Government of Canada Gouvernement du Canada

Screening Assessment Report

Ethane
Propane
Isobutane
Butane
Butane (branched and linear)

Chemical Abstracts Service Registry Numbers
74-84-0
74-98-6
75-28-5
106-97-8
68513-65-5

Environment and Climate Change Canada
Health Canada

November 2017

Canada

Cat. No.: En14-298/2017E-PDF

ISBN 978-0-660-23946-0

Aussi disponible en français

Synopsis

Pursuant to sections 68 or 74 of the *Canadian Environmental Protection Act, 1999* (CEPA), the Ministers of Environment and of Health have conducted an assessment of five substances as described below. Substances in this assessment were identified as priorities for assessment as they met the categorization criteria under subsection 73(1) of CEPA or were considered a priority based on other human health concerns. The Chemical Abstracts Service Registry Number (CAS RN)[1], the *Domestic Substances List* (DSL) name and the common name of the substances are presented in the table below.

CAS RN	**DSL name**	**Common name**
74-84-0	Ethane	Ethane
74-98-6	Propane	Propane
75-28-5	Propane, 2-methyl-	Isobutane
106-97-8	Butane	Butane
68513-65-5[a,b]	Butane, branched and linear	Butane (branched and linear)

[a] This CAS RN is a UVCB (unknown or variable composition, complex reaction products, or biological materials).
[b] This substance was not identified under subsection 73(1) of CEPA but was included in this assessment as it was considered a priority based on other human health concerns.

Ethane, propane, isobutane, butane and butane (branched and linear) are generally found as components of, or derived from, more complex petroleum substances, such as petroleum and refinery gases. Petroleum and refinery gases, including liquefied petroleum gases, were assessed previously by the Government of Canada. While these assessments addressed substances that may contain ethane, propane and/or butanes as components, the current assessment covers ethane, propane, isobutane, butane and butane (branched and linear) as individual substances, not as components of other complex substances. Similarly, while isobutane and butane that contain 1,3-butadiene have been previously assessed, those assessments only addressed the hazards associated with 1,3-butadiene. Therefore, the current assessment addresses isobutane and butane specifically in the absence of 1,3-butadiene.

The substances in this assessment are used primarily as domestic and industrial fuels and as refinery and chemical feedstocks. Propane, isobutane and butane can also be used as aerosol propellants in spray products such as air fresheners, cleaning products and spray paints and lubricants. Due to their use pattern and high vapour pressures, these five substances can be released into ambient air during handling or use.

Environmental exposure to these substances is predominantly by terrestrial organisms via inhalation. Measured environmental concentrations in air of these substances are

[1] The Chemical Abstracts Service Registry Number (CAS RN) is the property of the American Chemical Society and any use or redistribution, except as required in supporting regulatory requirements and/or for reports to the government when the information and the reports are required by law or administrative policy, is not permitted without the prior written permission of the American Chemical Society.

three orders of magnitude below concentrations which showed no adverse effects in laboratory studies.

Considering all lines of evidence presented in this screening assessment, there is a low risk of harm to organisms and the broader integrity of the environment from ethane, propane, isobutane, butane, and butane (branched and linear). It is concluded that ethane, propane, isobutane, butane, and butane (branched and linear) do not meet the criteria under paragraphs 64(*a*) and (*b*) of CEPA as they are not entering the environment in a quantity or concentration or under conditions that have or may have an immediate or long-term harmful effect on the environment or its biological diversity or that constitute or may constitute a danger to the environment on which life depends.

With respect to human health, these substances have not been identified as posing a high hazard to human health based on classifications by other national or international agencies for carcinogenicity, genotoxicity, developmental toxicity or reproductive toxicity.

Exposure of the general population to these substances may occur from both indoor and outdoor air, and particularly in the vicinity of industrial and petroleum facilities. Levels of exposure are several orders of magnitude below which demonstrated no adverse effects in laboratory studies. Similarly, the limited exposures associated with the use of household or personal care products that contain propane, butane or isobutane as propellants are not considered to be harmful to human health.

Based on the information presented in this screening assessment, it is concluded that ethane, propane, isobutane, butane, and butane (branched and linear) do not meet the criteria in paragraph 64(*c*) of CEPA as they are not entering the environment in a quantity or concentration or under conditions that constitute or may constitute a danger in Canada to human life or health.

It is concluded that ethane, propane, isobutane, butane and butane (branched and linear) do not meet any of the criteria set out in section 64 of CEPA.

Table of Contents

List of Tables

1. Introduction

Pursuant to sections 68 and 74 of the *Canadian Environmental Protection Act, 1999* (CEPA) (Canada 1999), the Minister of the Environment and the Minister of Health conduct screening assessments of substances to determine whether these substances present or may present a risk to the environment or to human health.

Ethane, propane, isobutane, butane and butane (branched and linear) were identified as priorities for assessment as they met categorization criteria under subsection 73(1) of CEPA or were considered a priority based on other human health concerns. Butane (branched and linear) is a simple UVCB (unknown or variable composition, complex reaction products, or biological materials) comprised of a variable composition of two substances in this assessment (isobutane and butane). As information was limited for butane (branched and linear), isobutane and butane were used as analogues.

Ethane, propane, isobutane, butane and butane (branched and linear) are generally found as components of, or derived from, more complex petroleum substances, such as petroleum and refinery gases. Petroleum and refinery gases, including liquefied petroleum gases, were assessed previously by the Government of Canada (Environment Canada, Health Canada 2013, 2014a, 2014b). While these assessments addressed substances that may contain ethane, propane and/or butanes as components, the current assessment covers ethane, propane, isobutane, butane and butane (branched and linear) as individual substances, not as components of other UVCB substances. Similarly, while isobutane and butane that contain 1,3-butadiene have been previously assessed (Environment Canada, Health Canada 2009), that assessment only addressed the hazards associated with 1,3-butadiene. Therefore, the current assessment addresses isobutane and butane specifically in the absence of 1,3-butadiene.

This screening assessment includes consideration of information on chemical properties, environmental fate, hazards, uses and exposure, including additional information submitted by stakeholders. Relevant data were identified up to April 2016. Empirical data from key studies, as well as some results from models and monitoring, were used to reach conclusions.

