.1 mg/L (RA)	No Data >23.1 mg/L (RA)
Repeated-Dose Toxicity NOAEC/LOAEC Inhalation (ppm/day)	No Data NOAEC = 5009 (RA)	No Data NOAEC = 5009 (RA)	No Data NOAEC = 5009 (RA)	No Data NOAEC = 8000 (RA)	No Data (rat) NOAEC = 7970 (mouse) NOAEC = 7980 (RA)	No Data NOAEC = 5009 (RA)	No Data NOAEC = 9157 (RA)
Repeated-Dose Toxicity NOAEL/LOAEL Oral (mg/kg-bw/day)	–	–	–	–	No Data NOAEL =14.9 LOAEL =148.6 (RA)	–	–
Reproductive Toxicity NOAEC/LOAEC Inhalation (ppm/day) Reproductive Toxicity	No Data NOAEC = 5009 (RA)	No Data NOAEC = 5009 (RA)	No Data NOAEC = 5009 (RA)	No Data NOAEC = 8000 (RA)	No Data A decrease in sperm motility was observed at 7970 ppm in the 14-week inhalation repeated-dose toxicity study in rats (RA)	No Data NOAEC = 5009 (RA)	No Data NOAEC = 9157 (RA)

Table 8. Summary of the Screening Information Data Set Under the U.S. HPV Challenge Program –Human Health Data							
Subcategory I: Streams of heterogeneous mixtures containing 1,3-butadiene				***Subcategory II: High purity streams containing 1,3-butadiene***		***Subcategory III: Streams not containing 1,3-butadiene***	
Endpoints	**SPONSORED CHEMICAL C4 Raffinate 1 Stream (No CASRN)**	**SPONSORED CHEMICAL C4 Raffinate 2 Stream (No CASRN)**	**SPONSORED CHEMICAL Catalytic Butylene Stream (25167-67-3)**	**SPONSORED CHEMICAL 1-Butene high purity stream (*Group 1*) (106-98-9)**	**SPONSORED CHEMICAL Isobutylene high purity stream (*Group 2*) (115-11-7)**	**SPONSORED CHEMICAL C4 Raffinate 3 Stream (*Group 1*) (No CASRN)**	**SPONSORED CHEMICAL High Purity Butane Stream (*Group 2*) (106-97-8)**
Developmental Toxicity NOAEC/LOAEC Inhalation (ppm/day)							
Maternal Toxicity	No Data NOAEC = 5009	No Data NOAEC = 5009	No Data NOAEC = 5009	No Data NOAEC = 8000	No Data NOAEC = 18.4 mg/L/day	No Data NOAEC = 5009	No Data NOAEC = 9157
Developmental Toxicity	NOAEC = 5009 (RA)	NOAEC = 5009 (RA)	NOAEC = 5009 (RA)	NOAEC = 8000 (RA)	NOAEC = 18.4 mg/L/day (RA)	NOAEC = 5009 (RA)	NOAEC = 9157 (RA)
Genetic Toxicity – Gene Mutation *In vitro*	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Positive (RA)	No Data Negative (RA)	No Data Negative (RA)
Genetic Toxicity – Gene Mutation *In Vivo*	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 Negative (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 Negative (RA)

(RA) = Read-Across; – indicates that endpoint was not addressed for this chemical

Table 8. Summary of the Screening Information Data Set Under the U.S. HPV Challenge Program – Human Health Data

