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Draft Assessment

Gas Oils and Kerosenes with Uses in Products Available to Consumers Group

Environment and Climate Change Canada
Health Canada

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Canada

Synopsis

Pursuant to section 68 of the *Canadian Environmental Protection Act, 1999* (CEPA), the Minister of the Environment and the Minister of Health have conducted an assessment of 16 substances referred to collectively under the Chemicals Management Plan as the Gas Oils and Kerosenes with Uses in Products Available to Consumers (GOKUPAC) Group. The Chemical Abstracts Service Registry Numbers (CAS RNs[1]) and their *Domestic Substances List* (DSL) names are listed in Appendix A. Forty-two CAS RNs were included in the initial draft assessment of the Gas Oils and Kerosenes Group, of which 27 substances are being addressed in separate assessments: 26 substances in an assessment of 26 Industry-restricted Gas Oils and Kerosenes and one substance, CAS RN 64742-88-7, in an assessment of the Low Boiling Point Naphthas (LBPNs) Group. The current assessment focuses on the 15 gas oils and kerosenes that remain from the 42 initially prioritized for assessment and CAS RN 64771-72-8, which is another substance prioritized for assessment that has similar physical and chemical properties as the other substances in the GOKUPAC Group.

Gas oils and kerosenes are complex and highly variable combinations of hydrocarbons produced either directly through atmospheric distillation of crude oil or by the cracking of heavier vacuum distillation streams into lighter fractions, and are considered to be of Unknown or Variable composition, Complex reaction products or Biological materials (UVCB). Six CAS RNs in this assessment are kerosenes: 8008-20-6, 64742-14-9, 64742-47-8, 64742-81-0, 64742-94-5, and 64742-96-7; the remaining ten CAS RNs are gas oils.

The gas oil and kerosene substances in this Group are found in a wide variety of products available to consumers, including self-care products (that is, cosmetics, natural health products [NHPs], and non-prescription drugs [NPDs]), air fresheners, do-it-yourself (DIY) products (for example, adhesives and lubricants), automotive products, paints and coatings, household cleaning products, and other miscellaneous products.

In addition to uses in products available to consumers, all 16 of the substances in the GOKUPAC Group were identified as being used industrially as petroleum diluents or in lubricants, petroleum production aids, printing inks, adhesives and sealants, and paints and coatings, or as industrial processing aids (for example, cleaners, degreasers). In industrial uses, gas oils and kerosenes may be consumed at the refinery where they are produced, blended into substances leaving the refinery under different CAS RNs, or transported by truck or train to other petroleum or non-petroleum sector facilities for use as feedstocks or to be blended with other feedstocks, resulting in a new CAS RN.

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Owing to the similarity between their sources, production, physical-chemical properties, and hazard, substances in the GOKUPAC Group have been assessed together in this report.

The ecological portion of this assessment uses a group-based approach that focuses on the 16 substances in the GOKUPAC Group. As there is a lack of information on when or if a CAS RN represents a refinery stream or a solvent, a range of aromatic contents from 20% to 80% by weight (wt%) is used, with one exception discussed below. The compositional variability that exists among CAS RNs and between substances with different CAS RNs in the GOKUPAC Group may lead to these substances being used interchangeably (provided they meet certain property specifications).

The uses of substances in the GOKUPAC Group identified as having the highest potential for release to the environment and that are considered in this assessment are: formulation of lubricants or lubricant additives; formulation of various products including oil-water separation aids, printing inks, adhesives and sealants, processing aids, and paints and coatings; the industrial application of certain formulated products including printing inks and adhesives and sealants; the use of processing aids by paper mills; the use of processing aids by facilities in other sectors including plastics and rubber, fabricated metal, machinery, and transportation equipment; and the application of biosolids containing gas oils and kerosenes to agricultural land. Environmental concentrations and compositions of substances in the GOKUPAC Group in surface water following wastewater treatment were estimated and compared with modelled predicted no-effect concentrations that were based on the predicted composition of substances in the GOKUPAC Group in the effluent.

Empirical and modelled aquatic toxicity data for substances in the GOKUPAC Group indicate moderate to high hazard, while empirical soil toxicity data indicate low hazard.

With the exception of the use of processing aids by paper mills, both low- and high-aromatic content GOKUPAC substances (that is, 20 wt% to 80 wt%) were predicted as unlikely to be causing harm to the environment when used in the abovementioned applications. An aromatic content of 13 wt% was applied as an upper limit in the scenario for the use of processing aids by paper mills on the basis of information provided by this industry sector. This aromatic content was also predicted as unlikely to be causing harm to the environment. It is likely that lower aromatic content GOKUPAC substances are used in most of the abovementioned applications; however, if an aromatic content greater than 13 wt% were used in processing aids used at paper mills, there would be potential for ecological harm. Substances in the GOKUPAC Group might accumulate in sediment near points of discharge; however, there is no information on their environmental concentrations or the impact of these substances on sediment-dwelling organisms.

Considering all available lines of evidence presented in this assessment, there is low risk of harm to the environment from the 16 substances in the GOKUPAC Group. It is proposed to conclude that the 16 substances in the GOKUPAC Group 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.

To assess the risk to human health, the 16 substances in the GOKUPAC Group are separated into two subgroups on the basis of differences in aromatic content and, by extension, their health effects. These subgroups are the C_9 to C_{25} predominantly aliphatic hydrocarbons (subgroup 1) and the C_9 to C_{16} predominantly aromatic hydrocarbons (subgroup 2). Within each subgroup, the CAS RNs are assumed to be interchangeable with respect to their use in categories of products available to consumers.

Gas oils and kerosenes are used in a number of industrial applications, and unintentional releases of gas oils and kerosenes may occur at production facilities. Two of the substances in this group are subject to reporting requirements for releases to air under the National Pollutant Release Inventory. This information suggests that these two substances may be present in ambient air from facilities reporting their release and could subsequently result in exposure. In addition to the potential for release of gas oil and kerosene substances to the aquatic environment through wastewater effluents from industrial sources, which may result in exposure from drinking water, exposure from food via potential use as a component in the manufacture of food packaging materials and/or as components in incidental additives may also be possible.

Exposure to the gas oil and kerosene substances in this group may also occur from the use of a wide variety of products available to consumers.

Given that health effects data specific to the gas oils and kerosenes in the human health portion of the current assessment are limited, data from similar substances (for example, kerosene-type aviation turbine fuels and LBPNs) were also considered. For the C_9 to C_{25} predominantly aliphatic hydrocarbons (subgroup 1), systemic effects on hematological parameters and spleen and adrenal weights were considered to be the critical effects following short- and long-term dermal exposures. Developmental neurotoxicity was considered to be the critical effect following short- and long-term oral and inhalation exposure. A comparison of the associated critical effect levels with the exposure estimates from some cosmetics, NHPs, an NPD, automotive products, cleaning products, DIY products, paints and coatings, and other household products available to consumers in Canada resulted in margins of exposure (MOEs) that are considered to be potentially inadequate to address uncertainties in the health effects and exposure data used to characterize risk.

For the C_9 to C_{16} predominantly aromatic hydrocarbons (subgroup 2), maternal and fetal toxicity was considered to be the critical effect following long-term oral exposures, short-term dermal exposures, and short- and long-term inhalation exposures. A comparison of the associated critical effect level with the exposure estimates from automotive products, paints and coatings, and other household products available to consumers in

Canada resulted in MOEs that are considered to be potentially inadequate to address uncertainties in the health effects and exposure data used to characterize risk.

A critical health effect used for the initial prioritization of gas oils and kerosenes for assessment was carcinogenicity, based primarily on classifications by foreign and international agencies. On the basis of the likelihood of gas oils and kerosenes to contain polycyclic aromatic compounds (PACs, comprising polycyclic aromatic hydrocarbons [PAHs] and aromatics containing heteroatoms), the European Commission classifies seven of the gas oil and kerosene CAS RNs in the present assessment as Category 1B carcinogens ("may cause cancer") and one gas oil CAS RN as a Category 2 carcinogen ("suspected of causing cancer"), but considers these substances not to be carcinogenic if they are refined to contain less than 3wt% dimethyl sulfoxide (DMSO)-extractable PAC content.

Given that the potential presence of PACs may be of concern to human health, 25 products readily available to consumers and containing substances in the GOKUPAC Group were tested to determine their levels of 16 PAHs (designated by the United States Environmental Protection Agency as priority pollutants) in order to give an approximate indication of their PAC content. Only residual to low levels (low parts per billion to low parts per million [ppm]) of these PAHs were found. According to the European Commission's classifications, these gas oils and kerosenes are therefore not considered to be carcinogenic. Converting all 16 priority pollutant PAHs into benzo[*a*]pyrene (B[*a*]P) equivalents resulted in an equivalent B[*a*]P level, which was lower than the European Union individual PAH limits for rubber and soft plastic toys and children's articles (0.5 ppm). Therefore, the PAH content in these gas oils and kerosenes used to formulate products available to consumers examined in this assessment is not considered to be of concern for human health.

On the basis of the carbon range of the gas oils and kerosenes, other potential components that may lead to health effects are benzene, toluene, ethylbenzene, and xylenes (BTEX). To address this concern, the levels of BTEX were determined in 20 products containing gas oils and kerosenes, which were readily available to Canadian consumers. On the basis of these results, the BTEX content in these gas oils and kerosenes used to formulate products available to consumers examined in this assessment is not considered to be of concern for human health.

The human health assessment for each substance took into consideration those groups of individuals within the Canadian population who, due to greater susceptibility or greater exposure, may be more vulnerable to experiencing adverse health effects. Fetuses, infants, children, and persons of reproductive age (that is, teens and adults capable of becoming pregnant) were identified as having the potential for greater susceptibility than the general population. People living in the vicinity of industrial facilities were identified as having the potential for higher exposure than the general population. In addition, young children and formula-fed infants were found to have higher exposure than adults. All of these populations were taken into consideration when assessing the potential harm to human health.

Considering all the information presented in this draft assessment, it is proposed to conclude that the 16 substances in the GOKUPAC Group meet the criteria under paragraph 64(*c*) of CEPA as they are 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.

Therefore, it is proposed to conclude that the 16 substances in the GOKUPAC Group meet the criteria set out in section 64 of CEPA.

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1. Introduction

Pursuant to section 68 of the *Canadian Environmental Protection Act, 1999* (CEPA) (Canada 1999), the Minister of the Environment and the Minister of Health have conducted an assessment of 16 substances, referred to collectively under the Chemicals Management Plan (CMP) as the Gas Oils and Kerosenes with Uses in Products Available to Consumers (GOKUPAC) Group, to determine whether these substances present or may present a risk to the environment or to human health. The 16 gas oils and kerosenes in this Group were identified as priorities for assessment as they met categorization criteria as described in ECCC, HC (modified 2017). The Chemical Abstracts Service Registry Numbers (CAS RNs[2]), *Domestic Substances List* (DSL) names, and descriptions of these 16 substances are provided in Table A-1 of Appendix A.

Forty-two CAS RNs were included in the initial draft assessment of the Gas Oils and Kerosenes Group (ECCC, HC 2019). However, 27 of the 42 substances are being addressed in separate assessments: 26 substances in an assessment of 26 Industry-restricted Gas Oils and Kerosenes (ECCC, HC 2023a) and one substance, CAS RN 64742-88-7, in an assessment of the Low Boiling Point Naphthas (LBPNs) Group (ECCC, HC 2023b). The current assessment focuses on the 15 gas oils and kerosenes that remain from the 42 initially prioritized for assessment and CAS RN 64771-72-8, which was another substance prioritized for assessment that was added to the GOKUPAC Group as it has physical and chemical properties similar to those of the other GOKUPAC substances.

The ecological assessment considers an upper aromatic content of 80% by weight (wt%) to be a reasonable worst-case for GOKUPAC substances. Compositional variability exists within and between individual gas oils and kerosenes, which can lead to these substances being used interchangeably in products, provided they meet product use specifications.

Some other gas oils were addressed previously for site-restricted (one CAS RN) or industry-restricted (two CAS RNs) uses (Environment Canada, Health Canada 2011, 2013). In addition, this draft assessment does not consider the use of kerosenes in aviation fuels or the use of gas oils in the heating fuel Fuel Oil No. 2 as these have also been assessed previously (Environment Canada, Health Canada 2014, 2015). The use of gas oils in diesel fuels is not addressed in this assessment. This assessment also

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does not consider the use of gas oils and kerosenes as petroleum diluents since this is more suitably considered in the context of the diluted petroleum substance(s).

This draft assessment includes consideration of information on chemical properties, environmental fate, hazards, uses, and exposures, including additional information submitted by stakeholders. Relevant data were identified up to March 2018, with targeted searches conducted up to June 2022. Additional data were submitted by stakeholders up to December 2019. Empirical data from key studies as well as some results from models were used to reach conclusions. When available and relevant, information presented in assessments from other jurisdictions was considered.

This draft assessment was prepared by staff in the CEPA Risk Assessment Program at Health Canada and Environment and Climate Change Canada and incorporates input from other programs within these departments. The ecological and human health portions of this assessment have undergone external written peer review and/or consultation. Comments on the technical portions relevant to the environment were received from Mr. Geoff Granville (GCGranville Consulting Corp) and Dr. Connie Gaudet (consultant). Comments on the technical portions relevant to human health were received from Ms. Theresa Lopez, Ms. Jennifer Flippin, and Dr. Joan Garey of Tetra Tech. While external comments were taken into consideration, the final content and outcome of the assessment remain the responsibility of Health Canada and Environment and Climate Change Canada.

Assessments focus on information critical to determining whether substances meet the criteria as set out in section 64 of CEPA by considering scientific information, including information, if available, on subpopulations who may have greater susceptibility or greater exposure, vulnerable environments and cumulative effects,[3] and by incorporating a weight-of-evidence approach and precaution.[4] This draft assessment presents the critical information and considerations on which the proposed conclusion is based.

2. Identity of substances

The substances in the GOKUPAC Group are of Unknown or Variable composition, Complex reaction products or Biological materials (UVCB). Six CAS RNs in this

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[3] The consideration of cumulative effects under CEPA may involve an analysis, characterization and possible quantification of the combined risks to health or the environment from exposure to multiple chemicals.

[4] 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 products intended for workplace use. 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.

assessment are kerosenes: 8008-20-6, 64742-14-9, 64742-47-8, 64742-81-0, 64742-94-5, and 64742-96-7 (CONCAWE 1995, 2001; API 2010); the remaining ten CAS RNs are gas oils. Operational definitions for all 16 GOKUPAC substances are included in Appendix A. These UVCB substances are complex combinations of hydrocarbon molecules that originate in nature or are the result of chemical reactions and processes that take place during the processing and blending of petroleum. Gas oils and kerosenes usually consist of variable proportions of straight and branched chain alkanes (also referred to as normal and isoparaffins), cycloalkanes (naphthenes), aromatic hydrocarbons, and alkenes. The aromatic fraction encompasses all components that contain an aromatic (that is, benzene) ring within their structures and includes monoaromatic hydrocarbons (MAHs) and polycyclic aromatic hydrocarbons (PAHs), aromatics containing heteroatoms (that is, nitrogen, oxygen, or sulfur atoms) in the PAH ring system, as well as alkylated derivatives of MAHs and PAHs (that is, MAHs and PAHs containing normal, branched, or cyclic alkyl groups, which are usually one to four carbons long and may also include heteroatoms). PAHs and aromatics containing heteroatoms are collectively referred to as polycyclic aromatic compounds (PACs). Overall, the relative abundance of the C_1 to C_4 alkylated PACs in petroleum far exceeds the abundance of the unsubstituted PACs (Altgelt and Boduszynski 1994 as cited in API 2012; Speight 2007 as cited in API 2012), and both heteroatom content and total PAC content increase with increasing boiling point ranges of the fractions (Speight 1998 as cited in API 2012). Given their complex and variable compositions, gas oils and kerosenes cannot practicably be synthesized by simply combining individual constituents and can be difficult to fully and consistently characterize.

Gas oils and kerosenes are both produced in a similar manner: they can be obtained directly through the atmospheric distillation of crude oil (straight-run) or from the cracking of heavier vacuum distillation streams (cracked), which usually results in higher levels of aromatics (including PACs) and alkenes (CONCAWE 2001; API 2010, 2012a). A distinction is made for hydrocracking as this process involves simultaneous cracking and hydrogenation, which converts aromatics and alkenes to cyclic, normal, and branched alkanes (CONCAWE 2001). Gas oils and kerosenes can also be a blend of various straight-run and/or cracked gas oil streams (API 2010, 2012). Light straight-run gas oils are composed predominantly of saturated hydrocarbons and the PACs are mainly two- and three-ringed compounds; heavier atmospheric, vacuum, or cracked gas oils may contain higher levels of PACs with four or more rings (API 2012). Additional processing of straight-run or cracked gas oils and kerosenes may be undertaken to remove or reduce the levels of undesirable components, such as sulfur, nitrogen, aromatics, or alkenes, and, in some cases, increase the levels of cycloalkanes and isoalkanes (CONCAWE 2001; API 2010).

Gas oils consist predominantly of molecules in the carbon number range of C_9 to C_{30} and boiling over the interval of approximately 150°C to 450°C, as defined by the American Petroleum Institute (API), which is a United States trade association representing different facets of the oil and natural gas industries (API 2012), and Conservation of Clean Air and Water in Europe (CONCAWE), which is a European petroleum industry organization (CONCAWE 2001). In the present assessment, two substances, CAS RNs 64741-85-1 and 64771-72-8, fall partly outside of the carbon and boiling point ranges identified above (that is, their carbon ranges begin at C_5, and their boiling ranges start at 35°C) (Appendix A). However, they are considered to be sufficiently similar in composition to the other gas oils and kerosenes to include them in this assessment.

Compositional information on 89 refinery gas oil samples (representing 22 CAS RNs) was generated by the API. Their aromatic content ranged from less than 1 wt% to 98.4 wt% (API 2014a). However, the less than 1 wt% and 98.4 wt% values were only found for single samples; most gas oil samples had aromatic content in the 20 wt% to 80 wt% range. Of the 22 CAS RNs for which compositional data exist, six are gas oils included in this assessment: CAS RNs 64741-44-2, 64741-77-1, 64742-38-7, 64742-46-7, 64742-79-6, and 68477-31-6. For the 20 samples representing the first five gas oil CAS RNs listed above, most had aromatic content in the 20 wt% to 40 wt% range; the only sample to contain more aromatics than aliphatics was one of four samples of CAS RN 64741-77-1, a hydrocracked gas oil, which had 64.3 wt% aromatics (API 2014a). Given that hydrocracking involves hydrogenation and that CAS RN 64741-77-1 is defined as consisting of predominantly saturated hydrocarbons (Appendix A), the other three samples of this gas oil (aromatic content of 21 wt% to 44.6 wt%) (API 2014a), are considered to be more representative of its composition. Considering these data along with the operational definitions of the gas oils in this assessment (Appendix A), nine of the ten gas oils are expected to be predominantly aliphatic, with the exception of CAS RN 68477-31-6. According to data from the API, its two samples contained 63 wt% aromatics on average (API 2014a), a finding in line with the fact that this CAS RN is the low-boiling end of a stream that is defined as consisting of predominantly aromatic hydrocarbons (ECHA 2022a).

Kerosenes,[5] the fraction of crude oil that boils approximately in the range of 150°C to 290°C and consists of hydrocarbons approximately in the range of C_9 to C_{16} (CONCAWE 2001; API 2010), represent the lighter end of the gas oil carbon range and tend to contain lower levels of aromatics than gas oils. Alkanes (normal, branched, and cyclic) generally constitute at least 70% by volume (vol%) of kerosenes, while aromatics (mainly alkylbenzenes and alkylnaphthalenes) and alkenes account for generally less than 25 and 5 vol%, respectively (API 2010). Compositional data were identified for one sample of kerosene (CAS RN 8008-20-6) and for four samples of hydrodesulfurized (HDS) kerosene (CAS RN 64742-81-0). The data for these kerosenes indicate that they contain aromatic content ranging from 18.8 wt% to 27 wt%, of which monoaromatics made up the majority (17.8 wt% to 24.7 wt%) (API 2014b). Considering this information, along with the operational definitions of the kerosenes in this assessment (Appendix A), five of the six kerosenes are expected to be predominantly aliphatic, with the exception

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[5] Kerosenes are synonymous with kerosines, and the terms appear interchangeably in the scientific literature.

of CAS RN 64742-94-5, which is defined as consisting of primarily aromatic hydrocarbons (Appendix A).

The CAS names for petroleum substances describe only the last refining step undertaken at the refinery; therefore, the source of the crude oil, overall degree of refinement, and thus the composition of a specific sample of the CAS RN of interest cannot be known solely on the basis of the CAS RN, resulting in gas oils and kerosenes with the same CAS RN having a range of possible compositions. Furthermore, refinery stream gas oils and kerosenes may undergo further refinement for use as solvents. This refinement greatly restricts the carbon range and, for many aliphatic solvents, reduces the aromatic content to below 30 wt%, with some being less than 2 wt% (HSPA 2018). However, these refined solvents often continue to be described by the CAS RNs of the refinery streams used in their production (HSPA 2018). It is likely that some of the gas oils and kerosenes CAS RNs reported for various uses herein refer to these solvents and not to refinery streams. Specific information on carbon range or aromatic content was available for some specific uses such as cosmetics (section 4) and processing aids used at paper mills (section 7.2.4) but was not generally available.

Aromatic components have been shown to be the greatest contributors to the ecotoxicity of petroleum substances (Cermak et al. 2013; Swigert et al. 2014). Due to the lack of available information on whether a CAS RN represents a refinery stream or a solvent, a range of 20 wt% to 80 wt% aromatics was generally used in the ecological assessment, with the upper end of the range, 80 wt%, considered as a worst-case scenario for the aromatic content of gas oils. However, after the publication of the initial draft assessment of the Gas Oils and Kerosenes Group, information was obtained from industry stakeholders indicating that the aromatic content of processing aids used in the paper industry ranges from 0 wt% to 13 wt%. Therefore, an aromatic content of 13 wt% was used in the paper mills exposure scenario (section 7.2.4). Distinction of gas oils from kerosenes (for example, via division into subgroups) was not necessary for the ecological assessment as gas oils and kerosenes have similar ecotoxicity (section 7.1.1).

For the human health risk assessment, the 16 substances in the GOKUPAC Group are separated into two subgroups on the basis of differences in aromatic content and, by extension, their health effects. Subgroup 1, the C_9 to C_{25} predominantly aliphatic hydrocarbons, includes nine gas oils (CAS RNs 64741-44-2, 64741-77-1, 64741-85-1, 64741-91-9, 64742-13-8, 64742-38-7, 64742-46-7, 64742-79-6, and 64771-72-8) and five kerosenes (CAS RNs 8008-20-6, 64742-14-9, 64742-47-8, 64742-81-0, and 64742-96-7) that are expected to be predominantly aliphatic. Subgroup 2, the C_9 to C_{16} predominantly aromatic hydrocarbons, includes one gas oil (CAS RN 68477-31-6) and one kerosene (CAS RN 64742-94-5) that are expected to be predominantly aromatic (see section 8.2 for more details). From a human health perspective, distinction of gas oils from kerosenes (for example, via division into subgroups) was not necessary as gas oils and kerosenes were considered to have similar health effects due to the similarity of their compositions (sections 8.2.1 and 8.2.2). Gas oils and kerosenes found in products available to consumers are expected to be highly refined and contain limited amounts of certain constituents of crude oil and refinery streams (for example, highly refined gas oils and kerosenes are expected to contain less than 3% w/w PAC content as extracted using dimethyl sulfoxide [DMSO] as determined by the Institute of Petroleum [IP] 346 method [Institute of Petroleum 1992]). However, on the basis of their carbon and boiling point ranges, the potential for the 16 substances in this assessment to contain residual levels of PAHs and benzene, plus low levels of toluene, ethylbenzene, and xylene components, was considered due to the known toxicity of these components. In certain situations, such as for the 16 substances in this assessment, the PAH content is expected to approximate the PAC content, given that the higher degree of refinement would remove the heterocyclic content. The results of the testing of Canadian products available to consumers containing gas oils and kerosenes for the 16 standard PAHs are described in section 8.1.3. The results of the testing of Canadian products available to consumers containing gas oils and kerosenes for benzene, toluene, ethylbenzene, and xylenes (BTEX) are described in section 8.1.4.

3. Physical and chemical properties

The composition and physical-chemical properties of gas oils and kerosenes vary with the source of crude oil or bitumen and the refining steps involved. General physical-chemical properties of gas oils and kerosenes are presented in Table 3-1.

Table 3-1. General physical and chemical properties of gas oils and kerosenes

Property	Substance type	Data type	Value	Temp (°C)	Reference
Pour point (°C)	Gas oils	Exp	-30 to 0	-	API 2012b
Boiling point (°C)	Gas oils	-	150 to 450	-	API 2012a
Boiling point (°C)	Kerosenes	Exp	150 to 290	-	API 2010a
Density (g/cm^3)	Gas oils	Exp	0.8 to 0.99	15	ECB 2000a-2000e
Density (g/cm^3)	Gas oils	Exp[a]	0.81 to 0.90	15	CONCAWE 1996a
Vapour pressure (Pa)	Gas oils	Mod	0.01 to 23	20	ECB 2000a-2000c
Vapour pressure (Pa)	Gas oils	-	≤133	20	SDS 2014
Vapour pressure (Pa)[b]	Gas oils	-	280 to 3520	21	Air Force 1989
Vapour pressure (Pa)	Kerosenes	Exp[c]	300 to 3500	21	API 2010a

Property	Substance type	Data type	Value	Temp (°C)	Reference
Vapour pressure (Pa)	Kerosenes	Exp[d]	1000	20	SDS 2022f
Vapour pressure (Pa)	Gas oils	Mod and exp[b]	3.6×10^{-9} to 384	20	ECCC 2023
Water solubility (mg/L)	Gas oils	-	<10	20	ECB 2000b, 2000c
Water solubility (mg/L)	Gas oils	Mod[b]	<0.001 to 52	25	API 2012b
Water solubility (mg/L)	Gas oils	Exp[e]	2.0 to 8.7	5 to 20	API 2012b
Water solubility (mg/L)	Gas oils	-	Negligible	-	SDS 2014; SDS 2018a
Water solubility (mg/L)	Kerosenes	Exp[d]	2.8 to 39	20 to 22	Murray et al. 1984; Sunito et al. 1986 as cited in Jokuty et al. 1999; MacLean and Doe 1989
Water solubility (mg/L)	Gas oils	Mod and exp[b]	8.6×10^{-11} to 95	20	ECCC 2023
Log K_{ow} (dimension-less)	Gas oils	Mod	3.4 to 9.2	-	ECB 2000a, 2000b, 2000d, 2000e
Log K_{ow} (dimension-less)	Kerosenes	Mod	3.3 to >6	20	API 2010
Log K_{ow} (dimension-less)	Gas oils	Mod and exp[b]	3.3 to 15	20	ECCC 2023

Abbreviations: exp, experimental; K_{ow}, octanol-water partition coefficient; mod, modelled; -, no data provided; temp, temperature

[a] Densities of automotive gas oil and heating oil

[b] Based on representative structures for typical gas oils and kerosenes with carbon length C_9 or C_{10} to C_{30}

[c] For kerosene-type jet fuels

[d] For diesel fuel consisting mainly of kerosenes

[e] For Fuel Oil No. 2 (a gas oil)

To predict the physical-chemical properties and ecological fate of complex petroleum substances such as gas oils and kerosenes, representative structures were chosen from each chemical class present in these substances. As the compositions of the gas oils and kerosenes are variable, representative structures were not chosen on the basis of their proportion in the mixture. This lack of general compositional data resulted in the selection of representative structures for alkanes, isoalkanes, alkenes, cycloalkanes, one-ring to six-ring aromatics, and alkyl-aromatics ranging from C_9 to C_{30}, solely on the basis of the carbon numbers for each hydrocarbon class. Physical-chemical data were assembled from scientific literature and from the Estimation Programs Interface (EPI) Suite (2008) group of environmental models. A summary of empirical and modelled physical and chemical property data for the representative hydrocarbon structures of GOKUPAC substances is provided in ECCC (2023).

It should be noted that the physical and chemical behaviour of the representative structures, when they are present as components in a UVCB substance, may differ from that of the pure form. The vapour pressures of components in a mixture are lower than their individual vapour pressures according to Raoult's Law (that is, the total vapour pressure of an ideal mixture is proportional to the sum of the vapour pressures of each individual component). Similarly, the water solubilities of components in a mixture are lower than when they are present individually (Banerjee 1984; Di Toro et al. 2007). Concurrently, when an individual petroleum hydrocarbon chemical that is normally solid under environmental conditions is part of a petroleum mixture (or UVCB), it may be found in a liquid state due to the lowering of its melting point when in a mixture (Di Toro et al. 2007). This results in an increase in the vapour pressure and water solubility of the hydrocarbon that is normally solid as determined by the subcooled vapour pressure (Staikova et al. 2005) and subcooled solubility (Di Toro et al. 2007). The physical and chemical properties of the individual representative structures (Table 1-1 in ECCC 2023) give an indication of how these components of the petroleum mixture behave in the environment. This is discussed in the assessment of Industry-restricted Gas Oils and Kerosenes (ECCC, HC 2023a) and the supporting document for this assessment (ECCC 2022).

4. Sources and uses

Information on a number of gas oils and kerosenes, including all 16 of the substances in the GOKUPAC Group, was gathered through several surveys issued pursuant to section 71 of CEPA (Canada 2008, 2009, 2011, 2015), as well as one voluntary data gathering initiative in 2015 (Table 4-1).[6]

[6] The 2008 and 2009 Notices applied only to petroleum refining and/or upgrading facilities. The 2008 survey collected information on the quantity of substances used and their industrial fate, while the 2009 survey collected information on the transportation of the substances. Seven gas oils (CAS RNs 64741-77-1, 64741-91-9, 64742-13-8, 64742-30-9, 64742-46-7, 64742-79-6, and 68477-31-6) were included in the

Table 4-1. Information on CEPA section 71 surveys and a voluntary survey that included substances in the Gas Oils and Kerosenes with Uses in Products Available to Consumers Group

Title of survey	CAS RNs from this Group surveyed	Reporting year	Survey year	Survey and data report references
Notice with respect to certain high priority petroleum substances	64741-77-1, 64741-91-9, 64742-13-8, 64742-46-7, 64742-79-6, 68477-31-6	2006	2008	Canada 2008; Environment Canada 2011a
Notice with respect to potentially industry-limited high priority petroleum substances	64741-77-1, 64742-46-7, 64742-79-6	2006	2009	Canada 2009; Environment Canada 2011b
Notice with respect to certain high priority petroleum substances on the Domestic Substances List	64741-77-1, 64741-91-9, 64742-13-8, 64742-46-7, 64742-79-6, 68477-31-6	2010	2011	Canada 2011; Environment Canada 2012
Notice with respect to certain priority petroleum substances on the Domestic Substances List	64741-85-1, 64742-14-9, 64742-38-7, 64742-81-0, 64742-96-7	2014	2015	Canada 2015; ECCC 2016a

2008 survey, and four of these (CAS RNs 64741-77-1, 64742-30-9, 64742-46-7, and 64742-79-6) were included in the 2009 survey. Of these seven CAS RNs, all but one are relevant to this assessment as CAS RN 64742-30-9 was not found to have consumer uses and is addressed in the Industry-restricted Gas Oils and Kerosenes Group assessment (ECCC, HC 2023a). The 2011 survey applied to all sectors and collected information on the manufacture, import, and use of the gas oils included in the 2008 and/or 2009 surveys. The 2015 survey collected information on industrial and commercial usage patterns, but not quantities, and included five substances in the GOKUPAC Group that were not included in the previous surveys. Information on the usage patterns of ten substances in the GOKUPAC Group were also reported to the 2015 voluntary data gathering initiative.

Title of survey	CAS RNs from this Group surveyed	Reporting year	Survey year	Survey and data report references
Voluntary data gathering initiative, 2015	8008-20-6, 64741-44-2, 64741-85-1, 64742-14-9, 64742-38-7, 64742-47-8, 64742-81-0, 64742-94-5, 64742-96-7, 64771-72-8	2014	2015	N/A; ECCC 2016b

Abbreviation: N/A, not applicable

The seven gas oils surveyed in 2008, 2009, and 2011 have been identified to be used as blending stocks for other products and/or in products available to consumers (Environment Canada 2011a, 2011b, 2012). Of these seven gas oils, five were consumed at the facilities, and three of the seven are transported mainly by pipeline to other Canadian petroleum refinery facilities. These seven gas oils may also enter commerce directly without further blending.

In general, gas oils are predominantly used as intermediate blending components in the production of fuels used in diesel engines (that is, diesel fuel) and for heating (that is, fuel oil) (API 2012). They may also serve as blending components for other fuels such as kerosene, gasoline, and aviation fuel, which leave the facility under different CAS RNs. Some gas oils are used in the production of products available to consumers.

The predominant use of kerosenes in general in the United States is as aviation turbine fuel for civilian (using Jet A or Jet A-1) and military (using JP-8 or JP-5) aircraft (API 2010), and a similar usage profile is expected in Canada. Kerosenes are also used as diesel fuel (No. 1), domestic heating fuel (Fuel oil No. 1), and illuminating kerosene (No.1-K), as well as being used as solvents in the formulation of a range of products including cleaning products, insecticides, antifoaming agents, and mold release agents (CONCAWE 1995). The kerosenes used in these products are often of a narrower distillation range than those used in fuels and are often further treated to reduce odour and aromatics content (CONCAWE 1995).

The seven gas oil substances surveyed in 2011 have been identified as being used in eight different use categories, as detailed in Table 4-2 (Environment Canada 2012). Later surveys have shown that the uses of other gas oil and kerosene substances also fall into these use categories. The highest usage quantity of these seven gas oils was as petroleum diluents (Table 4-2). In 2015, several kerosenes were also identified as being used in manufacturing in several sectors, including automotive manufacturing, fibres and filament manufacturing, and the pulp and paper sector (Table 4-3).

Table 4-2. Summary of Canadian uses and usage quantities of seven gas oils[a] submitted in response to a 2011 CEPA section 71 survey

Use category	Quantity (millions of kg)[b]	Activities	Usage information
Petroleum diluent, viscosity adjustor	1000–10 000	Pipeline transport	Blended with bitumen or crude oil
Lubricants and lubricant additives	10–100	Import, formulation, incorporation into equipment[c]	Viscosity adjustors, corrosion inhibitors, anti-scaling agents
Oil production aids[d]	1–10	Formulation, use in oil recovery	Surfactants, demulsifiers, defoamers, corrosion inhibitors, anti-scaling agents
Printing inks and printing ink additives	1–10	Import, formulation, commercial printing	Solvents, viscosity adjustors
Adhesives/sealants and their additives	0.1–1	Import, formulation, industrial use[e]	Solvents
Processing aids	0.1–1	Import, formulation, repackaging, industrial use[f]	Solvents (ingredient carriers, penetrating agents), surfactants
Products available to consumers	0.1–1	Import, formulation, distribution	Polishing agents, solvents
Paints and coatings, related additives[g]	0.01–0.1	Import, formulation, repackaging, industrial metal coating	Defoaming agents, solvents, surfactants

[a] These seven gas oils include six substances in the GOKUPAC Group (CAS RNs 64741-77-1, 64741-91-9, 64742-13-8, 64742-46-7, 64742-79-6, and 68477-31-6) and one substance in the Industry-Restricted Gas Oils and Kerosenes Group (CAS RN 64742-30-9).
[b] Values reflect quantities reported in response to the survey conducted under section 71 of CEPA (Environment Canada 2012). See survey for specific inclusions and exclusions (schedules 2 and 3).
[c] Equipment includes automobiles, engines, transformers, and rock-drilling equipment. In 2015, two other gas oils and five kerosenes were also identified as being used in lubricants and oils (Table 4-3).
[d] In 2015, one additional gas oil and two kerosenes were also identified as being used in the oil and gas industry as production or processing aids (Table 4-3).
[e] Uses include the production of flooring and glass.
[f] Industrial uses include pulp and paper production, equipment cleaning, water treatment, plastic or metal molding and gypsum board manufacture, and detection of defects in aerospace metal components.
[g] Five kerosene substances are also used in paint and coating manufacturing (Table 4-3).

Certain gas oil and kerosene CAS RNs that were surveyed (Environment Canada 2012; ECCC 2016a, 2016b) were identified as being present in, or as having the potential to be ingredients in, products available to Canadian consumers. Further gathering and review of information, including publicly available information such as safety data sheets (SDSs), indicated that the products containing these substances that are available to consumers in Canada include lubricants, automotive products, fuels and solvents, paints and coatings, adhesives and sealants, household cleaning products, lawn and garden care products, and other miscellaneous products (Table 4-3; SDSs of products containing these substances include SDSs listed in Table D-6 of Appendix D).