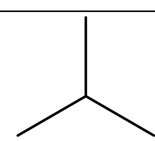
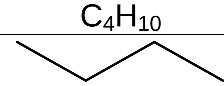
This screening assessment was prepared by staff in the CEPA Risk Assessment Programs at Health Canada and Environment and Climate Change Canada and incorporates input from other programs within these departments. Comments on the ecological portion of the assessment were received from Mr. Geoff Granville (GCGranville Consulting Corp.). Additionally, the draft of this screening assessment was subject to a 60-day public comment period. While external comments were taken into consideration, the final content and outcome of the screening assessment remain the responsibility of Environment and Climate Change Canada and Health Canada.

This screening assessment focuses on information critical to determining whether the substances meet the criteria as set out in section 64 of CEPA. It examines scientific information and develops a conclusion by incorporating a weight-of-evidence approach and precaution.[2] The screening assessment presents the critical information and considerations that form the basis of the conclusion.

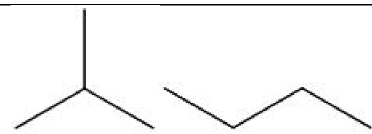
2. Identity of Substances

Ethane, propane, isobutane, butane and butane (branched and linear) are a category of light, saturated hydrocarbons produced from natural gases or during the refining of crude oil (Benz et al. 1960; Barber 2006; Thompson et al. 2011; Wiley 2007). The Chemical Abstracts Service Registry Numbers (CAS RN), *Domestic Substances List* (DSL) names and common names for the individual substances are presented in Table 2-1.

Table 2-1. Substance identities

CAS RN	DSL name (common name)	Chemical structure and molecular formula	Molecular weight (g/mol)
74-84-0	Ethane	C_2H_6	30.07
74-98-6	Propane	 C_3H_8	44.10
75-28-5	Propane, 2-methyl- (isobutane)	 C_4H_{10}	58.12
106-97-8	Butane (*n*-butane)	 C_4H_{10}	58.12

[2]A determination of whether one or more of the criteria of section 64 of CEPA are met is based upon an assessment of potential risks to the environment and/or to human health associated with exposures in the general environment. For humans, this includes, but is not limited to, exposures from ambient and indoor air, drinking water, foodstuffs, and products available to consumers. A conclusion under CEPA is not relevant to, nor does it preclude, an assessment against the hazard criteria specified in the *Hazardous Products Regulations*, which are part of the regulatory framework for the Workplace Hazardous Materials Information System for hazardous products intended for workplace use, handling and storage. Similarly, a conclusion based on the criteria contained in section 64 of CEPA does not preclude actions being taken under other sections of CEPA or other Acts.

CAS RN	DSL name (common name)	Chemical structure and molecular formula	Molecular weight (g/mol)
68513-65-5[1]	Butane, branched and linear	 C_4H_{10}	58.12

[1] This substance is a UVCB; comprised of a variable composition of isobutane and butane.

Butane (branched and linear) is a substance that contains *n*-butane and isobutane. As no data was found specifically on butane (branched and linear), isobutane and butane were used for read-across purposes unless specified otherwise. Isobutane, butane and butane (branched and linear) collectively will be referred to as butanes.

3. Physical and Chemical Properties

The physical and chemical properties of ethane, propane, isobutane and butane, as reported in the available literature, are presented in Tables A-1 to A-4 in Appendix A. At standard temperatures and pressures, ethane, propane and butanes occur as gases. These substances can be compressed into highly volatile liquids.

4. Sources and Uses

Ethane, propane and butanes occur naturally in crude oil and natural gas and are separated from these products at industrial facilities, including petroleum refineries and gas plants. Ethane, propane and butanes can comprise up to 20% of natural gas, which is used domestically for home heating and cooking. Other natural gas uses include power generation and transportation (Natural Gas 2015).

In 2011, the total Canadian supply of these substances, which includes production and imports, was 12 850 000 m^3 of ethane, 10 908 000 m^3 of propane and 7 714 600 m^3 of butane (including isobutane) (Statistics Canada 2012).

In Canada and around the world, ethane, propane and butanes have widespread uses, including in industry, transportation, commerce and residences. Ethane is used industrially as a fuel and fuel additive, production intermediate, ion exchange agent, paint and coating additive, pigment, plasticizer and processing aid (Bolton et al. 2008). Propane is used industrially in adhesives and sealants, adsorbents, fuels, intermediates, ion exchange agents, laboratory chemicals and propellant/blowing agents (Bolton et al. 2008). Similar uses were found for butane, with additional uses in petroleum processing and production and solvent formulations (Bolton et al. 2008). Isobutane has similar industrial uses as butane, with an additional use of plating and surface treating (Bolton et al. 2008). It is difficult to distinguish uses of propane and butanes from those of liquefied petroleum gases (LPGs) because it is often the case that the components of the LPGs (e.g., propane and butanes) are listed as ingredients, rather than the LPGs. LPGs can be commonly referred to or simply listed as “propane” and, in some cases, LPGs and propane/butanes are indistinguishable. Short-chain alkanes are also extensively used as feedstocks for manufacturing ethylene and other petrochemicals (communication of Environment and Climate Change Canada with Chemistry Industry Association of Canada, May 2015; unreferenced).

Propane, isobutane and butane are listed as formulants in Health Canada’s PMRA List of Formulants (PMRA 2010). Based on notifications submitted under the *Cosmetic Regulations* to Health Canada, propane, isobutane and butane were identified in 703 unique products, with 273 of these products containing all three substances (personal communication with Health Canada’s Consumer Product Safety Directorate, 2016). Propane, isobutane, and butane are permitted to be used as food additives (propellants and pressure dispensing agents) under the *Food and Drug Regulations* (email communication from Health Canada Food Directorate to Existing Substances Risk Assessment Bureau; unreferenced). Ethane was reported only at trace levels in two products, and butane (branched and linear) was not reported.