Endpoints	SUPPORTING CHEMICAL Butane (106-97-8)	SUPPORTING CHEMICAL Isobutane (75-28-5)	SUPPORTING CHEMICAL 1-Butene (106-98-9)	SUPPORTING CHEMICAL 2-Butene (107-01-7)	SUPPORTING CHEMICAL Isobutylene (115-11-7)	SUPPORTING CHEMICAL Isopentane (78-78-4)	SUPPORTING CHEMICAL 1,3-Butadiene (106-99-0)
Acute Inhalation Toxicity LC_{50} (ppm)	No Data 23.1 mg/L (RA)*	No Data 23.1 mg/L (RA)*	–	**(rat) >23.1 mg/L**	**(rat) 270,000 (mouse) 180,000**	**(rat) >12.1 mg/L**	–
Repeated-Dose Toxicity NOAEC/LOAEC Inhalation (ppm)	**(rat) NOAEC = 9157 (highest concentration tested)**	**(rat) NOAEC = 9148 (highest concentration tested)**	**(rat) NOAEC = 8000 (highest concentration tested)**	**(rat) NOAEC = 5009 (highest concentration tested)**	**(rat) NOAEC = 7970 (highest concentration tested) (mouse) NOAEC = 7980 (highest concentration tested)**	No Data NOAEC = 20 mg/L (RA)*	–
Repeated-Dose Toxicity NOAEL/LOAEL Oral (mg/kg-bw/day)	–	–	–	–	**NOAEL = 14.86 LOAEL = 148.55**	–	–
Reproductive Toxicity NOAEC/LOAEC Inhalation (ppm) **Reproductive Toxicity**	**NOAEC = 9157 (highest concentration tested)**	**NOAEC = 3122 LOAEC = 9148**	**NOAEC = 8000 (highest concentration tested)**	**NOAEC = 5009 (highest concentration tested)**	A decrease in sperm motility was observed at 7970 ppm in the 14-week inhalation repeated-dose toxicity study in rats	No Data No effect on reproductive organs in rats in 90-day repeated-dose study (RA)*	–

Table 8. Summary of the Screening Information Data Set Under the U.S. HPV Challenge Program – Human Health Data

Endpoints	SUPPORTING CHEMICAL Butane (106-97-8)	SUPPORTING CHEMICAL Isobutane (75-28-5)	SUPPORTING CHEMICAL 1-Butene (106-98-9)	SUPPORTING CHEMICAL 2-Butene (107-01-7)	SUPPORTING CHEMICAL Isobutylene (115-11-7)	SUPPORTING CHEMICAL Isopentane (78-78-4)	SUPPORTING CHEMICAL 1,3-Butadiene (106-99-0)
Developmental Toxicity NOAEL/LOAEL Oral (mg/kg/day) **Maternal Toxicity** **Developmental Toxicity**	– –	– –	– –	– –	– –	No Data NOAEL = 1000 NOAEL = 1000 (RA)*	– –
Developmental Toxicity NOAEC/LOAEC Inhalation (ppm) **Maternal Toxicity** **Developmental Toxicity**	**NOAEC = 9157 (highest concentration tested)** **NOAEC = 9157 (highest concentration tested)**	**NOAEC = 9148 (highest concentration tested)** **NOAEC = 9148 (highest concentration tested)**	**NOAEC = 8000 (highest concentration tested)** **NOAEC = 8000 (highest concentration tested)**	**NOAEC = 5009 (highest concentration tested)** **NOAEC = 5009 (highest concentration tested)**	**NOAEC = 18.4 mg/L/day (highest concentration tested)** **NOAEC = 18.4 mg/L/day (highest concentration tested)**	– –	– –
Genetic Toxicity – Gene Mutation *In vitro*	**Negative**	No Data Negative (RA)*	**Negative**	**Negative**	**Negative**	**Negative**	**Positive**
Genetic Toxicity – Gene Mutation *In Vivo*	–	–	–	–	–	–	**Positive**
Genetic Toxicity – Chromosomal Aberrations *In vitro*	–	No Data Negative (RA)*	–	**Negative**	–	–	**Positive**
Genetic Toxicity – Chromosomal Aberrations *In vivo*	No Data Negative (RA)*	–	**Negative**	–	**Negative**	No Data Negative (RA)*	**Positive**

Table 8. Summary of the Screening Information Data Set Under the U.S. HPV Challenge Program – Human Health Data