Table 4-3. Summary of Canadian usage information on substances in the Gas Oils and Kerosenes with Uses in Products Available to Consumers Group[a]

Use category	CAS RNs
Automobile and light-duty motor vehicle manufacturing	64742-46-7, 64742-81-0, 64742-94-5, 64742-96-7
Additive in rubber and plastic parts (for example, for automotive parts)	64741-44-2, 64742-81-0, 64771-72-8
Adhesives and sealants	64742-46-7, 64742-81-0, other (CBI)
Asphalt paving, roofing, and saturated materials manufacturing	64742-47-8
Automotive maintenance products and waxes	8008-20-6, 64741-44-2, 64742-46-7, 64742-14-9, 64742-81-0, 64742-96-7, 64771-72-8
Automotive products (unspecified) for consumer retail	64742-47-8, 64742-94-5, 64742-96-7
Cosmetics	64742-47-8, 64742-94-5
Fibres and filaments, artificial and synthetic, manufacturing	64742-81-0
Fuels (for example, gasoline, diesel, heating oil) and related products (for example, fuel additives)	64741-77-1, 64742-46-7, 64742-47-8, 64742-79-6, 64742-81-0, 64742-94-5, 8008-20-6
Ink, toner, and colourants	64741-91-9, 64742-13-8, 64742-46-7, 64742-81-0
Laboratory substances	One CAS RN (CBI)
Laundry detergent, stain remover	64742-47-8, 64742-94-5
Lubricants and oils	8008-20-6, 64741-44-2, 64742-14-9, 64742-38-7, 64742-46-7, 64742-47-8, 64742-79-6, 64742-94-5, 64742-81-0, 64742-96-7, 68477-31-6
Organic chemical manufacturing (other basic), other misc. chemical product manufacturing	64741-44-2, 64742-46-7, 64742-47-8[b], 64742-96-7
Other misc. products available to consumers (for example, candles, polish, floor care product, air freshener, insect repellant, plant fertilizer)	8008-20-6, 64742-46-7, 64742-47-8, 64742-81-0, 64742-96-7, 64771-72-8
Paints and coatings	8008-20-6, 64742-46-7, 64742-47-8, 64742-81-0, 64742-94-5, 2 others (CBI)
Paper manufacturing (paper process additive, processing aid, solids conditioning agent, carrier in defoaming	64742-13-8, 64742-46-7, 64742-47-8

Use category	CAS RNs
formulations, flocculant, coagulant aid/sludge conditioning agent, viscosity adjustor in printing inks)	
Pesticide products	64742-47-8, 64742-94-5
Products used in oil and gas industry (for example, used in oil and gas extraction, cleaning product, processing aids)	64741-77-1, 64742-47-8, 64742-79-6, 64742-81-0, 64742-96-7, 64771-72-8, 68477-31-6, other (CBI)
Pipeline transportation of crude oil	64742-81-0
Solvents (as part of a formulation)	64741-77-1, 64742-46-7, 64742-47-8, 64742-81-0, 64742-94-5, 68477-31-6, 4 others (CBI)
Surfactant/drying agent, emulsion breaker	64742-94-5
Mining sector, chemical reagent[c]	64741-85-1
Water treatment	64742-46-7, 64742-47-8

Abbreviation: CBI, Confidential Business Information

[a] Usage reflects information received in response to surveys conducted under section 71 of CEPA and a voluntary data gathering initiative (Environment Canada 2012; ECCC 2016a, 2016b). See surveys for specific inclusions and exclusions (schedules 2 and 3).

[b] Data obtained from the New Substances Notification Program

[c] Usage not commercialized as of March 2016

Eight of the 16 GOKUPAC substances (CAS RNs 8008-20-6, 64741-44-2, 64741-77-1, 64742-46-7, 64742-47-8, 64742-94-5, 64742-96-7, and 68477-31-6) are on the Pest Management Regulatory Agency (PMRA) List of Formulants as well as currently being used in pest control products in Canada (Health Canada 2022a; personal communication, email from the PMRA, Health Canada [HC], to the Existing Substances Risk Assessment Bureau [ESRAB], HC, dated March 2022; unreferenced).

Ten of the 16 GOKUPAC substances (CAS RNs 8008-20-6, 64741-44-2, 64742-14-9, 64742-46-7, 64742-47-8, 64742-81-0, 64742-94-5, 64742-96-7, 64771-72-8, and 68477-31-6) were identified as potentially being used as a component in the manufacture of food packaging materials and/or as components of incidental food additives as solvents, including lubricants for machinery, defoamers for food pads, cleaners (which are afterwards rinsed with potable water), coating for paper, paper board, inks, interior lacquer of cans, plastic films, and vinyl gloves (personal communication, emails from the Food Directorate [FD], HC, to the ESRAB, HC, dated April to June 2022; unreferenced).

Three of the 16 GOKUPAC substances (CAS RNs 64742-46-7, 64742-47-8, and 64771-72-8) were identified as being used in a wide range of cosmetic products including body moisturizers, hair products, and makeup (personal communication, emails from the Consumer and Hazardous Products Safety Directorate [CHPSD], HC, to the ESRAB, HC, dated March to June 2022; unreferenced). However, the International Nomenclature of Cosmetic Ingredients (INCI) provides ingredient names that differ from the general description for the CAS RN (for example, as per Appendix A), and multiple ingredient names are provided under the heading of each of these CAS RNs. For example, under CAS RN 64742-46-7, the following ingredient names are listed: “C13-14 Alkane”, “C13-15 Alkane”, “C15-19 Alkane”, and “C12-20 Isoparaffin”. In these circumstances, the suppliers are producing materials with more specific composition ranges and greater refinement (for example, removal of aromatic content) compared to others with the same CAS RN that may be used in other applications (personal communication, email from the CHPSD, HC, to the ESRAB, HC, dated December 2017; unreferenced). It is expected that the same substances that are listed in the Natural Health Products Ingredients Database (NHPID) (that is, CAS RNs 64742-46-7 and 64742-47-8) with specific composition ranges are used in licensed natural health products (NHPs) as they are also labelled as “C13-15 Alkane” and “C13-14 Alkane”, respectively (see below). These three substances (CAS RNs 64742-46-7, 64742-47-8, and 64771-72-8), as described under their ingredient names in the products, are therefore considered to be different in composition and much more refined than as defined by the standard CAS RN descriptions of gas oils and kerosenes when used in cosmetics.

Distillates (petroleum), hydrotreated middle (CAS RN 64742-46-7) is listed in the NHPID as “C13-15 Alkane” with a non-medicinal role for topical use only as solvent in NHPs (NHPID [modified 2022]). It is also listed in the Licensed Natural Health Products Database (LNHPD) as being present in licensed topical NHPs such as sunscreens, body moisturizers, and facial cleansers (LNHPD [modified 2021]; personal communications, emails from the Natural and Non-prescription Health Products Directorate [NNHPD], HC, to the ESRAB, HC, dated March to June 2022; unreferenced). This substance (CAS RN 64742-46-7), as described under its ingredient name in the products, is considered to be different in composition and much more refined than as defined by the standard CAS RN descriptions of gas oils and kerosenes when used in NHPs.

Distillates (petroleum), hydrotreated light (CAS RN 64742-47-8) is listed in the NHPID as “C13-14 Alkane” with a non-medicinal role for topical use only as solvent in NHPs (NHPID [modified 2022]). It is listed in the LNHPD and was identified as being present in two currently licensed NHPs that are sunscreens (LNHPD [modified 2021]; personal communication, emails from the NNHPD, HC, to the ESRAB, HC, dated March to June 2022; unreferenced). This substance (CAS RN 64742-47-8), as described under its ingredient name in the products, is considered to be different in composition and much more refined than as defined by the standard CAS RN descriptions of gas oils and kerosenes when used in NHPs.

Petroleum is listed in the NHPID as a standalone ingredient and as a homeopathic substance (for example, EHP Petroleum), which uses kerosene (CAS RN 8008-20-6) as a source material (NHPID [modified 2022]). Assuming that the ingredient “petroleum” therefore falls under CAS RN 8008-20-6, this substance is considered to be included in the LNHPD and was identified as being present as a medicinal ingredient in a number of NHPs licensed as homeopathic medicines (LNHPD [modified 2021]; personal communication, emails from the NNHPD, HC, to the ESRAB, HC, dated March to June 2022; unreferenced).

CAS RN 64742-47-8 is currently being used as a non-medicinal ingredient in one approved non-prescription drug (NPD) (sunscreen) (personal communication, email from the Pharmaceutical Drugs Directorate [PDD], HC, to the ESRAB, HC, dated March 2022; unreferenced).

5. Releases to the environment

Substances in the GOKUPAC Group may be released to the environment from activities associated with production and transportation and as a result of commercial, industrial or consumer uses. Intentional and unintentional releases of these substances from production, transportation, industrial facilities, storage, and spills were assumed to follow the same patterns identified in the assessments of Gas Oils [Industry-Restricted] (Environment Canada, Health Canada 2013) and Industry-restricted Gas Oils and Kerosenes (ECCC, HC 2023a), and details can be found in these assessments. Details on potential releases of gas oils within petroleum facilities from activities associated with processing these substances can be found in a previous assessment of Gas Oil [Site-Restricted] (Environment Canada, Health Canada 2011), and this information is also considered to apply to the processing of GOKUPAC substances.

5.1 Releases from products available to consumers

Substances in the GOKUPAC Group are found in many products available to consumers, as noted in section 4. Generally, the volume of gas oil or kerosene released from products available to consumers is small for each consumer application, and releases from these uses are expected to be dispersed across Canada. Thus, releases from consumer applications are not considered to be a significant point source of GOKUPAC substances to the environment, when compared with industrial point sources (section 7.2).

5.2 Releases from industrial facilities other than petroleum refineries

On the basis of the reported use patterns of these GOKUPAC substances as discussed in section 4, there is potential for releases to the aquatic environment through wastewater effluents from industrial sources other than petroleum refineries. Releases to the environment from industrial facilities are further discussed in section 7.2. The potential for inhalation exposure and drinking water exposure of Canadian populations that may reside near industrial facilities that release these substances to air and water, respectively, is further discussed in section 8.1.1.

6. Environmental fate and behaviour

The environmental fate and behaviour of gas oils and kerosenes, including environmental distribution, persistence, and bioaccumulation, are the same as those for Industry-restricted Gas oils and Kerosenes, which are discussed in ECCC, HC (2023a) and its supporting document (ECCC 2022).

7. Potential to cause ecological harm

7.1 Ecological effects assessment

7.1.1 Aquatic compartment

The effects of gas oils and kerosenes on aquatic organisms have previously been discussed in the assessment of Industry-restricted Gas Oils and Kerosenes (ECCC, HC 2023a) and the supporting document for this assessment (ECCC 2022). However, the aquatic toxicity of hydrocarbon solvents containing GOKUPAC substances is discussed below.

Gas oils and kerosenes may be further refined to produce hydrocarbon solvents with narrower carbon ranges and sometimes lower aromatics contents for uses in various applications. The toxicity of the five hydrocarbon solvent categories, as defined by the Hydrocarbon Solvents Producers Association and associated with the CAS RNs considered in this assessment (HSPA 2018), was modelled post-wastewater treatment to determine how the additional refining affects their toxicity compared to full-range gas oils (for example, C_9 to C_{30} hydrocarbons) (Table 2-1 in ECCC 2023). No observed effect loading rates (NOELRs) ranged from 0.011 mg/L to 0.62 mg/L for solvents with maximum aromatic contents ranging from 2 wt% to 100 wt%. These NOELRs are less hazardous than those for full-range gas oils with 20 wt% to 80 wt% aromatics (0.004 mg/L to 0.014 mg/L; Table 7-3 in ECCC, HC 2023a). Therefore, the toxicity of full-range gas oils is used as a conservative estimate of the toxicity of the GOKUPAC substances, including those used as solvents.

As gas oils and kerosenes can have differing aromatic contents, which affect their toxicity, both high and low aromatic content gas oils and kerosenes were considered for the purpose of critical toxicity value (CTV) derivation. A range of 20 wt% to 80 wt% aromatics was chosen to represent the typical range of aromatics found in gas oils and kerosenes (section 2). The high end of this range is not applicable to most kerosenes as they typically have a maximum aromatics content of about 30 wt% (section 2). The chronic toxicity of kerosenes (boiling point range of 150°C to 290°C) with an aromatics content of 30 wt% was modelled with PetroTox in low-resolution mode and was found to be similar to that of low-aromatics gas oils and kerosenes (20 wt%) (Table 4-6 of ECCC 2022). Therefore, the modelling for low aromatics gas oils and kerosenes is considered to be a good representation of the ecotoxicity of a kerosene with high aromatics content.

As these substances will persist in water long enough to have the potential to cause chronic toxicity (ECCC, HC 2023a), chronic aquatic toxicity values were considered to be most relevant for CTV derivation. Petroleum hydrocarbons, such as gas oils and kerosenes, are expected to have similar toxicities to both freshwater and marine species as they are non-polar narcotics and therefore will not be affected by the dissolved salts present in greater quantities in sea water. Therefore, aquatic toxicity data for both freshwater and marine species were considered in choosing the aquatic CTV.

The CTVs for the most sensitive species (*Rhepoxynius abronius*), which were modelled using the modelled post-wastewater treatment composition of gas oils and kerosenes, are a NOELR of 0.004 mg/L for gas oils and kerosenes with high (80%) aromatic content, and a NOELR of 0.014 mg/L with low (20%) aromatic content (Table 7-3 in ECCC, HC 2023a). These values for *R. abronius* are within one order of magnitude of most of the chronic toxicity values obtained for the six other aquatic species modelled (Table 7-3 in ECCC, HC 2023a). These values were modelled in low-resolution mode as these low-resolution values were found to be similar to, or slightly lower than, those modelled in high-resolution mode with the compositional data available for one gas oil and one kerosene (Table 7-4 in ECCC, HC 2023a).

As the maximum aromatics content of gas oils and kerosenes used in processing aids in paper mills was reported to be 13 wt%, as described in section 2, the PetroTox (2011) NOELR with *R. abronius* (0.022 mg/L), modelled as described above using an aromatics content of 13 wt%, is used as the aquatic CTV for the paper mills scenario (section 7.2.4).

As the CTVs are chronic values for the most sensitive species, no assessment factor was added to convert the CTVs to predicted no-effect concentrations (PNECs), so the PNECs are the same as the CTVs.

7.1.2 Sediment compartment

The effects of gas oils and kerosenes on sediment organisms have previously been discussed in the assessment of Industry-restricted Gas Oils and Kerosenes (ECCC, HC 2023a) and the supporting document for this assessment (ECCC 2022).

A CTV and PNEC for sediment organisms could not be determined due to the lack of data available on the toxicity of gas oils and kerosenes to organisms through sediment exposure, other than data for oil-based drilling mud fluids, which contain very low aromatic content and therefore may not be generally representative of gas oils and kerosenes.

7.1.3 Terrestrial compartment

The effects of gas oils and kerosenes on terrestrial organisms have previously been discussed in the assessment of Industry-restricted Gas Oils and Kerosenes (ECCC, HC 2023a) and the supporting document for this assessment (ECCC 2022).

The Canada-wide Standards for Petroleum Hydrocarbons (CCME 2008) provide soil standards for petroleum substances on the basis of the toxicity to a variety of terrestrial organisms (invertebrates, plants). These standards are based on four fractions of total petroleum hydrocarbons: F1 (C_6 to C_{10}), F2 (greater than C_{10} to C_{16}), F3 (greater than C_{16} to C_{34}), and F4 (greater than C_{34}) and assume an 80:20 ratio of aliphatics to aromatics. Fractions 2 and 3 encompass the carbon range of gas oils and kerosenes. The standards are also divided into four land-use classes (agricultural, residential, commercial, industrial) and two soil types (coarse-grained and fine-grained soils) for the determination of remedial standards. The most sensitive land-use and soil type is typically agricultural coarse-grained soils. The standards for F2 and F3 in agricultural coarse-grained soils are 150 and 300 mg/kg dry weight (dry wt.) of soil, respectively (CCME 2008). As gas oils could fall into both of these categories, the lower value, 150 mg/kg dry wt. of soil for F2, is the CTV for terrestrial exposure. This same value is used for kerosenes as they most resemble F2. As these Canada-wide Standards were developed to protect key ecological receptors in the soil (CCME 2008) and were chosen for the most protective scenario (that is, coarse-grained agricultural soils), no assessment factor was applied to convert the CTV to the PNEC.

7.2 Ecological exposure assessment

On the basis of the available survey data (Environment Canada 2012; ECCC 2016a, 2016b), the sectors with the greatest potential for releases of GOKUPAC substances to the environment are considered to be:

- formulation of lubricants or lubricant additives;
- formulation of various products (that is, oil-water separation aids, printing inks, adhesives and sealants, processing aids, products available to consumers, and paints and coatings) and the industrial application of certain formulated products (for example, printing inks, adhesives and sealants, and paints and coatings);
- the use of processing aids by paper mills;
- the use of processing aids by facilities in other sectors, including plastics and rubber, fabricated metal, machinery, and transportation equipment; and
- the application of biosolids to agricultural soils.

These sectors are therefore considered in the exposure scenarios described below.

7.2.1 Estimation of removal of petroleum components during wastewater treatment

The release of gas oils and kerosenes from industrial facilities generally results in a discharge to systems that treat wastewater prior to release to the aquatic environment. The composition of the components of gas oils or kerosenes that remain following wastewater treatment will differ from their original composition.

CONCAWE's (1996b) hydrocarbon block method, described in section 7.1.1 of ECCC, HC (2023a), was used to estimate the removal of petroleum hydrocarbons during wastewater treatment such that the post-wastewater treatment composition and concentration in effluent could be determined. The estimated removal rate (90% on average for gas oils and kerosenes with aromatic mass fraction ranging from 10% to 80%) was used to estimate the predicted environmental concentration (PEC) of gas oils and kerosenes in the receiving water. The estimated removal rate of 90% is applicable not only to the substances in the GOKUPAC Group but also to all 42 gas oils and kerosenes prioritized for assessment as the difference in removal estimates between these two groups is negligible (<1%).

7.2.2 Formulation of lubricants or lubricant additives

The formulation facilities identified for lubricants or lubricant additives are mainly indirect dischargers (discharging their wastewater to sewers). A conservative PEC was estimated on the basis of the largest facility in Canada, with the maximum annual lubricant formulation capacity not exceeding 1 000 000 tonnes/year (Environment Canada 2012) and an estimated 300 production days per year (ECB 2003). The facility's wastewater discharge was estimated to be 333 300 L/day on the basis of an estimated discharge rate of 100 L per tonne of lubricants formulated (OECD 2004). The quantity of gas oil and kerosene potentially released from this facility to sewer was estimated on the basis of the facility's maximum estimated wastewater discharge and a typical sewer discharge limit for oil and grease (15 mg/L as in the case of Toronto [2019]). The quantity released to receiving water was estimated as 0.5 kg/day by applying the estimated average wastewater treatment removal rate of 90%, as described above. The daily water volume was calculated as the product of the effluent flow of the local wastewater treatment system and the dilution factor of the receiving water near the discharge point. The aquatic PEC of GOKUPAC substances for the formulation of lubricants or lubricant additives was thus estimated as 3.3 µg/L on the basis of a daily water volume of 151 million L/day near the discharge point of the local wastewater treatment system receiving the facility's discharge.

The estimated PEC is considered to be a very conservative value because it is based on the highest possible release as estimated for the maximum formulation capacity for the largest facility in Canada. Adding to the conservatism of this PEC is the fact that it is applicable not only to substances in the GOKUPAC Group but also to all 42 gas oils and kerosenes prioritized for assessment. In addition, the use of the sewer discharge limit for oil and grease in the calculations implicitly assumes that GOKUPAC substances comprise the entirety of the discharged oils and greases, whereas in reality they make up only a fraction of the oils and greases discharged from these facilities.

7.2.3 Generic product formulation and industrial usage scenario

A generic indirect discharge scenario was used to provide an estimate for exposure resulting from the formulation and/or the industrial application of various products (for example, oil-water separation aids, printing inks, adhesives and sealants, products available to consumers, paints and coatings). The facilities involved in these activities are determined to be indirect dischargers that discharge their treated or untreated wastewater to wastewater treatment systems (WWTSs[7]) for final treatment before they

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[7] In this assessment, the term "wastewater treatment system" refers to a system that collects domestic, commercial, and/or institutional household sewage and possibly industrial wastewater (following discharge to the sewer), typically for treatment and eventual discharge to the environment. Unless otherwise stated, the term wastewater treatment system makes no distinction of ownership or operator type (municipal, provincial, federal, indigenous, private,

are released to the aquatic environment. This scenario is based on the facility with the highest use quantity for GOKUPAC substances and is expected to represent the largest potential release of all the facilities involved.

The annual use quantity of GOKUPAC substances was conservatively estimated by including both CAS RNs used in consumer products and industry-restricted CAS RNs. The estimate was derived by prorating for the 26 CAS RNs reported to be in commerce in Canada (ECCC 2016a, 2016b) by the seven priority gas oil CAS RNs for which use quantity data have been collected (Environment Canada 2012). The use quantity of these seven gas oils was in the range of 1 000 000 to 10 000 000 kg/year (Environment Canada 2012), and the range's logarithmic average, 3 162 000 kg/year, was used for the estimate.

Annual use quantity =

$$3\ 162\ 000 \text{ kg/year} \times 26/7 \approx 12\ 000\ 000 \text{ kg/year}$$

The daily quantity of gas oils and kerosenes released to sewer was estimated as 120 kg/day on the basis of300 days/year of estimated annual operation days and an estimated emission factor of 0.3% (ECB 2003). As this is a conservative assumption, it was assumed that there were no on-site WWTS at these facilities. The off-site wastewater treatment removal rate was estimated as 90%, as discussed above. The quantity released to receiving water was estimated as 12 kg/day.

The maximum concentration of gas oils and kerosenes in receiving water was estimated by dividing the daily quantity released to receiving water from the WWTS by the daily dilution water volume at 3500 million L/day (that is, daily wastewater flow rate × receiving water dilution near discharge point), corresponding to the site with the highest use quantity of gas oils and kerosenes. The aquatic PEC for the indirect discharge scenario was thus estimated to be 3.5 µg/L. This estimate is considered to be very conservative because the usage quantity includes both GOKUPAC substances and gas oils and kerosenes with industrial uses only (that is, all gas oils and kerosenes prioritized for assessment). Usage quantities of gas oils and kerosenes used in both consumer and industrial uses are generally higher than the usage quantities of substances with uses in products available to consumers only.

7.2.4 Use of processing aids by paper mills

This exposure scenario is based on the release of processing aids used in papermaking operations. Additional releases from deinking, an operation that occurs when inks are

partnerships). Systems located at industrial operations and specifically designed to treat industrial effluents will be identified by the terms "on-site wastewater treatment systems" and/or "industrial wastewater treatment systems".

removed from paper undergoing recycling, are possible and are discussed at the end of this section.

Information was submitted by Canadian suppliers of processing aids to the pulp and paper industry, including in response to a CEPA section 71 survey (Environment Canada 2012) and during and subsequent to the public comment period for the initial draft assessment of the Gas Oils and Kerosenes Group (personal communication, electronic messages and documents submitted from suppliers to ECCC, July to December 2019; unreferenced). This information included annual sales quantities to individual paper mills and specific functions of the processing aids, as well as the CAS RN compositions and aromatic contents of their products. The suppliers indicated that the processing aids contain a maximum aromatic content of 13 wt%, although most contain less than 5 wt%. Sales quantities were used as estimates of use quantities and ranged from less than 1 000 kg/year to more than 100 000 kg/year.

In Canada, 16 paper mills were identified as using processing aids containing GOKUPAC substances, according to data submitted in response to a CEPA section 71 survey (Environment Canada 2012). These mills are equipped with on-site secondary wastewater treatment systems, and the treated wastewater is discharged directly to receiving water, according to an in-house pulp and paper database of Environment and Climate Change Canada.

A mass balance method was used for PEC estimates. The principle of the method is described in the European Chemicals Agency (ECHA)'s guidance for environmental exposure assessment (ECHA 2016). A PEC was calculated for each of the 16 mills using the equation below:

$$\mathrm{PEC} = \frac{10^9 \times \mathrm{Q} \times \mathrm{E} \times (1 - \mathrm{R})}{\mathrm{N} \times \mathrm{F} \times \mathrm{D}}$$

where

PEC: predicted environmental concentration in receiving water near discharge point, µg/L

Q: annual use quantity of a substance at a mill, kg/year

E: emission factor to wastewater treatment, unitless fraction

R: wastewater treatment removal, unitless

N: number of annual operation days, days/year

F: daily wastewater treatment effluent flow, L/day

D: receiving water dilution factor near discharge point, unitless

10^9: conversion factor from kg to µg, µg/kg

The emission factor (E) for gas oils and kerosenes was estimated to be 0.18 using conservative assumptions, as detailed below. The remainder (0.82) of the gas oils and kerosenes contained in the processing aids is expected to sorb to pulp fibre and evaporate when paper sheets are dried through the paper machine.

Figure 7-1 shows the inputs and outputs of the papermaking process. In papermaking, a process water stream recirculated around the paper machine, called white water, is recycled and mixed with pulp feed. To prevent chemical buildup, excess white water is taken out of the recycle loop and discharged to wastewater treatment. Fresh water is added to maintain the balance of white water. The entire amount of GOKUPAC substances used during papermaking is assumed to end up in the white water and to enter the pulp feed via the white water recycle.

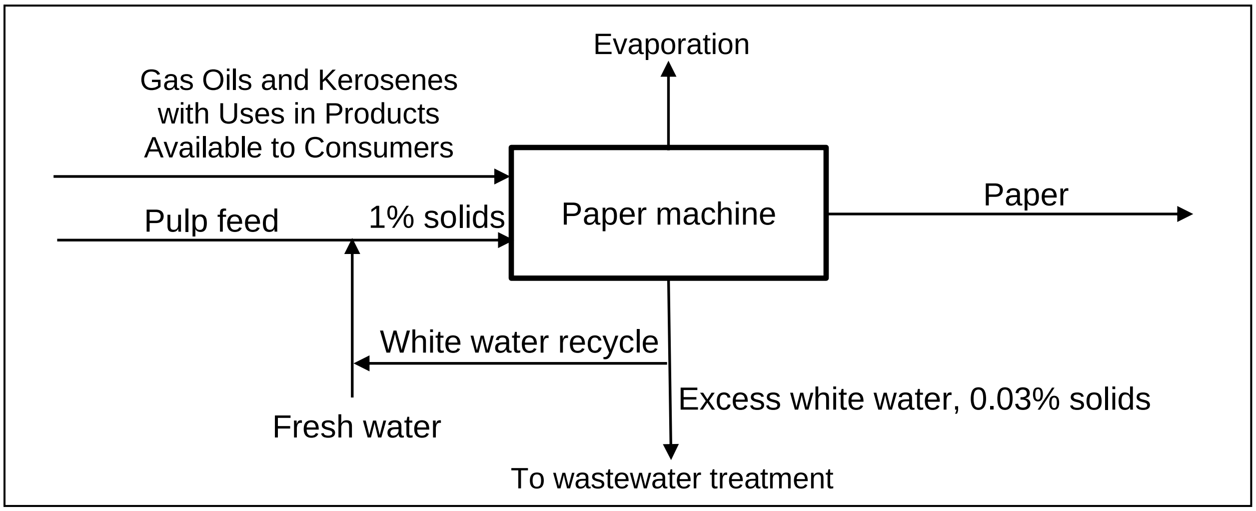

Figure 7-1. Papermaking process mass balance for emission factor estimation

By definition, the emission factor is the ratio of the quantity emitted to wastewater treatment divided by the use quantity. The quantity of GOKUPAC substances used in papermaking is proportional to their concentration in the pulp feed entering the paper machine. The quantity of GOKUPAC substances emitted to wastewater treatment is proportional to their concentration in the excess white water. As an approximation, the volumetric flow rate of the pulp feed is assumed to be the same as that of the excess white water. With this assumption, the emission factor can be estimated as the ratio of the concentration of GOKUPAC substances in the excess white water to that in the pulp feed. The gas oils and kerosenes occur in two phases, dissolved and solids. The solids-phase concentration can be correlated with the dissolved concentration, assuming equilibrium solids-water partitioning. Thus, the emission factor is given as:

$$\mathrm{E} = \frac{\mathrm{C_{excess}}}{\mathrm{C_{feed}}} = \frac{\mathrm{C_{aq} + C_{aq}K_dS_{excess}}}{\mathrm{C_{aq} + C_{aq}K_dS_{feed}}} = \frac{\mathrm{1 + K_dS_{excess}}}{\mathrm{1 + K_dS_{feed}}}$$

where

C_{excess}: concentration of GOKUPAC substances in excess white water, mg/L
C_{feed}: concentration of GOKUPAC substances in pulp feed, mg/L
C_{aq}: dissolved concentration in excess white water or pulp feed, mg/L
K_d: solids-water partition coefficient, L/kg
S_{excess}: solids content of excess white water, kg/L
S_{feed}: solids content of pulp feed, kg/L

The dissolved concentration (C_{aq}) is the same in the excess white water and the pulp feed. This is because the aqueous phase is a common phase as a result of the constant recycling of white water.

The pulp feed consists of 1% to 5% solids depending on the location of the feed line (Gavrilescu et al. 2008). Pulp fibre is an organic matter and constitutes most of the solids. The remainder of the solids consists of chemicals (for example, fillers) added during papermaking. Gas oils and kerosenes have the tendency to sorb to organic matter due to their hydrophobicity, with the extent of the sorption in direct proportion to the solids content of the pulp feed. The minimum solids content (1%) was used in this scenario to estimate the maximum loss to excess white water. Solids in white water are often removed by settling. The solids content in excess white water (S_{excess}) is in the order of 0.03% (Vurdiah 2015). This value (0.03%) was used together with the pulp feed solids content (S_{feed} = 1%) in the calculation of the emission factor.

The solids-water partition coefficient (K_d) was estimated from the octanol-water partition coefficient (K_{ow}). An empirical correlation derived for wastewater solids (equation below) was used (Dobbs et al. 1989). Wastewater solids and pulp fibre are equivalent to each other with respect to sorptive ability for neutral organic chemicals like gas oils and kerosenes owing to the presence of organic matter in the two matrices. Therefore, the use of this correlation equation for pulp fibre is deemed appropriate.

$$\log K_d = 0.58 \log Kow + 1.14 + \log f_{om}$$

where

K_{ow}: octanol-water partition coefficient, unitless

f_{om}: organic matter fraction of pulp feed solids, unitless

Values for log K_{ow} range from 3.3 to 15 for hydrocarbon components of gas oils and kerosenes (section 3). The lowest value of log K_{ow} = 3.3 was selected for an upper-end estimate for the emission factor. Pulp feed solids consist of fibre (organic matter) and added chemicals. The total chemicals added are less than 50 wt% of the pulp feed solids (OECD 2009), and the proportion of organic matter (f_{om}) is normally more than 50% but was conservatively assumed to be 50% in order to derive the maximum possible emission factor. The combination of log K_{ow} (3.3) and f_{om} (50%) yielded a lower-end estimate of 2.75 for log K_d. Using these values in the equation for the emission factor (E) above, the maximum possible emission factor was estimated as 0.18.

An average wastewater treatment removal rate of 90% was estimated, as described in section 7.2.1. Pulp and paper mills normally operate continuously throughout the year, with a typical number of annual operation days of 350 days/year (Environment Canada 2014).

The effluent flow rates of the 16 mills range from less than 10 million L/day to more than 100 million L/day. The receiving water bodies are large, and effluent needs to travel a long distance downstream before becoming fully diluted. A default value of 10-fold dilution was used to account for the limited dilution near the discharge point.

The predicted exposure concentrations (PECs) were estimated using the PEC equation given above. The PECs vary from mill to mill due to differences in use quantities and effluent flow rates. The resulting aquatic PECs are below 10 µg/L for 15 of the 16 mills, with the remaining mill having a PEC of 32 µg/L.

Deinking may contribute to releases from paper mills if both deinking and papermaking take place at a mill. GOKUPAC substances may be contained in printing ink and released during deinking. Releases from deinking are, however, expected to be negligible for a number of reasons including:

- most (up to 80%) of the gas oils and kerosenes in printing ink are expected to volatilize following the printing step, so paper products contain a relatively low content of these substances;
- most of the ink particles are removed during deinking prior to wastewater treatment via flotation followed by clarification, which has a removal efficiency rate of about 95%; and
- gas oils and kerosenes are removed in wastewater treatment systems at a rate of about 90%, as previously discussed.

Owing to the expected negligible releases of gas oils and kerosenes from deinking, these releases are not included in the above exposure scenario for paper mills.

7.2.5 Use of processing aids by facilities other than paper mills

GOKUPAC substances are present in processing aids used by various types of industrial facilities other than paper mills (Environment Canada 2012; ECCC 2016a, 2016b). They can be grouped under the following four sectors: plastics and rubber, fabricated metal, machinery, and transportation equipment.

Aquatic PECs were calculated as a distribution by dividing the maximum possible daily release quantity of gas oils and kerosenes (used as processing aids in facilities other than paper mills) by a distribution of daily dilution water volume (Table 7-2). The maximum possible daily release quantity of gas oils and kerosenes is an average quantity released to the aquatic environment from an industrial facility. It is calculated as the product of the maximum possible daily release quantity to sewer and the unremoved fraction after wastewater treatment.

The maximum possible daily release quantity to sewer was calculated as the product of the maximum possible concentration of gas oils and kerosenes in wastewater discharged to sewer and the daily wastewater volume discharged from a facility. The maximum possible concentration was assumed to equal a typical limit for the discharge of oil and grease to municipal sewers in Ontario (15 mg/L as in the case of Toronto [2019]), where 70% of industrial facilities other than paper mills are located according to section 71 survey data (Environment Canada 2012). This is a conservative assumption as gas oils and kerosenes make up only a fraction of the oil and grease discharged from these facilities.

The daily wastewater volume discharged from a facility (Table 7-1) was estimated from several data sets, including the total annual wastewater volume discharged from the four industrial sectors mentioned above (Statistics Canada 2009), the total number of establishments[8] (Industry Canada 2012), and an estimated number of annual operation days (250 days/year). This per-facility discharge volume is approximated by the per-establishment discharge volume.

Daily wastewater discharge volume from a facility

= Daily wastewater discharge volume from an establishment

= (Total annual wastewater discharge volume/Number of annual operation days)/Total number of establishments

= (59 600 million L/year / 250 days/year) / 11 883 facilities

= 20 062 L/day per facility

Table 7-1. Annual wastewater discharge volumes and number of establishments

Sector	Annual water volume discharged (million L/year) (Statistics Canada 2009)	Number of establishments (Industry Canada 2012)
Plastics and rubber	24 500	1 761
Fabricated metals	12 600	5 344

[8] The term “establishments” is broader than “facilities”. It includes industrial facilities as well as premises such as warehouses and distribution centres (Industry Canada 2012).

Machinery	2 500	3 362
Transportation equipment	20 000	1 416
Total	**59 600**	**11 883**

The maximum daily quantity of gas oils and kerosenes released from a facility to sewer was estimated as 0.30 kg/day from the daily wastewater discharge from a facility and the sewer limit for oil and grease. The quantity released to receiving water was estimated as 0.03 kg/day by applying the average wastewater treatment removal rate of 90%.

A distribution of PECs, reflecting differences in WWTS effluent flow and receiving water dilution, was determined (Table 7-2). The estimated PEC distribution is very conservative as it is applicable not only to the substances in the GOKUPAC Group but also to all 42 gas oils and kerosenes prioritized for assessment (section 4).

Table 7-2. Aquatic PEC distribution of gas oils and kerosenes used as processing aids by facilities other than paper mills

Percent of facilities (%)	Daily dilution water volume (million L/day)[a]	Aquatic PEC (μg/L)
Minimum	4556	0.007
10	2180	0.01
20	1423	0.02
30	1095	0.03
40	954	0.03
50	484	0.06
60	239	0.1
70	190	0.2
80	106	0.3
90	13.5	2.2
95	7.8	3.8
100	4.8	6.3

[a] The daily dilution water volume is calculated by multiplying the effluent flow of the wastewater treatment system by the dilution factor of the receiving water near the discharge point.

7.2.6 Agricultural soil exposure from biosolids application

Biosolids produced during wastewater treatment may be applied to agricultural fields as a soil amendment. An approach described by ECHA (2016) was used to obtain a conservative estimate for the soil exposure to GOKUPAC substances (PEC_{soil}, mg/kg). This estimate is very conservative as it is based on the use quantity of all 42 gas oils and kerosenes prioritized for assessment, as described below and in section 7.2.3.

$$\mathrm{PEC_{soil}} = \frac{\mathrm{C_s} \times \mathrm{A} \times \mathrm{N}}{\mathrm{d} \times \rho}$$

The amount of gas oils and kerosenes was assumed to accumulate over 10 consecutive years (N) within the top 0.2 m (d) layer of soil at a dry soil density of

1200 kg/m^3 (ρ), which is a generic value (Williams 1999). The maximum annual quantity limit for biosolids application in Canada is 0.83 kg/m^2-year (A) (Alberta Environment 2001). Losses via degradation, volatilization, leaching, or soil run-off were assumed to be nil, so estimates for PEC_{soil} are conservative.

The maximum concentration of gas oils and kerosenes in biosolids (C_s, mg/kg) was estimated on the basis of the maximum quantity (120 kg/day) estimated to be released to sewer from the largest formulator or industrial user (section 7.2.3). Assuming all removal (90%) was by sludge sorption, the resulting amount in biosolids was determined to be 110 kg/day. The amount of biosolids generated per day was estimated as 36 400 kg/day from the wastewater flow of 350 million L/day, associated with the largest formulator or industrial user, and the average biosolids generation rate of 104 mg per litre of wastewater derived from the field data of several Canadian secondary treatment systems (Kim et al. 2013). C_s was then calculated as 3 000 mg/kg (110 kg/day / 36 400 kg/day). The resulting soil PEC was estimated to be 103 mg/kg dry wt. This PEC is very conservative as it is applicable to all 42 gas oils and kerosenes prioritized for assessment, rather than only to those with uses in products available to consumers.