An additional search of the U.S. Household Products Database for these substances identified many consumer products containing propane, isobutane and butane, with a dominant use as aerosol propellants (HPD 2015).[3] Propane, isobutane and butane were often found in the same product, likely as part of an LPG used as an ingredient in the consumer product. Product types included adhesives and sealants, automotive care and maintenance products, fabric treatment products, household cleaners (e.g., for use on stainless steel, glass, furniture), air fresheners, household spot removers, disinfectants (e.g., hand sanitizers, air sanitizing sprays), lubricants and corrosion prevention sprays, and paints and coatings (spray paints). Household product database searches for ethane identified three products, none of which specified a concentration, suggesting ethane may only be present as a trace component in household products.

5. Releases to the Environment

Ethane, propane and butanes may be released during the extraction of natural gas and petroleum, as well as during their processing and refining at petroleum facilities. They may also be released during industrial foaming or blowing of materials (Bolton et al. 2008). Ethane may be released to the environment through various waste streams, including as a result of its production and use as a feedstock in the manufacture of ethene, vinyl chloride and chlorinated hydrocarbons, as well as its use as a refrigerant (SRC 2005). In addition, shale oil production may be a large emitter of ethane (Kort 2016).

[3] For the purpose of this document, a personal care product is defined as a product that is generally recognized by the public for use in personal cleansing or grooming. Depending on how the product is represented for sale and its composition, personal care products may fall into one of three regulatory categories in Canada: cosmetics, drugs or natural health products.

Releases of propane and butanes are reported to Canada's National Pollutant Release Inventory (NPRI). The total mass of propane and butanes released to air across all sectors in 2014 was reported to be approximately 6 667 000 kg of propane and 11 900 000 kg of butanes. Most releases were associated with petroleum-related activities and facilities, such as oil and gas extraction, refining, pipelines and petrochemical manufacturing (NPRI 2015). The main source of releases of these substances from petroleum facilities is expected to be various UVCB petroleum gases that disperse into the air in the vicinity of a facility via fugitive emissions from, for example, process equipment, valves and flanges.

The National Air Pollution Surveillance Program (NAPS) reported annual average concentrations of ethane, propane, isobutane and butane in ambient air for the 2013 calendar year (NAPS 2014). The average concentration range of these substances was determined at 46 locations across Canada (Table 5-1).

Table 5-1. Range of average annual ambient air concentrations for ethane, propane, isobutane and butane in Canada in 2013

Substance	**Concentration range** (µg/m^3)
Ethane	1.18 to 9.75
Propane	0.92 to 21.72
Isobutane	0.22 to 17.80
Butane	0.46 to 38.75

Analysis of the NAPS data revealed that the upper end of the average concentrations in Table 5-1 occurred in the vicinity of petroleum facilities.

Releases from industrial facilities and related air concentrations of substances have been quantified in several studies. Simpson et al. (2013) measured concentrations of ethane, propane, isobutane and butane in the vicinity of Alberta's industrial heartland, the largest hydrocarbon processing centre in Canada. Measurements were taken over the course of 2 days using multiple Summa canisters with 1-minute sampling rates (Table 5-2).

Table 5-2. Air concentrations of ethane, propane, isobutane and butane (in µg/m^3) in the vicinity of Alberta's industrial heartland

Substance	Minimum detected	Maximum detected	Upwind (average background)	Downwind (plume values; averaged 90th percentile data)
Ethane	1.38	15.3	1.62	9.64
Propane	0.52	80.23	0.93	20.98
Isobutane	0.12	62.03	0.21	24.98
***n*-butane**	0.2	119.2	0.45	52.12

Alberta Environment (2008) took measurements of propane, isobutane and butane near two industrial sites and at two background sites in the Fort Saskatchewan-Redwater area northeast of Edmonton between February 2006 and March 2007. The industrial sites were a grain and oilseeds processing plant (Bunge Canada) and an organic chemical manufacturer (Oxyvinyls/Gulf Chemicals). The highest concentrations of butane (8.24 µg/m^3) and isobutane (4.45 µg/m^3) were measured at a background site. The highest concentration of propane, 13.5 µg/m^3, was measured near the Bunge Canada plant.

The Clean Air Strategic Alliance (CASA) (an Alberta air monitoring organization) has very limited data for propane at three stations for the period 2009-2012. The highest concentration of propane measured was 21 µg/m^3 (personal communication between Environment Canada and Chemistry Industry Association of Canada, 2015, unreferenced). Concentrations fall within the range determined by NAPS (2014) and Simpson et al. (2013).

Monitoring data for non-methane hydrocarbons (NMHC) (a term that encompasses multiple substances including ethane, propane and butanes) provide further information on industrial releases. Hourly ambient NMHC data were collected at two locations at the NOVA Chemicals Joffre site in Alberta near the natural gas and ethane pipeline metering stations (NOVA Chemicals 2015). One of the monitoring stations is located adjacent to a pipeline that carries 15% of Alberta's total natural gas production, and the high readings may therefore result from fugitive emissions from this pipeline and the metering stations (e-mail from Nova Chemicals to ECCC, 2015, unreferenced). The single highest 1-hour value from January 2010 to January 2014 (from a total of 82 384 hours) was 14.4 ppm (equivalent to approximately 26 mg/m^3), although most of the hourly total NMHC results (99%) were less than 1 ppm (approximately 1.8 mg/m^3) (NOVA Chemicals 2015).

The use of propane and butanes as aerosol propellants in household products and other products available to consumers makes these products a source of release in residences. However, the average quantity used as a propellant is much smaller than the quantity used for heating, cooking and automotive fuels.

6. Environmental Fate and Behaviour

Based on the high vapour pressures and reported uses and releases of ethane, propane and butanes, it is expected that these substances will be released into ambient air during handling and use. When these substances are released to air, they are predicted to remain solely in air due to their very high vapour pressures (Tables A-1 to A-4). Therefore, exposure to these short-chain alkanes in media such as soil and water is not considered to be relevant and will not be discussed further.

These substances are persistent in air, with estimated half-lives in the atmosphere of 4.2 to 9.3 days for propane and butanes and 40 days for ethane (EPI Suite 2012, Level

III fugacity model). Since propane and butanes are heavier than air, they can accumulate in undisturbed low-lying areas.

Ethane, propane and butanes are expected to have low bioaccumulation potential based on log K_{ow} values.

7. Potential to Cause Ecological Harm

7.1 Ecological Effects Assessment

The toxicity of ethane, propane and butanes in air only will be reviewed here, as these substances are not expected to be found in water, sediment or soil. No studies on the toxicity of these substances to plants via air were found.