Endpoints	SUPPORTING CHEMICAL Butane (106-97-8)	SUPPORTING CHEMICAL Isobutane (75-28-5)	SUPPORTING CHEMICAL 1-Butene (106-98-9)	SUPPORTING CHEMICAL 2-Butene (107-01-7)	SUPPORTING CHEMICAL Isobutylene (115-11-7)	SUPPORTING CHEMICAL Isopentane (78-78-4)	SUPPORTING CHEMICAL 1,3-Butadiene (106-99-0)
Additional Information							
Respiratory Tract Irritation	–	–	–	–	–	**Not irritating**	–
Skin Sensitization	–	–	–	–	–	**Negative**	–
Carcinogenicity	–	–	–	–	**Positive (male rats) Negative (female rats and mice of both sexes)**	–	**Positive**

bold = measured data (i.e., derived from testing); (RA) = Read-Across; − indicates that endpoint was not addressed for this chemical; *as read-across in the Petroleum Hydrocarbon Gases Category Hazard Characterization - http://iaspub.epa.gov/oppthpv/hpv_hc_characterization.get_report_by_cas?doctype=2

4. Hazard to the Environment

A summary of aquatic toxicity data submitted for SIDS endpoints is provided in Table 9. The table also indicates where data for tested supporting chemicals are used to read-across (RA) for the untested members of the category.

Acute Toxicity to Fish

Pentane (CASRN 109-66-0, supporting chemical)
Rainbow trout (*Oncorhynchus mykiss)* were exposed to CASRN 109-66-0 for 96 hours. No other details were given: http://ecb.jrc.it/DOCUMENTS/Existing-Chemicals/RISK_ASSESSMENT/REPORT/n-pentanereport043.pdf.
96-h LC_{50} = 4.26 mg/L

2-Butene, 2-methyl- (CASRN 513-35-9, supporting chemical)
Rainbow trout (*Oncorhynchus mykiss*) were exposed to CASRN 513-35-9 at nominal concentrations of 0, 2.13, 4.7, 10.3, 22.7 or 50 mg/L under static renewal conditions for 96 hours. Mean measured concentrations were 0, 1.67, 2.93, 5.33, 8.51 and 25.9 mg/L. Mortality was observed at concentrations ≥ 5.33 mg/L. One hundred percent mortality was observed at ≥ 8.51 mg/L (http://www.chem.unep.ch/irptc/sids/OECDSIDS/513359.pdf).
96-h LC_{50} = 4.99 mg/L

Ethylene (CASRN 74-85-1, supporting chemical)
No acute toxicity data to fish is available for CASRN 74-85-1. ECOSAR (v. 1.00a) was used to estimate toxicity.
96-h LC_{50} = 95.7 mg/L (estimated)

Acute Toxicity to Aquatic Invertebrates

Pentane (CASRN 109-66-0, supporting chemical)
Daphnia magna were exposed to CASRN 109-66-0 for 48 hours. No other details were given: http://ecb.jrc.it/DOCUMENTS/Existing-Chemicals/RISK_ASSESSMENT/REPORT/n-pentanereport043.pdf.
48-h EC_{50} = 2.7 mg/L

2-Butene, 2-methyl- (CASRN 513-35-9, supporting chemical)
Daphnia magna were exposed to CASRN 513-35-9 at nominal concentrations of 2.13, 4.7, 10.3, 22.7 or 50 mg/L under static conditions for 48 hours. Mean measured concentrations were 0.691, 1.74, 2.95, 6.63 and 23.6 mg/L.
(http://www.chem.unep.ch/irptc/sids/OECDSIDS/513359.pdf).
48-h EC_{50} = 3.84 mg/L

Ethylene (CASRN 74-85-1, supporting chemical)
No acute toxicity data for aquatic invertebrates is available for CASRN 74-85-1. ECOSAR (v. 1.00a) was used to estimate toxicity.
48-h EC_{50} = 48.4 mg/L (estimated)