7.3 Characterization of ecological risk

The approach taken in this ecological assessment was to examine readily available information and develop proposed conclusions using a weight-of-evidence approach and precaution. Information was gathered to determine the potential for GOKUPAC substances to cause harm in the Canadian environment. Lines of evidence considered include those evaluated in this assessment that support the characterization of ecological risk in the Canadian environment. Reliable secondary or indirect lines of evidence were considered when available, including classifications of hazard or fate characteristics made by other regulatory agencies.

7.3.1 Risk quotient analysis

Risk quotient (RQ) analyses were performed by comparing the various estimates of exposure (PECs; see the Ecological Exposure Assessment section) with ecotoxicity information (PNECs; see the Ecological Effects Assessment section) to determine whether there is potential for ecological harm in Canada. RQs were calculated by dividing the PEC by the PNEC for relevant environmental compartments and associated exposure scenarios (Table 7-3).

Table 7-3. Summary of risk quotients obtained for exposure scenarios with Gas Oils and Kerosenes with Uses in Products Available to Consumers with low and high aromatic content

Exposure scenario (compartment)	PEC or PEC range (µg/L)	PNEC (high aromatic content) (µg/L)	PNEC (low aromatic content) (µg/L)[a]	RQ or RQ range (high aromatic content)	RQ or RQ range (low aromatic content)	Percentage of locations with RQ greater than 1
Formulation of lubricants and additives (water)	3.3	4	14	0.83	0.24	0
Generic indirect discharge (water)	3.5	4	14	0.88	0.25	0
Use of processing aids, paper mills (water)	0.02–32	N/A	22	N/A	<0.01–1.4	6
Use of processing aids, other industrial sectors (water)	0.007–6.3	4	14	<0.01–1.6	<0.01–0.45	<5 (if high aromatic content) 0 (if low aromatic content)
Biosolids application (soil)	103 mg/kg dw	150 mg/kg[b] dw	150 mg/kg[b] dw	0.69	0.69	0

Abbreviation: N/A, not applicable

[a] The low aromatic PNEC was based on an aromatics content of 13 wt% for the use of processing aids in paper mills and 20 wt% in the other industrial sectors.

[b] Based on Canada-wide Standard for petroleum hydrocarbons greater than C_{10} to C_{16}, with an aliphatics:aromatics ratio of 80:20.

As shown in Table 7-3, the RQs are mainly below 1, indicating low potential for ecological harm, with the following exceptions: 1 mill out of the 16 mills (that is, 6% of the mills) in the use of processing aids by paper mills has an RQ of 1.4, and a maximum RQ of 1.6 was determined for the scenario considering the use of processing aids by other industrial sectors. For the processing aids used by paper mills, because of the many conservative assumptions built into this scenario (as discussed in section 7.2.4), this RQ is not considered to indicate an actual risk to the environment. These conservative assumptions include the use of a low-end log K_{ow} value of 3.3 to overestimate emissions to wastewater, when in fact the log K_{ow} values for components of gas oils and kerosenes range from 3.3 to 15 (Table 3-1 and Table 3-2), and the assumption of a relatively low value for the fraction of organic matter in the pulp feed solids, which also overestimates releases to wastewater. In addition, a maximum aromatic content of the processing aids of 13% was used, when in fact most of the processing aids have an aromatic content of less than 5% (personal communication, electronic messages and documents submitted from suppliers to ECCC, July to December 2019; unreferenced). For the “use of processing aids by other industrial sectors” scenario, less than 5% of these facilities have RQs slightly greater than 1 for the high aromatic content scenario only; however, the actual RQs are expected to be lower than 1, considering that the exposure scenarios are very conservative as they are based on usage data for all 42 of the gas oils and kerosenes prioritized for assessment, rather than on only data for the substances in the GOKUPAC Group. This scenario also contains other conservative assumptions, such as that GOKUPAC substances comprise the entirety of the oils and greases discharged to sewer, whereas in reality they make up only a fraction of the oils and greases discharged from these facilities (section 7.2).

The RQs are below 1 for facilities using lower aromatic content (20%) GOKUPAC substances, indicating low concern for these scenarios.

7.3.2 Consideration of the lines of evidence

To characterize the ecological risk of substances in the GOKUPAC Group, technical information for various lines of evidence was considered (as discussed in the relevant sections of this report) and qualitatively weighted. The key lines of evidence supporting the assessment conclusion are presented in Table 7-4, with an overall discussion of the weight of evidence provided below. The level of confidence refers to the combined influence of data quality and variability, data gaps, causality, plausibility and any extrapolation required within the line of evidence. The relevance refers to the impact the line of evidence has when determining the potential to cause harm in the Canadian environment. Qualifiers used in the analysis ranged from low to high, with the assigned weight having five possible outcomes.

Table 7-4. Weighted lines of key evidence considered in order to determine the potential for gas oils and kerosenes to cause harm in the Canadian environment

Line of evidence	Level of confidence[a]	Relevance in assessment[b]	Weight assigned[c]
Persistence in the environment of components of gas oils and kerosenes in water, soil, and sediment	high	moderate	moderate to high
Bioaccumulation of components of gas oils and kerosenes in pelagic and mammalian aquatic organisms	high	moderate	moderate to high
PNEC for pelagic aquatic organisms (high aromatic content scenario)	moderate	high	moderate to high

Line of evidence	Level of confidence[a]	Relevance in assessment[b]	Weight assigned[c]
PNEC for pelagic aquatic organisms (low aromatic content scenario)	moderate	high	moderate to high
PNEC for soil organisms (low aromatic content scenario)	moderate	high	moderate to high
PNEC for soil organisms (high aromatic content scenario)	moderate	high	moderate to high
PEC (aquatic) for formulation of lubricants and lubricant additives	moderate	high	moderate to high
PEC (aquatic) for generic product formulation and industrial usage	moderate	high	moderate to high
PEC (aquatic) for processing aids used by paper mills	moderate	high	moderate to high
PEC (aquatic) for processing aids used by other facilities	moderate	high	moderate to high
PEC (soil) for biosolids application to agricultural soil	moderate	high	moderate to high
RQ (aquatic) for formulation of lubricants and lubricant additives	moderate	high	moderate to high
RQ (aquatic) for generic product formulation and industrial usage	moderate	high	moderate to high
RQ(s) (aquatic) for processing aids used by paper mills	moderate	high	moderate to high
RQ(s) (aquatic) for processing aids used by other facilities	moderate	high	moderate to high
RQ (soil) for biosolids application to soil	moderate	high	moderate to high

[a] Level of confidence is determined according to data quality, data variability, data gaps, and whether the data are fit for purpose.
[b] Relevance refers to the impact of the evidence in the assessment.
[c] Weight is assigned to each line of evidence according to the combined level of confidence and relevance in the assessment.

7.3.3 Weight of evidence for determining potential to cause harm to the Canadian environment

Gas oils and kerosenes contain components (for example, PAHs) that may persist in air and undergo long-range transport to remote regions. They also contain some components that might persist in soil, water, and/or sediment, thus increasing the duration of exposure to organisms. The gas oils and kerosenes assessed in this report are also expected to contain components that are highly bioaccumulative, such as PAHs and alkyl-PAHs. Studies suggest that parent PAHs will not likely biomagnify in food webs; however, there is some evidence that alkylated PAHs might. Also, PAHs and alkyl-PAHs may bioaccumulate in aquatic invertebrates as these lack the capacity to efficiently metabolize aromatic compounds.

The PNECs for aquatic organisms were modelled with PetroTox (2011) using the estimated post-wastewater treatment compositions of the gas oils and kerosenes. The PetroTox chronic modelled data without wastewater treatment are consistent with the limited empirical ecotoxicity data on gas oils and kerosenes, lending credibility to the modelled values. Most of the modelled and empirical chronic NOELRs for low and high aromatic gas oils and kerosenes are less than 0.1 mg/L, indicating that gas oils and kerosenes have high chronic toxicity to aquatic organisms. These substances will persist in water long enough to cause chronic toxicity, and they are released on a continuous basis from industry. The range of wastewater discharge rates and the average wastewater treatment removal rate of 90% for gas oils and kerosenes are considered to be reliable as the wastewater discharge rates are consistent with measured Canadian averages. The modelled removal rate is supported by monitoring data and is consistent with the physical-chemical properties of the gas oils and kerosenes (for example, high log K_{ow} and K_{oc} values of many representative structures). The main unknown for some of these scenarios is the aromatic contents of the gas oils and kerosenes, and for this reason, both low and high aromatic content scenarios were considered, where applicable. While it is recognized that gas oils and kerosenes may be further refined into solvents with smaller carbon ranges and aromatic contents ranging from very low (<2%) to very high (80% to 100%), estimations of the toxicity of solvents with various carbon ranges and maximum aromatic contents indicate that their hazard is similar to, or less than, the full carbon range gas oils and kerosenes (section 7.1.1). Thus, the use of PNECs derived from full carbon range gas oils and kerosenes provides a conservative estimate of risk for the GOKUPAC substances considered in this report (Appendix A), including their use as solvents.

RQ ranges of <0.01 to 1.4 and <0.01 to 1.6 were estimated for the scenarios involving the use of processing aids by paper mills and the use of processing aids by other industrial sectors, respectively (Table 7-3). However, as a result of the conservative assumptions used in these exposure scenarios, as discussed in section 7.3.1, these RQs are considered to be overestimates, and the risk to the environment is considered to be low. Additionally, for the “use of processing aids by other industrial sectors” scenario, RQs greater than 1 were only estimated using substances of high aromatic content, although GOKUPAC substances with lower aromatic content may often be used. On the basis of the information received (section 7.2.4), the aromatic content of the processing aids used at paper mills is 13 wt% or less. However, if the processing aids used at paper mills were to contain an aromatic content of greater than 13 wt%, there would be potential for ecological harm. For all other exposure scenarios, the RQs were below 1, indicating low potential for ecological harm at current exposure levels. The above information indicates that GOKUPAC substances are not likely to be causing harm to organisms in Canada

7.3.4 Sensitivity of conclusion to key uncertainties

The composition of gas oils and kerosenes as defined by the proportions of aliphatic and aromatic chemical classes varies greatly owing to natural compositional differences as well as the type of processing they have undergone, such that the aromatic content can vary substantially even within one CAS RN. There is uncertainty regarding whether, in some industrial facilities, normal variation in a single product from a single supplier would cover a broad range of aromaticity. This is important as aromatic content influences the toxicity of gas oils and kerosenes (section 7.1). To address this uncertainty, the analyses of risk for industrial uses considered a range of aromatic contents, where applicable. However, the lack of information on aromatics content would not affect the outcomes of most of the scenarios (for example, scenario for formulation of lubricants and lubricant additives, general indirect discharge scenario) as the level of risk was found to be low in these scenarios even with high aromatics content gas oils and kerosenes.

The Canada-wide Standards for Petroleum Hydrocarbons in Soil (CCME 2008) assumes an aromatic to aliphatic ratio of 20:80. As aromatic hydrocarbons have been found to be the primary contributors to toxicity in earthworms (Cermak 2013), the standards are expected to be protective for gas oils and kerosenes with aromatic contents lower than 20%. For gas oils and kerosenes with a higher aromatic content, the standards may be less protective. However, given that the soil RQ was less than 1 on the basis of the standard for Fraction 2 (greater than C_{10} to C_{16}), which is conservative for gas oils and kerosenes as it represents only the lower, more toxic portion of the carbon range, this uncertainty is not considered to affect the proposed conclusion.

Some components of GOKUPAC substances released to water are expected to partition to sediments and may accumulate over time, with some of these components persisting in sediment. A determination of risk to sediment organisms could not be made due to the lack of information on environmental concentrations in sediment near points of effluent discharge and on the toxicity of gas oils and kerosenes to organisms through sediment exposure.

Since quantity data for GOKUPAC substances were very limited, the ecological exposure assessment used average quantity data for seven gas oils in this assessment, most of which have both industrial and consumer uses and thus are expected to have greater usage quantities than their consumer use only quantities (section 7.2.3). In addition, the exposure calculations assumed releases of GOKUPAC substances that were up to the sewer discharge limit for all oils and greases, although the substances would be expected to represent only a fraction of the oil and grease discharged from facilities. This resulted in very conservative PECs and RQs, which strengthen the proposed conclusion that substances in the GOKUPAC Group are unlikely to be causing ecological harm in Canada.

8. Potential to cause harm to human health

For the purpose of the human health assessment, the 16 substances in the GOKUPAC Group have been separated into two subgroups, the members of which are expected to have similar toxicological properties (see section 8.2 for more details).

8.1 Exposure assessment

The focus of the human health exposure assessment in this report is to characterize general population exposure to GOKUPAC substances from the use of products available to consumers and from environmental media and food. Exposures from industry-restricted, site-restricted, and certain fuel uses of gas oils and kerosenes have been previously assessed (Environment Canada, Health Canada 2011, 2013, 2014, 2015; ECCC, HC 2023a).

8.1.1 Environmental media and food

Environmental media

Substances in the GOKUPAC Group may be released to the environment from activities associated with production and transportation, and as a result of commercial, industrial, or consumer uses. The activities identified in section 7.2 as the ones with the greatest potential for release of these substances to the environment are the formulation of lubricants or lubricant additives, the industrial application of certain formulated products, the use of processing aids by facilities in certain sectors (including in the paper industry), and the application of biosolids to agricultural soils. Releases to ambient air may occur as a result of industrial and commercial activities. In industrial settings, wastewater containing gas oils and kerosenes are typically subject to wastewater treatment, but residual gas oils and kerosenes may be released in treated water into streams, rivers, and lakes. Spills of gas oils and kerosenes may occur during the transportation of these substances for industrial use. As described in section 5, potential releases from spills are addressed in the assessment of Industry-restricted Gas Oils and Kerosenes (ECCC, HC 2023a) and are not addressed further in this assessment.

No Canadian or recent international data on the levels of GOKUPAC substances in indoor or outdoor air, water, dust, or soil were identified through searches of available literature.

Potential intake of subgroup 1 and subgroup 2 GOKUPAC substances via ambient air is described below in sections 8.1.1.1 and 8.1.1.2, respectively.

There is potential for release of substances in the GOKUPAC Group to the aquatic environment through wastewater effluents from industrial sources, as described in section 7.2. Given the absence of surface or drinking water monitoring data attributable to the whole substances in the GOKUPAC Group, an estimated concentration of the substances in surface water was used as a surrogate for drinking water. Specifically, the highest industrial aquatic PEC calculated in section 7.2, which is 32 µg/L (from the use of processing aids by paper mills), was used. The ranges of PECs described in section 7.2 represent the potential concentrations of these gas oil and kerosene substances in a receiving body of water near the discharge point of a WWTS. These scenarios, which were developed for the purpose of ecological exposure assessment, are anticipated to be overly conservative within the context of assessing drinking water exposures that would be expected to occur downstream rather than at the point of discharge. One of the key input parameters in the scenarios in section 7.2 is the application of a dilution factor of 10 to account for limited dilution near the discharge point; application of such a dilution factor, however, would likely not be representative of a realistic scenario for assessing drinking water exposures farther downstream and may result in an overestimate of the concentration that would potentially be present in drinking water. The maximum daily intake estimate for GOKUPAC substances in drinking water for formula-fed infants (0 to 5 months; via the use of drinking water in formula) was calculated as 0.0042 mg/kg bw/day using the industrial aquatic PEC of 32 µg/L (section 7.2), body weight of 6.3 kg (Appendix D) and infant formula intake of 0.826 L/day (Health Canada [modified 2022]). This estimated daily intake is applicable to all CAS RNs in this assessment. For the combined daily intakes estimated in sections 8.3.1.1 and 8.3.2.1, the daily intake from drinking water for infants of 1 year of age is used (0.00105 mg/kg bw/day) instead of the higher value for formula-fed infants of 0 to 5 months because infants of 1 year are the highest exposed age group on a mg/kg bw/day basis when daily intakes from environmental media and food are combined for each age group.

Implications regarding potential PAH and BTEX content in drinking water are discussed in section 8.3.3.

Direct releases to soil are not anticipated. While biosolids produced during wastewater treatment may contain these substances and may be applied to agricultural land (section 7.2.6), this application is not expected to be a significant source of exposure to the general population as the resulting soil PEC was estimated to be in the ppm range and was considered very conservative, and because the general population would not likely be exposed to agricultural soil directly.

8.1.1.1 Subgroup 1 (C9 to C25 predominantly aliphatic hydrocarbons)

One of the substances in subgroup 1 of the GOKUPAC Group, CAS RN 64742-47-8, was included in the National Pollutant Release Inventory (NPRI) (NPRI 2021). On the basis of information submitted to the NPRI, there may be a potential for inhalation exposure to this substance for populations that reside near these facilities. SCREEN3, a tier-one air dispersion model developed by the United States Environmental Protection Agency (US EPA) (SCREEN3 2013), was used to estimate the potential ambient air concentration of substances in this group.

To determine the highest estimated daily and annual average ambient air concentrations that the general population may be exposed to, both the release amounts and the distance of the reporting facility to nearby residential areas from the reported releases for the past five years (2017 to 2021) were considered. The highest estimated concentrations were derived for a facility that released 161 tonnes of CAS RN 64742-47-8 for the 2017 reporting year, where residences were identified at a distance of 350 m from the release site (NPRI 2018). Using the release rates and exposure factors described in Table D-2 of Appendix D, the daily and annual average ambient air concentrations for CAS RN 64742-47-8 resulting from facility releases to air at a distance of 350 m were estimated to be 0.54 and 0.27 mg/m^3, respectively. Assuming 100% systemic absorption by the inhalation route, these concentrations represent a potential daily intake of 0.11 mg/kg bw/day (adults, 19+ years) to 0.32 mg/kg bw/day (infants, 1 year) when considering the daily average concentration, and of 0.055 mg/kg bw/day (adults, 19+ years) to 0.16 mg/kg bw/day (infants, 1 year) when considering the annual average concentration. As the estimated air concentrations of CAS RN 64742-47-8 are expected to be the highest of those within the vicinity of a residential area, in consideration of the NPRI data available for the past five years (2017 to 2021), the respective intake estimates are considered to be a conservative overall representation of environmental exposure to the subgroup 1 gas oil and kerosene substances in this assessment. Details on the exposure factors and parameters used to generate the air concentrations and intake estimates are presented in Appendix D.

8.1.1.2 Subgroup 2 (C9 to C16 predominantly aromatic hydrocarbons)

One of the substances in subgroup 2 of the GOKUPAC Group, CAS RN 64742-94-5, was included in the NPRI (NPRI 2021). On the basis of information submitted to the NPRI, there may be a potential for inhalation exposure to this substance for populations that reside near these facilities. SCREEN3, a tier-one air dispersion model developed by the US EPA (SCREEN3 2013), was used to estimate the potential ambient air concentration of substances in this group.

To determine the highest estimated daily and annual average ambient air concentrations that the general population may be exposed to, both the release amounts and the distance of the reporting facility to nearby residential areas from the reported releases for the past five years (2017 to 2021) were considered. The highest estimated concentrations were derived for a facility that released 57 tonnes of CAS RN 64742-94-5 for the same year where residences were identified at a distance of 400 m (NPRI 2020). Using the release rates and exposure factors described in Table D-2 of Appendix D, the daily and annual average ambient air concentrations for CAS RN 64742-94-5 resulting from facility releases to air at a distance of 400 m were estimated to be 0.078 and 0.039 mg/m^3, respectively. Assuming 100% systemic absorption by the inhalation route, these concentrations represent a potential daily intake of 0.034 mg/kg bw/day (adults, 19+ years) to 0.12 mg/kg bw/day (infants, 1 year) when considering the daily average concentration, and 0.017 mg/kg bw/day (adults, 19+ years) to 0.058 mg/kg bw/day (infants, 1 year) when considering the annual average concentration. As the estimated air concentrations of CAS RN 64742-94-5 are expected to be the highest of those within the vicinity of a residential area, in consideration of the NPRI data available for the past five years (2017 to 2021), the intake estimate is considered to be a conservative overall representation of environmental exposure to the subgroup 2 gas oil and kerosene substances in this assessment. Details on the exposure factors and parameters used to generate the air concentrations and intake estimates are presented in Appendix D.

Food

8.1.1.3 Subgroup 1 (C9 to C25 predominantly aliphatic hydrocarbons)

An analysis of the ten substances in the GOKUPAC Group identified as potentially present in food packaging and/or incidental additives identified three subgroup 1 substances (CAS RNs 64741-44-2, 64742-46-7, and 64742-47-8) that may be used as a component in the manufacture of food packaging materials and that have the potential for direct contact with food, resulting in potential exposure at or above 25 ng/kg bw/day (2.5×10^{-5} mg/kg bw/day). CAS RN 64742-47-8 may also be used as a solvent in the manufacturing of vinyl gloves, which have a food packaging application. Probable daily intake (PDI) of these substances were estimated to be 0.33, 0.26, and 0.029 µg/kg bw/day (3.3×10^{-4}, 2.6×10^{-4}, and 2.9×10^{-5} mg/kg bw/day), respectively. In the absence of migration data to refine the exposure estimate, worst-case scenarios were assumed, and as a result, these estimates should be considered as conservative (personal communication, emails from the FD, HC, to the ESRAB, HC, dated November 2017 and April to June 2022; unreferenced).

For the other subgroup 1 substances that may be used as a component in the manufacture of food packaging materials where the potential for direct food contact has been identified (CAS RNs 64742-14-9, 64742-94-5, and 64742-96-7), the exposure is considered to be below 25 ng/kg bw/day (2.5×10^{-5} mg/kg bw/day). Additionally, the oral exposures for CAS RNs 8008-20-6, 64742-81-0, and 64771-72-8 from food packaging (no food contact) and CAS RNs 64742-46-7, 64742-47-8, 64742-81-0, 64742-94-5, 64771-72-8, and 68477-31-6 from their potential use as components in incidental additives are considered to be below the same threshold (personal communication, emails from the FD, HC, to the ESRAB, HC, dated November 2017 and April 2022; unreferenced).

With respect to the potential combined daily intake of subgroup 1 substances that may be present in environmental media and food, the highest potential daily intake of CAS RN 64742-47-8 amongst all age groups was estimated to be 0.32 mg/kg bw/day (infants, 1 year; from drinking water, ambient air, and food). This estimate is considered to be highly conservative as it assumes that individuals live within the proximity of industrial releases to both air and water emitted by different facilities. The highest potential daily intakes of CAS RNs 64741-44-2 and 64742-46-7 were estimated to be 0.0045 mg/kg bw/day for each substance (formula-fed infants, 0 to 5 months; from drinking water and food).

8.1.1.4 Subgroup 2 (C9 to C16 predominantly aromatic hydrocarbons)

For the one subgroup 2 substance (CAS RN 64742-94-5) identified by Health Canada's Food Directorate that may be used as a component in the manufacture of food packaging materials where there is potential for direct food contact, and that has potential use as a component in incidental additives where there is potential for oral exposure, the exposures are considered to be below 25 ng/kg bw/day (2.5×10^{-5} mg/kg bw/day) (personal communication, emails from the FD, HC, to the ESRAB, HC, dated November 2017 and April 2022; unreferenced).

With respect to the potential combined daily intake of subgroup 2 substances that may be present in environmental media and food, the highest potential daily intake of CAS RN 64742-94-5 was estimated to be 0.12 mg/kg bw/day (infants, 1 year; from drinking water and ambient air). This estimate is considered to be highly conservative as it assumes that individuals live within the proximity of industrial releases to both air and water emitted by different facilities.

8.1.2 Products available to consumers

Exposure to substances in the GOKUPAC Group may occur from the use of various products available to consumers, such as cosmetics, do-it-yourself (DIY) products (for example, adhesives and lubricants), automotive products, paints and coatings, household cleaning products, and other miscellaneous products. Depending on the product, exposure may occur via the oral, dermal, and/or inhalation route.

In addition, there is the potential for exposure to carcinogenic PAHs as residual components in products available to consumers containing gas oil and kerosenes. For the inhalation route, potential exposures to residual BTEX fractions were also considered. Consideration of potential exposure to these residual components is presented in sections 8.1.3 and 8.1.4.

To evaluate the potential for exposure to the 16 gas oil and kerosene substances in this assessment, the sentinel scenarios that resulted in the highest levels of exposure potential via the oral, dermal, and inhalation routes were selected. Factors such as reported concentration (that is, the products containing the highest concentration of a gas oil or kerosenes CAS RN among products in the same category) and availability to Canadians for the purpose of home use or DIY projects were taken into consideration. Due to the high number of products available to consumers that contain these substances, it is possible that additional products that may result in a similar or even higher level of exposure may be available to consumers but not be represented in this assessment. Sentinel scenarios were identified on the basis of the best available information at the time of the assessment.

If multiple substances from the same subgroup were present in the same product, exposure from these substances was combined as their resulting hazard is expected to be similar, and the cumulative exposure is considered for risk characterization purposes.

8.1.2.1 Subgroup 1 (C9 to C25 predominantly aliphatic hydrocarbons)

For subgroup 1 substances, route-specific hazard studies are used for risk characterization; as a result, exposures via the dermal and inhalation routes from use of the same product are considered separately.

The following exposure estimates were calculated using the exposure factors and scenario parameters described in Appendix D.

Potential oral exposure from use of lipstick or lip balm containing CAS RN 64742-46-7 was estimated to range from 0.27 mg/kg bw/day to 0.66 mg/kg bw/day on the basis of the maximum concentration of 44.9%. Potential oral exposure from use of lipstick or lip balm containing CAS RN 64742-47-8 was estimated to range from 0.18 mg/kg bw/day to 0.44 mg/kg bw/day on the basis of a maximum concentration of 30%. Exposure from the oral route for subgroup 1 CAS RNs 8008-20-6, 64741-44-2, 64741-77-1, 64741-91-9, 64742-14-9, 64742-81-0, 64742-96-7, and 64771-72-8 is not expected from the use of products available to consumers owing to the types of uses identified.

Potential dermal exposure to CAS RN 64771-72-8 from use of mascara was estimated to range from 0.0024 mg/kg bw/day to 0.0078 mg/kg bw/day on the basis of the maximum concentration of 1%. The potential inhalation exposure was estimated to range from 1.4×10^{-4} mg/kg bw/day to 3.2×10^{-4} mg/kg bw/day. Estimated dermal and inhalation exposures from use of cosmetics containing CAS RN 64742-46-7 and 64742-47-8 are summarized in Table 8-1 and Table 8-2, respectively.

Table 8-1. Estimated dermal and inhalation exposures to CAS RN 64742-46-7 from use of cosmetics on the day of use

Exposure scenario	Maximum concentration (%)[a]	Subpopulations	Dermal exposure (mg/kg bw/day)	Inhalation exposure (mg/kg bw/day)[b]
Face moisturizer	46.55	Children, teens, adults	11 to 19	0.23 to 0.27
Hand moisturizer	5	Children, teens, adults	1.3 to 2.9	0.068 to 0.11
Body moisturizer	50	Infants, children, teens, adults	68 to 159	0.39 to 0.85
Deodorant/antiperspirant (solid/roll-on)	10	Children, teens, adults	1.0 to 1.8	Minimal[c]
Facial foundation (liquid)	13.75	Children, teens, adults	0.91 to 2.0	0.050 to 0.078

Hair conditioner, leave-on (cream or semi-solid cream)	3	Children, teens, adults	0.48 to 1.0	0.11 to 0.16
Hair oil or serum	80	Children, teens, adults	0.34	0.044 to 0.076
Hair styling product (for example, pomade, balm, cream, or putty)	15	Children, teens, adults	0.75 to 2.8	0.16 to 0.37
After hair-removal wipe	10	Children, teens, adults	1.2 to 2.1	0.016 to 0.025
Hairspray (for example, aerosol)	10	Children, teens, adults	0.32 to 0.85	0.019 to 0.036
Facial make-up remover (for example, biphasic oil and water)	34.67	Children, teens, adults	1.2 to 3.3	0.026 to 0.052
Face mask	30	Teens, adults	3.9 to 4.7	0.00010 to 0.00013
Massage oil	30	Infants, children, teens, adults	13 to 86	0.038 to 0.081
Spray perfume/eau de toilette	10	Children, teens, adults	0.62 to 1.9	0.0037 to 0.0065
Face spray (anti-aging)	30	Adults	2.3	0.013
Hair conditioner, wash-off	30	Children, teens, adults	0.48 to 1.0	0.011 to 0.016
Temporary hair dye	1	Children, teens, adults	0.47 to 1.5	0.0030 to 0.0047
Eye shadow	20	Children, teens, adults	0.029 to 0.078	0.0013 to 0.0030
Shampoo	3	Infants, children, teens, adults	0.050 to 0.19	0.00093 to 0.0021

[a] On the basis of notifications submitted under the *Cosmetic Regulations* to Health Canada (personal communication, emails from the CHPSD, HC, to the ESRAB, HC, dated March to June 2022; unreferenced)
[b] Internal dose (mg/kg bw/day) = mean air concentration on day of exposure (mg/m^3) × inhalation rate (m^3/day) / body weight (kg) (see Appendix D)
[c] The applied skin surface area is occluded or obstructed, thereby limiting volatilization of the substance from the applied skin surface to room air and inhalation exposure.

Table 8-2. Estimated dermal and inhalation exposures to CAS RN 64742-47-8 from use of cosmetics on the day of use

Exposure scenario	Maximum concentration (%)[a]	Subpopulations	Dermal exposure (mg/kg bw/day)	Inhalation exposure (mg/kg bw/day)[b]
Face moisturizer	30	Children, teens, adults	7.3 to 12	0.37 to 0.63

Hand moisturizer	5	Children, teens, adults	1.3 to 2.9	0.069 to 0.11
Body moisturizer	20	Infants, children, teens, adults	27 to 63	0.15 to 0.33
Spray perfume/eau de toilette	30	Children, teens, adults	1.8 to 5.6	0.011 to 0.019
Hair conditioner, leave-on (cream or semi-solid cream)	30	Children, teens, adults	4.8 to 10	1.1 to 1.6
Hair oil or serum	100	Children, teens, adults	0.42	0.052 to 0.087
Hair styling product (for example, pomade, balm, cream, or putty)	17.16	Children, teens, adults	0.86 to 3.2	0.18 to 0.42
Genital product	1.5	Adults	2.0	Minimal[c]
Permanent hair dye	4.55	Teens, adults	8.2 to 9.7	0.053 to 0.066
Semi-permanent hair dye	4.55	Teens, adults	2.2 to 2.6	0.052 to 0.063
Hairspray (aerosol)	60	Children, teens, adults	1.9 to 5.1	0.11 to 0.21
Waterless hand cleaner	37	Adults	10	0.52
Massage oil	1.92	Infants, children, teens, adults	0.83 to 5.5	0.019 to 0.038
Foot moisturizer	10	Teens, adults	5.6 to 6.6	Minimal[c]
Body pack	0.73	Adults	2.9	0.17
Sunless tanning lotion	1	Adults	1.4	0.028
Facial foundation (liquid)	10	Children, teens, adults	0.66 to 1.5	0.036 to 0.056
Facial makeup remover (lotion)	10	Children, teens, adults	0.52 to 0.95	0.010 to 0.016
Face mask	10	Teens, adults	1.3 to 1.6	0.0030 to 0.0037
After hair-removal (body)	0.6	Children, teens, adults	0.58 to 0.78	0.0072 to 0.0090
Heavy duty hand cleaner	30	Adults	0.70	0.015

After sun (cream/milk)	0.3	Infants, children, teens, adults	0.49 to 1.8	0.0081 to 0.017
Shaving cream (face)	1	Children, teens, adults	0.0092 to 0.015	0.00019 to 0.00029
Shampoo	3	Infants, children, teens, adults	0.050 to 0.19	0.00092 to 0.0020

[a] On the basis of notifications submitted under the *Cosmetic Regulations* to Health Canada (personal communication, emails from the CHPSD, HC, to the ESRAB, HC, dated March to June 2022; unreferenced)
[b] Internal dose (mg/kg bw/day) = mean air concentration on day of exposure (mg/m^3) × inhalation rate (m^3/day) / body weight (kg) (see Appendix D)
[c] Inhalation exposure during application is expected to be minimal, and the applied skin surface area is occluded or obstructed, thereby limiting volatilization of the substance from the applied skin surface to room air and inhalation exposure.

The estimated dermal and inhalation exposures to CAS RN 64742-46-7 and CAS RN 64742-47-8 from use of NHPs are summarized in Table 8-3.

Table 8-3. Estimated dermal and inhalation exposures to gas oils and kerosenes from use of NHPs on the day of use

Exposure scenario (CAS RN)	Maximum concentration (%)[a]	Subpopulations	Dermal exposure (mg/kg bw/day)	Inhalation exposure (mg/kg bw/day)[b]
Sunscreen (64742-46-7)	3	Infants, children, teens, adults	6.3 to 28	0.12 to 0.28
Liquid foundation with SPF (64742-46-7)	9	Children, teens, adults	0.60 to 0.84	0.032 to 0.040
Facial cleanser (64742-46-7)	5.297	Children, teens, adults	0.034 to 0.047	4.8×10^{-4} to 7.4×10^{-4}
Body moisturizer (64742-46-7)	4	Children, teens, adults	5.4 to 7.3	0.056 to 0.067
Sunscreen (64742-47-8)	4.85	Infants, children, teens, adults	10 to 46	0.20 to 0.45

Abbreviation: NHP, Natural Health Product; SPF, sun protection factor
[a] Personal communication, emails from the NNHPD, HC, to the ESRAB, HC, dated March to June 2022; unreferenced
[b] Internal dose (mg/kg bw/day) = mean air concentration on day of exposure (mg/m^3) × inhalation rate (m^3/day) / body weight (kg) (see Appendix D)

There is one approved NPD, a sunscreen, which contains CAS RN 64742-47-8 as a non-medicinal ingredient at 4% (personal communication, email from the PDD, HC, to the ESRAB, HC, dated March 2022; unreferenced). The exposure from the use of this NPD is considered to be within the same range as the NHP sunscreen presented in Table 8-3 above.

The estimated dermal and inhalation exposures to subgroup 1 substances in the GOKUPAC Group from the use of other types of products available to consumers (for example, DIY products) are presented in Table 8-4. Product scenarios presented in Table 8-4 represent both scenarios that are associated with the highest exposure and the range of product types that are available to consumers. In certain cases, there are other products within a product category that are also associated with high exposure, but these were not presented as it was considered more appropriate to present the variety of products available to consumers as opposed to all products within a specific category with high exposure potential. The maximum concentrations (wt%) of the gas oil and kerosene CAS RNs used in these products were obtained predominantly from SDSs; the individual SDSs used in the scenarios presented below are cited in Appendix D.

Table 8-4. Estimated dermal and/or inhalation exposures to subgroup 1 gas oils and kerosenes from other products available to consumers on the day of use

Exposure scenario[a] (CAS RN)	Maximum concentration (%)	Dermal exposure (mg/kg bw/day)	Inhalation exposure (mg/kg bw/day)[b]
Engine cleaner spray (8008-20-6)[c]	30[c]	0.20	0.35
Penetrating lubricant spray (8008-20-6)	30	0.81	2.30
Engine cleaner spray (64741-77-1)	85	0.57	1.0
Automotive interior detailer/cleaner spray (64741-44-2)	5	0.50	0.34
Firearm cleaner (64741-91-9)	60	5.3	0.00044
Automotive wax (64742-14-9)	30	2.9	N/A
Automotive interior detailer/cleaner spray (64742-46-7)	30	2.9	2.1
Construction adhesive (64742-46-7)	5	0.18	6.5
Countertop polish/cleaner (64742-46-7)	25	1.1	1.1
Furniture polish liquid	100	7.6	85

Exposure scenario[a] (CAS RN)	Maximum concentration (%)	Dermal exposure (mg/kg bw/day)	Inhalation exposure (mg/kg bw/day)[b]
(64742-46-7)			
Furniture polish spray (64742-46-7)	60	6.1	76
Leather protectant spray (64742-46-7)	6	0.49	1.7
Adhesive spray – automotive (64742-47-8)	1.5	0.11	0.49
Adhesive remover liquid – larger scale project (64742-47-8)	100	97	290
Adhesive remover spray – smaller scale project (64742-47-8)	100	0.041	0.40
Automotive polish (64742-47-8)	50	4.9	N/A
Air freshener – nebula diffuser for home (64742-47-8)	80	N/A	1.2 (infant, 1 year) 0.33 (adult, 19+ years)
Automotive interior detailer/cleaner spray (64742-47-8)	90	7.5	6.2
Automotive metal polish (64742-47-8)	65	3.7	0.62
Automotive spray paint (64742-47-8)	25	5.1	5.5
Fabric waterproofing spray (64742-47-8)[c]	75	0.32	18
Floor paste wax (64742-47-8)	100	1.4	11
Furniture polish spray (64742-47-8)	65.6	6.7	82

Exposure scenario[a] (CAS RN)	Maximum concentration (%)	Dermal exposure (mg/kg bw/day)	Inhalation exposure (mg/kg bw/day)[b]
Interior paint primer (64742-47-8)	30	15	160
Lamp oil (64742-47-8)	100	0.0022	0.0012
Paint thinner – cleaning brushes (64742-47-8)	100	28	1.2
Penetrating lubricant spray (64742-47-8)	80	2.2	6.2
Portable heater fuel (64742-47-8)	100	0.037	0.00048
Silicone lubricant spray (64742-47-8)	80	0.18	3.1
Stainless steel polish spray (64742-47-8)	40	0.70	0.61
Rust paint (64742-47-8)	75	3.6 (small scale) 34 (large scale)	0.62 (small scale) 110 (large scale)
Wood paste varnish – furniture (64742-47-8)	20	6.2	3.6
Wood stain – floor (64742-47-8)	43.7[c]	25	68
Wood stain – furniture (64742-47-8)[c]	47	2.3 (small scale) 21 (large scale)	0.57 (small scale) 36 (large scale)
Fabric waterproofing liquid (64742-81-0)	100	31	N/A
Fabric waterproofing spray (64742-81-0)	100	0.91	52
Tire cleaner spray (64742-96-7)	100	3.6	0.98

Abbreviation: N/A, not applicable
[a] Adult population (19+ years) considered, unless specified otherwise

[b] Internal dose (mg/kg bw/day) = mean air concentration on day of exposure (mg/m^3) × inhalation rate (m^3/day) / body weight (kg) (see Appendix D)
[c] This product also contains CAS RN 64742-94-5, which is listed separately in Table 8-6 as it is a subgroup 2 substance and is treated separately for risk characterization purposes.