As these substances are released to air from petroleum facilities and industrial operations on an ongoing basis, exposure to them in the environment is expected to be chronic. Chronic and reproductive inhalation toxicity studies for terrestrial organisms are therefore considered to be most relevant to the ecological assessment.

Short-term, subchronic and reproduction rat toxicity studies with ethane, propane, isobutane and butane are described in Section 8.2. The studies showed no significant effects at the highest exposure levels (19 000 mg/m^3 for ethane, 21 700 mg/m^3 for butane and 22 000 mg/m^3 for propane). A NOAEC for reproductive toxicity based on ethane of 19 000 mg/m^3 was chosen to be representative for this group of substances.

Based on the above data, the toxicity of ethane, propane and butanes is expected to be low.

7.2 Ecological Exposure Assessment

Monitoring data for ethane, propane and butanes are described in Section 5. The highest hourly concentration of non-methane hydrocarbons (NMHC), measured at the NOVA Chemicals facility in Joffre, Alberta, over a 4-year period was 14.4 ppm (equivalent to approximately 26 mg/m^3) (NOVA Chemicals 2015). As this value encompasses the combined concentration of many non-methane hydrocarbons, it can be considered a worst-case value for the chronic environmental exposure for each substance. It will therefore be considered the critical exposure value for the purpose of the characterization of ecological risk.

7.3 Characterization of Ecological Risk

Ecological exposure to these substances is considered to be principally through inhalation. The critical worst-case exposure concentration of 26 mg/m^3 total NMHC, as described in Section 7.2, is compared to the most sensitive reproductive NOAEC of 19 000 mg/m^3. There is a difference of three orders of magnitude between the critical exposure value and the most sensitive effects value, indicating that these substances are unlikely to cause effects to terrestrial mammals, even at worst-case exposure levels.

This information indicates that ethane, propane, isobutane, butane and butane (branched and linear) have low potential to cause ecological harm in Canada. Since there is measured data from multiple studies involving industrial sites, and since there are at least three orders of magnitude of difference between the critical exposure and effect levels, the uncertainty associated with the conclusion for these substances is low.

8. Potential to Cause Harm to Human Health

8.1 Exposure Assessment

8.1.1 Environmental media

When released, ethane, propane and butanes rapidly disperse into ambient air. Inhalation is therefore the primary route of exposure for the general population. Dermal contact and oral ingestion are not expected to be significant routes of exposure. Data from separate sources measured by Simpson et al. (2013) and NAPS contain similar values when considering upper bounding air concentrations. The upper concentration levels presented in Table 5-2 were considered relevant for assessing potential highest exposures of the general population that reside in the vicinity of petroleum facilities.

To assess potential typical exposures for the general population, air monitoring studies conducted inside and outside of residences were reviewed. Bari et al. (2015) recently measured seasonal variations in ethane, propane, isobutane and butane, both indoors and outdoors in Edmonton, Alberta (Tables 8-1, 8-2). Indoor and outdoor air monitoring studies were also recently performed in Edmonton (Health Canada 2013), Halifax (Health Canada 2012), Regina (Health Canada 2010a), and Windsor (Health Canada 2010b). The mean concentrations and minimum and maximum ranges of concentration from sampling over 24 hr periods are given for winter conditions in Table 8.1 and for summer conditions in Table 8.2.

Table 8.1 24 hr sample concentration ranges in winter indoor and outdoor air of ethane, propane, isobutane and butane in Edmonton, Halifax, Regina, and Windsor. The highest mean values among the four cities are also given.

Scenario	Indoor	Indoor	Outdoor	Outdoor
Parameter (in µg/m^3)	Highest Mean	Min-Max	Highest Mean	Min-Max
Ethane	78.5	1.2-1465.9	12.7	2.0-305.8
Propane	89.4	1.6-1271.0	11.1	0.96-92.4
Isobutane	68.4	0.1-1442.2	4.60	0.2-134.9
Butane	54.7	0.2-948.0	8.6	0.4-110.7

Table 8.2. 24 hr sample concentration in summer indoor and outdoor air of ethane, propane, isobutane and butane in Edmonton, Halifax, Regina, and Windsor. The highest mean values among the four cities are also given.

Scenario	**Indoor**	**Indoor**	**Outdoor**	**Outdoor**
Parameter (in µg/m^3)	Highest Mean	Min-Max	Highest Mean	Min-Max
Ethane	135.6	0.0-1763.5	3. 8	0.6-36.5
Propane	77.8	0.9-2340.0	4.2	0.3-139.3
Isobutane	124.0	0.4-1917.0	1.9	0.1-46.8
Butane	78.6	0.3-1448.2	3.7	0.1-45.1

The highest mean concentrations were considered representative of average long-term exposure of the general population from indoor and outdoor ambient air. For the purpose of characterizing risk to human health (see Section 9.3), the highest maximum exposure levels identified in this monitoring study were also considered.

8.1.2 Products Available to Consumers

Propellants are used in various product categories, including adhesives, auto care, fabric treatments, household cleaners, air fresheners, spot removers, hobby materials, lubricants/corrosion prevention, disinfectants, paints, deodorants and perfumes, hair spray, shaving cream, dry shampoo, pesticide/insect repellants and various pet care products. In a propellant aerosol spray can, these gases are pressurized into liquid form and mixed with a liquid product. The pressure in the can is reduced by depressing the nozzle, which opens the valve. In this way, these substances immediately vaporize, forming a gas phase in the headspace of the can that exerts pressure on the liquid product, effectively pushing the product out of the can. As the liquid (a mixture of product and propane or butanes) leaves the can and enters atmospheric pressure, the liquefied propellant rapidly expands into gas, which can further atomize the liquid product to form a fine spray (CAPCO 2011). Accordingly, inhalation is the primary route of exposure to propellant substances. It is noted that aerosol droplets may be of sufficient size to result in an oral exposure (inhalation exposure results in the swallowing of aerosols that settle in the pharynx), although this would typically be to the liquid product substance and not to the propellant substance that has already vaporized under atmospheric pressure. Similarly, spray products used on the skin would predominantly result in dermal exposure to the product, not to the vaporized propellant substances.