Toxicity to Aquatic Plants

Pentane (CASRN 109-66-0, supporting chemical)
Green algae (*Pseudokirchneriella subcapitata*) were exposed to CASRN 109-66-0 for 72 hours. No other information was provided: http://ecb.jrc.it/DOCUMENTS/Existing-Chemicals/RISK_ASSESSMENT/REPORT/n-pentanereport043.pdf.
72-h EC_{50} = 7.5 mg/L (biomass)
72-h EC_{50} = 10.7 mg/L (growth rate)

2-Butene, 2-methyl- (CASRN 513-35-9, supporting chemical)
Green algae (*Pseudokirchneriella subcapitata*) were exposed to CASRN 513-35-9 at nominal concentrations of 0, 3.20, 7.04, 15.5, 34.1 and 75.0 mg/L for 96 hours. Mean measured concentrations were 0, 0.689, 1.53, 3.61, 7.22 and 21.1 mg/L. (http://www.chem.unep.ch/irptc/sids/OECDSIDS/513359.pdf).
72-h EC_{50} = 10.5 mg/L (biomass)
72-h EC_{50} = 12.0 mg/L (growth rate)

Ethylene (CASRN 74-85-1, supporting chemical)
Green algae (*Pseudokirchneriella subcapitata*) were exposed to CASRN 74-85-1 at nominal concentrations of 8.2 – 131 mg/L for 72 hours. Mean measured concentrations were 3.3, 7.8, 13.9, 32 and 58 mg/L. Growth inhibition was observed at concentrations ≥ 32 mg/L. During the 72-h exposure period there was a loss of ethylene in the range of 64-91 %, however in calculation of results the mean measured ethylene concentration was used (http://www.chem.unep.ch/irptc/sids/OECDSIDS/74851.pdf.).
72-h EC_{50} (biomass) = 40 mg/L
72-h EC_{50} (growth) = 72 mg/L

Conclusion: Based on the supporting chemical, CASRN 109-66-0, the 96-h LC_{50} for fish is 4.26 mg/L and the 48-h EC_{50} for aquatic invertebrates is 2.7 mg/L. The 72-h EC_{50} for aquatic plants ranges from 7.5 to 40 mg/L (supporting chemicals, CASRNs 109-66-0 and 74-85-1, respectively) for biomass and 10.7 to 72 mg/L (supporting chemicals, CASRNs 109-66-0 and 74-85-1, respectively) for growth rate.

Table 9. Summary of the Screening Information Data Set as Submitted under the U.S. HPV Challenge Program – Aquatic Toxicity Data

Endpoints	SUPPORTING CHEMICAL **Ethylene** **(74-85-1)**	SPONSORED CHEMICAL **C4 Raffinate 1** **(No CASRN)**	SPONSORED CHEMICAL **C4 Raffinate 2** **(No CASRN)**	SPONSORED CHEMICAL **C4 Raffinate 3** **(No CASRN)**	SPONSORED CHEMICAL **Catalytic Butylenes** **(25167-67-3)**	SPONSORED CHEMICAL **Butane** **(106-97-8)**	SPONSORED CHEMICAL **Butene-1** **(106-98-9)**	SPONSORED CHEMICAL **Isobutylene** **(115-11-7)**	SUPPORTING CHEMICAL **2-Butene, 2-methyl-** **(513-35-9)**	SUPPORTING CHEMICAL **n-Pentane** **(109-66-0)**
Fish 96-h LC_{50} (mg/L)	–	No Data 4.26 (RA)	No Data 4.26 (RA)	No Data 4.26 (RA)	No Data 4.26 (RA)	No Data 4.26 (RA)	No Data 4.26 (RA)	No Data 4.26 (RA)	**4.99**	**4.26**
Aquatic Invertebrates 48-h EC_{50} (mg/L)	–	No Data 2.7 (RA)	No Data 2.7 (RA)	No Data 2.7 (RA)	No Data 2.7 (RA)	No Data 2.7 (RA)	No Data 2.7 (RA)	No Data 2.7 (RA)	**3.84**	**2.7**
Aquatic Plants 72-h EC_{50} (mg/L) **(biomass)** **(growth rate)**	 **40** **72**	 No Data 7.5 – 40 10.7 – 72 (RA)	 No Data 7.5 – 40 10.7 – 72 (RA)	 No Data 7.5 – 40 10.7 – 72 (RA)	 No Data 7.5 – 40 10.7 – 72 (RA)	 No Data 7.5 – 40 10.7 – 72 (RA)	 No Data 7.5 – 40 10.7 – 72 (RA)	 No Data 7.5 – 40 10.7 – 72 (RA)	 **10.5** **12**	 **7.5** **10.7**