CAS RN 64771-72-8 is used as fuel in lamp oil, in liquid candles (SDS 2012, 2016a), and in firestarter packets for camping or emergency situations (SDS 2015a). From these limited uses, exposure of the general population to this substance is either not expected or expected to be minimal.

Exposure of the Canadian general population to the four remaining substances in this subgroup (that is, CAS RNs 64741-85-1, 64742-13-8, 64742-79-6, and 64742-38-7) is either not expected or is expected to be minimal.

8.1.2.2 Subgroup 2 (C9 to C16 predominantly aromatic hydrocarbons)

To estimate systemic exposures to subgroup 2 substances from the dermal route, the dermal absorption of possible discrete components of CAS RNs 64742-94-5 and 68477-31-6 was considered. The dermal absorption of the C_8 aromatic hydrocarbon ethylbenzene when applied neat in an *in vivo* study of albino hairless mice was determined to be 3.4%, where the majority of the test substance was found to have been lost via evaporation (Susten 1990; ECHA 2021). The dermal absorption of a C_9 aromatic hydrocarbon 1,2,4-trimethylbenzene (1,2,4-TMB) was studied by Korinth et al. (Korinth et al. 2003; ECHA 2020) from a neat liquid and from 50% ethanol solutions on untreated occluded human skin in a static diffusion cell (*in vitro*); the amount of 1,2,4-TMB penetrating the skin from these studies was found to be low (that is, less than 1%) after 8 hours of exposure (ECHA 2020). Following the dermal application of naphthalene (a C_{10} aromatic compound) in an ethanol solution administered to male rats *in vivo* at a dose of 3.3 µg/cm^2, excretion in urine, feces, and expired air was determined at the 12-hour, 24-hour, and 48-hour timepoints to be approximately 58%, 78%, and 88% of the total applied dose, respectively (Turkall et al. 1994; ATSDR 2005). On the basis of the results of a tape-stripping study done on human volunteers, where naphthalene was used as a marker for the dermal absorption of jet fuel (Mattorano et al. 2004), CONCAWE (2010) indicated that naphthalene penetrates rapidly into the deeper layers of the stratum corneum. While no quantitative dermal absorption studies were found for the C_{11} aromatic compound 2-methylnaphthalene, systemic effects were observed following the dermal route in toxicological studies. When comparing the effects observed from toxicological studies with the dermal and oral routes of exposure, the US EPA suggested that either considerable dermal absorption or significant first-pass metabolism is occurring via the oral route (US EPA 2003). Given that the log K_{ow} values of these four substances are similar, the observed differences in dermal absorption may be due to differences in vapour pressure and experimental factors such as vehicle, substance loading, animal/skin type, *in vivo* versus *in vitro* study, etc. Considering the weight of evidence available, a conservative estimate of dermal absorption of 75%, largely based on the dermal absorption of naphthalene, was applied.

To prevent the double counting of exposure that occurred via the dermal route in the inhalation exposure amount, the total amount of systemically available substance via dermal absorption was subtracted from the total amount available for inhalation. Exposures from the dermal and inhalation routes were combined for risk characterization purposes.

The following exposure estimates were calculated using the exposure factors and scenario parameters described in Appendix D.

Unlike the substances in subgroup 1, no uses in self-care products (that is, cosmetics, NHPs, and NPDs) were identified for subgroup 2 substances.

Exposure from the oral route for CAS RNs 64742-94-5 and 68477-31-6 is not expected from the use of products available to consumers on the basis of the types of uses identified.

The estimated dermal and inhalation exposures to subgroup 2 substances in the GOKUPAC Group from the use of other types of products available to consumers (for example, DIY products) are presented in Table 8-5. Product scenarios presented in Table 8-5 represent both scenarios that are associated with the highest exposure and the range of product types that are available to consumers. In certain cases, there are additional products within a product category that are also associated with high exposure, but these were not presented as it was considered more appropriate to present the variety of products available to consumers as opposed to all products within a specific category with high exposure potential. The maximum concentrations (wt%) of the gas oil and kerosene CAS RNs used in these products were obtained predominantly from SDSs; the individual SDSs used in the scenarios presented below are cited in Appendix D.

Table 8-5. Estimated dermal and inhalation exposures to subgroup 2 gas oils and kerosenes from other products available to consumers on the day of use

Exposure scenario[a] (CAS RN)	Maximum concentration (%)	Dermal systemic exposure (mg/kg bw/day)[b]	Inhalation exposure (mg/kg bw/day)[c]	Combined exposure (mg/kg bw/day)
Automotive undercoating spray (64742-94-5)	1	0.61	0.15	0.76
Engine cleaner spray (64742-94-5)[d]	5	0.026	0.059	0.085
Fabric waterproofing spray (64742-94-5)[e]	8.2	0.026	2.0	2.0

Exposure scenario[a] (CAS RN)	Maximum concentration (%)	Dermal systemic exposure (mg/kg bw/day)[b]	Inhalation exposure (mg/kg bw/day)[c]	Combined exposure (mg/kg bw/day)
Lacquer spray paint (64742-94-5)	7	1.1	1.5	2.6
Shoe polish spray (64742-94-5)	10	2.9	0.66	3.6
Wood stain – floor (64742-94-5)	2.5	1.1	2.3	3.3
Wood stain – furniture (64742-94-5)[e]	2.5	0.090 (small scale) 0.83 (large scale)	0.022 (small scale) 0.96 (large scale)	0.11 (small scale) 1.8 (large scale)
Spray paint (68477-31-6)	1	0.15	0.22	0.37

[a] Adult population (19+ years) was considered, unless specified otherwise
[b] Dermal systemic exposure was estimated by applying a 75% dermal absorption factor to the external dermal exposure amount.
[c] Internal dose (mg/kg bw/day) = mean air concentration on day of exposure (mg/m^3) × inhalation rate (m^3/day) / body weight (kg). See Appendix D. The product amount available for inhalation exposure was adjusted on the basis of the systemic dermal exposure.
[d] This product also contains CAS RN 8008-20-6, which is listed separately in Table 8-5 as it is a subgroup 1 substance and is treated separately for risk characterization purposes.
[e] This product also contains CAS RN 64742-47-8, which is listed separately in Table 8-5 as it is a subgroup 1 substance and is treated separately for risk characterization purposes.

8.1.3 PAH compositional analysis of products available to consumers containing gas oils and kerosenes

PAHs are naturally occurring components of crude oil that co-migrate with normal and branched alkanes of similar molecular weight in the initial stages of refining (that is, during atmospheric and vacuum distillation). Unrefined gas oil and kerosene streams can therefore contain PAHs. The proportion of PAHs in gas oils and kerosenes varies depending on the source of crude oil used and the severity/type of the refining steps. To produce gas oils and kerosenes for use in the formulation of products available to consumers, the PAH composition of gas oils and kerosenes can be reduced to residual levels using the most severe refining processes. This refinement is desirable, given the toxicity concerns associated with exposure to PAHs (section 8.2.3).

The US EPA previously identified PAHs that may be carcinogenic in animals and humans (US EPA 1993), ultimately listing 16 substances that became known as the priority PAHs. These 16 priority PAHs are naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benz[*a*]anthracene, chrysene, benzo[*b+j*]fluoranthene, benzo[*k*]fluoranthene, benzo[*a*]pyrene, indeno[*1,2,3-cd*]pyrene, dibenz[*a,h*]anthracene, and benzo[*ghi*]perylene.

Since gas oil and kerosene substances with different CAS RNs have similar physical-chemical properties, it is possible that certain substances are used interchangeably as ingredients in products. Compositional analysis of selected products available to consumers was conducted to determine the PAH content of gas oils and kerosenes used. In total, 25 products containing gas oils and/or kerosene ingredients from the GOKUPAC Group were analyzed: 7 products using standard Health Canada chemical laboratory methodology with limits of quantification (LOQs) in the 100 parts per million (ppm) range, and 18 products using a more sensitive method with limits of detection (LODs) in the parts per billion (ppb) range. Each of the 25 products was unique, that is, they originated from different use categories and/or had different brand names.

The concentrations of 18 PAH species, including 14 of the 16 priority PAHs listed above, were analyzed in seven products using solvent extraction, followed by gas chromatography and mass spectrometry detection in accordance with the Health Canada C11.5 Method (Health Canada 2015b, 2017). The highest LOQ for a PAH using this method was 303 ppm. The 18 PAH species analyzed were acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, retene, benz[*a*]anthracene, chrysene, benzo[*b*]fluoranthene, benzo[*k*]fluoranthene, benzo[*a*]pyrene, benzo[*e*]pyrene, indeno[*1,2,3-cd*]pyrene, dibenz[*a,h*]anthracene, benzo[*ghi*]perylene, and coronene. The LOQs determined for the priority PAHs tested are given in Table B-1 of Appendix B. None of the seven product samples were found to contain any of the priority PAHs tested at (or higher than) their respective LOQs.

In order to quantify the low levels of PAHs in gas oil and/or kerosene-containing products, a PAH compositional analysis with higher analytical sensitivity was conducted on 18 products available to consumers containing gas oils and/or kerosenes from the GOKUPAC Group (Health Canada 2015b). This analysis was performed using a dual gas chromatography / high-resolution mass spectrometry instrument. The LODs for the 16 PAHs tested were 0.5 ppb to 1.0 ppb (0.0005 ppm to 0.001 ppm).

The concentrations of each of the 16 PAHs in all 18 products tested are given in Table B-2 of Appendix B. This analysis confirmed the absence in all products of 7 of the 16 priority PAHs, including benzo[*a*]pyrene and dibenz[*a,h*]anthracene. Other priority PAHs may be individually present at very low levels in these products, from less than 12 ppm to low ppb. The highest levels of PAHs that were identified using the more sensitive method (Table B-2 of Appendix B) were seen in an automotive engine cleaning product. Lower levels of PAHs were seen in other products categories, with none detected in the cosmetic products.

8.1.4 BTEX compositional analysis of products available to consumers containing gas oils and kerosenes

Given the carbon range of gas oils and kerosenes, there is a potential for the presence of BTEX in these substances. The BTEX content of gas oils and kerosenes can be reduced to residual levels or essentially eliminated using refining processes for use in the formulation of products available to consumers. This refinement is desirable, given the toxicity concerns associated with exposure to BTEX (section 8.2.4)

A total of 20 products available to the general population in Canada and that contain gas oils and/or kerosenes from the GOKUPAC Group were subject to testing for BTEX substances using a high-speed gas chromatography / field desorption mass spectrometry method to analyze the liquid samples (Health Canada 2015c). The values of the BTEX components in the 20 products are given in Table C-1 of Appendix C, and the ranges of measured BTEX concentrations in different categories of products available to consumers are given in Table 8-6.

As in the PAH analysis, these products often contained CAS RNs of other petroleum substances that were not in the GOKUPAC Group, which could potentially have BTEX components. In these cases, a conservative approach was taken such that all of the BTEX components detected were attributed to the GOKUPAC substance CAS RN listed as being present in the product. Furthermore, there were a number of products that listed toluene (from 20% to 40%), ethylbenzene (3% to 7%), and/or xylene (from 0.1% to 30%) as constituents. In these cases, the specific BTEX component present in the sample was not attributed to the GOKUPAC substance.

Table 8-6. The BTEX concentration (ppm) of products available to the general Canadian population from different product categories[a]

Product category	Benzene	Toluene	Ethylbenzene	Xylenes
Cleaning products	ND–1.8 (0.5)	ND–92 (0.5)	ND–230 (0.5)	ND–1400 (1.5)
Cosmetics	ND (0.5)	ND (0.5)	ND (0.5)	ND (1.5)
Paints and coatings	ND–0.6 (0.5–5)	7.2 – 940 (0.5 – 5)	15–1200 (0.5–5)	120–6300 (1.5–15)
DIY products	ND (0.5–300)	8.6 – 9.4[b] (0.5)	ND–14 (0.5–300)	ND–71 (1.5–800)
Automotive products	ND–36 (0.5–30)	ND – 630 (0.5 – 30)	ND–480[c] (0.5–5)	ND–6300[d] (1.5–15)

Abbreviations: DIY, do-it-yourself; ND, not detected; ppm, parts per million
[a] The reportable detection limit range for each product type is shown in parentheses.
[b] Excludes one product that contains toluene as an ingredient.
[c] Excludes one product that contains ethylbenzene as an ingredient.
[d] Excludes two products that contain xylene as an ingredient.

8.1.5 Exposure to PAH and BTEX components of gas oils and kerosenes

On the basis of the information described in sections 8.1.3 and 8.1.4, exposure to products that contain a gas oil or kerosene ingredient also carries a potential for exposure to low levels of PAHs and BTEX substances that remain after the refining process.

The CAS RNs that were identified as being present in cosmetics, NHPs, and/or NPDs (that is, CAS RNs 8008-20-6, 64742-46-7, and 64742-47-8), as described in section 4, are more refined than as defined by the standard CAS RN descriptions of these gas oil and kerosene substances (personal communication, email from the CHPSD, HC, to the ESRAB, HC, dated August 2017; unreferenced; personal communication, email from the NNHPD, HC, to the ESRAB, HC, dated August 2017; unreferenced). As a result, potential exposure to PAHs and BTEX from these types of products is not expected.

Exposure of the general population to residual PAHs in products available to consumers is expected to be via the inhalation and/or dermal route. All exposures from the use of these types of products are expected to be intermittent, infrequent, and of short duration. The characterization of risk to human health from exposure to residual PAHs is based on a direct comparison of a reference concentration value against the maximum PAH concentrations detected in the products available to consumers (converted into B[*a*]P equivalents; see section 8.3.3).

With respect to BTEX, exposure to these substances in products available to consumers is expected to be via the inhalation route. Nearly all of the products tested were found not to contain benzene at levels above the detection limit. The highest estimated inhalation exposure to benzene resulted from the use of an engine cleaner containing up to 5% of CAS RN 64742-94-5 and approximately 36 ppm or 0.0036% benzene. For exposure to the TEX components, the highest estimated inhalation exposures resulted from the use of a paste varnish containing up to 30% of CAS RN 64742-47-8 and approximately 1200 ppm or 0.12% of ethylbenzene, 6300 ppm or 0.63% of xylenes, and 940 ppm or 0.094% of toluene.

Modelling of an engine cleaner spray (SDS 2018b) for potential benzene exposure was performed using the ConsExpo “exposure to vapour–instantaneous release” model (ConsExpo Web 2021). Parameters used included a product amount of 18 g (based on an application duration of 15 seconds [professional judgment based on a video on the manufacturer’s website] and a mass generation rate for an aerosol of 1.2 g/second), an exposure time of 20 minutes, and a room volume of 34 m^3 with an air exchange rate of 1.5 times per hour to mimic a garage setting. The resulting mean event concentration for benzene from the engine cleaner was estimated to be 0.014 mg/m^3 (Table 8-7). For risk characterization purposes (see section 8.3.3), an internal dose was estimated to be 0.000057 mg/kg bw/day.

The ConsExpo “exposure to vapour–evaporation model” (ConsExpo Web 2021) was used to estimate inhalation exposure to TEX components released from a paste varnish

(SDS 2018c). A product amount of 144 g was assumed on the basis of a 1.44 m^2 surface area corresponding to the application to furniture (according to product-specific coverage data). An application duration of 60 minutes, an exposure duration of 90 minutes, and a room volume of 34 m^3 with an air exchange rate of 1.5 times per hour were also assumed. The resulting mean event concentrations for the TEX components from the paste varnish are provided in Table 8-7. For risk characterization purposes (see section 8.3.3), internal doses were estimated to be 0.017, 0.022, and 0.11 mg/kg bw/day for toluene, ethylbenzene, and xylenes, respectively.

Table 8-7. Inhalation exposure concentrations of BTEX concentrations for products

Substance	Product	Concentration in product (ppm)	Mean event concentration (mg/m^3)
Benzene	Engine cleaner	36	0.014
Toluene	Paste varnish	940	1.4
Ethylbenzene	Paste varnish	1200	1.7
Xylenes	Paste varnish	6300	8.8

Abbreviation: ppm, parts per million

8.1.6 Consideration of subpopulations who may have greater exposure

There are groups of individuals within the Canadian population who, due to greater exposure, may be more vulnerable to experiencing adverse health effects from exposure to substances. The potential for elevated exposure within the Canadian population was examined. In the current assessment, subpopulations living within the vicinity of industrial facilities were considered. In addition, exposure estimates were calculated by age in order to account for physical and behavioural differences during different stages of life. In the assessment of exposure from environmental media and food, including drinking water, young children had higher levels of estimated exposure than adults. Formula-fed infants, specifically those consuming formula reconstituted with drinking water potentially containing elevated levels of these substances, had higher levels of estimated exposure than adults and human milk-fed infants. In the assessment of exposure to these substances in products available to consumers, products that could be used on or by children and that could otherwise result in exposure by children, including self-care products (that is, cosmetics, NHPs, and NPDs) and air fresheners, were assessed.

8.2 Health effects assessment

8.2.1 Subgroup 1 (C9 to C25 predominantly aliphatic hydrocarbons)

Some substances in subgroup 1 were previously evaluated by the Agency for Toxic Substances and Disease Registry (ATSDR 1995), the US EPA (2011a), and the Organisation for Economic Co-operation and Development (OECD 2011, 2012a). Given the limited health effects information specific to most of the 14 gas oils and kerosenes in this subgroup, studies on similar UVCB substances were taken into account. This included data described in the assessments on aviation fuels (that is, the kerosene-type aviation turbine fuels Jet A, JP-5, and JP-8) and LBPNs (that is, C_9 to C_{14} aliphatic hydrocarbon solvents) (Environment Canada, Health Canada 2014; ECCC, HC 2023b).

Kerosene-type jet fuels differ from each other and from kerosene streams mainly in their performance additives, which are generally less than 0.1% by volume, and performance specifications (McDougal et al. 2000; API 2010). Extrapolation of jet fuel hazard data to other kerosenes is supported by industry (API 2010). Jet fuels have previously been evaluated by the ATSDR (2017) and are considered by IARC (1989) to be "not classifiable as to its carcinogenicity to humans" (Group 3).

C_9 to C_{14} aliphatic LBPNs overlap significantly with the five C_9 to C_{16} predominantly aliphatic kerosenes in this subgroup and are considered to cover the lighter end of the nine C_9 to C_{25} predominantly aliphatic gas oils. They share similar physical-chemical properties and are expected to share similar constituents. In the absence of data to demonstrate that the health effects of C_9 to C_{14} aliphatic LBPNs are not relevant for the heavier end of the C_9 to C_{25} gas oils, a conservative approach was taken to extrapolate the C_9 to C_{14} aliphatic LBPNs' data set to all substances in subgroup 1.

Data from other gas oils, which have been described in the screening assessments on CAS RNs 68333-25-5, 64741-59-9, and 64741-82-8, were not considered in the current assessment (Environment Canada, Health Canada 2011, 2013). This is because the bulk of those hazard data were obtained from gas oils containing more than 3% w/w DMSO-extractable PAC content according to the IP 346 method (Institute of Petroleum 1992; API 2012), whereas the gas oils found in products available to consumers are expected to be highly refined and contain minimal amounts of DMSO-extractable PAC content.

Toxicokinetics

Toxicokinetics information for kerosenes, jet fuels, and gas oils mainly comes from studies on individual constituents or studies conducted with radiolabelled aliphatic and aromatic markers spiked into the full mixtures and then quantified as surrogates for the aliphatic and aromatic fractions overall.

While the OECD Screening Information Dataset Initial Assessment Profiles for relevant aliphatic hydrocarbon solvent categories estimate that 61% to 81% of C_9 to C_{14} aliphatic hydrocarbons and 37% to 61% of C_{14} to C_{20} aliphatic hydrocarbons would be absorbed when ingested (OECD 2011, 2012a), other sources indicate that absorption of kerosene from the gastrointestinal tract is low and incomplete, with aromatic constituents being better absorbed than aliphatic ones (Mann et al. 1977; ECHA 2022b). Aromatic constituents were also better absorbed than aliphatic ones via the dermal route, with 11% to 16% of a radiolabelled aromatic surrogate penetrating the skin both in an *in vitro* study conducted with HDS kerosene (CAS RN 64742-81-0) (Schreiner et al. 1997) and in an *in vivo* study conducted with a 30:70 blend of CAS RNs 64742-81-0 and 64741-

77-1 (Mobil 1994 as cited in ECHA 2022b), compared to 5% to 7% of a radiolabelled aliphatic surrogate in the same *in vivo* study (Mobil 1994 as cited in ECHA 2022b).

In a pair of studies on the dermal absorption and subsequent distribution of kerosene components in male rats, markers for the aromatic fraction, TMBs, were detected in the blood 5 to 20 minutes after the start of dermal exposure and the extent of TMB absorption was greater than that of the C_9 to C_{16} aliphatic hydrocarbons (AHCs) (Tsujino et al. 2002, 2003). Kerosene components were distributed preferentially to lipid-rich tissues (for example, fat and brain) and highly vascularized organs involved in metabolism and excretion (for example, kidney and liver). Kinetics of these components were notably different in adipose tissue compared to other tissues, including the brain, with evidence of short-term accumulation occurring with increased exposure duration (Tsujino et al. 2002) or upon repeated exposures (Fujihara et al. 2004), limited to adipose tissue only. After the cessation of exposure, 1,2,4-TMB levels decreased quickly with time in most tissues, except for adipose tissue, where levels increased up to three hours post-exposure before declining (Tsujino et al. 2002). Unlike TMBs, AHCs accumulated in the skin with repeated exposures (Fujihara et al. 2004), and it has been hypothesized that they may initially be stored in deeper skin layers before entering systemic circulation (Kim et al. 2006).

These results were mostly in line with a study that examined the distribution of the related LBPN substance, dearomatized white spirit, in the brain, blood, and adipose tissue of male rats after inhalational exposure for 6 hours/day, 5 days/week, for up to three weeks (Löf et al. 1999). At the end of the three weeks, brain levels of total white spirit were roughly three times higher than blood levels, and adipose tissue levels were about 250 times higher. The concentrations of total white spirit and its aliphatic constituents were relatively steady in the blood and brain over the course of the three-week exposure period, but quickly declined within the first 24 hours post-exposure. However, concentrations in adipose tissue increased during the exposure period, indicating that steady-state levels had not been reached, and the decline post-exposure was much slower (Löf et al. 1999). The half-life of white spirit in adipose tissue has been estimated to be 46 to 48 hours (OECD 2012a).

Metabolism of gas oil and kerosene components typically occurs by oxidation to alcohol and carboxylic acid derivatives, followed sometimes by conjugation, and the majority of these metabolites are then expected to be excreted in the urine within the first 24 hours (OECD 2011, 2012a).

Repeated-dose toxicity

In a dermal National Toxicology Program (NTP) study, B6C3F1 mice (5/sex/dose) were treated with JP-5 diluted in 95% ethanol at 0, 5 000, 10 000, 20 000, 30 000 or 40 000 mg/kg bw/day for 14 consecutive days (NTP 1986). All mice in the highest dose group and all female mice in the second highest dose group died before study termination. Starting at 10 000 mg/kg bw/day, treated mice lost weight. At the site of application (shaved back), scaly skin, hair loss, and microscopic lesions indicative of skin irritation and inflammation were observed. However, other tissues did not undergo microscopic examination. A no observed adverse effect level (NOAEL) of 5 000 mg/kg bw/day was determined on the basis of body weight loss at 10 000 mg/kg bw/day.

In a short-term dermal study, New Zealand White rabbits (5/sex/dose) were treated with undiluted straight-run kerosene (CAS RN 8008-20-6) at 0, 200, 1000, or 2000 mg/kg bw/day for 6 hours/day, 3 days/week, for 4 weeks (API 1985 as cited in API 2010a, 2010b; US EPA 2011a). The site of application was occluded. Skin irritation was slight at the low dose and moderate at the mid and high doses. In the high-dose group, one male and one female died, which the study authors considered to be a treatment-related effect. Treatment-related clinical signs included thinness, lethargy, and wheezing. Reduced body weight gain and body weight loss were observed in the mid- and high-dose groups, respectively. Decreases in hematological parameters (for example, red blood cell [RBC] count, hematocrit, and hemoglobin) were observed in male rabbits starting at the lowest dose. Differences in organ weights occurred in both sexes, including significant increases in the absolute and relative weight of the spleen and adrenal glands in the females. The authors considered the adrenal weight increases to be stress-related. On the basis of the 13% reduction in RBC count in males and the organ weight changes in females, a lowest observed adverse effect level (LOAEL) of 200 mg/kg bw/day, the lowest dose tested, was identified.

Effects from short-term inhalation exposure were also studied. Sprague-Dawley (SD) rats (20/sex/concentration) were exposed to HDS kerosene (CAS RN 64742-81-0) at 0 or 24 mg/m^3 (equivalent to approximately 0 or 5 mg/kg bw/day) for 6 hours/day, 5 days/week, for 4 weeks (API 1986 as cited in API 2010a, 2010b). No treatment-related changes in body weight, clinical condition, organ weights, histopathology, hematology, or clinical chemistry were reported.

The NTP conducted a sub-chronic dermal study to determine appropriate doses for their 2-year carcinogenicity study. In this study, B6C3F1 mice (10/sex/dose) were treated with JP-5 diluted in acetone at 0, 500, 1000, 2000, 4000, or 8000 mg/kg bw/day for 5 days/week, for 13 weeks (NTP 1986). Mortality occurred for four females at 2000 mg/kg bw/day, one male and five females at 4000 mg/kg bw/day, and five males at 8000 mg/kg bw/day. Terminal body weights were 7% lower than control for surviving males at the highest dose, but no differences were noted for females. Other treatment-related effects included increased incidences of splenic extramedullary hematopoiesis and hepatic karyomegaly and increased severity of dermatosis. A NOAEL of 500 mg/kg bw/day was determined on the basis of the spleen and liver findings at 1000 mg/kg bw/day.

In another sub-chronic dermal study, Breglia et al. (2014) treated SD rats (12/sex/dose) with HDS kerosene (CAS RN 64742-81-0) diluted in United States Pharmacopeia (USP)-grade mineral oil at 0, 165, 330, or 495 mg/kg bw/day for 6 hours/day, 5 days/week, for 13 weeks. The site of application was dorsal skin that was clipped free of fur every week and remained uncovered during treatment. Satellite groups for control and the high dose (an additional 12 of each sex per dose) underwent a 4-week recovery period. Small but statistically significant changes in hematological and clinical chemistry parameters included increased mean corpuscular hemoglobin concentration (MCHC) in the mid- and high-dose males, decreased hematocrit in the high-dose males, increased neutrophils in the high-dose females, and increased sorbitol dehydrogenase levels in the mid-dose and high-dose recovery group males. However, the authors deemed these differences to be either not treatment-related or not toxicologically relevant. Relative spleen weight was elevated in high-dose females at the termination of treatment, whereas absolute spleen weight was higher in high-dose recovery group females; no gross or microscopic findings accompanied this change in spleen weight. This study also assessed motor activity, startle response, and a functional observation battery for which there were no notable differences between control and exposed animals. No neuropathological or other findings were reported during gross and microscopic examination. The authors concluded that no adverse effects were observed up to the highest dose tested. However, the US EPA (2011a) identified a NOAEL of 330 mg/kg bw/day on the basis of increased spleen weight in female rats at 495 mg/kg bw/day.

In a sub-chronic oral study, male SD rats (minimum of 20/dose, with 9 or 10/dose for the evaluation of systemic toxicity) were administered undiluted JP-8 by gavage at 0, 750, 1500, or 3000 mg/kg bw/day for 90 days (Mattie et al. 1995). A significant dose-dependent decrease in body weight of 7%, 14%, and 43% were observed for the low-, mid-, and high-dose groups, respectively. No significant differences in brain, kidney, liver, testes, and spleen absolute weights were observed. Increased relative weights were noted, particularly at the high dose. Clinical chemistry revealed elevated levels of total bilirubin, aspartate aminotransferase, and alanine aminotransferase (ALT) in all three treatment groups. Some hematological parameters were also affected by JP-8 treatment, including increased percent neutrophils and decreased percent lymphocytes at all doses. The US EPA (2011a) identified a LOAEL of 750 mg/kg bw/day, the lowest dose tested, given the totality of effects observed at this dose. Although no NOAEL was established for these male rats, Mattie et al. (2000) also conducted a similar gavage study where female SD rats (minimum of 35/dose, with 7 to 10/dose for the evaluation of systemic toxicity) were treated with undiluted JP-8 by gavage at 0, 325, 750, or 1500 mg/kg bw/day for a total of 21 weeks (90 days premating and throughout mating with naïve males; gestation; and lactation). The authors noted a dose-dependent decrease in body weight, which reached statistical significance at the high dose, beginning in the latter half of the premating period through most of the lactation period (weeks 8 to 20). However, at study termination (week 21), the weight of high-dose animals was no longer distinguishable from that of controls. Absolute and relative liver weights were higher in the mid- and high-dose groups. However, there were no histopathological or clinical chemistry findings indicative of liver damage. Nonetheless, the authors determined a NOAEL of 325 mg/kg bw/day on the basis of the liver weight increase at 750 mg/kg bw/day.

To examine the effects of sub-chronic whole-body inhalation exposure to JP-5, Fischer 344 rats (75/sex/concentration) were continuously exposed to petroleum- or oil shale-derived JP-5 vapours at 0, 150, or 750 mg/m^3 (equivalent to approximately 0, 135 to 138, or 681 to 688 mg/kg bw/day) for 90 days (Gaworski et al. 1985). Some animals were held for observation up to 19 months post-exposure. Exposure to 150 mg/m^3 of either type of JP-5 caused a significant irreversible reduction in male body weight. At 750 mg/m^3, this effect was more severe, and female rats treated with shale JP-5 also exhibited lower body weights. Structural changes characteristic of alpha 2u-globulin-mediated nephropathy were noted in the kidneys of male rats at both concentrations, an effect that is well established as not relevant to human health. At the end of the exposure period, histopathological examination also found an increased incidence of hepatocellular vacuolization in females at the low concentration of shale JP-5 and in both sexes at the high concentration of shale JP-5. However, this liver effect was not observed in animals treated with petroleum JP-5 and was no longer significant in shale JP-5-treated rats after the post-exposure period. Moreover, there were no clinical chemistry findings to suggest altered liver function at either time point. Hematological analysis revealed small but statistically significant decreases in erythrocyte parameters (for example, RBC count, hematocrit) in the males at both concentrations of either type of JP-5. The US EPA (2011a) identified a no observed adverse effect concentration (NOAEC) of 150 mg/m^3 (equivalent to 135 to 138 mg/kg bw/day) on the basis of reduced body weight in rats of both sexes at 750 mg/m^3.

In addition, Gaworski et al. (1985) described a parallel study with the same study design that was conducted in female C57BL/6 mice (111/concentration; equivalent to approximately 0, 211, or 1053 mg/kg bw/day). In contrast to the rat study, body weights were overall unaffected in female mice, and survival time was reduced by 20% in the group exposed to 750 mg/m^3 of petroleum JP-5. However, similar to the rats, an increased incidence of hepatocellular fatty change and vacuolization at the end of the exposure period was reported for all the treatment groups. After the post-exposure holding period, this liver lesion became common among controls, and the incidences were no longer higher in treated mice. Hematological and serum chemistry analyses were not conducted. On the basis of these observations, along with the observations in rats, the authors concluded that liver damage induced by sub-chronic inhalation of JP-5 at up to 750 mg/m^3 was mild and reversible. The US EPA (2011a) identified a NOAEC of 150 mg/m^3 (equivalent to 211 mg/kg bw/day) on the basis of reduced survival time at 750 mg/m^3.

In the derivation of screening sub-chronic and chronic provisional oral reference doses for midrange aliphatic hydrocarbon streams, the US EPA considered three unpublished sub-chronic gavage studies that examined the effects of a mixture of C_{11} to C_{17} isoparaffins, a mixture of C_{10} to C_{13} aliphatics, and a mixture of C_9 to C_{12} aliphatics, respectively (Anonymous 1990, 1991a, 1991b as cited in US EPA 2009). In all three studies, the test material had very limited aromatic content (less than 1%) and was administered to SD rats (10/sex/dose) on a daily basis for 13 weeks at doses of 0, 100, 500, or 1000 mg/kg bw/day (Anonymous 1990, 1991a as cited in US EPA 2009) or 0, 500, 2500, or 5000 mg/kg bw/day (Anonymous 1991b as cited in US EPA 2009). Each study also had a high-dose recovery group that was maintained for at least 28 untreated days post-exposure. Across these three studies, differences in multiple systemic endpoints were reported at the 500 mg/kg bw/day dose level, including changes in various hematological parameters. Overall, the most consistently observed effects in these studies were increases in absolute and/or relative liver weight, hepatocellular hypertrophy, and serum chemistry changes (for example, elevated ALT in males and cholesterol in females, and reduced glucose in both sexes). The high-dose recovery group in each study indicated the potential for at least partial reversibility of these effects. Nonetheless, the US EPA (2009) identified a LOAEL of 500 mg/kg bw/day, and in the two studies that included a dose lower than the LOAEL, the NOAEL was determined to be 100 mg/kg bw/day.

A dermal repeated-dose toxicity study from the C_9 to C_{14} aliphatic LBPNs data set was also considered. Verkkala et al. (1984) examined the neurotoxic potential of the related LBPN substance, white spirit. Male Wistar rats (5/group) were treated on the tail with a dearomatized white spirit at 855 mg/kg bw/day or an aromatic white spirit at 691 mg/kg bw/day for 3 hours/day, 5 days/week, for 6 weeks. Another group of five rats served as the sham-exposed controls. Both formulations of the white spirit produced local skin effects in the form of keratolysis and a local axonopathy characterized by prenodal swellings with widening of the nodes of Ranvier. When the animals underwent electrophysiological testing, there was a significant increase in the duration of motor responses (that is, the time from the initial deflection from baseline to the terminal deflection back to baseline), and in the dearomatized white spirit group, motor responses became polyphasic. A LOAEL of 691 mg/kg bw/day was determined on the basis of this local axonopathy.

Reproductive and developmental toxicity

Reproductive parameters were assessed separately in male and female rats after sub-chronic exposure to undiluted JP-8 by gavage (Mattie et al. 2000; as described above). In the first study, male SD rats were administered undiluted JP-8 by gavage at 0, 750, 1500, or 3000 mg/kg bw/day for 70 days before mating with naïve females. Treatment continued during cohabitation. No effects were reported on sperm parameters, pregnancy rate, or gestation length. In the second study, female SD rats were treated by gavage with 0, 325, 750, or 1500 mg/kg bw/day of undiluted JP-8 for 90 days premating and throughout mating with naïve males, gestation, and lactation. No effects were reported on pregnancy rate, gestation length, litter size, or percent of live pups. Offspring born to the treated dams were weighed on postnatal day (PND) 1, 4, 14, 21, and 90. While there were no remarkable differences on PND 1, mid- and high-dose pups weighed significantly less than controls (by 8% to 9% and just over 11%, respectively) on PND 4. By PND 21, only high-dose pup body weights remained significantly lower than controls, and by PND 90, body weights were similar across all groups. Overall, the study authors concluded that JP-8 did not appear to be a reproductive toxicant as no adverse effects on reproductive parameters were observed at doses up to 3000 mg/kg bw/day in male rats and 1500 mg/kg bw/day in female rats. The authors identified a developmental NOAEL of 750 mg/kg bw/day in the female rat study on the basis of a reduction in pup body weight at 1500 mg/kg bw/day.

Schreiner et al. (1997) conducted a reproductive and developmental toxicity screening test in which SD rats (10/sex/dose) were dermally exposed to HDS kerosene (CAS RN

64742-81-0) diluted in USP-grade mineral oil at 0, 165, 330, or 494 mg/kg bw/day for 7 days/week for 7 to 8 weeks. The site of application was left uncovered, and there were two control groups, one sham-treated and one treated with the vehicle. The study authors concluded that no treatment-related adverse effects were observed up to 494 mg/kg bw/day, the highest dose tested.

In an oral prenatal developmental toxicity study, pregnant SD rats (30/dose) were administered undiluted JP-8 by gavage at 0, 500, 1000, 1500, or 2000 mg/kg bw/day from gestational day (GD) 6 to 15 (Cooper and Mattie 1996). Mortality of one, three, and nine dams at 1000, 1500, and 2000 mg/kg bw/day, respectively, was attributed to the presence of JP-8 in the lungs. Significant maternal body weight gain decreases of 31%, 70%, and 85% were observed at 1000, 1500, and 2000 mg/kg bw/day, respectively. Gravid uterine weight-adjusted maternal body weight and fetal body weight were also significantly reduced at the two highest doses. A maternal NOAEL of 500 mg/kg bw/day was identified on the basis of decreased maternal body weight gain at 1000 mg/kg bw/day; a developmental NOAEL of 1000 mg/kg bw/day was identified on the basis of decreased fetal body weight at 1500 mg/kg bw/day.