As discussed previously, ethane does not appear to be used as an aerosol propellant in spray cans. MSDS sheets that list ethane are from refined gas products (gas cylinders, laboratory supplies, etc.) to which the general population would not typically be exposed (MSDS 2016).

Exposure to propellants released from aerosol spray cans was modelled with ConsExpo, version 4.1 (ConsExpo 2006). ConsExpo is a multi-tiered predictive model used to derive estimates of exposure to substances in products available to consumers via inhalation, dermal contact and oral ingestion. The IHMod version 0.198 model created by the American Industrial Hygiene Association (AIHA 2009) was also considered, with predictions being similar to those from ConsExpo. Thus, only the estimates from the ConsExpo model are presented here.

Short-term exposures to propane, isobutane and butane were therefore modelled based on the use of aerosol propellant spray cans. Products from various product categories were modelled, and a spray product was identified after considering propellant concentration, product use amount and frequency of use. The largest potential exposure was found to be associated with fabric treatment products.

Table 8-1. Exposure estimates for a spray product scenario (i.e., use of an aerosol propellant fabric protector)[a]

Substance	Estimated 24-hour Mean Air Concentration (mg/m^3)
Propane	39.3
Isobutane	236
Butane	197

[a] Maximum weight fraction relative to weight of liquid product released: 0.1 for propane, 0.6 for isobutane and 0.5 forbutane (fractions were considered independent of each other to generate a worst-case exposure to each substance); Frequency of use: 1/year (professional judgement); Use duration: 15 min.; Amount of liquid product released: 480 g (professional judgement); Room volume: 10 m^3; Ventilation rate: 2/hr

The highest mean air concentrations amortized over 24 hours on the day of the event are 39.3 mg/m^3 for propane, 236 mg/m^3 for isobutane, and 197 mg/m^3 for butane. These values are based on an adult using the product in an indoor environment with good ventilation and are higher than exposure estimates derived from the use of aerosol propellant products from other product categories.

Exposure and risk from food additive uses of these substances have been considered by Health Canada's Food Directorate and are considered to be negligible (email communications from the Food Directorate to Existing Substances Risk Assessment Bureau May 2016; unreferenced).

8.2 Health Effects Assessment

Ethane, propane, isobutane and butane exhibit low toxicity in studies of inhalation exposure in laboratory animals and in human volunteers. These substances have high no observed (adverse) effect concentrations (NO(A)ECs) in repeated-dose studies.

Across several studies, groups of rats exposed over the short-term to one of propane, isobutane or butane up to the highest tested concentration of approximately 22 000 mg/m^3 (9150 to 12 200 ppm) for 6 hours per day for at least 28 days exhibited genderspecific effects. While effects were also not consistent between substances, depending on the study, male rats exhibited decreased body weight gain, decreased platelet count, increased sodium, increased mean corpuscular hemoglobin, nasal discharge, decreased bilirubin concentration and decreased forelimb grip strength, whereas females exhibited increases in hemoglobin concentration, hematocrit, erythrocytes and absolute eosinophils, decreased monocytes and phosphorus, and increased forelimb grip strength. The toxicological significance of these effects are considered to be low, as many did not exhibit a dose-response trend, and some changes were small and within the normal range observed in control rats. The lack of significant effects across these studies demonstrates low toxicity in rats at high levels of exposure. Short-term NOAECs were therefore established for propane, isobutane and butane at approximately 22 000 mg/m^3 (US EPA 2011a). Rats exposed to ethane for 6 hours per day for 28 days did not exhibit health effects at the highest tested concentration of approximately 19 000 mg/m^3 (15 500 ppm) (US EPA 2011a).

In a subchronic inhalation exposure study, rats were exposed to mixtures of butane/pentane or isobutane/isopentane at 1000 (approximately 2700 mg/m^3) and 4500 ppm (approximately 12 000 mg/m^3) for 6 hours per day, 5 days per week for 13 weeks. During exposure to either mixture, some rats exhibited transient hunched posture and/or lethargy with intermittent tremors, but this was not dose-dependent. Also, although rats in the butane/pentane exposure groups exhibited decreased body weights (approximately 6 to 7% reduction), no dose-response effect was observed, the effect persisted in females only, and the reduced female body weights were within the level of a control group of female rats serving in a concurrent arm of the study. Therefore, the rats were determined by the authors to have not been significantly affected by subchronic exposure to these substances (Aranyi et al. 1986).

In vitro genotoxicity assays showed negative results for these substances (Petroleum HPV 2009; U.S. EPA 2010).

In reproductive toxicity studies, ethane and butane exhibited no effects (NOAECs) on reproductive parameters at the highest tested exposure levels of approximately 19 000 mg/m^3 and 21 700 mg/m^3, respectively. Similarly, while exposure of pregnant rats to propane at approximately 7200 mg/m^3 (4000 ppm) or 22 000 mg/m^3 (12 200 ppm) decreased live pups and increased stillborn pups for each exposure group, the effect was attributed to a single dam losing an entire litter in each group (with the effect preceded by severely reduced body weight gain in the last week of gestation) (US EPA 2010). No other effects on reproductive or developmental parameters were observed. As the litter loss lacked a dose-response profile and has not been corroborated in other studies of propane or studies of related substances, the authors considered it to be spurious. The highest reproductive NOAEC for propane was therefore determined to be 22 000 mg/m^3. In another study, rats exposed daily to isobutane at approximately 21 700 mg/m^3 (9150 ppm; 50% of the explosion limit of the substance) for two weeks prior to mating exhibited a non-statistically significant 25% decrease in fertility index as well as a statistically significant increase in post-implantation loss (0.8 +/- 0.9 (controls) vs. 1.8 +/- 0.8 (exposed group)) (Petroleum HPV 2009; U.S. EPA 2010; McKee et al. 2014).

Other parameters for the highest exposed group, such as live offspring per litter, percent live offspring born, offspring surviving to postnatal day 4, and offspring birth weight and weight gain, were normal. Given the lack of corroboratory effect (i.e., no effect on mating in the highest dose groups) in reproductive studies of ethane, propane, butane, liquefied petroleum gases and structurally related 2-methyl butane (McKee et al. 2014), it remains to be established whether isobutane can affect reproduction at very high levels of exposure. Given the available information, a reproductive NOAEC of 19 000 mg/m^3 (based on ethane) was considered to be conservative and representative for this group of substances.