bold = measured data (i.e., derived from testing); (e) = estimated data (i.e., derived from modeling); (RA) = Read-Across; − indicates that endpoint was not addressed for this chemical

APPENDIX

The following pages show:

- Table 10 with a list of the major constituents in the category streams
- Table 11 with a list of representative structures
- Table 12 with TSCA Definitions for Certain Hydrocarbon Streams
- Table 13 with Reference Sources for Supporting Chemical Data
- Explanation and figure(s) showing how the low 1,3-butadiene C4 category streams are made and used (taken from

"Category Summary for Low 1,3-butadiene C4 Category" document:
http://www.epa.gov/oppt/chemrtk/pubs/summaries/lowbutd/c13122rt.pdf)

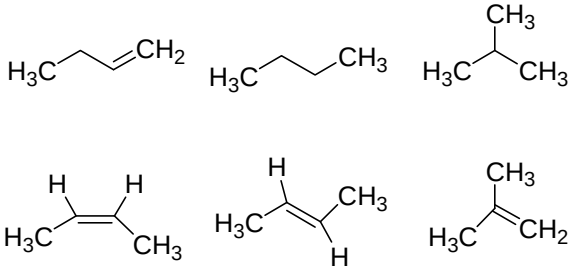
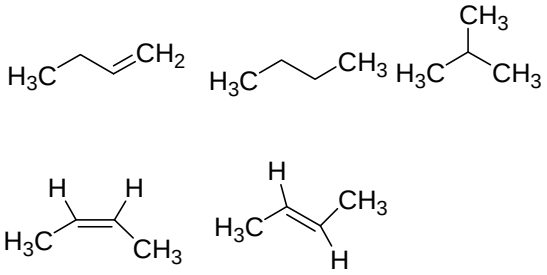
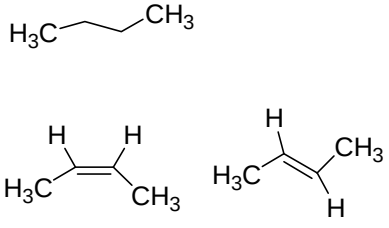
Table 10. Typical Constituent (wt%) Ranges in Streams of the Low 1,3-Butadiene C4 Category as described in the test plan: http://www.epa.gov/oppt/chemrtk/pubs/summaries/lowbutd/c13122rt.pdf

Constituent	C4 Raffinate 1 (wt%)	C4 Raffinate 2 (wt%)	C4 Raffinate 3 (wt%)	Catalytic Butylenes (wt%)	Butane (wt%)	Butene-1 (wt%)	Iso-butylene (wt%)
Acetonitrile	0-50*						
Carbonyl	0-50*						
Propylene		0 - 1					
Propane	1 - 5			1.2 - 1.3			
Propadiene	0 - 1	0 - 1					
Isobutane	0 - 65	1 - 7.5			3.5		
Isobutylene (Isobutene)	30 - 55	1 - 5		5			99.4
C5 Olefins							1.1
Butene-1	7 - 50	2.5 - 65	0.2			99.2	
1,3-Butadiene	0 - 5	0.1 - 0.5		0.5		0.005	0.1
Other C4s						1.4	
Butanes				40 - 46			
Butane	1 - 26	10 - 39	55.2		88.2		
Butenes				48 - 58			
Butene-2 (isomer mix)	1 - 50	11 - 55	45.2				
Isopentane (2-methyl-butane)					5.3		

* ppm

Note 1: The balance of these streams is expected to include other hydrocarbons that have boiling points in the ranges of the listed constituents.