Pregnant SD rats (20/concentration) were exposed by whole-body inhalation to 0, 102.5, or 394.7 ppm of Jet A vapour (equivalent to approximately 0, 166, or 638 mg/kg bw/day) for 6 hours/day, from GD 6 to 15 (API 1979a as cited in API 2010a, 2010b). The only effect noted by the authors was a dose-related occurrence of eye irritation, lasting two to eight days, that presented as ocular discharge, swollen eyelids, or swollen areas around the eye. Another study with the same study design was conducted using 0, 106, or 364 ppm of kerosene vapour (equivalent to approximately 0, 162, or 556 mg/kg bw/day), and no treatment-related effects were observed up to the highest concentration tested (API 1979b as cited in API 2010a, 2010b).

Developmental neurotoxicity has been examined in pups exposed gestationally to a related LBPN substance (Hass et al. 2001; ECCC, HC 2023b). Pregnant Wistar rats (12 to 14/concentration) were exposed by whole-body inhalation to dearomatized white spirit (CAS RN 64742-48-9) at 0 or 4679 mg/m^3 (equivalent to approximately 0 or 1116 mg/kg bw/day) for 6 hours/day from GD 7 to 20, and were then allowed to deliver and nurse their litters. Exposed dams weighed 7% less than controls on GD 20, but there were no overt signs of toxicity in the offspring. However, despite comparable swimming abilities and initial learning in the Morris water maze, the exposed offspring performed significantly poorer when tested for their memory at two and five months of age and during reversal learning at two months of age. A developmental LOAEC of 4679 mg/m^3 was determined on the basis of this impairment of learning and memory.

Genotoxicity

In a variety of *in vitro* and *in vivo* genotoxicity assays, gas oils and kerosenes have produced mixed results depending on the specific material tested (ATSDR 1995, 2017; API 2010a, 2010b, 2012a, 2012b; US EPA 2011a; Environment Canada, Health Canada 2011, 2013). API reported that mutagenic activity is related to the % w/w

DMSO-extractable PAC, and cuts with very low PAC content are generally inactive in mutagenicity assays (API 2012). Given that the gas oils and kerosenes used in products available to consumers are expected to be highly refined, these substances are considered to contain minimal amounts of DMSO-extractable PAC.

Carcinogenicity

Seven of the gas oil and kerosene substances are classified as Category 1B “may cause cancer” (CAS RNs 64741-91-9, 64742-13-8, 64742-14-9, 64742-38-7, 64742-46-7, and 64742-79-6) or Category 2 “suspected of causing cancer” (CAS RN 64741-77-1) (EC 2004, 2008). However, the European Commission (Regulation EC No. 1272/2008, Annex VI) states that classification as a carcinogen does not apply to these gas oils and kerosenes if the refining history is known and if the substance(s) from which they are produced can be shown not to be carcinogenic. This is typically demonstrated if the substance contains less than 0.1% individual carcinogens (for example, benzene) and/or less than 3% w/w DMSO-extractable total PAC content (EC 2004, 2008; Clark et al. 2013; CONCAWE 2022). The gas oils found in products available to consumers are expected to be highly refined and contain minimal amounts of DMSO-extractable PAC content.

In an NTP 2-year dermal carcinogenicity study, B6C3F1 mice (50/sex/dose) were treated with JP-5 diluted in acetone at 0, 250, or 500 mg/kg bw/day for 5 days/week, for 103 weeks (NTP 1986). The high-dose female group was terminated at 90 weeks due to ulceration at the site of application. Survival was reduced in treated females at both doses. A decrease in body weight (13% to 25%) and body weight gain (12% to 25%) was reported for high-dose animals of both sexes. The incidence of skin ulcers and chronic dermatitis at the application site and in the inguinal region was higher with JP-5 treatment, but there was no evidence of local or systemic tumorigenesis at doses up to 500 mg/kg bw/day, the highest dose tested.

Several other skin painting studies that tested higher doses of gas oils and kerosenes applied two to three times a week over the lifetime of mice have shown that these substances can produce local skin tumours (Clark et al. 1988; Freeman et al. 1993; Nessel et al. 1998; Walborg et al. 1998; Nessel et al. 1999). This is likely via a non-genotoxic mechanism of skin tumour promotion, related at least in part to chronic dermal irritation (Freeman et al. 1993; Nessel et al. 1998; Nessel et al. 1999) and/or sustained hyperplasia of the epidermis (Skisak 1991). Although neither irritation nor hyperplasia was singularly sufficient to induce skin tumours, it has been demonstrated that the tumorigenic activity of gas oils and kerosenes can be abrogated by experimental design changes that limited skin irritation during the course of the exposure (for example, by diluting the gas oil or kerosene with a highly refined mineral oil) (API 2010; Nessel et al. 1999).

Epidemiology studies

A limited number of studies in humans, including case reports and studies conducted on volunteers, were identified for gas oils. One case report describes substantial and prolonged dermal exposure to “diesel oil”, which was used over several weeks as an arm and hand cleaner. Development of epigastric and loin pains, nausea, anorexia, degeneration of kidney tubular epithelium, and reversible renal failure were observed (Crisp et al. 1979). With respect to occupational exposures, in a case-control study of male cancer patients in Montreal, Quebec, Canada, exposure to jet fuel (kerosene-type and wide-cut) was associated with an increased risk of kidney cancer (a combined adjusted odds ratio of 3.1; 90% confidence interval of 1.5 to 6.6) (Siemiatycki et al. 1987; IARC 1989). IARC (1989) considered that there was some indication of a positive dose-response as the adjusted odds ratio was greater for men who were estimated to have substantial exposure (3.4; 1.5 to 7.6) than for those estimated to have non-substantial exposure (2.1; 0.3 to 12.7). However, the largest occupational group exposed to jet fuel consisted of aircraft mechanics and repairmen, meaning there was likely overlap with exposures to aviation gasoline, complicating the interpretation of this finding (IARC 1989). Long-term dermal occupational exposures to kerosene (for 5 hours/day, doses unknown) produced dermatosis and erythema in factory workers (Jee et al. 1986; ATSDR 1995). However, no studies that examined the ability of fuel oils to cause hepatic, musculoskeletal, reproductive, developmental, or immunological effects following dermal exposure in humans were identified (ATSDR 1995).

A cross-sectional study examined the relationship between exposure to a related LBPN substance, white spirit, in paints and the risk of developing any degree of dementia (Mikkelsen et al. 1988; ECHA 2011). This study used 85 male bricklayers as a non-exposed control group and stratified 85 male painters into low (less than 15 [L/day] years), medium (15 to 30 [L/day] years), and high (more than 30 [L/day] years) solvent exposure groups on the basis of time spent doing specific painting activities. Impairment of central nervous system function was assessed through a neurophysiological examination by computed tomography, a neuropsychological test battery (13 tests on intellectual functions and psychomotor performance), and several neurological tests (motor performance, coordination, reflexes, sensitivity). It was concluded that the risk was approximately equal between the bricklayers and the low solvent exposure group (odds ratio [OR] of 1.1) but that there was a dose-dependent increase in the risk for medium (OR of 3.6) and high (OR of 5.0) solvent exposure groups. An average NOAEL of 40 ppm was calculated for 13 years of exposure to white spirit containing 15% to 20% aromatics, which would be equivalent to approximately 17.45 mg/kg bw/day.

8.2.2 Subgroup 2 (C9 to C16 predominantly aromatic hydrocarbons)

CAS RNs 64742-94-5 and 68477-31-6 have previously been evaluated by the US EPA (2005), and CAS RN 64742-94-5 has also been evaluated by the OECD (2012b). CAS RNs 64742-94-5 and 68477-31-6 are predominantly alkylbenzenes and alkylnaphthalenes (DeWitt et al. 2008; US EPA 2005). They share comparable physical-chemical properties, common functional substructures, and similar expected pathways and kinetics of metabolism with some other alkylbenzenes (for example, C9 aromatics) and alkylnaphthalenes. Indeed, certain cuts of CAS RN 64742-94-5 may contain up to

22% C9 aromatics (OECD 2012b). As a result, the related LBPN substance, CAS RN 64742-95-6 (a C9 aromatic hydrocarbon solvent also known as high flash aromatic naphtha [HFAN]), is considered to be a valid analogue of CAS RNs 64742-94-5 and 68477-31-6 for predicting toxicity, and data described in the LBPNs assessment for CAS RN 64742-95-6 were considered in the present assessment (ECCC, HC 2023b).

Toxicokinetics

No toxicokinetics studies specific to the substances in this subgroup were available. However, considering data from other alkylbenzenes (for example, TMBs) and alkylnaphthalenes (for example, methylnaphthalenes), CAS RNs 64742-94-5 and 68477-31-6 are expected to be absorbed into and widely distributed within the body (particularly to lipid-rich tissues), extensively metabolized, and rapidly excreted mainly via urine (US EPA 2005). For example, the terminal half-lives of elimination for the three TMB isomers in venous blood were within the range of 4.6 to 9.9 hours (US EPA 2016), and approximately 70% to 80% of absorbed 2-methylnaphthalene was eliminated within 48 hours in guinea pigs, with 55% eliminated in rats (US EPA 2003). However, small amounts may remain in lipid-rich tissues for longer (US EPA 2005; OECD 2012b).

Repeated-dose toxicity

In a sub-chronic oral study, SD rats (number of each sex per dose not stated in the limited summary available) were administered CAS RN 64742-94-5 by gavage at 0, 300, 600, or 1200 mg/kg bw/day for 13 weeks (EMBSI 1991 as cited in US EPA 2005 and OECD 2012b). A satellite high-dose group also underwent four weeks of recovery. Due to the appearance of clinical signs in several animals, the high dose was reduced to 1000 mg/kg bw/day starting from the fourth day of treatment. A total of 10 early deaths occurred, and after accounting for dosing trauma and aspiration of the test substance, the death of one low-dose female, one high-dose male, and four high-dose females remained unexplained. During the first week, food consumption was lower in treated male rats. For the high-dose males, the reduction in their body weight was significant at all intervals of the study. Kidney and liver weights (absolute and relative) were increased for both sexes in all dose groups. Although no histopathological changes were described for the kidneys, liver hypertrophy was observed in females at all doses and sporadically in males. Additional microscopic findings included thyroid hyperplasia and hypertrophy of the follicular epithelial cells (incidences were higher for both sexes at all doses), splenic hemosiderosis (both sexes at the mid and high doses), and hyperplasia of the urinary bladder mucosa (both sexes at all doses, except for low-dose females). Changes in hematological and clinical chemistry parameters (details not given in the study summary in US EPA 2005) were also observed at the mid and high doses. In the high-dose recovery group, effects on organ weights, microscopic findings in the liver and thyroid, and differences in hematological and clinical chemistry parameters were not observed, indicating their reversibility. However, effects on the spleen and urinary bladder were reduced but not absent after the four-week recovery. A LOAEL of 300 mg/kg bw/day was identified on the basis of the kidney, liver, and thyroid effects.

In a sub-chronic neurotoxicity study, male SD rats (20/concentration) were exposed via whole-body inhalation to the related LBPN substance, HFAN (CAS RN 64742-95-6), at 0, 101, 432, or 1320 ppm (equivalent to approximately 0, 105, 453, or 1411 mg/kg bw/day) for 6 hours/day, 5 days/week, for 90 days (Douglas et al. 1993). The authors examined the following parameters: body weight, clinical signs, motor activity, a functional observation battery (grip strength, acoustic startle response, thermal response, and landing foot splay), and neuropathology. At the highest concentration, the animals exhibited significantly lower body weights throughout the treatment period (12%). No treatment-related neurotoxic effects were observed up to the highest tested concentration of 1320 ppm (approximately 1411 mg/kg bw/day).

Clark et al. (1989) examined the effects of chronic inhalation exposure to HFAN (CAS RN 64742-95-6). Wistar rats (50/sex/concentration) were exposed to HFAN via whole-body inhalation at 0, 470, 970, or 1830 mg/m^3 (equivalent to approximately 0, 103, 213, or 402 mg/kg bw/day) for 6 hours/day, 5 days/week. In each concentration group, one subset (10/sex) was exposed for 6 months, while another subset (25/sex) was exposed for 12 months, and a third subset (15/sex) was exposed for 12 months and held for a 4-month recovery period. During the initial weeks of exposure, decreases in body weight gain were reported for females at mid concentration (2% during the first four weeks) and for both sexes at the high concentration (2% during the first four weeks for males, 3% during the first twelve weeks for females); however, their growth rates became indistinguishable from control for the rest of the experiment. A possible increase in “aggression” was observed in the males at the highest concentration, which persisted into the recovery period. At the same concentration, significant increases in organ weight of 10% or higher were reported for the kidneys and the liver at 6 and 12 months; however, organ weight differences were not observed in the recovery animals. No treatment-related histopathological changes or tumour incidences were observed, and hematological (for example, reversible increase in MCHC and decreases in RBC count and hematocrit in males) and clinical chemistry changes (for example, reversible increase in sodium and decrease in albumin in females) were deemed by the study authors to be of no biological significance. A NOAEC of 970 mg/m^3 (equivalent to 213 mg/kg bw/day) was determined in this assessment on the basis of organ weight changes and aggression.

No repeated-dose studies by the dermal route were identified.

Reproductive and developmental toxicity

In a prenatal developmental study, pregnant SD rats (number per dose not stated in the limited summary available) were administered CAS RN 64742-94-5 by oral gavage at 0, 75, 150, or 450 mg/kg bw/day from GD 6 to 15 (EMBSI 1992 as cited in US EPA 2005). The only effect reported was a significant reduction in body weight gain and in food consumption during the first three days of exposure in the high-dose group. Based on this observation, a maternal NOAEL of 150 mg/kg bw/day was identified. No developmental effects were observed up to 450 mg/kg bw/day, the highest dose tested.

In another prenatal developmental study, pregnant CD-1 mice (30/concentration) were exposed to the related LBPN substance, HFAN (CAS RN 64742-95-6), by whole-body inhalation at 0, 102, 500, or 1514 ppm (equivalent to approximately 0, 176, 857, or 2620 mg/kg bw/day) for 6 hours/day, from GD 6 to 15 (McKee et al. 1990). Evidence of maternal toxicity was observed in all the treatment groups. At the low, mid, and high concentrations, dam body weight on GD 15 was decreased by 10%, 8%, and 15%, respectively, and overall body weight gain (GD 0 to 18) was decreased by 17%, 17%, and 39%, respectively. Except for body weight gain at the low concentration, these reductions were all statistically significant. In addition, one unexplained death occurred at the mid concentration. At the high concentration, there were 14 deaths, and dams also exhibited clinical signs of toxicity and altered hematological parameters (for example, reduced percent hematocrit and mean corpuscular volume). Parallel to the evidence of maternal toxicity, signs of embryo-fetotoxicity were also observed in all the treatment groups, such as a reduction in the number of live fetuses per litter. The accompanying increase in post-implantation loss per dam attained statistical significance at the high concentration. At the mid concentration, fetal body weight was decreased by 7%. At the high concentration, fetal body weight was decreased by 34%, and there were higher incidences of delayed ossification and cleft palate. A maternal and developmental LOAEC of 102 ppm (equivalent to 176 mg/kg bw/day) was determined on the basis of reduced dam body weight and fewer live fetuses per litter.

McKee et al. (1990) also examined the effects of inhalation exposure to HFAN using a 3-generation reproductive toxicity study. COBS CS rats (30/sex/dose) were exposed to HFAN via whole-body inhalation at 0, 103, 495, or 1480 ppm (equivalent to approximately 0, 111, 534, or 1597 mg/kg bw/day). The F0 generation animals were exposed for 6 hours/day, 5 days/week, for 10 weeks prior to mating and during the two-week mating period. Once mating was confirmed, the male animals were sacrificed, while the dams continued to receive treatment from GD 0 to 20. The dams were then placed in nesting boxes to deliver their pups (F1 generation). Exposure was re-initiated on PND 5 and continued until weaning (PND 21). A week after weaning, animals from the F1 generation (30/sex/dose) were exposed in the same way that F0 animals were to produce the F2 generation. Immediately after weaning on PND 22, treatment was initiated for animals in the F2 generation (40/sex/dose, eventually reduced to 30/sex/dose for mating) in order to produce the F3 generation. However, because the majority of the F2 animals in the high-concentration group died during the first week of exposure, all survivors in that group were mated to generate F3 pups. Details of the results from this study have been described in the assessment of LBPNs (ECCC, HC 2023b). Briefly, the high concentration produced a range of toxic affects across all the generations, including mortality, decreased adult body weights and/or body weight gains, clinical signs, reduced F1 male fertility index, smaller litter sizes, and lower pup body weights. At the mid concentration, an effect on body weight and/or body weight gain was also consistently observed across all the generations of adults and pups, with the magnitude of the body weight reduction reaching 16% for F2 adults and 11% for F3 pups. At the low concentration, the only effect reported was a sustained decrease in body weight in the F2 males (10%) and females (6%). A NOAEC of 103 ppm (equivalent to 111 mg/kg bw/day) was considered on the basis of body weight effects across all generations at 495 ppm, in line with the OECD (2012b).

No reproductive or developmental toxicity studies by the dermal route were identified.

Genotoxicity

CAS RN 64742-94-5 was not mutagenic in an *in vitro* bacterial reverse mutation assay (with and without metabolic activation) and was not clastogenic in an *in vivo* micronucleus test (OECD 2012b). The lack of genotoxic potential of substances in this subgroup is supported by the results of assays conducted using the related LBPN substance, CAS RN 64742-95-6. This C9 aromatic hydrocarbon tested negative in *in vitro* bacterial reverse mutation, mammalian cell gene mutation, chromosome aberration, and sister chromatid exchange assays (each with and without metabolic activation) and in an *in vivo* chromosomal aberration test (Schreiner et al. 1989).

Carcinogenicity

CAS RN 68477-31-6 is classified as Category 1B “may cause cancer” (EC 2004, 2008). However, the European Commission (Regulation EC No. 1272/2008, Annex VI) states that the classification as a carcinogen does not apply to gas oils and kerosenes if the refining history is known and if the substance(s) from which they are produced can be shown not to be carcinogenic. This is typically demonstrated if the substance contains less than 0.1% individual carcinogens and/or less than 3% w/w DMSO-extractable total PAC content (EC 2004, 2008; Clark et al. 2013; CONCAWE 2022). The gas oils found in products available to consumers are expected to be highly refined and contain minimal amounts of DMSO-extractable PAC content.

The potential for CAS RN 64742-94-5 to be a local skin tumour promoter was examined in a tumour initiation-promotion bioassay (IITRI 1988). Male CD-1 mice (30/group) were treated dermally with either acetone or a known skin tumour initiator, 9,10-dimethyl-1,2-benzanthracene (DMBA). After resting for two weeks, all of the animals were then treated dermally with 50 µl of undiluted CAS RN 64742-94-5 (equivalent to approximately 1500 mg/kg bw for each application) twice per week for 25 weeks. No skin tumours were observed in the acetone-initiated controls, while 14 benign skin tumours (13 squamous cell papillomas and one keratoacanthoma) were histologically confirmed in the DMBA-initiated group.

In a chronic skin painting study, male C3H/HeJ mice (25 controls, 50 treated) were administered 0 or 25 mg of CAS RN 68477-31-6 twice per week for 13, 27, 41, or 52 weeks (Anonymous 1978). Histopathology revealed slight acanthosis and fibrosis of the dermis, increased severity of liver degeneration with increased duration of exposure, and reactive proliferation of lymphocytes within the spleen of treated animals. Overall, only five treated mice had histologically confirmed tumours (one squamous cell carcinoma and four squamous cell papillomas), and the authors concluded that the single malignant skin tumour was insufficient evidence of carcinogenicity.

In the chronic inhalation study conducted by Clark et al. (1989), which exposed Wistar rats to the related LBPN substance HFAN at 0, 470, 970, or 1830 mg/m^3 (equivalent to approximately 0, 103, 213, or 402 mg/kg bw/day) for 6 hours/day, 5 days/week for up to 12 months, no treatment-related differences in tumour incidence were reported at any of the concentrations tested.

8.2.3 Health effects of PAH and BTEX components

PAHs

The potential for exposure to PAHs, which may be present in gas oils and kerosenes, was considered. PAH species that have sufficient toxicological information can be ranked according to their toxicological potency relative to B[*a*]P through the use of potency equivalency factors (PEFs) (see Table 8-12).

The Government of Canada previously completed a human health risk assessment of certain PAHs, including B[*a*]P, under the *Priority Substances List* Program. On the primary basis of the results of carcinogenicity bioassays in animal models, five PAHs were considered “probably carcinogenic to humans,” substances for which there is believed to be some chance of adverse effects at any level of exposure (Environment Canada, Health Canada 1994). PAHs were added to Schedule 1 of CEPA (Canada 1999).

The US EPA previously determined that PAHs may be carcinogenic to animals and humans (US EPA 1993), ultimately listing 16 substances that became known as the “priority pollutant” PAHs (Menzie et al. 1992; US EPA 2014). They are naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benz[*a*]anthracene, chrysene, benzo[*b+j*]fluoranthene, benzo[*k*]fluoranthene, benzo[*a*]pyrene, indeno[*1,2,3-cd*]pyrene, dibenz[*a,h*]anthracene, and benzo[*ghi*]perylene.

BTEX

The potential for short-term exposures to BTEX, which may be present in gas oils and kerosenes, was considered. This section outlines relevant toxicological information for these scenarios.

In a whole-body inhalation developmental toxicity study, pregnant Swiss Webster mice (5/concentration/time point) were exposed to benzene vapour at 0, 5.1, 9.9, or 20.4 ppm (equivalent to approximately 0, 6, 11, or 23 mg/kg bw/day) for 6 hours/day from GD 6 to 15, and randomly selected offspring from each litter were examined on GD 16 (2/sex), PND 2 (2/sex), and PND 42 (1/sex) (Keller and Snyder 1988). The study authors noted a clear concentration-dependent reduction in early nucleated RBC (basophilic normoblast) counts in the peripheral blood of PND 2 pups, which was statistically significant in all three treatment groups. On the basis of this effect on basophilic normoblast numbers, the California Environmental Protection Agency’s Office of

Environmental Health Hazard Assessment determined the LOAEC to be 5.1 ppm (equivalent to 6 mg/kg bw/day), the lowest concentration tested (OEHHA 2014).

The health effects of toluene were examined in a Canadian residential indoor air quality guideline (RIAQG), which established a short-term (8 h) exposure limit of 15 mg/m^3 for toluene (Health Canada 2011). For a 74 kg adult human, this is approximately equivalent to 2 mg/kg bw/day.

Ethylbenzene was previously assessed by Environment Canada and Health Canada (ECCC, HC 2016a). In a short-term inhalation study that exposed Wag/Rij rats (8/concentration) to ethylbenzene at 0, 300, 400, or 550 ppm (equivalent to 0, 424, 566, or 778 mg/kg bw/day) for 8 hours/day for 5 days, hearing loss associated with the mid-frequency region was observed at 400 ppm and above (Cappaert et al. 2000). A NOAEC of 300 ppm (equivalent to 424 mg/kg bw/day) was identified.

The health effects of xylenes were examined in a Canadian RIAQG, which established a short-term (1 h) exposure limit of 7200 $\mu g/m^3$ for xylenes (Health Canada 2022b). For a 74 kg adult human, this is approximately equivalent to 0.1 mg/kg bw/day.

8.2.4 Consideration of subpopulations who may have greater susceptibility

There are groups of individuals within the Canadian population who, due to greater susceptibility, may be more vulnerable to experiencing adverse health effects from exposure to substances. The potential for susceptibility during different life stages or by sex are considered on the basis of the available studies. In the current assessment, animal studies that examined developmental and neurodevelopmental effects in the young were considered. Overall, developing fetuses, infants, children, and persons of reproductive age (that is, teens and adults capable of becoming pregnant) were identified as the most susceptible subpopulations for adverse health effects. A developmental neurotoxicity endpoint was used as one of the critical health effects to characterize risk from exposure to subgroup 1 substances (see section 8.3.1), and a developmental hematotoxicity endpoint was used as the critical health effect to characterize risk from exposure to residual levels of benzene in products available to consumers containing gas oils and kerosenes (see section 8.3.3).

8.3 Characterization of risk to human health

8.3.1 Subgroup 1 (C9 to C25 predominantly aliphatic hydrocarbons)

A LOAEL of 200 mg/kg bw/day was selected as the most relevant critical effect level to characterize the risk from both short- and long-term dermal exposures to subgroup 1 substances. This effect level was identified on the basis of decreased RBC count (in males) and increased spleen and adrenal weights (in females) after dermal exposure to undiluted kerosene in a 28-day rabbit study (API 1985 as cited in API 2010). This effect level was considered to be protective of similar systemic effects observed in a longer-term dermal study in rats exposed to HDS kerosene (Breglia et al. 2014) and of other systemic effects observed by the dermal route (that is, local axonopathy after treatment with dearomatized and aromatic white spirits) (Verkkala et al. 1984).

A LOAEC of 4679 mg/m^3 (an adjusted LOAEL of 1116 mg/kg bw/day) was selected as the most relevant critical effect level to characterize the risk from both short- and long-term inhalation and oral exposures to subgroup 1 substances. This effect level was identified on the basis of impaired learning and memory in rat offspring exposed gestationally to dearomatized white spirit in an inhalation developmental neurotoxicity study (Hass et al. 2001). This LOAEC was also determined to be the most relevant critical effect level for oral exposures to subgroup 1 substances as developmental toxic effects are systemic and are not expected to be limited to inhalation exposures. Furthermore, given its associated target margin of exposure (MOE) of 1000, this LOAEC was considered to be protective of neurotoxicity observed epidemiologically in humans (Mikkelsen et al. 1988) and of other systemic effects observed in repeated dose, reproductive, and developmental studies conducted in animals.

8.3.1.1 Exposure from environmental media and food

Potential risks to the general population from possible exposure to gas oils from industry-restricted, site-restricted, and fuel uses of gas oils and kerosenes have been previously assessed (Environment Canada, Health Canada 2011, 2013, 2014, 2015).

The maximum daily average exposure to a subgroup 1 substance via inhalation for the general population living in the vicinity of a non-petroleum facility using gas oils was 0.32 mg/kg bw/day (infants, 1 year), assuming 100% systemic absorption by the inhalation route.

As described in section 8.1.1, there is the potential for GOKUPAC substances to be released to water bodies via wastewater treatment systems. There is a potential for exposure if these substances were to be released into water bodies that become a source of drinking water. Using the highest industrial aquatic PEC calculated in section 7.2, the maximum daily intake estimate for GOKUPAC substances in drinking water for formula-fed infants (0 to 5 months; via the use of drinking water in formula) was estimated to be 0.0042 mg/kg bw/day. This estimated daily intake for drinking water is applicable to all substances in this assessment (that is, subgroups 1 and 2). For the combined daily intake estimates, the daily intake from drinking water for infants of 1 year of age (0.00105 mg/kg bw/day) is used instead of the higher value for formula-fed infants of 0 to 5 months because infants of 1 year are the highest exposed age group on a mg/kg bw/day basis when daily intakes from environmental media and food are combined for each age group.

Regarding potential exposure from food, the PDIs from the potential use of three subgroup 1 substances as components in the manufacture of food packaging materials are 0.33, 0.26, and 0.029 µg/kg bw/day (3.3×10^{-4}, 2.6×10^{-4}, and 2.9×10^{-5} mg/kg bw/day) (personal communication, emails from the FD, HC, to the ESRAB, HC, dated November 2017 and April to June 2022; unreferenced). Other substances in subgroup 1 were considered to have food-related exposures of below 25 ng/kg bw/day (2.5×10^{-5} mg/kg bw/day) (personal communication, email from the FD, HC, to the ESRAB, HC, dated April 2022; unreferenced).

To address potential risk from the combined daily intake of subgroup 1 substances in the GOKUPAC Group that may be present in environmental media and food, as described above, the estimates of potential daily intakes for the subgroup 1 substances resulting in the highest combined daily intake estimate (for the overall highest exposed age group of infants, 1 year) and MOE are presented in Table 8-8.

Table 8-8. Relevant daily intake estimates and resulting MOE for environmental media and food for subgroup 1

Daily intake from ambient air (mg/kg bw/day)[a]	Daily intake from drinking water (mg/kg bw/day)[a]	Daily intake from food (mg/kg bw/day)[a]	Combined daily intake (mg/kg bw/day)[a]	MOE for combined daily intake[b]
0.32	0.00105	0.000029	0.32	3500

Abbreviations: MOE, margin of exposure
[a] For infants, 1 year
[b] The critical health effect level used for these combined oral and inhalation exposures is an adjusted lowest observed adverse effect level (LOAEL) of 1116 mg/kg bw/day identified on the basis of impaired learning and memory observed in a rat inhalation developmental neurotoxicity study in which dams were exposed to dearomatized white spirit from gestational day 7 to 20. This adjusted LOAEL was calculated by converting the lowest observed adverse effect concentration of 4679 mg/m^3 from the inhalation developmental neurotoxicity study into an internal dose that accounted for animal inhalation rate (m^3/day), body weight (kg), and time adjustment factors (hours of exposure/24; days of exposure in a week/7). Animal inhalation rates were determined using the equation provided in Bide et al. (2000). Animal body weights were derived from the study report if available; a default value as presented in Meek et al. (1994) was used otherwise. Target MOE = 1000 (x10 for interspecies variation; x10 for intraspecies variation; x10 for the use of a LOAEL).

For subgroup 1 substances, comparison of the critical effect level with the highest estimated combined daily intake from ambient air, drinking water, and food resulted in a MOE of 3500. This MOE is above 1000 and is therefore considered adequate to address uncertainties in the health effects and exposure data used to characterize risk.

8.3.1.2 Exposure from products available to consumers

Oral, dermal, and inhalation exposure estimates, and resulting MOEs, for the gas oil and kerosene substances in subgroup 1 from the use of products available to consumers are presented in Table 8-9 for the characterization of risk. For each category of products available to consumers, the exposure estimates are given as the range of all products identified for risk characterization in that category for each route of exposure. For subgroup 1 substances, route-specific hazard studies are used for risk characterization; as a result, exposures via the dermal and inhalation routes from use of the same product are considered separately. Refer to Appendix E for exposure estimates and MOEs for specific product scenarios.

Table 8-9. Relevant exposure estimates and resulting MOEs for subgroup 1 substances in products available to consumers

Scenario	Population	Route	Exposure (mg/kg bw/day)	MOE[a,b]
Automotive products	Adults	Dermal	0.11 to 7.5	27 to 1 800
Automotive products	Adults	Inhalation	0.34 to 6.2	180 to 3 300
Cosmetics	Children, teens, adults	Oral	0.18 to 0.66	1 700 to 6 200
Cosmetics	Infants, children, teens, adults	Dermal	0.0011 to 159	1 to 180 000
Cosmetics	Infants, children, teens, adults	Inhalation	8.2×10^{-5} to 1.6	700 to 11 million
Cleaning products	Adults	Dermal	0.11 to 97	2 to 4 900
Cleaning products	Adults	Inhalation	0.00044 to 290	4 to 2.5 million
DIY products	Adults	Dermal	0.18 to 28	7 to 1100
DIY products	Adults	Inhalation	2.3 to 6.2	180 to 490
NHPs and NPDs	Infants, children, teens, adults	Dermal	0.034 to 46	4 to 5 900
NHPs and NPDs	Infants, children, teens, adults	Inhalation	4.8×10^{-4} to 0.45	2 500 to 2.3 million
Other household products	Adults	Dermal	8.1×10^{-5} to 31	6 to 91 000
Other household products	Infants, adults	Inhalation	5.9×10^{-4} to 52	21 to 2.5 million
Paints and coatings	Adults	Dermal	2.3 to 34	6 to 87
Paints and coatings	Adults	Inhalation	0.57 to 160	7 to 2 000

Abbreviations: DIY, do-it-yourself; MOE, margin of exposure

[a] The critical health effect level used for oral and inhalation exposures is an adjusted lowest observed adverse effect level (LOAEL) of 1116 mg/kg bw/day identified on the basis of the impaired learning and memory observed in a rat inhalation developmental neurotoxicity study in which dams were exposed to dearomatized white spirit from gestational day 7 to 20. This adjusted LOAEL was calculated by converting the lowest observed adverse effect concentration of 4679 mg/m^3 from the inhalation developmental neurotoxicity study into an internal dose that accounted for animal inhalation rate (m^3/day), body weight (kg), and time adjustment factors (hours of exposure/24; days of exposure in a week/7). Animal inhalation rates were determined using the equation provided in Bide et al. (2000). Animal body weights were derived from the study report if available; a default value as presented in Meek et al. (1994) was used otherwise. Target MOE = 1000 (x10 for interspecies variation; x10 for intraspecies variation; x10 for the use of a LOAEL).

[b] The critical health effect level used for dermal exposures is a LOAEL of 200 mg/kg bw/day identified on the basis of the hematological effects in male rabbits and increased spleen and adrenal weights in female rabbits after dermal exposure to undiluted kerosene in a 28-day study. Target MOE = 1000 (x10 for interspecies variation; x10 for intraspecies variation; x10 for the use of a LOAEL).

For subgroup 1 substances, the comparisons of the critical effect levels with their dermal and inhalation exposure estimates from their uses in cosmetics, NHPs, NPDs, and other products available to consumers resulted in MOEs as low as 1 and as high as 180 000 for dermal exposure scenarios and in MOEs as low as 4 and as high as 11 million for inhalation exposure scenarios (Table 8-9). The MOEs for dermal and/or inhalation exposures are below 1000 for some cosmetics (moisturizers [including face sprays and masks], after hair-removal products, sunless tan lotions, after sun products, body packs, facial foundations, facial makeup removers, hair conditioning products, hair dyes, hair styling products, massage oils, spray perfumes, deodorants/antiperspirants, waterless hand cleaners, and genital products), NHPs and NPDs (moisturizers, sunscreens, and liquid foundation with sun protection factor), automotive products (vehicle cleaners and polishes [including engine, exterior, and interior]), cleaning products (household cleaning products [including firearm, furniture, and surface cleaners and polishes] and adhesive removers), DIY products (lubricants, adhesives, and paint thinners), paints and coatings (paints [including spray, automotive, and primer] and wood stains and coatings [including varnish and wax]), and other household products (fabric and leather protectants and air fresheners). These MOEs that fall below 1000 are considered to be potentially inadequate to address uncertainties in the health effects and exposure data used to characterize risk.

Owing to the similarities in the expected health effects and physical-chemical properties of all of the substances in subgroup 1, it is expected that these substances could be used interchangeably in products available to consumers and that they would pose the same potential risk. Therefore, the risk characterization is considered to be applicable to all subgroup 1 substances, resulting in MOEs that are considered to be potentially inadequate for all subgroup 1 substances. Potential exposures from the use of products that could be used concurrently (for example, cosmetics, automotive products) were not aggregated as risk concerns were identified for individual scenarios. However, individuals who use multiple products containing these substances could be exposed to higher levels and could therefore be at higher risk.

8.3.2 Subgroup 2 (C9 to C16 predominantly aromatic hydrocarbons)

A LOAEC of 102 ppm (an adjusted LOAEL of 176 mg/kg bw/day) was selected as the most relevant critical effect level to characterize the risk from both short- and long-term inhalation exposures, as well as short-term dermal and long-term oral exposures, to subgroup 2 substances. This effect level was identified on the basis of maternal toxicity (reduced body weight and body weight gain) and fetal toxicity (fewer live fetuses per litter) in an inhalation prenatal developmental toxicity study in CD-1 mice exposed to high flash aromatic naphtha (McKee et al. 1990). The signs of maternal and fetal toxicity observed by McKee et al. (1990) were systemic and may therefore be relevant to exposures by all three routes. This effect level was also considered to be protective of other systemic effects (for example, body weight reduction and thyroid, liver, and kidney effects) observed in longer-term oral and inhalation studies.

8.3.2.1 Exposure from environmental media and food

Potential risks to the general population from possible exposure to gas oils from industry-restricted, site-restricted, and fuel uses of gas oils and kerosenes have been previously assessed (Environment Canada, Health Canada 2011, 2013, 2014, 2015).

The maximum daily average exposure to a subgroup 2 substance via inhalation for the general population living in the vicinity of a non-petroleum facility using gas oils was 0.12 mg/kg bw/day (infants, 1 year), assuming 100% systemic absorption by the inhalation route.

As described in section 8.1.1, there is the potential for GOKUPAC substances to be released to water bodies via wastewater treatment systems. There is a potential for exposure if these substances were to be released into water bodies that become a source of drinking water. Using the highest industrial aquatic PEC calculated in section 7.2, the maximum daily intake estimate for GOKUPAC substances in drinking water for formula-fed infants (0 to 5 months; via the use of drinking water in formula) was estimated to be 0.0042 mg/kg bw/day. This estimated daily intake for drinking water is applicable to all substances in this assessment (that is, subgroups 1 and 2). For the combined daily intake estimates, the daily intake from drinking water for infants of 1 year of age (0.00105 mg/kg bw/day) is used instead of the higher value for formula-fed infants of 0 to 5 months because infants of 1 year are the highest exposed age group on a mg/kg bw/day basis, when daily intakes from environmental media and food are combined for each age group.