In humans, a study of elevated short-term exposures of volunteers to propane, isobutane or propane/isobutane mixtures have shown limited, reversible health effects. There were no effects observed for a single exposure of up to 8 hours to 1000 ppm of propane (1800 mg/m^3) or isobutane (approximately 2400 mg/m^3) (Stewart 1977). Additionally, repeated exposures to propane (up to 1000 ppm) or isobutane (up to 500 ppm) were also conducted for 8 hours per day, 5 days per week for 2 weeks, as well as 2-day exposures to propane/isobutane mixtures (Stewart 1977). Clinical and functional tests showed no effect on cardiac, pulmonary or cognitive function. Blood counts, clinical chemistry and adrenal gland responses were normal. In the second week of exposure to isobutane at 500 ppm (approximately 1200 mg/m^3), there was a decrease in visual evoked response (VER) which the author suggested could indicate a potential for CNS depression. However, the lack of any other treatment related effect seen in neurological studies, electroencephalography, and cognitive function, combined with the lack of any treatment related effects of the study participants who were monitored for 1 year after termination, indicates that the change in VER does not meet criteria for an adverse effect (Stewart 1977).

8.3 Characterization of Risk to Human Health

General population exposures to ethane, propane and butanes from indoor and ambient outdoor air, as well as in the vicinity of petroleum facilities, are low and several orders of magnitude lower than NOAECs derived from studies with laboratory animals. The highest exposures for the general population are less than 0.04 mg/m^3 in ambient outdoor air (highest annual average; see Table 5-1); less than 0.120 mg/m^3 in the vicinity of a refinery (maximum concentration detected; see Table 5-2); and less than 2.5 mg/m^3 in summertime indoor air (maximum concentration detected; see Table 8-2). Exposure of rats to high levels (approximately 12 000 mg/m^3) of butane/pentane or isobutane/isopentane did not result in significant health effects. Human volunteers have also been repeatedly exposed to 1200 to 1800 mg/m^3 propane, isobutane and propane/isobutane mixtures over several weeks without exhibiting adverse health effects. Risks to human health from exposure to ethane, propane and butanes in ambient air are therefore considered to be low.

Similarly, while the use of an aerosol propellant spray product may result in exposure above ambient levels over a short duration (with the highest 24-hour mean exposure concentrations, as derived by modelling the use of a spray product, of less than 40 mg/m^3 for propane, less than 200 mg/m^3 for butane and less than 240 mg/m^3 for isobutane), such exposures are well below no-adverse-effect levels in animals and lower than levels that have been shown to be without effect in humans. Additionally, use of the majority of aerosol propellant products under typical conditions (e.g., hair sprays, shaving creams, air fresheners and cleaning products) results in exposures much lower than the level derived for a spray product (i.e., this product is considered to generate an upper-bound estimate of exposure, as derived by emptying an entire can of fabric treatment during a single application). Therefore, risk to human health from exposure to propane, butane and isobutane from the use of aerosol propellant spray products is considered to be low.

General population exposures to ethane, propane, isobutane, butane and butane (branched and linear) are not considered to be harmful to human health.

8.4 Uncertainties in Evaluation of Risk to Human Health

Potential exposures from use of products by consumers were estimated using models and conservative assumptions and are expected to be overestimates of actual exposures.

While the toxicity profile for these substances as a group is robust and indicates low toxicity, there is some uncertainty regarding relevance of a potential effect on mating in rats for very high exposures to isobutane.

9. Conclusion

Considering all available lines of evidence presented in this screening assessment, there is low risk of harm to organisms and the broader integrity of the environment from ethane, propane, isobutane, butane and butane (branched and linear). It is concluded that ethane, propane, isobutane, butane and butane (branched and linear) do not meet the criteria under paragraphs 64(*a*) or 64(*b*) of CEPA as they are not entering the environment in a quantity or concentration or under conditions that have or may have an immediate or long-term harmful effect on the environment or its biological diversity or that constitute or may constitute a danger to the environment on which life depends.

Based on the information presented in this screening assessment, it is concluded that ethane, propane, isobutane, butane and butane (branched and linear) do not meet the criteria under paragraph 64(*c*) of CEPA as they are not entering the environment in a quantity or concentration or under conditions that constitute or may constitute a danger in Canada to human life or health.

It is concluded that ethane, propane, isobutane, butane and butane (branched and linear) do not meet any of the criteria set out in section 64 of CEPA.

References

[AIHA] American Industrial Hygiene Association. 2009. Exposure Assessment Strategies Committee Industrial Hygiene Model version 0.198. Fairfax (VA): AIHA.

Alberta Environment. 2008. Air quality monitoring: in the Fort Saskatchewan and Redwater area, 2006 and 2007 final report. http://open.alberta.ca/publications/9780778575962.

Aranyi C, O'Shea WJ, Halder CA, Holdsworth CE, Cockrell BY. 1986. Absence of hydrocarbon-induced nephropathy in rats exposed subchronically to volatile hydrocarbon mixtures pertinent to gasoline. Toxicol Ind Health. 2(1):85–98.

Barber D. 2006. Liquefied petroleum gas. Chapter 3 in Tolly's Basic Science and Practice of Gas Service (Gas Service Technology Vol. 1). Edited by Saxon F. 4th edition. Published by Elsevier Ltd.

Bari MA, Kindzierski WB, Wheeler AJ, Herous ME, Wallace LA. 2015. Source apportionment of indoor and outdoor volatile compounds at homes in Edmonton, Canada. Building and Environment. 90:114–124.

Bolton EE, Wang Y, Thiessen PA, Bryant SH. 2008. Chapter 12 -- PubChem: Integrated Platform of Small Molecules and Biological Activities. Vol. 4: 217-241. In: Wheeler RA and Spellmeyer DC, editors. Annual Reports in Computational Chemistry, Oxford (UK): Elsevier.

Canada. 1999. *Canadian Environmental Protection Act, 1999*. S.C., 1999, c. 33, Canada Gazette Part III, vol. 22, No. 3.