Note 2: The ranges should not be considered to represent absolute limits for these streams. They represent the high and low reported values, and are industry typical limit values.

Table 11. Representative Structures of the Low 1,3-Butadiene C4 Category Sponsored Chemicals		
Chemical Name	**CASRN**	**Description or Chemical Structure**
C4 Raffinate 1	68477-42-9; 25167-67-3; 68477-83-8; 68527-19-5; 68606-31-5	 This stream is a co-product of the butadiene extraction process unit. Raff 1 is the balance of the C4 butadiene concentrate after separation of butadiene by a solvent process (either extraction or, more typically, extractive distillation). Raff 1 consists predominantly of C4 mono-olefins and C4 paraffins. This stream is sometimes referred to as mixed butylenes because the composition is often about 75% C4 mono-olefins. The saturated hydrocarbons in Raff 1 are mostly iso- and normal-butane. The mono-olefin content varies depending on the feedstock of the ethylene process unit that produced the C4 butadiene concentrate. For example, an ethylene unit that uses butane as cracking feedstock would yield a Raff 1 stream with much lower butane content than an ethylene plant cracking ethane or propane feedstocks.
C4 Raffinate 2	68606-31-5; 25167-67-3	 This stream is produced from the C4 Raffinate 1 stream by additional processing to remove isobutylene. This is accomplished in a two-step process by reaction with water to make tertiary-butyl alcohol or with methanol to produce methyl-tertiary-butyl-ether, which can then be re-cracked to high purity isobutylene. Raff 2 consists predominantly of butene-1, butene-2, and butanes.
C4 Raffinate 3	68606-24-6; 25167-67-3	 This stream is produced from the C4 Raffinate 2 stream by additional processing to remove butene-1. It contains mixed butenes, including

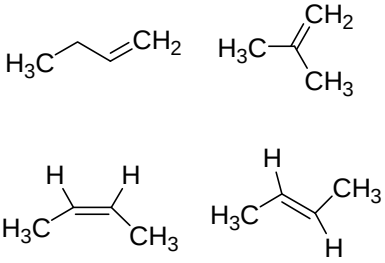
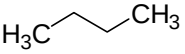
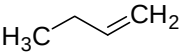
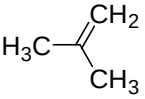
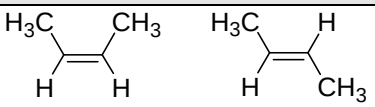
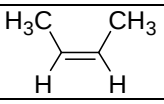
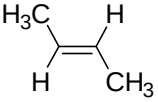
		the cis- and trans-butene-2 isomers and sometimes n-butane.
Catalytic Butylenes	25167-67-3	 Refers to the C4 cut from a catalytic cracker (a petroleum refinery process). A typical composition is about 55% butenes and 45% butanes with a complete carbon number distribution of C3 to C5. The stream is relatively low in 1,3-butadiene and diolefins (a few tenths of a percent). In some cases, the stream is a combination of catalytic cracker C4 butylenes and ethylene process C4 Raffinate 1 from the butadiene production unit.
Butane Stream	106-97-8	 This stream can be used as a feedstock for the ethylene process (Appendix I). An ethylene producer who operates an isobutylene alkylation process (typically a petroleum refinery process used to produce alkylates for gasoline formulations) lists butane from this source as a co-product. Butane is also sometimes separated by distillation from C4 Raffinate 3.
Butene-1 Stream	106-98-9	 This high purity stream is produced by distillation from isobutylene plant raffinate.
Isobutylene Stream	115-11-7	 Can be obtained from C4 Raffinate 1 by reaction with water or methanol and then re-cracking the product to high purity isobutylene. Alternately, isobutylene is obtained by isomerization of C4 Raffinate 2 or by dehydrogenation of isobutene.
Supporting Chemicals		
Chemical Name	**CASRN**	**Structure**
2-Butene	107-01-7	
2-Butene, (2Z)-	590-18-1	
2-Butene, (2E)-	624-64-6	