Regarding potential exposure from food, the one applicable subgroup 2 substance was considered to have food-related exposures of below 25 ng/kg bw/day (2.5×10^{-5} mg/kg bw/day) (personal communication, email from the FD, HC, to the ESRAB, HC, dated April 2022; unreferenced).

To address potential risk from the combined daily intake of subgroup 2 substances in the GOKUPAC Group that may be present in environmental media and food, as described above, the highest potential daily intake estimates (for the overall highest exposed age group of infants, 1 year) and MOE for subgroup 2 are presented in Table 8-10.

Table 8-10. Relevant daily intake estimates and resulting MOE for environmental media and food for subgroup 2

Daily intake from ambient air (mg/kg bw/day)[a]	Daily intake from drinking water (mg/kg bw/day)[a]	Daily intake from food (mg/kg bw/day)[a]	Combined daily intake (mg/kg bw/day)[a]	MOE for combined daily intake[b]
0.12	0.00105	N/A	0.12	1500

Abbreviations: MOE, margin of exposure; N/A, not applicable
[a] For infants, 1 year
[b] The critical health effect level used for this combined oral and inhalation exposure is an adjusted lowest observed adverse effect level (LOAEL) of 176 mg/kg bw/day identified on the basis of maternal and fetal toxicity in an inhalation prenatal developmental toxicity study in CD-1 mice exposed to high flash aromatic naphtha from gestational day 6 to

15. This adjusted LOAEL was calculated by converting the lowest observed adverse effect concentration of 102 ppm from the inhalation prenatal developmental toxicity study into an internal dose that accounted for animal inhalation rate (m^3/day), body weight (kg), and time adjustment factors (hours of exposure/24; days of exposure in a week/7). Animal inhalation rates were determined using the equation provided in Bide et al. (2000). Animal body weights were derived from the study report if available; a default value as presented in Meek et al. (1994) was used otherwise. Target MOE = 1000 (x10 for interspecies variation; x10 for intraspecies variation; x10 for the use of a LOAEL).

For subgroup 2 substances, comparison of the critical effect level with the highest estimated combined daily intake resulted in a MOE of 1500. This MOE is above 1000 and is therefore considered adequate to address uncertainties in the health effects and exposure data used to characterize risk.

8.3.2.2 Exposure from products available to consumers

Dermal and inhalation exposure estimates, as well as combined exposure estimates for the dermal and inhalation routes, and resulting MOEs, for the gas oil and kerosene substances in subgroup 2 from the use of products available to consumers are presented in Table 8-11 for the characterization of risk. For each category of products available to consumers, the exposure estimates are given as the range for all products identified for risk characterization in that category for the dermal and inhalation routes separately and combined. Refer to Appendix E for exposure estimates and the MOEs for specific product scenarios.

Table 8-11. Relevant exposure estimates and resulting MOEs for subgroup 2 substances in products available to consumers

Scenario	Population	Route	Exposure (mg/kg bw/day)[a]	MOE[b]
Automotive products	Adults	Dermal	0.026 to 0.61[c]	290 to 6800
Automotive products	Adults	Inhalation	0.059 to 0.15	1200 to 3000
Automotive products	Adults	Combined	0.085 to 0.76	230 to 2100
Other household products	Adults	Dermal	0.026 to 2.9[c]	61 to 6800
Other household products	Adults	Inhalation	0.66 to 2.0	88 to 270
Other household products	Adults	Combined	2.0 to 3.6	49 to 88
Paints and coatings	Adults	Dermal	0.090 to 1.1[c]	160 to 2000
Paints and coatings	Adults	Inhalation	0.022 to 2.3	77 to 8000
Paints and coatings	Adults	Combined	0.11 to 3.3	53 to 1600

Abbreviation: MOE, margin of exposure

[a] Internal dose (mg/kg bw/day) = mean air concentration on day of exposure (mg/m^3) × Inhalation rate (m^3/day) / body weight (kg).

[b] The critical health effect level used for these combined dermal and inhalation exposures is an adjusted lowest observed adverse effect level (LOAEL) of 176 mg/kg bw/day identified on the basis of maternal and fetal toxicity in an inhalation prenatal developmental toxicity study in CD-1 mice exposed to high flash aromatic naphtha from gestational day 6 to 15. This adjusted LOAEL was calculated by converting the lowest observed adverse effect concentration of 102 ppm from the inhalation prenatal developmental toxicity study into an internal dose that accounted for animal inhalation rate (m^3/day), body weight (kg), and time adjustment factors (hours of exposure/24; days of exposure in a week/7). Animal inhalation rates were determined using the equation provided in Bide et al. (2000). Animal body weights were derived from the study report if available; a default value as presented in Meek et

al. (1994) was used otherwise. Target MOE = 1000 (x10 for interspecies variation; x10 for intraspecies variation; x10 for the use of a LOAEL).
[c] Dermal systemic exposure estimated by applying a 75% dermal absorption factor to the external dermal exposure amount.

For subgroup 2 substances, the comparison of the critical effect level with the combined dermal and inhalation exposure estimates resulted in MOEs ranging from 49 to 2100 (Table 8-11). The MOEs for combined dermal and inhalation exposures are below 1000 for some automotive products (automotive undercoating sprays), paints and coatings (spray paints and wood stains), and other household products (fabric and leather protectants). These MOEs that fall below 1000 are considered to be potentially inadequate to address uncertainties in the health effects and exposure data used to characterize risk. Similarly to subgroup 1, there are similarities in the expected health effects and physical-chemical properties of the two substances in subgroup 2, and it is expected that these substances could be used interchangeably in products available to consumers. Although the MOEs for both substances are already considered to be potentially inadequate, the risk characterization is considered to be applicable to both subgroup 2 substances. Potential exposures from the use of products that could be used concurrently (for example, automotive products) were not aggregated since risk concerns were identified for individual scenarios. However, individuals who use multiple products containing these substances could be exposed to higher levels and could therefore be at higher risk.

8.3.3 PAH and BTEX components of gas oils and kerosenes

The presence of PAHs or BTEX in drinking water from GOKUPAC substances is expected to be limited. There are Canadian federal guidelines, various provincial and municipal guidelines, and other mechanisms, including regulations, that are in place to limit concentrations of certain PAHs and BTEX in municipal drinking water, as well as in certain sewer discharges and surface water that could be sourced for drinking water. Examples of some of these at the federal, provincial, and municipal level include: Ontario 1994; CCME 1999; Ottawa 2011; British Columbia Ministry of Environment and Climate Change 2020; Health Canada 2020; Alberta Environment and Parks 2021; Ontario 2022; Ottawa 2022a; and Quebec 2022. A selection of recent municipal drinking water testing results for major urban centres (Calgary 2021; Hamilton 2021; Montreal 2021; Toronto 2021; Metro Vancouver 2022; Ottawa 2022b), taken as examples, have shown that levels of tested PAHs and BTEX are below the maximum accepted concentration values stated therein, which are either equal to or stricter than those set out in the Canadian Drinking Water Quality Guidelines (CDWQGs; Health Canada 2020). Some jurisdictions adopt the CDWQGs through legislation, while others use them as a guide; this approach grants each jurisdiction the ability to develop or adopt drinking water quality standards that are appropriate for the region. It is generally expected that, by the time any surface water intended for use as drinking water has been processed through a drinking water treatment facility, it will not contain any PAH or BTEX components of GOKUPAC substances at a level that would be considered to be of concern for human health.

Compositional analyses of a total of 18 products available to consumers that contain gas oil and/or kerosene ingredients from the GOKUPAC Group showed that they may contain certain PAH species in the order of low ppb to ppm (section 8.1.3). The highest combined level of PAHs contained in any product (engine cleaner) was 0.0013% by weight; this was predominantly due to the presence of naphthalene, with a smaller contribution from fluorene. In order to evaluate the potential risk to human health, PEFs were used. These PEFs are given in Table 8-12. The PAHs found at the highest concentrations in Table 8-15 have low toxicological potency relative to B[*a*]P.

Table 8-12. PAH compositional analysis (ppm) from high sensitivity testing of 18 gas oil or kerosene-based products available to consumers

PAH	C_{max} in high sensitivity testing of 18 products[a]	Potency equivalency factor (PEF) relative to B[*a*]P[b]
Naphthalene	11.6	0.001
Acenaphthylene	0.004	0.001
Acenaphthene	0.014	0.001
Fluorene	1.29	0.001
Phenanthrene	0.128	0.001
Anthracene	0.038	0.01
Fluoranthene	0.003	0.001
Pyrene	0.004	0.001
Benz[*a*]anthracene	0.002	0.1
Chrysene	ND	0.01
Benzo[*b+j*]fluoranthene	ND	0.1
Benzo[*k*]fluoranthene	ND	0.1
Benzo[*a*]pyrene	ND	1
Indeno[*1,2,3-cd*]pyrene	ND	0.1
Dibenz[*a,h*]anthracene	ND	5
Benzo[*ghi*]perylene	ND	0.01

Abbreviations: B[*a*]P, Benzo[*a*]pyrene; C_{max}, maximum concentration; ND, not detected; PAH, Polycyclic Aromatic Hydrocarbon; ppm, parts per million

[a] Health Canada 2015b. Limit of detection of the methodology was 0.5 or 1.0 ppb (0.0005 or 0.001 ppm)

[b] From Nisbet and LaGoy (1992)

Converting the highest PAH concentrations detected for each PAH across all tested products, as well as one-half of the LOD for each non-detected PAH, into B[*a*]P equivalents results in an upper bounding B[*a*]P concentration of 2.0×10^{-2} ppm, which is about 25 times lower than the EU individual PAH limit of 0.5 mg/kg (ppm) set out for rubber and soft plastic toys and children's articles (ECHA 2018). The risk to human health from potential incidental exposure to low levels of PAHs resulting from exposure to GOKUPAC substances is therefore considered to be low.

Estimates of short-term inhalation exposure to BTEX from the use of an engine cleaner and paste varnish were compared with the critical points of departure or the internal dose equivalents of short-term RIAQG exposure limits described in section 8.2.3. The risk from short-term inhalation exposure to BTEX resulting from exposure to GOKUPAC substances is considered to be low.

8.4 Uncertainties in evaluation of risk to human health

The key sources of uncertainty are presented in Table 8-14 below.

Table 8-13. Sources of uncertainty in the risk characterization

Key source of uncertainty	Impact
The composition of the UVCB substances may be variable in different products available to consumers and other names may be associated with the CAS RNs, which makes the identification of some products and relevant studies difficult.	+/-
Due to the high number of products available to consumers that contain the gas oil and kerosene substances in this assessment, professional judgment was applied to determine which scenarios were most likely to result in the highest general population exposures across product categories. There is a potential that some products on the Canadian market not captured in this assessment could result in similar or potentially higher exposures.	-
While an effort was made to make the selection of products for exposure modelling representative of the most widely used products, there is uncertainty in the extent to which the chosen products represent the cross section of all products containing gas oils and kerosenes available to the Canadian consumer (that is, with respect to the amount of gas oil and kerosene present in the product and the PAH and BTEX compositions of the gas oil and kerosene ingredient).	+/-
There is limited substance-specific information on environmental media exposure to the gas oils and kerosenes in this assessment (for example, no measured data with source attribution to the substances in this assessment; NPRI data available for only two substances).	+/-
Environmental fate processes and behaviours are difficult to predict for complex mixtures owing to the complex interactions of components within the mixtures, and there is variability in the fate and behaviour of different components in the mixtures as they have different physical-chemical properties.	+/-
The application of biosolids containing gas oils and kerosenes to agricultural land was not evaluated, but is not expected to be a significant source of exposure to the general population. There is, however, a lack of data on this source of exposure.	-
Potential exposures from the use of products that could be used concurrently were not aggregated; however, individuals who use multiple products containing these substances could be exposed to higher levels and could therefore be at higher risk. This potential higher risk was not quantified.	-
Toxicokinetics information on the entire mixture of constituents in these complex UVCB substances was not identified. There are uncertainties associated with extrapolating the kinetics data from single constituent studies as each constituent in a mixture can affect the absorption,	+/-

Key source of uncertainty	Impact
distribution, metabolism, and/or excretion of the other constituents. There are also uncertainties associated with extrapolating the kinetics data from radiolabelled surrogate measurements as the rest of the aliphatic and aromatic fractions may not behave identically to the chosen surrogates.	
The health effects data available for subgroup 1 and 2 substances were considered to be limited. Toxicological data from similar UVCB mixtures (for example, kerosene-type aviation turbine fuels and LBPNs) were used to inform the hazard characterization.	+/-
There is a lack of substance-specific information on dermal absorption as direct measurements for the subgroup 2 substances are not available.	+/-
The total product amount of subgroup 1 substances was considered to be available by both the dermal and inhalation route, which may overestimate exposure by the individual route for products available to consumers.	+
Due to the similarities in the physical-chemical properties and the expected health effects of the substances in subgroup 1, it is expected that these substances could be used interchangeably in certain products available to consumers and could therefore pose the same potential risk. This is a conservative approach as not all substances in this subgroup had identified risks of concern on a per substance basis.	+

+ = uncertainty with potential to cause overestimation of exposure and/or risk; - = uncertainty with potential to cause underestimation of exposure and/or risk; +/- = unknown potential to cause over- or underestimation of risk.

9. Conclusion

Considering all available lines of evidence presented in this draft assessment, there is low risk of harm to the environment from the 16 Gas Oils and Kerosenes with Uses in Products Available to Consumers in this assessment. It is proposed to conclude that the 16 Gas Oils and Kerosenes with Uses in Products Available to Consumers in this assessment 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 under conditions that constitute or may constitute a danger to the environment on which life depends.

Considering all the information presented in this draft assessment, it is proposed to conclude that the 16 Gas Oils and Kerosenes with Uses in Products Available to Consumers in this assessment meet the criteria under paragraph 64(*c*) of CEPA as they are 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.

Therefore, it is proposed to conclude that the 16 Gas Oils and Kerosenes with Uses in Products Available to Consumers in this assessment meet the criteria set out in section 64 of CEPA.

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Appendices

Appendix A. Substances in the Chemicals Management Plan Gas Oils and Kerosenes with Uses in Products Available to Consumers Group

Table A-1. *Domestic Substances List* (DSL) names and definitions of the 16 substances in the Gas Oils and Kerosenes with Uses in Products Available to Consumers Group (NCI 2015)

CAS RN	DSL Name	Definition
8008-20-6	Kerosene (petroleum)	A complex combination of hydrocarbons produced by the distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C9 through C16 and boiling in the range of approximately 180°C to 300°C (356°F to 572°F).
64741-44-2	Distillates (petroleum), straight-run middle	A complex combination of hydrocarbons produced by the distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C11 through C20 and boiling in the range of 205°C to 345°C (401°F to 653°F).
64741-77-1	Distillates (petroleum), light hydrocracked	A complex combination of hydrocarbons from distillation of the products from a hydrocracking process. It consists predominantly of saturated hydrocarbons having carbon numbers predominantly in the range of C10 through C18, and boiling in the range of approximately 160°C to 320°C (320°F to 608°F).
64741-85-1	Raffinates (petroleum), sorption process	A complex combination of hydrocarbons remaining after removal of normal paraffins in a selective adsorption process. It consists predominantly of branched chain and cyclic hydrocarbons having carbon numbers predominantly in the range of C5 through C25 and boiling in the range of approximately 35°C to 400°C (95°F to 752°F).
64741-91-9	Distillates (petroleum), solvent-refined middle	A complex combination of hydrocarbons obtained as the raffinate from a solvent extraction process. It consists predominantly of aliphatic hydrocarbons having carbon numbers predominantly in the range of C9 through C20 and boiling in the range of approximately 150°C to 345°C (302°F to 653°F).
64742-13-8	Distillates (petroleum), acid-treated middle	A complex combination of hydrocarbons obtained as a raffinate from a sulfuric acid treating process. It consists of hydrocarbons having carbon numbers predominantly in the range of C11 through C20 and boiling in the range of approximately 205°C to 345°C (401°F to 653°F).

CAS RN	DSL Name	Definition
64742-14-9	Distillates (petroleum), acid-treated light	A complex combination of hydrocarbons obtained as a raffinate from a sulfuric acid treating process. It consists of hydrocarbons having carbon numbers predominantly in the range of C9 through C16 and boiling in the range of approximately 150°C to 290°C (302°F to 554°F).
64742-38-7	Distillates (petroleum), clay-treated middle	A complex combination of hydrocarbons resulting from treatment of a petroleum fraction with natural or modified clay, usually in a percolation process to remove the trace amounts of polar compounds and impurities present. It consists of hydrocarbons having carbon numbers predominantly in the range of C9 through C20 and boiling in the range of approximately 150°C to 345°C (302°F to 653°F).
64742-46-7	Distillates (petroleum), hydrotreated middle	A complex combination of hydrocarbons obtained by treating a petroleum fraction with hydrogen in the presence of a catalyst. It consists of hydrocarbons having carbon numbers predominantly in the range of C11 through C25 and boiling in the range of approximately 205°C to 400°C (401°F to 752°F).
64742-47-8	Distillates (petroleum), hydrotreated light	A complex combination of hydrocarbons obtained by treating a petroleum fraction with hydrogen in the presence of a catalyst. It consists of hydrocarbons having carbon numbers predominantly in the range of C9 through C16 and boiling in the range of approximately 150°C to 290°C (302°F to 554°F).
64742-79-6	Gas oils (petroleum), hydrodesulfurized	A complex combination of hydrocarbons obtained from a petroleum stock by treating with hydrogen to convert organic sulfur to hydrogen sulfide, which is removed. It consists predominantly of hydrocarbons having carbon numbers predominantly in the range of C13 through C25 and boiling in the range of approximately 230°C to 400°C (446°F to 752°F).
64742-81-0	Kerosine (petroleum), hydrodesulfurized	A complex combination of hydrocarbons obtained from a petroleum stock by treating with hydrogen to convert organic sulfur to hydrogen sulfide, which is removed. It consists of hydrocarbons having carbon numbers predominantly in the range of C9 through C16 and boiling in the range of approximately 150°C to 290°C (302°F to 554°F).
64742-94-5	Solvent naphtha (petroleum), heavy arom.	A complex combination of hydrocarbons obtained from distillation of aromatic streams. It consists predominantly of aromatic hydrocarbons having carbon numbers predominantly in the range of C9

CAS RN	DSL Name	Definition
		through C16 and boiling in the range of approximately 165°C to 290°C (330°F to 554°F).
64742-96-7	Solvent naphtha (petroleum), heavy aliph.	A complex combination of hydrocarbons obtained from the distillation of crude oil or natural gasoline. It consists predominantly of saturated hydrocarbons having carbon numbers predominantly in the range of C11 through C16 and boiling in the range of approximately 190°C to 290°C (374°F to 554°F).
64771-72-8	Paraffins (petroleum), normal C_{5-20}	A complex combination of normal paraffins obtained by a selective adsorption process using a solid adsorbent such as a molecular sieve. It consists of straight chain saturated hydrocarbons having carbon numbers predominantly in the range of C5 through C20 and boiling in the range of 35°C to 345°C (95°F to 653°F).
68477-31-6	Distillates (petroleum), catalytic reformer fractionator residue, low-boiling	The complex combination of hydrocarbons from the distillation of catalytic reformer fractionator residue. It boils approximately below 288°C (550°F).

Appendix B. PAH compositional testing of products available to consumers in Canada

Table B-1. Testing results[a] for the priority PAHs in seven Canadian household products containing gas oils and kerosenes[b] (ppm)

Priority PAH species	LOQ per priority PAH species	Results[c]
Naphthalene	Not measured	N/A
Acenaphthalene	195	<LOQ
Acenaphthene	200	<LOQ
Fluorene	193	<LOQ
Phenanthrene	195	<LOQ
Anthracene	185	<LOQ
Fluoranthene	197	<LOQ
Pyrene	196	<LOQ
Benz[*a*]anthracene	222	<LOQ
Chrysene	230	<LOQ
Benzo[*b+j*]fluoranthene	Not measured	N/A
Benzo[*k*]fluoranthene	252	<LOQ
Benzo[*a*]pyrene	243	<LOQ
Indeno[*1,2,3-cd*]pyrene	298	<LOQ
Dibenz[*a,h*]anthracene	303	<LOQ
Benzo[*ghi*]perylene	291	<LOQ

Abbreviations: LOQ, limit of quantification; N/A, not applicable; PAH, polycyclic aromatic hydrocarbon; ppm, parts per million

[a] Health Canada 2013

[b] Household products containing gas oils and kerosenes that were tested consisted of a leather cleaner and conditioner, adhesive remover, waterproofing liquid, butcher block oil and cleaner, automotive rubbing compound, automotive wax, and lubricant.

[c] The testing results are presented in terms of the LOQ of the methodology and are applicable to all seven household products. None of the products tested had measured PAH concentrations at or above the listed LOQs.

Table B-2. Results of high sensitivity testing for the 16 priority PAHs[a] in 18 Canadian products available to consumers[b] (ppb) containing gas oils and kerosenes

Product	Product category	NA	AY	AN	FE	PA	AA	FA	PY
Detection limit (ppb)	-	1	1	1	0.5	0.5	0.5	0.5	0.5
Lemon oil wood cleaner	Cleaning	9.9	ND	ND	2.0	1.9	ND	ND	ND
Lemon oil wood cleaner	Cleaning	ND	ND	ND	ND	ND	ND	ND	ND
Fibreglass colour restorer and cleaner	Cleaning	111	ND	ND	ND	ND	ND	ND	ND
Adhesive remover liquid	Cleaning	1.2	ND	ND	ND	ND	ND	ND	ND
Adhesive remover spray gel	Cleaning	ND	ND	ND	ND	ND	ND	ND	ND
Stainless steel cleaner	Cleaning	18	2.5	ND	7.5	ND	ND	ND	ND
Firearm cleaner	Cleaning	1030	4.0	ND	49.7	ND	ND	ND	ND
Hand cleaner	Cosmetics	ND	ND	ND	ND	ND	ND	ND	ND
Hand cleaner	Cosmetics	ND	ND	ND	ND	ND	ND	ND	ND
Anti-rust spray	Paints & coatings	35.3	ND	ND	ND	ND	ND	ND	ND
Paste varnish	Paints & coatings	19.2	ND	ND	ND	ND	ND	ND	ND
Penetrating lubricant	DIY	177	ND	ND	916	109	29.7	ND	ND
Liquid sander	DIY	476	ND	ND	ND	ND	ND	ND	ND
Automotive polish	Automotive	4.5	1.4	ND	3.4	ND	ND	3.4	3.5
Automotive polish	Automotive	7.4	ND	ND	ND	ND	ND	ND	ND
Automotive wax	Automotive	28.5	2.4	ND	0.7	ND	ND	2.5	2.6
Engine cleaner	Automotive	4900	ND	ND	ND	ND	ND	ND	ND
Engine cleaner	Automotive	11600	ND	13.9	1290	128	38.2	ND	ND

Product	Product category	BA	CH	BF	BK	BP	IP	DA	BG
Detection limit (ppb)	-	1	1	1	1	1	1	1	1
Lemon oil wood cleaner	Cleaning	ND	ND	ND	ND	ND	ND	ND	ND
Lemon oil wood cleaner	Cleaning	ND	ND	ND	ND	ND	ND	ND	ND
Fibreglass colour restorer and cleaner	Cleaning	ND	ND	ND	ND	ND	ND	ND	ND
Adhesive remover liquid	Cleaning	ND	ND	ND	ND	ND	ND	ND	ND
Adhesive remover spray gel	Cleaning	ND	ND	ND	ND	ND	ND	ND	ND
Stainless steel cleaner	Cleaning	ND	ND	ND	ND	ND	ND	ND	ND
Firearm cleaner	Cleaning	ND	ND	ND	ND	ND	ND	ND	ND
Hand cleaner	Cosmetics	ND	ND	ND	ND	ND	ND	ND	ND
Hand cleaner	Cosmetics	ND	ND	ND	ND	ND	ND	ND	ND
Anti-rust spray	Paints & coatings	ND	ND	ND	ND	ND	ND	ND	ND
Paste varnish	Paints & coatings	ND	ND	ND	ND	ND	ND	ND	ND
Penetrating lubricant	DIY	ND	ND	ND	ND	ND	ND	ND	ND
Liquid sander	DIY	ND	ND	ND	ND	ND	ND	ND	ND
Automotive polish	Automotive	ND	ND	ND	ND	ND	ND	ND	ND
Automotive polish	Automotive	ND	ND	ND	ND	ND	ND	ND	ND
Automotive wax	Automotive	1.8	ND	ND	ND	ND	ND	ND	ND
Engine cleaner	Automotive	ND	ND	ND	ND	ND	ND	ND	ND
Engine cleaner	Automotive	ND	ND	ND	ND	ND	ND	ND	ND

Abbreviations: DIY, do-it-yourself; ND, not detected; ppb, parts per billion

[a] PAHs tested were naphthalene (NA), acenaphthylene (AY), acenaphthene (AN), fluorene (FE), phenanthrene (PA), anthracene (AA), fluoranthene (FA), pyrene (PY), benz[*a*]anthracene (BA), chrysene (CH), benzo[*b+j*]fluoranthene (BF), benzo[*k*]fluoranthene (BK), benzo[*a*]pyrene (BP), indeno[*1,2,3-cd*]pyrene (IP), dibenz[*a,h*]anthracene (DA) and benzo[*ghi*]perylene (BG).

[b] Health Canada 2015b

Appendix C. BTEX compositional testing of products available to consumers in Canada

Table C-1. Results of testing for BTEX in 20 Canadian products available to consumers[a] (ppm) containing gas oils and kerosenes

Product	Product category	Benzene	Toluene	Ethylbenzene	o-Xylene	m- and p-Xylene
Reportable detection limit range (ppm)	-	0.5–300	0.5–300	0.5–300	0.5–300	1–500
Lemon oil wood cleaner	Cleaning	ND	ND	ND	ND	ND
Lemon oil wood cleaner	Cleaning	ND	9.0	7.8	27	25
Fibreglass colour restorer and cleaner	Cleaning	ND	3.7	9	19	38
Adhesive remover liquid	Cleaning	ND	ND	ND	ND	ND
Adhesive remover spray gel	Cleaning	ND	1.1	ND	ND	ND
Stainless steel cleaner[b]	Cleaning	ND	ND	ND	ND	ND
Firearm cleaner	Cleaning	1.8	92	230	470	890
Hand cleaner	Cosmetics	ND	ND	ND	ND	ND
Hand cleaner	Cosmetics	ND	ND	ND	ND	ND
Anti-rust[c]	Paints & coatings	0.6	7.2	15	34	88
Paste varnish[d]	Paints & coatings	ND	943	1 200	1 550	4 700
Penetrating lubricant[e]	DIY	ND	8.6	7.9	12	28
Penetrating lubricant[f]	DIY	ND	9.4	14	19	52
Liquid sander[g]	DIY	ND	180 000	ND	ND	ND
Automotive polish[h]	Automotive	ND	1.8	0.8	1	3
Automotive polish[i]	Automotive	ND	ND	ND	ND	ND
Automotive wax	Automotive	ND	ND	22	48	89
Engine cleaner[j]	Automotive	ND	49	290	2 200	4 100
Engine cleaner[k]	Automotive	36	530	480	740	1 500

Product	Product category	Benzene	Toluene	Ethylbenzene	o-Xylene	m- and p-Xylene
Engine cleaner[l]	Automotive	ND	625	36 000	41 000	120 000

Abbreviations: BTEX, benzene, toluene, ethylbenzene, and xylene; DIY, do-it-yourself; ND, not detected; ppm, parts per million

[a] Health Canada 2015c

[b] Contains CAS RNs 64742-52-5 (60% to 70%) and 64742-89-8 (10% to 20%)

[c] Contains CAS RNs 8052-41-3 (1% to 5%), 64742-54-7 and/or 64742-52-5 (3% to 7%), 64742-53-6 (3% to 7%), 74-98-6 (5% to 15%), 75-28-5 (5% to 10%)

[d] Contains CAS RN 8052-41-3 (10% to 30%)

[e] Contains CAS RNs 64742-52-5 and/or 64742-53-6 (30% to 60%)

[f] Contains CAS RN 64742-65-0 (20% to 30%)

[g] Contains toluene (20% to 40%)

[h] Contains CAS RNs 64742-48-9 (3% to 7%) and 8012-95-1 (1% to 5%)

[i] Contains CAS RNs 8052-95-1 (<10%) and 95-63-6 (<1%)

[j] Contains CAS RN 74-98-6 (7% to 13%)

[k] Contains CAS RN 68476-34-6 (60% to 100%), 91-20-3 (1% to 5%), 78330-12-8 (1% to 5%), xylene (0.1% to 1%), 95-63-6 (0.1% to 1%), and 26264-05-1 (0.1% to 1%)

[l] Contains xylene (10% to 30%), ethylbenzene (3% to 7%), and CAS RNs 74-98-6 (3% to 7%) and 75-28-5 (5% to 10%)

Appendix D. Exposure factors used in determining exposure of the general population to Gas Oils and Kerosenes with Uses in Products Available to Consumers

Body weights and inhalation rates used in the exposure estimates are presented in Table D-1.

Table D-1. General human exposure factors for different age groups in scenarios[a]

Age groups	Body weight (kg)	Inhalation rate (m^3/day)
0 to 5 months	6.3	3.7
6 to 11 months	9.1	5.4
1 year	11	8.0
2 to 3 years	15	9.2
4 to 8 years	23	11.1
9 to 13 years	42	13.9
14 to 18 years	62	15.9
Adults (19+ years)	74	15.1

[a] Health Canada [modified 2022]

Table D-2. Variable inputs to SCREEN3 calculation of industrial exposure of the general population to CAS RNs 64742-47-8 and 64742-94-5

Variables	Input Value
Source type[a]	Area
Effective emission area[a]	100 m × 120 m (CAS RN 64742-47-8) 43 m × 163 m (CAS RN 64742-94-5)
Emission rate (g/s•m^2)[b]	4.2×10^{-4} (CAS RN 64742-47-8) 1.2×10^{-4} (CAS RN 64742-94-5)
Source release height (m)[a]	8 (CAS RN 64742-47-8) 14 (CAS RN 64742-94-5)
Receptor height (m)[c]	1.74
Variable wind adjustment factor	0.4 (daily average), 0.2 (annual average)
Urban/Rural option[a]	Urban
Type of meteorology[d]	Full
Minimum and maximum distance (m)	0–1000

[a] Professional judgment based on aerial photo analysis
[b] Estimated based on the highest quantity of the substance released during the past five years (2017-2021) by a single submitter and an assumed continuous release (NPRI 2022). As a result, data from the reporting years 2017 and 2019 were used for CAS RNs 64742-47-8 and 64742-94-5, respectively.
[c] Curry et al. 1993
[d] Regulatory default from the SCREEN3 model

Cosmetics and Natural Health Products

The values used for product amount, frequency of use and retention factors were developed through a process established for CMP assessments (Health Canada 2020). This process includes a review of available data on product amount, frequency of use and retention factors of self-care products for comprehensiveness of the study or survey, the relevance of the data collected, and the type of information collected. The highest central tendency value from the studies with the highest quality rating is selected for use in CMP assessments, and underlying studies are cited. The concentration data were based on information notified to Health Canada under the *Cosmetic Regulations* (personal communication, emails from the CHPSD, HC, to the ESRAB, HC, dated March to June 2022; unreferenced) and information provided to Health Canada under the *Natural Health Product Regulations* (personal communication, emails from the NNHPD, HC, to the ESRAB, HC, dated March to June 2022; unreferenced). Product scenarios with frequencies less than one per day were set to a minimum frequency of 1 to assess exposure on the day of use.

Dermal exposure on the day of use was estimated using the following algorithm:

Dermal exposure (mg/kg bw/day) = product amount (g) * concentration (fraction) * retention factor (fraction) * frequency of use (times/day) * 1000 (mg/g) / body weight (kg)

No dermal absorption factor was applied since route-to-route extrapolation to the dermal route was not required for risk characterization of cosmetics and natural health products (subgroup 1 substances only).

Similarly, oral exposure on the day of use was estimated using the following algorithm:

Oral exposure (mg/kg bw/day) = product amount (g) * concentration (fraction) * frequency of use (times/day) * 1000 (mg/g) / body weight (kg)

The three substances present in cosmetic and natural health products (that is, CAS RN 64742-46-7, CAS RN 64742-47-8 and CAS RN 64771-72-8) are considered to be volatile. Inhalation exposure was estimated using the ConsExpo Web model (ConsExpo Web 2021). For inhalation exposure from spray products, the "Exposure to vapour–Instantaneous release" model was used. For inhalation exposure to substances volatilized from leave-on products, the "Exposure to vapour–evaporation–constant release area" model and the following parameters were used:

- Molecular weight matrix: 1000 g/mol
- Temperature: 32°C
- Mass transfer coefficient: 10 m/hr
- As a conservative approach, vapour pressure and molecular weight were selected based on the substance representative of the lowest carbon number in the substance ingredient name in the sentinel product; see Table D-3 for vapour pressure and molecular weight default values used for estimating exposures from use of cosmetics. There is more than one cosmetic ingredient name for a given CAS RN, and therefore different values of vapour pressure and molecular weights were used in the exposure characterization depending on the ingredient

name. The vapour pressure and molecular weight of tridecane (7 Pa and 184 g/mol, respectively) were used in estimating exposures from use of natural health products, as these products contained CAS RN 64742-46-7 by the ingredient name of “C13-15 Alkane” and CAS RN 64742-47-8 by the ingredient name of “C13-14 Alkane.”

Table D-3. Vapour pressures and molecular weights used in estimating inhalation exposures from cosmetics

CAS RN	Cosmetic ingredient name in sentinel product	Lowest carbon-number representative structure	Vapour pressure (Pa)[a]	Molecular weight (g/mol)[a]
64742-46-7	C13-15 Alkane	C13 Alkane, tridecane	7	184
64742-46-7	C15-19 Alkane	C15 Alkane, pentadecane	0.5	212
64742-47-8	C13-14 Isoparaffin C13-16 Isoparaffin	2-methyldodecane (C13)	31	184
64742-47-8	C11-15 Alkane/cycloalkane	C11 Alkane, undecane	55	156
64771-72-8	Alkanes C10-13	C10 Alkane, decane	191	142

[a] Vapour pressure and molecular weight values were derived from EPI Suite (2008).

Negligible inhalation exposure from volatilization is expected when the applied skin surface area is occluded or obstructed, thereby limiting volatilization of the substance from the applied skin surface to room air.