[CAPCO] Consumer Aerosol Products Council. 2011. Aerosol technology. [cited 2013 Jun]. Available from: http://www.aerosolproducts.org.

[ConsExpo] Consumer Exposure Model. 2006. Version 4.1. Bilthoven (NL): Rijksinstituut voor Volksgezondheid en Milieu [National Institute for Public Health and the Environment]. [cited 2013 Jun]. Available from: http://www.rivm.nl/en/healthanddisease/productsafety/ConsExpo.jsp#tcm:13-42840.

Environment Canada, Health Canada. 2009. Screening assessment for the Challenge: Butane (CAS RN 106-97-8) containing 1,3-butadiene (CAS RN 106-99-0) and propane, 2-methyl (CAS RN 75-28-0) containing 1,3-butadiene (CAS RN 106-99-0) [Internet]. Ottawa (ON): Environment Canada, Health Canada. [cited 2013 Aug]. Available from: http://www.chemicalsubstanceschimiques.gc.ca/challenge-defi/batch-lot-4/index-eng.php.

Environment Canada, Health Canada. 2013. Screening assessment for Petroleum and refinery gases [Site-restricted] [Internet]. Ottawa (ON): Environment Canada; Health Canada. [cited 2013 Aug]. Available from: http://www.ec.gc.ca/ese-ees/08D395AD-07E1-4CD2-9503-EC72D721C64F/PRGs_FSAR_EN.pdf.

Environment Canada, Health Canada. 2014a. Screening assessment for Petroleum and refinery gases [Industry-restricted] [Internet]. Ottawa (ON): Environment Canada, Health Canada. [cited

2014 Feb]. Available from: http://www.ec.gc.ca/ese-ees/D5D72B57-016F-43BF-B926-DA229E97C1F2/FSAR_Stream%202%20-%20PRGs_EN.pdf.

Environment Canada, Health Canada. 2014b. Draft screening assessment for Liquefied Petroleum Gases Stream 4 [Internet]. Ottawa (ON): Environment Canada, Health Canada. [cited 2015 Oct]. Available from: http://www.ec.gc.ca/ese-ees/D5D72B57-016F-43BF-B926-DA229E97C1F2/FSAR_Stream%202%20-%20PRGs_EN.pdf

[EPI Suite] Estimation Program Interface Suite for Microsoft Windows [estimation model]. c2000-2012. Ver. 4.11. Washington (DC): US Environmental Protection Agency, Office of Pollution Prevention and Toxics; Syracuse (NY): Syracuse Research Corporation. http://www.epa.gov/tsca-screening-tools/epi-suitetm-estimation-program-interface.

[EPI Suite] Estimation Program Interface Suite for Microsoft Windows [estimation model]. 2012. Version 4.1 Washington (DC): US Environmental Protection Agency, Office of Pollution Prevention and Toxics; Syracuse (NY): Syracuse Research Corporation. [cited 2015 Oct 26].

Hansch C, Leo A, Hoekman D. 1995. Exploring QSAR - Hydrophobic, Electronic, and Steric Constants. American Chemical Society, Washington (DC). [cited in EPI Suite 2012].

Health Canada. (2010a) Regina Indoor Air Quality Study (2007): Data Summary for Volatile Organic Compound Sampling, Health Canada, Ottawa, Ontario K1A 0K9. [Accessed 2017, June] http://publications.gc.ca/collections/collection_2012/sc-hc/H128-1-10-617-eng.pdf

Health Canada. (2010b) Windsor Exposure Assessment Study (2005-2006): Data Summary for Volatile Organic Compound Sampling, Health Canada, Ottawa, Ontario K1A 0K9. [Accessed 2017, June] http://publications.gc.ca/collections/collection_2012/sc-hc/H128-1-10-618-eng.pdf

Health Canada. (2012) Halifax Indoor Air Quality Study (2009): Volatile Organic Compounds (VOC) Data Summary, Health Canada, Ottawa, Ontario K1A 0K9.

[HPD] Household Products Database. 2015. Searches for ethane, propane, butane and isobutane. Bethesda (MD): National Institutes of Health, National Library of Medicine. [cited 2015 Oct].

[ICAEH] Industrial Chemical Additives Electronic Handbook. 2000. Synapase Information Resources, Inc. Endicott (NY).

Kort EA, Smith ML, Murray LT, Gvakharia A, Brandt AR, Peischl J, Ryerson TB, Sweeney C, Travis K. 2016. Fugitive Emissions from the Bakken shale illustrate role of shale production in global ethane shift. Geophys Res Lett. 43:1–7.

McAuliffe C. 1966. J Phys Chem. 70: 1267-75. [cited in: EPI Suite 2012].

McKee RH, Herron D, Saperstein M, Podhasky P, Hoffman GM, Roberts L. 2014. The toxicological properties of petroleum gases. Int. J Toxicol. 33:28S–51S.

[MSDS] Material Safety Data Sheet. 2016. Ethane P-4592. Danbury(CT): Praxair. [accessed 2016 09 26].

[NAPS] National Air Pollution Surveillance Network. 2014. NAPS data for 2013. Ottawa (ON): Environment Canada. [cited 2015 Nov]. Available from: http://maps-cartes.ec.gc.ca/rnspa-naps/data.aspx

[Natural Gas] 2015. Overview of Natural Gas – Background. Typical composition of Natural Gas. Washington (DC): Natural Gas Supply Association.

Nova Chemicals. 2015. NMHC monitoring data for NOVA Chemicals site in Joffre, AB. 2010-2014. Sent by e-mail from Nova Chemicals to Ecological Assessment Division, ECCC, Oct. 2015.

[NPRI] National Pollutant Release Inventory. 2015. NPRI 2014 datasets for propane and butane. Gatineau (QC): Environment and Climate Change Canada. [accessed 2016 May 25]. Available from: http://www.ec.gc.ca/inrp-npri/.

[Petroleum HPV] The Petroleum HPV Testing Group. 2009. Robust summaries of studies used to characterize the petroleum gases category. Submitted to the US EPA. Consortium registration # 1100997. [cited 2013 Jun]. Available from: http://www.petroleumhpv.org/petroleum-substances-and-categories/~/media/2925647CA44342AE9D48A2377DB1F3A8.ashx.