Table 12. TSCA Definitions for Certain Hydrocarbon Streams		
CASRN	**Name**	**TSCA Definition**
68477-42-9	Gases (petroleum), extractive, C3-5, butene-isobutylene-rich	A complex combination of hydrocarbons obtained from extractive distillation of saturated and unsaturated aliphatic hydrocarbons usually ranging in carbon numbers from C3 through C5, predominantly C4. It consists of saturated and unsaturated hydrocarbons having carbon numbers predominantly in the range of C3 through C5, predominantly butenes and isobutylene.
68477-83-8	Gases (petroleum), C3-5 olefinic-paraffinic alkylation feed	A complex combination of olefinic and paraffinic hydrocarbons having carbon numbers in the range of C3 through C5 which are used as alkylation feed. Ambient temperatures normally exceed the critical temperature of these combinations.
68606-24-6	Hydrocarbons, C4, butene concentrator by-product	A complex combination of hydrocarbons obtained in the production of butene concentrate. It consists of hydrocarbons having carbon numbers predominantly in the range of C3 through C5.
68606-31-5	Hydrocarbons, C3-5, butadiene purifn. by-product	A complex combination of hydrocarbons produced during butadiene purification. It consists predominantly of hydrocarbons having carbon numbers predominantly in the range of C3 through C5.

Table 13: Reference Sources for Supporting Chemical Data		
CASRN	**CHEMICAL**	**SOURCE**
74-85-1	Ethylene	Assessed as OECD HPV at SIAM 5: http://www.chem.unep.ch/irptc/sids/OECDSIDS/74851.pdf)
106-99-0	1,3-Butadiene	Assessed in HPV submission for Crude Butadiene C4 Category http://www.epa.gov/chemrtk/pubs/summaries/olefins/c12064tc.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 Assessed by EPA, IRIS assessment: http://www.epa.gov/ncea/iris/subst/0139.htm Assessed as OECD HPV at SIAM 4: http://ecb.jrc.ec.europa.eu/DOCUMENTS/Existing-Chemicals/RISK_ASSESSMENT/REPORT/butadienereport019.pdf
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
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.
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 being prepared and will be available for viewing at http://iaspub.epa.gov/oppthpv/hpv_hc_characterization.get_report?doctype=2
513-35-9	2-Butene, 2-methyl-	Assessed as OECD HPV at SIAM 19; http://www.chem.unep.ch/irptc/sids/OECDSIDS/513359.pdf
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.

Table 13: Reference Sources for Supporting Chemical Data		
CASRN	**CHEMICAL**	**SOURCE**
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
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.
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 being prepared and will be 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

ETHYLENE PROCESS DESCRIPTION

A. Ethylene Process

1. Steam Cracking

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

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

2. Refinery Gas Separation

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

B. Products of the Ethylene Process

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

The final products of the ethylene process include hydrogen, methane (frequently used as fuel), and the high purity products ethylene and propylene. Other products of the ethylene process are typically mixed streams that are isolated by distillation according to boiling point ranges. Further processing of one of these mixed streams, the Crude Butadiene C4 stream, results in additional mixed streams and high purity products that make up the main constituents of the Low 1,3-

Butadiene C4 Category.

Low 1,3 Butadiene C4 Process Streams Flow Diagram from the Ethylene Manufacturing Process Unit