Table D-4: Cosmetics – exposure: detailed calculations and inputs for exposure estimates

Exposure scenario	Inputs
Face moisturizer (CAS RN 64742-46-7 and CAS RN 64742-47-8)	Frequency (per day): 19+ years: 2 (Loretz et al. 2005) 9–18 years: 1 (Ficheux et al. 2015) Weight fractions: Product 1: 0.4655 (CAS RN 64742-46-7) Product 2: 0.3 (CAS RN 64742-47-8) Product amount (g): 14+ years: 1.5 (Ficheux et al. 2016a) 9–13 years: 1.1 (Ficheux et al. 2016a) *Dermal*:

Exposure scenario	Inputs
	Retention factor: 1 *Inhalation:* Exposure and emission duration (hours): 19+ years: 12 9–18 years: 24 Room volume (m^3): 20 (unspecified room, RIVM 2014) Ventilation rate (per hour): 0.6 (unspecified room, RIVM 2014) Surface area (cm^2) (equal to half of the head to approximate face; based on defaults from Health Canada [modified 2022]): 19+ years: 585 14–18 years: 370 9–13 years: 350 Sentinel products contained CAS RN 64742-46-7 by the cosmetic ingredient name of "C15-19 Alkane" and CAS RN 64742-47-8 by the cosmetic ingredient name of "C13-16 Isoparaffin."
Hand moisturizer (CAS RN 64742-46-7 and CAS RN 64742-47-8)	Frequency (per day): 19+ years: 2 (Loretz et al. 2005) 4–18 years: 1 (Wu et al. 2010; Ficheux et al. 2015) 2–3 years: 1 (assumed, to estimate exposure on the day of use) Weight fractions: Product 1: 0.05 (CAS RN 64742-46-7) Product 2: 0.05 (CAS RN 64742-47-8) Product amount (g): 14+ years: 1.6 (Ficheux et al. 2016a) 4–13 years: 1.2 (Ficheux et al. 2016a) 2–3 years: 0.87 (Ficheux et al. 2016a; surface area adjustment) *Dermal*: Retention factor: 1 *Inhalation:* Exposure and emission duration (hours): 19+ years: 12 9–18 years: 24 Room volume (m^3): 20 (unspecified room, RIVM 2014) Ventilation rate (per hour): 0.6 (unspecified room, RIVM 2014) Surface area (cm^2) (based on defaults from Health Canada [modified 2022]): 19+ years: 910 14–18 years: 770

Exposure scenario	Inputs
	9–13 years: 610 4–8 years: 430 2–3 years: 310 Sentinel products contained CAS RN 64742-46-7 by the cosmetic ingredient name of “C13-15 Alkane” and CAS RN 64742-47-8 by the cosmetic ingredient name of “C13-16 Isoparaffin.”
Body moisturizer (CAS RN 64742-46-7 and CAS RN 64742-47-8)	Frequency (per day): 19+ years: 1 (Wu et al. 2010; Ficheux et al. 2015) 0–5 months to 14–18 years: 1 (assumed, to estimate exposure on the day of use) Weight fractions: Product 1: 0.5 (CAS RN 64742-46-7) Product 2: 0.2 (CAS RN 64742-47-8) Product amount (g): 19+ years: 4.87 (Ficheux et al. 2016a) 14–18 years: 4.65 (Ficheux et al. 2016a) 9–13 years: 3.61 (Ficheux et al. 2016a; surface area adjustment) 4–8 years: 2.30 (Ficheux et al. 2016a; surface area adjustment) 2–3 years: 1.85 (Ficheux et al. 2016a) 1 year: 1.45 (Ficheux et al. 2016a; surface area adjustment) 6–11 months: 1.16 (Ficheux et al. 2016a; surface area adjustment) 0–5 months: 0.93 (Ficheux et al. 2016a; surface area adjustment) *Dermal*: Retention factor: 1 Product amount (g): 19+ years: 10 (Ficheux et al. 2016a) 14–18 years: 10 (Ficheux et al. 2016a) 9–13 years: 7.7 (Ficheux et al. 2016a; surface area adjustment) 4–8 years: 5 (Ficheux et al. 2016a; surface area adjustment) 2–3 years: 4.1 (Ficheux et al. 2016a) 1 year: 3.1 (Ficheux et al. 2016a; surface area adjustment) 6–11 months: 2.5 (Ficheux et al. 2016a; surface area adjustment) 0–5 months: 2 (Ficheux et al. 2016a; surface area adjustment) *Inhalation:* Product amount (g; adjusted from above for exposed surface area as indicated below): 19+ years: 4.87 14–18 years: 4.65 9–13 years: 3.61 4–8 years: 2.30

Exposure scenario	Inputs
	2–3 years: 1.85 1 year: 1.45 6–11 months: 1.16 0–5 months: 0.93 Exposure and emission duration (hours): 24 Room volume (m^3): 58 (living room, RIVM 2014) Ventilation rate (per hour): 0.5 (living room, RIVM 2014) Surface area (cm^2) (unclothed skin of short-sleeved shirt and shorts, exposing arms, ¾ legs, hands, ½ feet; based on defaults from Health Canada [modified 2022]): 19+ years: 8543 14–18 years: 7655 9–13 years: 5953 4–8 years: 3813 2–3 years: 2685 1 year: 2070 6–11 months: 1703 0–5 months: 1325 Sentinel products contained CAS RN 64742-46-7 by the cosmetic ingredient name of “C13-15 Alkane” and CAS RN 64742-47-8 by the cosmetic ingredient name of “C13-16 Isoparaffin.”
Deodorant/ antiperspirant (solid/roll-on) (CAS RN 64742-46-7)	Frequency (per day): 19+ years: 1.3 (Loretz et al. 2006) 9–18 years: 1.1 (Wu et al. 2010; Ficheux et al. 2015) Weight fraction: 0.1 Product amount (g): 14+ years: 1 (Ficheux et al. 2016a) 9–13 years: 0.4 (Ficheux et al. 2016a) *Dermal:* Retention factor: 1
Spray perfume/eau de toilette (CAS RN 64742-46-7 and CAS RN 64742-47-8)	Frequency (per day): 19+ years: 1.7 (Loretz et al. 2006) 9–18 years: 1.4 (Statistics Canada 2017) 2–8 years: 1 (Statistics Canada 2017; rounded up to estimate exposure on the day of use) Weight fractions: Product 1: 0.1 (CAS RN 64742-46-7) Product 2: 0.3 (CAS RN 64742-47-8) Product amount (g):

Exposure scenario	Inputs
	2–19+ years: 0.33 (Loretz et al. 2006) *Dermal:* Retention factor: 0.85 *Inhalation:* Exposure duration (min): 5 (Bremmer et al. 2006) Room volume (m^3): 10 m^3 (bathroom, RIVM 2014) Ventilation rate (per hour): 2 (bathroom, RIVM 2014) Application temperature (°C): 20 Sentinel products contained CAS RN 64742-46-7 by the cosmetic ingredient name of “C15-19 Alkane” and CAS RN 64742-47-8 by the cosmetic ingredient name of “C13-16 Isoparaffin.”
Lipstick/lip balm (CAS RN 64742-46-7 and CAS RN 64742-47-8)	Frequency (per day): 19+ years: 2.0 (Statistics Canada 2017) 14–18 years: 2.5 (Statistics Canada 2017) 4–13 years: 1.2 (Statistics Canada 2017) 2–3 years: 1 (Statistics Canada 2017) Weight fractions: Product 1: 0.449 (CAS RN 64742-46-7) Product 2: 0.3 (CAS RN 64742-47-8) Product amount (g): 2–19+ years: 0.022 (Ficheux et al. 2016a) Exposure from use of this product is conservatively assumed to be via the oral route exclusively.
Facial foundation (liquid) (CAS RN 64742-46-7 and CAS RN 64742-47-8)	Frequency (per day): 19+ years: 1.2 (Loretz et al. 2006) 14–18 years: 1 (Ficheux et al. 2015) 4–13 years: 1 (Garcia-Hidalgo et al. 2017; rounded up to estimate exposure on day of use) Weight fractions: Product 1: 0.1375 (CAS RN 64742-46-7) Product 2: 0.1 (CAS RN 64742-47-8) Product amount (g): 19+ years: 0.54 (Loretz et al. 2006) 14–18 years: 0.41 (Ficheux et al. 2016a) 9–13 years: 0.39 (Ficheux et al. 2016a; surface area adjustment) 4–8 years: 0.34 (Ficheux et al. 2016a; surface area adjustment)

Exposure scenario	Inputs
	Dermal: Retention Factor: 1 *Inhalation:* Exposure and emission duration (hours): 16 (Bremmer et al. 2006) Room volume (m^3): 20 (unspecified room, RIVM 2014) Ventilation rate (per hour): 0.6 (unspecified room, RIVM 2014) Surface area (cm^2) (equal to half of the head to approximate face; based on defaults from Health Canada [modified 2022]): 19+ years: 585 14–18 years: 370 9–13 years: 350 4–8 years: 305 Sentinel products contained CAS RN 64742-46-7 by the cosmetic ingredient name of “C13-15 Alkane” and CAS RN 64742-47-8 by the cosmetic ingredient name of “C13-16 Isoparaffin.”
Facial make-up remover (for example, biphasic oil and water) (CAS RN 64742-46-7)	Frequency (per day): 14+ years: 1 (Ficheux et al. 2015) 9–13 years: 1 (Ficheux et al. 2015; rounded up to estimate exposure on day of use) 4–8 years: 1 (Garcia-Hidalgo et al. 2017; rounded up to estimate exposure on day of use) Weight fraction: 0.3467 Product amount (g): 14+ years: 2.6 (Ficheux et al. 2016a) 9–13 years: 2.5 (Ficheux et al. 2016a; surface area adjustment) 4–8 years: 2.2 (Ficheux et al. 2016a) *Dermal:* Retention factor: 0.1 *Inhalation:* Retention factor: 0.1 Exposure and emission duration (hours): 24 (professional judgment) Room volume (m^3): 58 (living room, RIVM 2014) Ventilation rate (per hour): 0.5 (living room, RIVM 2014) Surface area (cm^2) (equal to half of the head to approximate face; based on defaults from Health Canada [modified 2022]): 19+ years: 585 14–18 years: 370

Exposure scenario	Inputs
	9–13 years: 350 4–8 years: 305 Sentinel product contained CAS RN 64742-46-7 by the cosmetic ingredient name of “C15-19 Alkane.”
Facial make-up remover (lotion) (CAS RN 64742-47-8)	Frequency (per day): 9+ years: 1 (Ficheux et al. 2015) 4–8 years: 1 (Garcia-Hidalgo et al. 2017; rounded up to estimate exposure on day of use) Weight fraction: 0.1 Product amount (g): 14+ years: 4.4 (Ficheux et al. 2016a) 4–13 years: 2.2 (Ficheux et al. 2016a) *Dermal:* Retention factor: 0.1 *Inhalation:* Retention factor: 0.1 Exposure and emission duration (hours): 24 (professional judgment) Room volume (m^3): 58 (living room, RIVM 2014) Ventilation rate (per hour): 0.5 (living room, RIVM 2014) Surface area (cm^2) (equal to half of the head to approximate face; based on defaults from Health Canada [modified 2022]): 19+ years: 585 14–18 years: 370 9–13 years: 350 4–8 years: 305 Sentinel product contained CAS RN 64742-47-8 by the cosmetic ingredient name of “C13-16 Isoparaffin.”
Face mask/pack (CAS RN 64742-46-7 and CAS RN 64742-47-8)	Frequency (per day): 14+ years: 1 (Ficheux et al. 2015; rounded up to estimate exposure on day of use) Weight fractions: Product 1: 0.3 (CAS RN 64742-46-7) Product 2: 0.1 (CAS RN 64742-47-8) Product amount (g): 14+ years: 9.7 (Ficheux et al. 2016a) *Dermal:*

Exposure scenario	Inputs
	Retention Factor: 0.1 *Inhalation:* Exposure and emission duration (min): 20 (professional judgment) Room volume (m^3): 58 (living room, RIVM 2014) Ventilation rate (per hour): 0.5 (living room, RIVM 2014) Surface area (cm^2) (equal to half of the head to approximate face; based on defaults from Health Canada [modified 2022]): 19+ years: 585 14–18 years: 370 Sentinel products contained CAS RN 64742-46-7 by the cosmetic ingredient name of “C15-19 Alkane” and CAS RN 64742-47-8 by the cosmetic ingredient name of “C13-16 Isoparaffin.”
Hair conditioner, leave-on (cream or semi-solid cream) (CAS RN 64742-46-7 and CAS RN 64742-47-8)	Frequency (per day): 19+ years: 1.1 (Loretz et al. 2008) 2–18 years: 1 (Wu et al. 2010; rounded up to estimate exposure on day of use) Weight fractions: Product 1: 0.03 (CAS RN 64742-46-7) Product 2: 0.3 (CAS RN 64742-47-8) Product amount (g): 19+ years: 13.1 (Loretz et al. 2008) 14–18 years: 10 (Ficheux et al. 2016a) 9–13 years: 7.8 (Ficheux et al. 2016a) 4–8 years: 7.8 (Ficheux et al. 2016a) 2–3 years: 5.2 (Garcia-Hidalgo et al. 2017) *Dermal:* Retention factor: 0.1 *Inhalation:* Exposure and emission duration (hours): 19+ years: 21.8 (24 hours divided by frequency) 2–18 years: 24 Room volume (m^3): 58 (living room, RIVM 2014) Ventilation rate (per hour): 0.5 (living room, RIVM 2014) Surface area (cm^2) (surface area of hair assumed to be equivalent to that of head; based on defaults from Health Canada [modified 2022]): 19+ years: 1170 14–18 years: 740

Exposure scenario	Inputs
	9–13 years: 700 4–8 years: 610 2–3 years: 550 Sentinel products contained CAS RN 64742-46-7 by the cosmetic ingredient name of “C13-15 Alkane” and CAS RN 64742-47-8 by the cosmetic ingredient name of “C13-16 Isoparaffin.”
Hair oil or serum (CAS RN 64742-46-7 and CAS RN 64742-47-8)	Frequency (per day): 2+ years: 1 (to estimate exposure on day of use) Weight fractions: Product 1: 0.8 (CAS RN 64742-46-7) Product 2: 1.0 (CAS RN 64742-47-8) Product amount (g; based on mean hair oil product exposure of 0.42 mg/kg bw/day reported in Ficheux et al. 2016b, divided by the retention rate reported therein and multiplied by body weights from Table D-1 above): 19+ years: 0.31 14–18 years: 0.26 9–13 years: 0.18 4–8 years: 0.097 2–3 years: 0.063 *Dermal:* Retention factor: 0.1 *Inhalation:* Exposure and emission duration (hours): 2+ years: 24 Room volume (m^3): 58 (living room, RIVM 2014) Ventilation rate (per hour): 0.5 (living room, RIVM 2014) Surface area (cm^2) (surface area of hair assumed to be equivalent to that of head; based on defaults from Health Canada [modified 2022]): 19+ years: 1170 14–18 years: 740 9–13 years: 700 4–8 years: 610 2–3 years: 550 Sentinel products contained CAS RN 64742-46-7 by the cosmetic ingredient name of “C15-19 Alkane” and CAS RN 64742-47-8 by the cosmetic ingredient name of “C13-16 Isoparaffin.”
Hair styling product (for	Frequency (per day):

Exposure scenario	Inputs
example, pomade, balm, cream or putty) (CAS RN 64742-46-7 and CAS RN 64742-47-8)	2+ years: 1 (Ficheux et al. 2015; rounded up to estimate exposure on day of use) Weight fractions: Product 1: 0.15 (CAS RN 64742-46-7) Product 2: 0.1716 (CAS RN 64742-47-8) Product amount (g): 14+ years: 3.7 (Ficheux et al. 2016a) 9–13 years: 3.5 (Ficheux et al. 2016a; surface area adjustment) 4–8 years: 3.1 (Ficheux et al. 2016a; surface area adjustment) 2–3 years: 2.8 (Ficheux et al. 2016a; surface area adjustment) *Dermal:* Retention factor: 0.1 *Inhalation:* Exposure and emission duration (hours): 24 Room volume (m^3): 58 (living room, RIVM 2014) Ventilation rate (per hour): 0.5 (living room, RIVM 2014) Surface area (cm^2) (surface area of hair assumed to be equivalent to that of head; based on defaults from Health Canada [modified 2022]): 19+ years: 1170 14–18 years: 740 9–13 years: 700 4–8 years: 610 2–3 years: 550 Sentinel products contained CAS RN 64742-46-7 by the cosmetic ingredient name of “C13-15 Alkane” and CAS RN 64742-47-8 by the cosmetic ingredient name of “C13-16 Isoparaffin.”
Hairspray (for example, aerosol) (CAS RN 64742-46-7 and CAS RN 64742-47-8)	Frequency (per day): 19+ years: 1.49 (Loretz et al. 2008) 14–18 years: 1 (Wu et al. 2010; rounded up to estimate exposure on day of use) 4–13 years: 1 (Ficheux et al. 2015; rounded up to estimate exposure on day of use) Weight fractions: Product 1: 0.1 (CAS RN 64742-46-7) Product 2: 0.6 (CAS RN 64742-47-8) Product amount (g): 19+ years: 2.6 (Loretz et al. 2008)

Exposure scenario	Inputs
	4–18 years: 2.3 (Ficheux et al. 2016a) *Dermal:* Retention factor: 0.085 *Inhalation:* Exposure duration (min): 5 (Bremmer et al. 2006) Room volume (m^3): 10 m^3 Ventilation rate (per hour): 2 (bathroom, RIVM 2014) Application temperature (°C): 20 (bathroom, RIVM 2014) Sentinel products contained CAS RN 64742-46-7 by the cosmetic ingredient name of “C13-15 Alkane” and CAS RN 64742-47-8 by the cosmetic ingredient name of “Isoparaffinic Hydrocarbon.” In the latter case, the vapour pressure and molecular weight of 2-methyldodecane were used as defaults in the ConsExpo Web model.
Genital product (CAS RN 64742-47-8)	Frequency (per day): 19+ years: 1 (ECCC, HC 2016b) Weight fraction: 0.015 Product amount (g): 19+ years: 10 (ECCC, HC 2016b) *Dermal:* Retention factor: 1
Permanent hair dye (CAS RN 64742-47-8)	Frequency (per day): 14–19 years: 1 (Bernard et al. 2016; rounded up to estimate exposure on day of use) Weight fraction: 0.0455 Product amount (g): 14+ years: 132.6 (Ramirez-Martinez et al. 2015) *Dermal:* Retention factor: 0.1 *Inhalation:* Exposure and emission duration (min): 40 (Bremmer et al. 2006) Room volume (m^3): 10 (bathroom, RIVM 2014) Ventilation rate (per hour): 2 (bathroom, RIVM 2014)

Exposure scenario	Inputs
	Surface area (cm^2) (surface area of hair assumed to be equivalent to that of head; based on defaults from Health Canada [modified 2022]): 19+ years: 1170 14–18 years: 740 Sentinel product contained CAS RN 64742-47-8 by the cosmetic ingredient name of “C13-16 Isoparaffin.”
Semi-permanent hair dye (CAS RN 64742-47-8)	Frequency (per day): 14–19 years: 1 (Bernard et al. 2016; rounded up to estimate exposure on day of use) Weight fraction: 0.0455 Product amount (g): 14+ years: 35 (SCCS 2015) *Dermal:* Retention factor: 0.1 *Inhalation:* Exposure and emission duration (min): 40 (Bremmer et al. 2006) Room volume (m^3): 10 (bathroom, RIVM 2014) Ventilation rate (per hour): 2 (bathroom, RIVM 2014) Surface area (cm^2) (surface area of hair assumed to be equivalent to that of head; based on defaults from Health Canada [modified 2022]): 19+ years: 1170 14–18 years: 740 Sentinel product contained CAS RN 64742-47-8 by the cosmetic ingredient name of “C13-16 Isoparaffin.”
After hair-removal wipe (CAS RN 64742-46-7)	Frequency (per day): 9+ years: 1 (Biesterbos et al. 2013; rounded up to estimate exposure on day of use) Weight fraction: 0.1 Product amount (g): 9+ years: 0.9 (Ficheux et al. 2016) *Dermal:* Retention factor: 1 *Inhalation:*

Exposure scenario	Inputs
	Exposure and emission duration (min): 20 (professional judgment) Room volume (m^3): 10 (bathroom, RIVM 2014) Ventilation rate (per hour): 2 (bathroom, RIVM 2014) Surface area (cm^2) (half of total surface area; based on defaults from Health Canada [modified 2022]): 19+ years: 9350 14–18 years: 8600 9–13 years: 6700 Sentinel product contained CAS RN 64742-46-7 by the cosmetic ingredient name of “C13-15 Alkane.”
Waterless hand cleaner (CAS RN 64742-47-8)	Frequency (per day): 19+ years: 2.9 (Wu et al. 2010) Weight fraction: 0.37 Product amount (g): 19+ years: 0.7 (Health Canada 2015d) *Dermal:* Retention factor: 1 *Inhalation:* Exposure and emission duration (hours): 19+ years: 8.3 (assumed to be 24 hours divided by frequency) Room volume (m^3): 20 (unspecified room, RIVM 2014) Ventilation rate (per hour): 0.6 (unspecified room, RIVM 2014) Surface area (cm^2) (based on defaults from Health Canada [modified 2022]): 19+ years: 910 Sentinel product contained CAS RN 64742-47-8 by the cosmetic ingredient name of “C11-15 Alkane/cycloalkane.”
Massage oil (CAS RN 64742-46-7 and CAS RN 64742-47-8)	Frequency: 1 (to estimate exposure on day of use) Weight fractions: Product 1: 0.3 (CAS RN 64742-46-7) Product 2: 0.0192 (CAS RN 64742-47-8) Product amount (g): 19+ years: 3.2 (Ficheux et al. 2016a) 14–18 years: 2.9 (Ficheux et al. 2016a; surface area adjustment) 9–13 years: 2.3 (Ficheux et al. 2016a; surface area adjustment) 4–8 years: 1.9 (Ficheux et al. 2016a; surface area adjustment) 2–3 years: 1.8 (Ficheux et al. 2016a)

Exposure scenario	Inputs
	1 year: 1.8 (Ficheux et al. 2016a) 6–11 months: 1.8 (Ficheux et al. 2016a) 0–5 months: 1.8 (Ficheux et al. 2016a) *Dermal:* Retention factor: 1 *Inhalation:* Exposure and emission duration (hour): 1 (professional judgment) Room volume (m^3): 20 (unspecified room, RIVM 2014) Ventilation rate (per hour): 0.6 (unspecified room, RIVM 2014) Surface area (cm^2) (based on defaults from Health Canada [modified 2022]): 19+ years: 17 530 14–18 years: 16 460 9–13 years: 12 700 4–8 years: 8 290 2–3 years: 5 950 1 year: 4 430 6–11 months: 3 680 0–5 months: 2 860 Sentinel products contained CAS RN 64742-46-7 by the cosmetic ingredient name of “C15-19 Alkane” and CAS RN 64742-47-8 by the cosmetic ingredient name of “C13-14 Isoparaffin.”
Foot moisturizer (CAS RN 64742-47-8)	Frequency (per day): 14+ years: 1 (Loretz et al. 2005; round up to estimate exposure on day of use) Weight fraction: 0.1 Product amount (g): 14+ years: 4.1 (Ficheux et al. 2016a) *Dermal:* Retention factor: 1
Face spray (anti-aging) (CAS RN 64742-46-7)	Frequency (per day): 19+ years: 2 (specific to product) Weight fraction: 0.3 Product amount (g): 19+ years: 0.33 (Loretz et al. 2006) *Dermal:*

Exposure scenario	Inputs
	Retention factor: 0.85 (RIVM 2006) *Inhalation:* Exposure duration (min): 5 (Bremmer et al. 2006) Room volume (m^3): 10 (bathroom, RIVM 2014) Ventilation rate (per hour): 2 (bathroom, RIVM 2014) Application temperature (°C): 20 Sentinel products contained CAS RN 64742-46-7 by the cosmetic ingredient name of “C15-19 Alkane.”
Hair conditioner, wash-off (CAS RN 64742-46-7)	Frequency (per day): 19+ years: 1.1 (Loretz et al. 2008) 2–18 years: 1 (Wu et al. 2010; rounded up to estimate exposure on day of use) Weight fraction: 0.3 Product amount (g): 19+ years: 13.1 (Loretz et al. 2008) 14–18 years: 10 (Ficheux et al. 2016a) 9–13 years: 7.8 (Ficheux et al. 2016a) 4–8 years: 7.8 (Ficheux et al. 2016a) 2–3 years: 5.2 (Garcia-Hidalgo et al. 2017) *Dermal:* Retention factor: 0.01 *Inhalation:* Retention factor: 0.01 Exposure and emission duration (hours): 19+ years: 21.8 (24 hours divided by frequency) 2–18 years: 24 Room volume (m^3): 58 (living room, RIVM 2014) Ventilation rate (per hour): 0.5 (living room, RIVM 2014) Surface area (cm^2) (surface area of hair assumed to be equivalent to that of head; based on defaults from Health Canada [modified 2022]): 19+ years: 1170 14–18 years: 740 9–13 years: 700 4–8 years: 610 2–3 years: 550 Sentinel product contained CAS RN 64742-46-7 by the cosmetic ingredient name of “C13-15 Alkane.”

Exposure scenario	Inputs
Temporary hair dye (CAS RN 64742-46-7)	Frequency (per day): 19+ years: 1 (Bernard et al. 2016; rounded up to estimate exposure on day of use) 4–18 years: 1 (Bremmer et al. 2006; rounded up to estimate exposure on day of use) Weight fraction: 0.01 Product amount (g): 4+ years: 35 (SCCS 2015) *Dermal:* Retention factor: 0.1 *Inhalation:* Exposure and emission duration (min): 40 (Bremmer et al. 2006) Room volume (m^3): 10 (bathroom, RIVM 2014) Ventilation rate (per hour): 2 (bathroom, RIVM 2014) Surface area (cm^2) (surface area of hair assumed to be equivalent to that of head; based on defaults from Health Canada [modified 2022]): 19+ years: 1170 14–18 years: 740 9–13 years: 700 4–8 years: 610 Sentinel products contained CAS RN 64742-46-7 by the cosmetic ingredient name of “C13-15 Alkane.”
Sunless tanning lotion (CAS RN 64742-47-8)	Frequency (per day): 19+ years: 1 (to estimate exposure on day of use) Weight fraction: 0.01 Product amount (g): 19+ years: 10 (assumed to be same as body lotion) *Dermal:* Retention factor: 1 *Inhalation* Exposure and emission duration (hours): 24 Room volume (m^3): 58 (living room, RIVM 2014) Ventilation rate (per hour): 0.5 (living room, RIVM 2014)

Exposure scenario	Inputs
	Surface area (cm^2) (unclothed skin of short-sleeved shirt and shorts, exposing arms, ¾ legs, hands, ½ feet; based on defaults from Health Canada [modified 2022]): 19+ years: 8543 Sentinel product contained CAS RN 64742-47-8 by the cosmetic ingredient name of “C13-14 Isoparaffin.”
Body pack (CAS RN 64742-47-8)	Frequency (per day): 19+ years: 1 (to estimate exposure on day of use) Weight fraction: 0.0073 Product amount (g): 19+ years: 290 (calculated based on face mask usage and surface area adjustment) *Dermal:* Retention factor: 0.1 *Inhalation* Exposure and emission duration (hours): 1 Room volume (m^3): 20 (unspecified room, RIVM 2014) Ventilation rate (per hour): 0.6 (unspecified room, RIVM 2014) Surface area (cm^2) (based on defaults from Health Canada [modified 2022]): 19+ years: 17 530 Sentinel product contained CAS RN 64742-47-8 by the cosmetic ingredient name of “C13-14 Isoparaffin.”
After sun cream/milk (CAS RN 64742-47-8)	Frequency (per day): 19+ years: 1 (Ficheux et al. 2015) Weight fraction: 0.003 Product amount (g): 14+ years: 12.2 (Ficheux et al. 2016a) 4–13 years : 5.9 (Ficheux et al. 2016a) 6 months to 3 years: 5.4 (Ficheux et al. 2016a) *Dermal:* Retention factor: 1 *Inhalation:* Exposure and emission duration (hours): 24 Room volume (m^3): 58 (living room, RIVM 2014) Ventilation rate (per hour): 0.5 (living room, RIVM 2014)

Exposure scenario	Inputs
	Surface area (cm^2) (unclothed skin of short-sleeved shirt and shorts, exposing arms, ¾ legs, hands, ½ feet; based on defaults from Health Canada [modified 2022]): 19+ years: 8543 14–18 years: 7656 9–13 years: 5953 4–8 years: 3813 2–3 years: 2685 1 year: 2070 6–11 months: 1703 Sentinel product contained CAS RN 64742-47-8 by the cosmetic ingredient name of “C13-14 Isoparaffin.”
After hair-removal (body) (CAS RN 64742-47-8)	Frequency (per day): 9+ years: 1 (Biesterbos et al. 2013; rounded up to estimate exposure on day of use) Weight fraction: 0.006 Product amount (g): 14+ years: 7.1 (Ficheux et al. 2016a) 9–13 years: 5.5 (based on surface area adjustment) *Dermal:* Retention factor: 1 *Inhalation:* Exposure and emission duration (min): 20 (professional judgment) Room volume (m^3): 10 (bathroom, RIVM 2014) Ventilation rate (per hour): 2 (bathroom, RIVM 2014) Surface area (cm^2) (half of total surface area; based on defaults from Health Canada [modified 2022]): 19+ years: 9350 14–18 years: 8600 9–13 years: 6700 Sentinel product contained CAS RN 64742-47-8 by the cosmetic ingredient name of “C13-14 Isoparaffin.”
Heavy duty hand cleaner (CAS RN 64742-47-8)	Exposure on day of use was considered to similar to that from using liquid hand soap. Frequency (per day): 19+ years: 4.6 (Wu et al. 2010) Weight fraction: 0.3

Exposure scenario	Inputs
	Product amount (g): 19+ years: 4 (Garcia-Hidalgo et al. 2017) *Dermal:* Retention factor: 0.01 *Inhalation:* Retention factor: 0.01 Exposure and emission duration (hours): 5.2 (24 hours divided by frequency) Room volume (m^3): 58 (living room, RIVM 2014) Ventilation rate (per hour): 0.5 (living room, RIVM 2014) Surface area (cm^2) (based on defaults from Health Canada [modified 2022]): 19+ years: 910 Sentinel products contained CAS RN 64742-47-8 by the cosmetic ingredient name of "C11-15 Alkane/cycloalkane."
Eye shadow (CAS RN 64742-46-7)	Frequency (per day): 19+ years: 1.2 (Loretz et al. 2008) 4–18 years: 1 (Ficheux et al. 2015; rounded up to estimate exposure on day of use) Weight fraction: 0.2 (CAS RN 64742-46-7) Product amount (g): 4+ years: 0.009 (Ficheux et al. 2016a) *Dermal:* Retention Factor: 1 *Inhalation:* Exposure and emission duration (hours): 16 (Bremmer et al. 2006) Room volume (m^3): 20 (unspecified room, RIVM 2014) Ventilation rate (per hour): 0.6 (unspecified room, RIVM 2014) Surface area (cm^2) (eyelid; Bremmer et al. 2006): 4+ years: 24 Sentinel product contained CAS RN 64742-46-7 by the cosmetic ingredient name of "C15-19 Alkane."
Shampoo (CAS RN 64742-46-7 and CAS RN 64742-47-8)	Frequency (per day): 19+ years: 1.1 (Loretz et al. 2008) 0–18 years: 1 (Wu et al. 2010; Ficheux et al. 2015; rounded up to estimate exposure on day of use)

Exposure scenario	Inputs
	Weight fractions: Product 1: 0.03 (CAS RN 64742-46-7) Product 2: 0.03 (CAS RN 64742-47-8) Product amount (g): 19+ years: 11.8 (Loretz et al. 2008) 14–18 years: 10.4 (Ficheux et al. 2016a) 9–13 years: 7.5 (Ficheux et al. 2016a) 4–8 years: 9.7 (Gomez-Berrada et al. 2013) 2–3 years: 7.9 (Gomez-Berrada et al. 2013) 1 year: 6.1 (Gomez-Berrada et al. 2013) 6–11 months: 5.6 (Gomez-Berrada et al. 2013) 0–5 months: 3.9 (Gomez-Berrada et al. 2017) *Dermal:* Retention factor: 0.01 *Inhalation:* Retention factor: 0.01 Exposure and emission duration (hours): 19+ years: 21.8 (24 hours divided by frequency) 0–18 years: 24 Room volume (m^3): 58 (living room, RIVM 2014) Ventilation rate (per hour): 0.5 (living room, RIVM 2014) Surface area (cm^2) (surface area of hair assumed to be equivalent to that of head; based on defaults from Health Canada [modified 2022]): 19+ years: 1170 14–18 years: 740 9–13 years: 700 4–8 years: 610 2–3 years: 550 1 year: 870 6–11 months: 820 0–5 months: 640 Sentinel products contained CAS RN 64742-46-7 by the cosmetic ingredient name of “C13-15 Alkane” and CAS RN 64742-47-8 by the cosmetic ingredient name of “C13-16 Isoparaffin.”
Shaving cream (face) (CAS RN 64742-47-8)	Frequency (per day): 9+ years: 1 (Wu et al. 2010; rounded up to estimate exposure on day of use) Weight fraction: 0.01

Exposure scenario	Inputs
	Product amount (g): 14+ years: 6.8 (Ficheux et al. 2016a) 9–13 years: 6.4 (based on surface area adjustment) *Dermal:* Retention factor: 0.01 *Inhalation:* Retention factor: 0.01 Exposure and emission duration (hours): 24 Room volume (m^3): 58 (living room, RIVM 2014) Ventilation rate (per hour): 0.5 (living room, RIVM 2014) Surface area (cm^2) (based on defaults from Health Canada [modified 2022]): 19+ years: 292.5 14–18 years: 185 9–13 years: 175 Sentinel product contained CAS RN 64742-47-8 by the cosmetic ingredient name of “C13-16 Isoparaffin.”
Mascara (CAS RN 64771-72-8)	Frequency (per day): 9+ years: 1 (Ficheux et al. 2015) 4–18 years: 1 (Statistics Canada 2012) Weight fraction: 0.01 Product amount (g): 4+ years: 0.018 (Ficheux et al. 2016a) *Dermal:* Retention factor: 1 *Inhalation:* Exposure and emission duration (hours): 16 (Bremmer et al. 2006) Room volume (m^3): 20 (unspecified room, RIVM 2014) Ventilation rate (per hour): 0.6 (unspecified room, RIVM 2014) Surface area (cm^2) (approximated by surface area of eyelid; Bremmer et al. 2006): 4+ years: 24 Sentinel product contained CAS RN 64771-72-8 by the cosmetic ingredient name of “Alkanes C10-13.”

Table D-5: NHPs – exposure: detailed calculations and inputs for exposure estimates

Exposure scenario	**Inputs**
Body moisturizer (CAS RN 64742-46-7)	Modelled for adults and adolescents based on product directions of use (personal communication, email from the NNHPD, HC, to the ESRAB, HC, 2022; unreferenced). Frequency (per day): 19+ years: 1 (Wu et al. 2010; Ficheux et al. 2015) 9–18 years: 1 (Wu et al. 2010; rounded up to estimate exposure on the day of use) Weight fraction: 0.04 Product amount (g): 14+ years: 10 (Ficheux et al. 2016a) 9–13 years: 7.7 (Ficheux et al. 2016a; surface area adjustment) *Dermal*: Retention factor: 1 *Inhalation:* Exposure and emission duration (hours): 24 Surface area (cm^2) (equal to arms, ¾ legs, hands, ½ feet to account for unclothed surface area of short-sleeved shirt and shorts; based on defaults from Health Canada [modified 2022]): 19+ years: 8543 14–18 years: 7655 9–13 years: 5953 Room volume (m^3): 58 (living room, RIVM 2014; larger room to simulate moving between rooms during the day) Ventilation rate (per hour): 0.5 (living room, RIVM 2014) Sentinel products contained CAS RN 64742-46-7 by the natural health product ingredient name of “C13-15 Alkane.”
Facial cleanser (CAS RN 64742-46-7)	Frequency (per day): 19+ years: 1.6 (Loretz et al. 2008) 9–18 years: 1.2 (Ficheux et al. 2015) Weight fraction: 0.05297

Exposure scenario	Inputs
	Product amount (g): 14+ years: 3.3 (Ficheux et al. 2016a) 9–13 years: 3.1 (Ficheux et al. 2016a; surface area adjustment) *Dermal:* Retention factor: 0.01 *Inhalation:* Exposure and emission duration (hours): 24 Surface area (cm^2) (equal to half of the head to approximate face; based on defaults from Health Canada [modified 2022]): 19+ years: 585 14–18 years: 370 9–13 years: 350 Room volume (m^3): 58 (living room, RIVM 2014; larger room to simulate moving between rooms during the day) Ventilation rate (per hour): 0.5 (living room, RIVM 2014) Sentinel products contained CAS RN 64742-46-7 by the natural health product ingredient name of “C13-15 Alkane.”
Liquid foundation with SPF (CAS RN 64742-46-7)	Frequency (per day): 14+ years: 1.2 (Loretz et al. 2006) 9–13 years: 1 (Ficheux et al. 2015) Weight fraction: 0.09 Product amount (g): 19+ years: 0.54 (Loretz et al. 2006) 14–18 years: 0.41 (Ficheux et al. 2016a) 9–13 years: 0.39 (Ficheux et al. 2016a; surface area adjustment) Surface area (cm^2) (equal to half of the head to approximate face; based on defaults from Health Canada [modified 2022]): 19+ years: 585 14–18 years: 370 9–13 years: 350 *Dermal*: Retention factor: 1

Exposure scenario	Inputs
	Inhalation: Exposure and emission duration (hours): 9–19+ years: 16 (Bremmer et al. 2006) Room volume (m^3): 20 (unspecified room, RIVM 2014) Ventilation rate (per hour): 0.6 (unspecified room, RIVM 2014) Sentinel products contained CAS RN 64742-46-7 by the natural health product ingredient name of "C13-15 Alkane."
Sunscreen (CAS RN 64742-46-7 and CAS RN 64742-47-8)	Frequency (per day): 4+ years: 1.4 (Ficheux et al. 2015) 6 months to 3 years: 1.6 (Ficheux et al. 2015) Weight fractions: Product 1: 0.03 (CAS RN 64742-46-7) Product 2: 0.0485 (CAS RN 64742-47-8) Product amount (g): 14+ years: 18.2 (Ficheux et al. 2016a) 4–13 years: 6.3 (Ficheux et al. 2016a) 6 months to 3 years: 5.4 (Ficheux et al. 2016a) *Dermal*: Retention factor: 1 *Inhalation:* Exposure and emission duration (hours): 4+ years: 17 (24 hours divided by frequency) 6 months to 3 years: 15 (24 hours divided by frequency) Exposed surface area (cm^2) (equal to arms, ¾ legs, hands, ½ feet, ½ head to account for unclothed surface area of short-sleeved shirt and shorts; based on defaults from Health Canada [modified 2022]): 19+ years: 9127.5 14–18 years: 8025 9–13 years: 6302.5 4–8 years: 4117.5 2–3 years: 2960 1 year: 2505 6–11 months: 2112.5

Exposure scenario	Inputs
	Room volume (m^3): 58 (living room, RIVM 2014; larger room to simulate moving between rooms during the day) Ventilation rate (per hour): 0.5 (living room, RIVM 2014) Sentinel products contained CAS RN 64742-46-7 by the natural health product ingredient name of "C13-15 Alkane" and CAS RN 64742-47-8 by the natural health product ingredient name of "C13-14 Alkane."

Abbreviation: NHP, Natural Health Product

Other products available to consumers

For other products available to consumers (for example, DIY products), exposure was estimated using defaults from relevant ConsExpo factsheets where relevant, and on a "per event" basis (using the frequency of once per day) unless otherwise noted. In cases where daily exposure is expected, daily estimates of exposure were based on a frequency of one time per day unless otherwise noted. Exposure estimates were derived using the highest concentration (weight fraction) of the gas oil or kerosene CAS RN found per product type or scenario. The concentration data was obtained through information submitted to Health Canada or through publicly available information as described in section 4 and/or elsewhere in Appendix D.