[PMRA] Pest Management Regulatory Agency. 2010. Catalogue number H114-22/2010E: PMRA list of formulants [Internet]. Ottawa (ON): Health Canada, Pest Management Regulatory Agency. [cited 2016 Jul]. Available from: http://publications.gc.ca/site/eng/377973/publication.html.

Simpson IJ, Marrero JE, Batterman S, Meinardi S, Barletta B, Blake DR. 2013. Air quality in the Industrial Heartland of Alberta, Canada and potential impacts on human health. Atmos Environ. 81:702–709.

Statistics Canada. 2012. Energy Statistics Handbook. First quarter 2012. Catalogue no. 57-601-X. Ottawa (ON): Statistics Canada.

Stewart RD, Herrmann AA, Baretta ED, Forster HV, Sikora JJ, Newton PE, Soto RJ. 1977. Acute and repetitive human exposure to isobutane. Scand J Work Environ Health. 3:234–243.

Stewart RD, Newton PE, Baretta ED, Herrmann AA, Forster HV, Soto RJ. 1978.

Thompson SM, Robertson G, Johnson E. 2011. Liquefied Petroleum Gas in Ullmann’s Encyclopedia of Industrial Chemistry. Available from: http://onlinelibrary.wiley.com/doi/10.1002/14356007.a15_347.pub2/full.

[US EPA] United States Environmental Protection Agency. 2010. Hazard characterization document: Screening-level hazard characterization petroleum hydrocarbon gases category. [cited 2013 Jul]. Available from: http://www.petroleumhpv.org/petroleum-substances-and-categories/~/media/274FF48B799B4C688149641E6C6723E5.ashx.

[US EPA] United States Environmental Protection Agency. 2011a. Technology Transfer Network – Support Centre for Atmospheric Modelling – Screening Models – AERSCREEN.

Research Triangle Park (NC): U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Emissions, Monitoring, and Analysis Division. Available from: http://www.epa.gov/ttn/scram/dispersion_screening.htm#aerscreen.

Wiley 2007. Wiley Critical Content: Petroleum Technology Volumes 1 and 2: Petroleum Refinery Processes (Chapter 7) and Liquefied Petroleum Gas (Chapter 23). Published by John Wiley & Sons.

Yalkowsky SH, Yan H. 2003. Handbook of Aqueous Solubility Data: An Extensive Compilation of Aqueous Solubility Data for Organic Compounds. [cited in EPI Suite 2012].

Appendix A – Physical and Chemical Properties

Table A-1. Physical and chemical properties of ethane

Property[a]	Value	Reference
Flash point (ºC)	-94.4	ICAEH 2000
Liquid density (g/mL)	0.446 at 0ºC	Bolton et al. 2008
Vapour density (Air = 1)	1.05	Bolton et al. 2008
Explosive limit, % v/v in atmosphere	3.0 to 12%	ICAEH 2000
Vapour pressure (Pa)	4.20×10^{6} at 25ºC	EPI Suite c2000-2012
Boiling point (°C)	-88.6	HSDB 2016
Water solubility (mg/L)	383.3 (est.) at 25ºC	EPI Suite c2000-2012
Henry's law constant ($Pa \cdot m^3$/mol at 25°C)	5.07×10^{4}	EPI Suite c2000-2012
Log K_{OW}	1.81	EPI Suite c2000-2012

[a] All values are experimental, except for the Henry's law constant, which was derived from the vapour pressure and water solubility.

Table A-2. Physical and chemical properties of propane

Property[a]	Value	Reference
Flash point (ºC)	-104	ICAEH 2000
Liquid density (g/mL)	0.493 at 25ºC	Bolton et al. 2008
Vapour density (Air = 1)	2.05	Bolton et al. 2008
Explosive limit, % v/v in atmosphere	2.3 to 9.5%	ICAEH 2000
Vapour pressure (Pa)	9.53×10^{5} at 25ºC	EPI Suite c2000-2012
Boiling point (°C)	-42.1	HSDB 2016
Water solubility (mg/L)	62.4 at 25ºC	EPI Suite c2000-2012
Henry's law constant ($Pa \cdot m^3$/mol at 25°C)	7.16×10^{4}	EPI Suite c2000-2012
Log K_{OW}	2.36	EPI Suite c2000-2012

[a] All values are experimental, except for the Henry's law constant, which was derived from the vapour pressure and water solubility.

Table A-3. Physical and chemical properties of isobutane

Property[a]	Value	Reference
Flash point (ºC)	-83	ICAEH 2000
Liquid density (g/mL)	0.551 at 25ºC	Bolton et al. 2008
Vapour density (Air = 1)	2.01	Bolton et al. 2008

Explosive limit, % v/v in atmosphere	1.8 to 8.4%	ICAEH 2000
Vapour pressure (Pa)	$3.48×10^5$ at 25ºC	EPI Suite c2000-2012
Boiling point (°C)	-11.7	EPI Suite c2000-2012
Water solubility (mg/L)	48.8 at 25ºC	EPI Suite c2000-2012
Henry's law constant ($Pa·m^3$/mol at 25°C)	1.21×10^5	EPI Suite c2000-2012
Log K_{OW}	2.76	EPI Suite c2000-2012

[a] All values are experimental, except for the Henry's law constant, which was derived from the vapour pressure and water solubility.

Table A-4. Physical and chemical properties of *n*-butane

Property[a]	**Value**	**Reference**
Flash point (ºC)	-60	ICAEH 2000
Liquid density (g/mL)	0.573 at 25ºC	Bolton et al. 2008
Vapour density (Air = 1)	2.1	Bolton et al. 2008
Explosive limit, % v/v in atmosphere	1.9 to 8.5	ICAEH 2000
Vapour pressure (Pa)	$2.43×10^5$ at 25ºC	EPI Suite c2000-2012
Boiling point (°C)	-0.50	EPI Suite c2000-2012
Water solubility (mg/L)	61.2	EPI Suite c2000-2012
Henry's law constant ($Pa·m^3$/mol at 25°C)	9.63×10^4	EPI Suite (2012)
Log K_{OW}	2.89	EPI Suite c2000-2012

[a] All values are experimental, except for the Henry's law constant, which was derived from the vapour pressure and water solubility.