Dermal exposure was estimated using the following algorithm, unless a film thickness approach was used:

Dermal exposure (mg/kg bw/day) = product amount (g) * concentration (fraction) * retention factor (fraction) * frequency of use (times/day) * 1000 (mg/g) / body weight (kg)

For scenarios where a film thickness approach was used, dermal exposure was estimated using the following algorithm:

Dermal exposure (mg/kg bw/day) = concentration (fraction) * film thickness on skin (cm) * density (g/cm^3) * Exposed skin surface area (cm^3) * 1000 (mg/g) / body weight (kg)

No dermal absorption factor was applied for subgroup 1 substance scenarios since route-to-route extrapolation to the dermal route was not required for risk characterization. For subgroup 2 substance scenarios, a dermal absorption factor of 75% was applied. A retention factor of 1 was assumed for all scenarios.

Inhalation exposure was estimated using the ConsExpo Web model (2021). For inhalation exposure to substances from spray products, the "exposure to vapour–instantaneous release" model was used. For inhalation exposure to substances volatilized from non-spray products, the "exposure to vapour–evaporation–increasing release area" model and the following parameters were used unless noted otherwise:

- Molecular weight matrix: 3000 g/mol (as the substance of interest is the main component and/or the composition of the product is unknown, and using 3000 g/mol is used as a conservative approach, RIVM 2022)
- Temperature: 20°C
- Mass transfer coefficient: 10 m/h
- Vapour pressure and molecular weight selected was based on the substance representative of the lowest carbon number in the description in Appendix A, or as otherwise specified in product information, as a conservative approach. Vapour pressure and molecular weight values were derived from EPI Suite (2008).
    - 593 Pa and 128 g/mol for CAS RNs 8008-20-6, 64742-14-9, 64742-47-8, and 64742-81-0 (based on nonane)
    - 191 Pa and 142 g/mol for CAS RN 64741-77-1 (based on decane)
    - 1.5 Pa and 198 g/mol for CAS RN 64741-91-9 (based on tetradecane)
    - 55 Pa and 156 g/mol for CAS RNs 64742-46-7 and 64742-96-7 (based on undecane)
    - 384 Pa and 120 g/mol for CAS RNs 64742-94-5 and 68477-31-6 (based on ethylmethylbenzene)
- Product amount (that is, available for inhalation) was adjusted for subgroup 2 substance scenarios by subtracting the amount of substance systematically available via dermal absorption. Product amount for subgroup 1 substance scenarios was not adjusted.

Table D-6. Exposure factors for gas oil and kerosene components of other products available to consumers leading to general population exposure

Exposure scenario (CAS RN)	Model and inputs
Engine cleaner spray (8008-20-6; 64741-77-1; 64742-94-5)	Population: Adult (19+ years) Weight fractions: Product 1: 0.3 (CAS RN 8008-20-6); 0.05 (CAS RN 64742-94-5) (SDS 2018b) Product 2: 0.85 (CAS RN 64741-77-1) (Environment Canada 2012) *Dermal* Product amount on skin: 0.05 g (based on release duration and contact rate) Release duration: 30 seconds (2x spray duration (RIVM 2018), professional judgment based on manufacturer’s video online) Contact rate: 100 mg/min (default for aerosol spray cans, RIVM 2018) *Inhalation* Spray duration: 15 sec (professional judgment based on manufacturer’s video online)

	Exposure duration: 20 min (professional judgment based on product instructions; includes application, soaking, and rinsing time) Mass generation rate: 1.2 g/s (default for aerosol spray cans, RIVM 2018) Product amount: 18 g (based on spray duration and mass generation rate) Room volume: 34 m^3 (garage, RIVM 2014) Ventilation rate: 1.5/hr (garage, RIVM 2014)
Penetrating lubricant spray – removing rusted screw nuts (8008-20-6; 64742-47-8)	Population: Adult (19+ years) Weight fractions: Product 1: 0.3 (CAS RN 8008-20-6) (SDS 2017a; 0.3 is selected based on an older SDS (0.1 to 0.3) and because it is still within the range of the 2017 SDS (0.15 to 0.4)) Product 2: 0.8 (CAS RN 64742-47-8) (SDS 2020a) *Dermal* Product amount on skin: 0.2 g (based on release duration and contact rate) Release duration: 120 seconds (default for rust remover spray, RIVM 2022) Contact rate: 100 mg/min (default for rust remover spray (aerosol), RIVM 2022) *Inhalation* Spray duration: 50 sec (default for rust remover spray, RIVM 2022) Exposure duration: 60 min (default for rust remover spray, RIVM 2022; includes time needed for product left on to soak before screw nut is removed, the removal process, and cleanup) Mass generation rate: 1.2 g/s (default for rust remover spray, RIVM 2022) Product amount: 60 g (default for rust remover spray (aerosol), RIVM 2022) Room volume: 34 m^3 (garage, RIVM 2014) Ventilation rate: 1.5/hr (garage, RIVM 2014)
Automotive interior detailer/cleaner spray (64741-44-2; 64742-46-7; 64742-47-8)	Population: Adult (19+ years) Weight fractions: Product 1: 0.05 (CAS RN 64741-44-2) (SDS 2017b) Product 2: 0.3 (CAS RN 64742-46-7) (SDS 2011a; more recent SDS (2018d) does not list all product components) Product 3: 0.9 (CAS RN 64742-47-8) (SDS 2005) *Dermal – thin film approach*

	Film thickness: 1.64×10^{-3} cm (handling rag, no wipe (mineral oil); US EPA 2011b) Density product 1: 0.995 g/cm3 (SDS 2017b) Density product 2: 0.964 g/cm^3 (SDS 2011a; 2018b) Density product 3: 0.83 g/cm^3 (SDS 2005) Exposed skin surface area: 455 cm^2 (half of both hands/palms, Health Canada [modified 2022]) *Inhalation* Exposure duration: 15 min (professional judgment) Mass generation rate: 1.6 g/s (default for trigger sprays and for all-purpose cleaner spray, RIVM 2018) Spray duration: 1.38 min (Versar 1986) Product amount: 132 g (based on spray duration and mass generation rate) Room volume: 34 m^3 (garage, RIVM 2014; assumed car doors or windows would be open) Ventilation rate: 1.5/hr (garage, RIVM 2014; assumed car doors or windows would be open)
Firearm cleaner (64741-91-9)	Population: Adult (19+ years) Weight fraction: 0.6 (SDS 2015b) *Dermal – thin film approach* Film thickness: 1.64×10^{-3} cm (handling rag, no wipe (mineral oil); US EPA 2011b) Density: 0.88 g/cm^3 (SDS 2015b) Exposed skin surface area: 455 cm^2 (half of two whole hands, Health Canada [modified 2022]) *Inhalation* Model: Exposure to vapour–evaporation–increasing release Exposure duration: 30 min (professional judgment based on manufacturer's video and other internet sources. This is broken down into 5 min application, 15 min dwell time and 10 min wiping and re-assembly of the firearm) Product amount: 2.6 g (professional judgment based on the manufacturer's videos that demonstrates the application of the cleaning solvent to four pads and brushes) Room volume: 20 m^3 (unspecified room, RIVM 2014) Ventilation rate: 0.6/hr (unspecified room, RIVM 2014) Release area: 0.027 m^2 (professional judgment based on the bore and parts dimensions of a hunting rifle and the surface area of moistened cleaning pads and wetted areas on a towel, as illustrated on the manufacturer's website) Application duration: 5 min (professional judgment based on the manufacturer's videos; represents amount of time used

	to pass four impregnated cleaning pads through the bore and brush the bore and parts)
Automotive wax (64742-14-9); Automotive polish (64742-47-8)	Population: Adult (19+ years) Weight fractions: Product 1: 0.3 (CAS RN 64742-14-9) (SDS 2015c) Product 2: 0.5 (CAS RN 64742-47-8) (SDS 2015d) *Dermal – thin film approach* Film thickness: 1.64×10^{-3} cm (handling rag, no wipe (mineral oil); US EPA 2011b) Density product 1: 0.96 g/cm^3 (SDS 2015c) Density product 2: 0.98 g/cm^3 (SDS 2015d) Exposed skin surface area: 455 cm^2 (half of both hands/palms, Health Canada [modified 2022]) *Inhalation* N/A since product is assumed to be applied outdoors
Construction adhesive (64742-46-7)	Population: Adult (19+ years) Weight fraction: 0.05 (SDS 2021a) *Dermal* Product amount on skin: 0.25 g (default for construction glue, RIVM 2022) *Inhalation* Exposure duration: 240 min (default for construction glue, RIVM 2022) Product amount: 250 g (default for construction glue, RIVM 2022) Room volume: 20 m^3 (unspecified room, RIVM 2014) Ventilation rate: 0.6/hr (unspecified room, RIVM 2014) Release area: 1 m^2 (default for construction glue, RIVM 2022) Application duration: 90 min (default for construction glue, RIVM 2022)
Countertop polish/cleaner liquid (64742-46-7)	Population: Adult (19+ years) Weight fraction: 0.25 (SDS 2011b) *Dermal* Film thickness: 1.64×10^{-3} cm (handling rag, no wipe (mineral oil); US EPA 2011b) Density: 0.9 g/cm^3 (professional judgment; SDS 2011b lists specific gravity <1) Exposed skin surface area: 227.5 cm^2 (half of one hand/palm, Health Canada [modified 2022])

	Inhalation Exposure duration: 60 min (all-purpose cleaning spray, RIVM 2018) Product amount: 22 g (assumed to be the same amount needed as all-purpose cleaning spray to cover a 2 m^2 kitchen counter, RIVM 2018) Room volume: 15 m^3 (kitchen, RIVM 2014) Ventilation rate: 2.5/hr (kitchen, RIVM 2014) Release area: 2 m^2 (all-purpose cleaning spray, RIVM 2018) Application duration: 5 min (professional judgment)
Furniture polish liquid (64742-46-7)	Population: Adult (19+ years) Weight fraction: 1.0 (SDS 2017c) *Dermal* Product amount on skin: 0.56 g (adjusted from default for furniture polish liquid (RIVM 2018) using surface area for half of one hand/palm of 227.5 cm^2 (Health Canada [modified 2022])) *Inhalation* Exposure duration: 240 min (default for furniture polish liquid, RIVM 2018) Product amount: 550 g (default for furniture polish liquid, RIVM 2018) Room volume: 58 m^3 (living room, default for furniture polish liquid, RIVM 2018) Ventilation rate: 0.5/hr (living room, default for furniture polish liquid, RIVM 2018) Release area: 22 m^2 (default for furniture polish liquid, RIVM 2018) Application duration: 90 min (default for furniture polish liquid, RIVM 2018) Note: Molecular weight matrix N/A since modelled as a pure substance (weight fraction = 1.0)
Furniture polish spray (64742-46-7; 64742-47-8)	Population: Adult (19+ years) Weight fractions: Product 1: 0.6 (CAS RN 64742-46-7) (SDS 2017d) Product 2: 0.656 (CAS RN 64742-47-8) (SDS 2016b) *Dermal* Spraying: Product amount on skin: 0.184 g (based on release duration and contact rate and default for furniture polish spray, RIVM 2018) Release duration: 4 min (default for furniture polish spray, RIVM 2018)

	Contact rate: 46 mg/min (default for furniture polish spray, RIVM 2018) Rubbing in: Product amount on skin: 0.57 g (adjusted from default for furniture polish spray (RIVM 2018) using surface area for half of one hand/palm of 227.5 cm^2 (Health Canada [modified 2022])) Total product amount on skin from spraying + rubbing in = 0.75 g *Inhalation* Exposure duration: 240 min (default for furniture polish spray, RIVM 2018) Product amount: 200 g (default for furniture polish spray, RIVM 2018) Room volume: 20 m^3 (unspecified room, default for furniture polish spray, RIVM 2018) Ventilation rate: 0.6/hr (unspecified room, default for furniture polish spray, RIVM 2018)
Leather protectant spray (64742-46-7)	Population: Adult (19+ years) Weight fraction: 0.06 (SDS 2020b) *Dermal* Spraying: Product amount on skin: 0.138 g (based on release duration and contact rate) Release duration: 3 min (default for leather maintenance spray, RIVM 2018) Contact rate: 46 mg/min (default for leather maintenance spray – trigger spray, RIVM 2018) Rubbing in: Product amount on skin: 0.46 g (adjusted from default for leather maintenance spray (RIVM 2018) using surface area for half of one hand/palm of 227.5 cm^2 (Health Canada [modified 2022])) Total product amount on skin from spraying + rubbing in = 0.6 g *Inhalation* Exposure duration: 240 min (default for leather maintenance spray, RIVM 2018)

	Product amount: 109 g (based on spray duration and mass generation rate, RIVM 2018) Spray duration: 68 sec (default for leather maintenance spray – trigger spray, RIVM 2018) Mass generation rate: 1.6 g/s (default for leather maintenance spray – trigger spray, RIVM 2018) Room volume: 58 m^3 (living room, default for leather maintenance spray, RIVM 2018) Ventilation rate: 0.5/hr (living room, default for leather maintenance spray, RIVM 2018)
Adhesive spray – automotive headliner and fabric adhesive (64742-47-8)	Population: Adult (19+ years) Weight fraction: 0.015 (SDS 2022a) *Dermal* Product amount on skin: 0.525 g (based on release duration and contact rate) Release duration: 315 sec (default for glue spray, RIVM 2022) Contact rate: 100 mg/min (default for glue spray, RIVM 2022) *Inhalation* Exposure duration: 30 min (assumed applicator left the garage following application - professional judgment) Product amount: 375 g (default for glue spray, RIVM 2022) Spray duration: 315 sec (default for glue spray, RIVM 2022) Mass generation rate: 1.2 g/s (default for glue spray, RIVM 2022) Room volume: 34 m^3 (garage, RIVM 2014) Ventilation rate: 1.5/hr (garage, RIVM 2014)
Adhesive remover liquid (64742-47-8)	Population: Adult (19+ years) Weight fraction: 1.0 (SDS 2021b) This adhesive remover liquid scenario corresponds to a larger-scale project (removing carpet glue) compared to the adhesive remover spray scenario below, which corresponds to a smaller-scale project (removing sticker adhesive). An adhesive remover liquid (SDS 2019a) could also be used for a smaller-scale project such as removing a sticker, which may result in exposure that is similar to the adhesive remover spray scenario below. *Dermal* Product amount on skin: 7.2 g (based on release duration and contact rate)

	Release duration: 240 min (default for glue remover, RIVM 2022) Contact rate: 30 mg/min (default for glue remover, RIVM 2022) *Inhalation* Exposure duration: 240 min (default for glue remover, RIVM 2022) Product amount: 2000 g (default for glue remover, RIVM 2022) Room volume: 30 m^3 (default for glue remover, RIVM 2022) Ventilation rate: 1.5/hr (default for glue remover, RIVM 2022) Release area: 5 m^2 (default for glue remover, RIVM 2022) Application duration: 240 min (modified from default for glue remover in that the application duration is the same as the exposure duration, RIVM 2022) Note: Molecular weight matrix N/A since modelled as a pure substance (weight fraction = 1.0)
Adhesive remover spray (64742-47-8)	Population: Adult (19+ years) Weight fraction: 1.0 (SDS 2019b) This adhesive remover spray scenario corresponds to a smaller-scale project (removing sticker adhesive) compared to the adhesive remover liquid scenario above, which corresponds to a larger-scale project (removing carpet adhesive). An adhesive remover spray (SDS 2019c) could also be used for a larger-scale project such as removing carpet glue, as per the manufacturer's website, which may result in exposure that is similar to the adhesive remover liquid scenario above. *Dermal* Product amount on skin: 0.003 g (based on release duration and contact rate) Release duration: 3.75 sec (modified from default for glue remover spray – based on product amount and mass generation rate for trigger spray, RIVM 2022) Contact rate: 46 mg/min (default for trigger spray, RIVM 2022) *Inhalation* Exposure duration: 10 min (default for glue remover spray, RIVM 2022) Product amount: 6 g (default for glue remover spray, RIVM 2022)

	Spray duration: 3.75 sec (modified from default for glue remover spray – based on product amount and mass generation rate for trigger spray, RIVM 2022) Mass generation rate: 1.6 g/s (default for trigger spray, RIVM 2022) Room volume: 20 m^3 (unspecified room, RIVM 2014) Ventilation rate: 0.6/hr (unspecified room, RIVM 2014)
Air freshener – nebula diffuser for home (64742-47-8)	Populations: Infant (1 year) and adult (19+ years) Weight fraction: 0.8 (SDS 2021c) *Dermal* N/A (dermal exposure is not expected because of the touchless refill mechanism of the diffuser product as seen in video on manufacturer's website) *Inhalation* Model: Exposure to vapour–constant rate Exposure duration: 480 min (modified from default for nebula diffusers, RIVM 2021, based on modified emission duration) Product amount: 0.736 g (modified from default for nebula diffusers based on modified emission duration, RIVM 2021) Room volume: 20 m^3 (unspecified room, default for nebula diffusers, RIVM 2021) Ventilation rate: 0.6/hr (unspecified room, default for nebula diffusers, RIVM 2021) Emission duration: 480 min (modified from default for nebula diffusers, RIVM 2021, based on product-specific information)
Automotive metal polish (64742-47-8)	Population: Adult (19+ years) Weight fraction: 0.65 (SDS 2019d) *Dermal – thin film approach* Film thickness: 1.64×10^{-3} cm (handling rag, no wipe (mineral oil), US EPA 2011b) Density: 1.128 g/cm^3 (SDS 2019d) Exposed skin surface area: 227.5 cm^2 (half of one hand/palm, Health Canada [modified 2022]) *Inhalation* Exposure duration: 30 min (professional judgment) Product amount: 40 g (assumed 10% of the 355 mL bottle is used, professional judgment, and using product-specific density of 1.128 g/cm^3) Room volume: 90 m^3 (garage; changed ConsExpo default of 34 m^3 to 90 m^3 as per estimate of a two car garage. 90 m^3 is

	the default garage volume used in US EPA Consumer Exposure Model v.2.1 (2019) and is consistent with values in Batterman et al. (2007); this garage size allows sufficient space to work on, and move around, an automobile) Ventilation rate: 1.5/hr (garage, RIVM 2014) Release area: 0.6 m^2 (based on cleaning 4 × 17-inch wheels) Application duration: 15 min (professional judgment)
Automotive spray paint (64742-47-8)	Population: Adult (19+ years) Weight fraction: 0.25 (SDS 2022b) *Dermal* Product amount on skin: 1.5 g (based on release duration and contact rate) Release duration: 15 min (default for spraying paint with a spray can, RIVM 2007) Contact rate: 100 mg/min (default for spraying paint with a spray can, RIVM 2007) *Inhalation* Exposure duration: 20 min (default for spraying paint with a spray can, RIVM 2007) Product amount: 340 g (whole can, default for spraying paint with a spray can (RIVM 2007) and considering use on auto parts rather than the auto body) Room volume: 34 m^3 (garage, RIVM 2014) Ventilation rate: 1.5/hr (garage, RIVM 2014)
Fabric waterproofing spray (64742-47-8; 64742-94-5)	Population: Adult (19+ years) Weight fractions: Product 1: 0.75 (64742-47-8) (SDS 2022c) Product 2: 0.082 (CAS RN 64742-94-5) (SDS 2018e) *Dermal* Product amount on skin: 0.032 g (based on release duration and contact rate) Release duration: 42 sec (based on product amount of 38 g and mass generation rate of 1.8 g/s for furniture polish spray (RIVM 2018), which leads to 21 sec spray time; release duration is equal to 2x spray duration (RIVM 2018)) Contact rate: 46 mg/min (default for furniture polish spray, RIVM 2018) *Inhalation* Exposure duration: 240 min (based on default for furniture spray polish, RIVM 2018)

	Product amount: 38 g (based on product-specific average coverage of 40 sq. ft. per 325 mL bottle (product density of 0.785 g/mL, SDS 2018e) and 6 sq. ft backpack) Room volume: 20 m^3 (unspecified room, RIVM 2014) Ventilation rate: 0.6/hr (unspecified room, RIVM 2014)
Floor paste wax (64742-47-8)	Population: Adult (19+ years) Weight fraction: 1.0 (SDS 2021d) *Dermal* Product amount on skin: 0.113 g (modified from floor polish liquid, RIVM 2018; assuming contact with half of one hand/palm (227.5 cm^2, Health Canada [modified 2022] and product-specific coverage of 0.495 mg/cm^2) *Inhalation* Exposure duration: 120 min (professional judgment) Product amount: 103.6 g (based on product-specific coverage of 4.71 g/m^2 and living room floor surface area default for floor polish liquid, RIVM 2018) Room volume: 58 m^3 (living room, default for floor polish liquid, RIVM 2018) Ventilation rate: 0.5/hr (living room, default for floor polish liquid, RIVM 2018) Release area: 22 m^2 (default for floor polish liquid, RIVM 2018) Application duration: 120 min (modified from floor polish liquid scenario (RIVM 2018) to account for a paste wax, which takes longer to apply than a liquid)
Lamp oil – while pouring into lamp (64742-47-8)	Population: Adult (19+ years) Weight fraction: 0.4 (SDS 2017e) *Dermal* Product amount on skin: 0.165 mg (based on product amount of 340 g and unit exposure 200 µg/lb ai handled, US EPA 2021a) *Inhalation* Exposure duration: 240 min (professional judgment; assuming that the pouring takes place in the same room as the subsequent use of the lamp) Product amount: 340 g (based on filling lamp fuel tank to capacity by volume) Room volume: 20 m^3 (unspecified room, RIVM 2014) Ventilation rate: 0.6/hr (unspecified room, RIVM 2014) Release area: 5 cm^2 (based on size of the lamp oil container opening and the lamp fuel tank opening)

	Application duration: 0.75 min (based on default for pouring liquids, RIVM 2018)
Interior paint primer (64742-47-8)	Population: Adult (19+ years) Weight fraction: 0.3 (SDS 2020c) *Dermal* Product amount on skin: 3.6 g (based on release duration and contact rate) Release duration: 120 min (default for high solids paint, RIVM 2007) Contact rate: 30 mg/min (default for high solids paint, RIVM 2007) *Inhalation* Exposure duration: 132 min (default for high solids paint, RIVM 2007) Product amount: 1731 g (based on product-specific coverage) Room volume: 20 m^3 (unspecified room, default for high solids paint, RIVM 2007) Ventilation rate: 0.6/hr (unspecified room, default for high solids paint, RIVM 2007) Release area: 10 m^2 (default for high solids paint, RIVM 2007) Application duration: 120 min (default for high solids paint, RIVM 2007)
Paint thinner – cleaning brushes (64742-47-8)	Population: Adult (19+ years) Weight fraction: 1.0 (SDS 2015f) *Dermal* Product amount on skin: 2.07 g (Versar 1986) *Inhalation* Model: Exposure to vapour–evaporation–constant release Exposure duration: 30 min (Versar 1986) Product amount: 290 g (US EPA 2011b; estimated from average amounts used per year and the numbers of uses per year; paint thinners are used an average of 6.78 times per year, and an average of 69.45 ounces are used per year, for an estimate of 290 grams/use (69.45 ounces/year divided by 6.78 uses/year = 10.24 ounces/use or 290 grams) Room volume: 20 m^3 (unspecified room, RIVM 2014) Ventilation rate: 0.6/hr (unspecified room, RIVM 2014) Release area: 0.078 m^2 (Versar 1986, based on cleaning paint brushes in a 1.4 kg coffee can)

	Emission duration: 30 min (assumed to be equivalent to exposure duration)
Portable heater fuel – pouring into heater (64742-47-8)	Population: Adult (19+ years) Weight fraction: 1.0 (SDS 2015g) *Dermal* Product amount on skin: 2.75 mg (based on product amount of 5670 g and unit exposure 200 µg/lb ai handled, US EPA 2021a) *Inhalation* Exposure duration: 20 min (professional judgment; assuming that the heater is subsequently brought inside for use after filling in the garage) Product amount: 5670 g (based on size of fuel tank on heater according to manufacturer's website and product density specified on SDS) Room volume: 34 m^3 (garage, RIVM 2014; it is assumed that because of the size of the heater and amount of fuel that is needed to fill it, this process will take place in a garage) Ventilation rate: 1.5/hr (garage, RIVM 2014) Release area: 5 cm^2 (based on size of the fuel container opening and the heater fuel tank opening) Application duration: 3 min (professional judgment)
Silicone lubricant spray – lubricating two door hinges (64742-47-8)	Population: Adult (19+ years) Weight fraction: 0.8 (SDS 2018f) *Dermal* Product amount on skin: 0.017 g (based on release duration and contact rate) Release duration: 10 seconds (professional judgment) Contact rate: 100 mg/min (default for aerosol spray cans, RIVM 2018) *Inhalation* Spray duration: 10 sec (professional judgment) Exposure duration: 1.0 hr (professional judgment) Mass generation rate: 1.2 g/s (default for aerosol spray cans, RIVM 2018) Product amount: 12 g (based on spray duration and mass generation rate) Room volume: 20 m^3 (unspecified room, RIVM 2014) Ventilation rate: 0.6/hr (unspecified room, RIVM 2014)
Stainless steel polish spray	Population: Adult (19+ years) Weight fraction: 0.4 (SDS 2015h)

(64742-47-8)	*Dermal* Product amount on skin: 0.13 g (modified from metal cleaner scenario, RIVM 2018; based on contact with surface with one hand palm (227.5 cm^2, Health Canada [modified 2022]) and product loading of 0.572 mg/cm^2) *Inhalation* Exposure duration: 1.0 hr (default for metal cleaner, RIVM 2018) Product amount: 7.32 g (based on mass generation rate of 0.4 g/s for shoe polish (RIVM 2018) and surface area of front of fridge 1.28 m^2 (Weerdesteijn et al. 1999)) Room volume: 15 m^3 (kitchen, default for metal cleaner, RIVM 2018) Ventilation rate: 2.5/hr (kitchen, default for metal cleaner, RIVM 2018)
Rust paint – brush/roller painting (64742-47-8)	Population: Adult (19+ years) Weight fraction: 0.75 (SDS 2017f) Smaller scale project (1 m^2): *Dermal* Product amount on skin: 0.36 g (based on release duration and contact rate) Release duration: 12 min (based on application rate of 12 min/m^2 derived from solvent-rich paint scenario, RIVM 2007) Contact rate: 30 mg/min (default for solvent rich paint, RIVM 2007) *Inhalation* Exposure duration: 13.2 min (adjusted from default for solvent rich paint based on surface area, RIVM 2007) Product amount: 133 g (based on product-specific surface area coverage average of 6.35 m^2 per 0.946 L and product density of 0.893 g/mL) Room volume: 34 m^3 (garage, RIVM 2014) Ventilation rate: 1.5/hr (garage, RIVM 2014) Release area: 1 m^2 (represents smaller scale project such as metal coffee table (US EPA 2020) or metal chair) Application duration: 12 min (based on application rate of 12 min/m^2 derived from solvent-rich paint scenario, RIVM 2007) Larger scale project (9 m^2): *Dermal*

	Product amount on skin: 3.24 g (based on release duration and contact rate) Release duration: 108 min (based on application rate of 12 min/m^2 derived from solvent-rich paint scenario, RIVM 2007) Contact rate: 30 mg/min (default for solvent rich paint, RIVM 2007) *Inhalation* Exposure duration: 119 min (adjusted from default for solvent rich paint based on surface area, RIVM 2007) Product amount: 1197 g (based on product-specific surface area coverage average of 6.35 m^2 per 0.946 L and product density of 0.893 g/mL) Room volume: 34 m^3 (garage, RIVM 2007) Ventilation rate: 1.5/hr (garage, RIVM 2014) Release area: 9 m^2 (represents larger scale project such as metal dining set, US EPA 2020) Application duration: 108 min (based on application rate of 12 min/m^2 derived from solvent-rich paint scenario, RIVM 2007)
Wood paste varnish – furniture (64742-47-8)	Population: Adult (19+ years) Weight fraction: 0.2 (SDS 2018c) It is assumed that a paste varnish will be used on smaller pieces of furniture (for example, coffee table or end tables) as the application of the product is more labour-intensive compared to a liquid varnish. *Dermal* Product amount on skin: 2.3 g (assuming contact with the treated surface with half of one hand/palm (227.5 cm^2, Health Canada [modified 2022]) and applied amount of 100 g/m^2) *Inhalation* Exposure duration: 90 min (professional judgment) Product amount: 144 g (based on product-specific surface area coverage of 9 m^2/L and product density of 0.9 g/mL, and assuming a surface area of 1.44 m^2) Room volume: 34 m^3 (garage, RIVM 2014) Ventilation rate: 1.5/hr (garage, RIVM 2014) Release area: 1.44 m^2 (represents a coffee table and two end tables, Versar 1986) Application duration: 60 min (professional judgment)
Wood stain – floor	Population: Adult (19+ years) Weight fractions:

(64742-47-8; 64742-94-5)	Product 1: 0.437 (CAS RN 64742-47-8) (SDS 2022d; 0.437 is selected based on an older SDS (from 2017) and because it is still within the range of the 2022 SDS (0.25 to 0.5)) Product 2: 0.025 (CAS RN 64742-94-5) (SDS 2017g) *Dermal* Product amount on skin: 4.2 g (based on release duration and contact rate) Release duration: 140 min (assumed 90th percentile from Westat 1987 was representative of living room floor, professional judgment) Contact rate: 30 mg/min (default for solvent rich paint, RIVM 2007) *Inhalation* Exposure duration: 140 min (assumed 90th percentile from Westat 1987 was representative of living room floor, and assumed the applicator left the living room following application, professional judgment) Product amount: Product 1: 1317.5 g (based on product-specific surface area coverage of 13.9 m^2 per 0.946 L and product-specific density of 0.88 g/mL) Product 2: 781.1 g (based on product specific-surface area coverage of 25.5 m^2 per 0.946 L, and product-specific density of 0.957 g/cm^3) Room volume: 58 m^3 (living room, RIVM 2014) Ventilation rate: 0.5/hr (living room, RIVM 2014) Release area: 22 m^2 (living room floor surface area, RIVM 2014) Application duration: 140 min (assumed 90th percentile from Westat 1987 was representative of living room floor, professional judgment)
Wood stain – furniture (64742-47-8; 64742-94-5)	Population: Adult (19+ years) Weight fractions: Product 1: 0.47 (CAS RN 64742-47-8) (SDS 2022e; 0.47 is selected based on an older SDS (from 2017) and because it is still within the range of the 2022 SDS (0.25 to 0.5)) Product 2: 0.025 (CAS RN 64742-94-5) (SDS 2017g) Smaller scale project (1 m^2): *Dermal* Product amount on skin: 0.36 g (based on release duration and contact rate)

	Release duration: 12 min (based on application rate of 12 min/m^2 derived from solvent-rich paint scenario, RIVM 2007) Contact rate: 30 mg/min (default for solvent rich paint, RIVM 2007) *Inhalation* Exposure duration: 13.2 min (adjusted from default for solvent-rich paint based on surface area, RIVM 2007) Product amount: Product 1: 69.5 g (based on product-specific average surface area coverage of 13.2 m^2 per L and product-specific density of 0.92 g/mL) Product 2: 35.5 g (based on product-specific surface area coverage of 25.5 m^2 per 0.946 L and product-specific density of 0.957 g/cm^3) Room volume: 34 m^3 (garage, RIVM 2014) Ventilation rate: 1.5/hr (garage, RIVM 2014) Release area: 1 m^2 (represents smaller scale project such as coffee table, US EPA 2020a) Application duration: 12 min (based on application rate of 12 min/m^2 derived from solvent-rich paint scenario, RIVM 2007) Larger scale project (9 m^2): *Dermal* Product amount on skin: 3.24 g (based on release duration and contact rate) Release duration: 108 min (based on application rate of 12 min/m^2 derived from solvent-rich paint scenario, RIVM 2007) Contact rate: 30 mg/min (default for solvent-rich paint, RIVM 2007) *Inhalation* Exposure duration: 119 min (adjusted from default for solvent rich paint based on surface area, RIVM 2007) Product amount: Product 1: 625.6 g (based on product-specific average surface area coverage of 13.2 m^2 per L and product-specific density of 0.92 g/mL) Product 2: 319.5 g (based on product-specific surface area coverage of 25.5 m^2 per 0.946 L, and product-specific density of 0.957 g/cm^3) Room volume: 34 m^3 (garage, RIVM 2007) Ventilation rate: 1.5/hr (garage, RIVM 2014) Release area: 9 m^2 (represents larger scale project such as dining room set, US EPA 2020a)

	Application duration: 108 min (based on application rate of 12 min/m^2 derived from solvent-rich paint scenario, RIVM 2007)
Fabric waterproofing liquid (64742-81-0)	Population: Adult (19+ years) Weight fraction: 1.0 (SDS 2016c) This scenario represents waterproofing a 10 m^2 canvas tarp outdoors as it is assumed that the use of a brush-on liquid is more likely to be used for a larger project outdoors than the spray can version of the product in the scenario below. Note that this product could also potentially be used for even larger projects (for example, waterproofing a canvas tent, awning, etc.). *Dermal* Product amount on skin: 2.3 g (based on product-specific coverage of 4 m^2/L where 10 m^2 treated area is equivalent to 2.5 L used, product-specific density of 0.81 g/mL, and PHED paintbrush scenario unit exposure 513.36 mg/kg ai handled, Health Canada 2002) *Inhalation* N/A since product is likely applied outdoors.
Fabric waterproofing spray (64742-81-0)	Population: Adult (19+ years) Weight fraction: 1.0 (SDS 2016d) This scenario represents waterproofing a backpack indoors as it is assumed that the use of a spray product is more likely to be used for a smaller project indoors than the brush-on liquid version of the product in the scenario above. Note that this product could also potentially be used for larger projects, including those that would occur outdoors (for example, waterproofing a canvas tent, awning, etc.). *Dermal* Product amount on skin: 0.068 g (based on release duration and contact rate) Release duration: 89 sec (based on product amount of 80 g and mass generation rate of 1.8 g/s for furniture polish spray (RIVM 2018), which leads to 44.4 sec spray time, and release duration is equal to 2x spray duration (RIVM 2018)) Contact rate: 46 mg/min (default for furniture polish spray, RIVM 2018) *Inhalation*

	Exposure duration: 240 min (based on default for furniture spray polish, RIVM 2018) Product amount: 80 g (considering the stated product-specific coverage of 30 sq. ft. per litre (product-specific density of 0.81 g/mL) and 6 sq. ft backpack, and using professional judgment that no more than 20% of a 398 g can should be used to spray a backpack) Room volume: 20 m^3 (unspecified room, RIVM 2014) Ventilation rate: 0.6/hr (unspecified room, RIVM 2014)
Automotive undercoating spray (64742-94-5)	Population: Adult (19+ years) Weight fraction: 0.01 (SDS 2018g) Note that the parameters below correspond to one coat, but two coats are recommended for best results according to product-specific data. Exposure on a per coat basis was calculated since it is assumed that the consumer will leave the garage after applying the first coat while allowing it to dry, and the first coat of this polymer-containing product will cure and cease to emit vapour when the second coat is applied overtop. For exposure estimates presented in section 8.1.2, the dose per coat was doubled to estimate the total event dose each for the dermal and inhalation routes. *Dermal (per coat)* Product amount on skin: 3 g (based on release duration and contact rate) Release duration: 30 min (professional judgment) Contact rate: 100 mg/min (default for spray paint, RIVM 2007) *Inhalation (per coat)* Model: Exposure to vapour–evaporation–increasing release area was used as this spray product is expected to result in a thick rubberized coating and the majority of exposure would occur via evaporation from the applied surface. Exposure duration: 30 min (professional judgment) Product amount: 425 g (assuming the whole can is used per coat, professional judgment) Room volume: 90 m^3 (garage; changed ConsExpo default of 34 m^3 to 90 m^3 as per estimate of a two car garage. 90 m^3 is the default garage volume used in US EPA Consumer Exposure Model v.2.1 (2019) and is consistent with values in Batterman et al. (2007); this garage size allows sufficient space to work on, and move around, an automobile) Ventilation rate: 1.5/hr (garage, RIVM 2014)

	Release area: 4.3 m^2 (calculated using footprint of 46.6 sq. ft. for “All Car” for the year 2020, US EPA 2021b) Application duration: 30 min (professional judgment)
Lacquer spray paint (64742-94-5)	Population: Adult (19+ years) Weight fraction: 0.07 (SDS 2016e) *Dermal* Product amount on skin: 1.5 g (based on release duration and contact rate) Release duration: 15 min (default for spraying paint with a spray can, RIVM 2007) Contact rate: 100 mg/min (default for spraying paint with a spray can, RIVM 2007) *Inhalation* Exposure duration: 20 min (default for spraying paint with a spray can, RIVM 2007) Product amount: 315 g (whole can, default for spraying paint with a spray can, RIVM 2007) Room volume: 34 m^3 (garage, RIVM 2014) Ventilation rate: 1.5/hr (garage, RIVM 2014)
Shoe polish spray (64742-94-5)	Population: Adult (19+ years) Weight fraction: 0.1 (SDS 2016f) *Dermal* Product amount on skin: 2.8 g (default for shoe polish spray, RIVM 2018) *Inhalation* Exposure duration: 240 min (default for shoe polish spray, RIVM 2018) Product amount: 28 g (default for shoe polish spray, RIVM 2018) Room volume: 58 m^3 (living room, default for shoe polish spray, RIVM 2018) Ventilation rate: 0.5/hr (living room, default for shoe polish spray, RIVM 2018)
Tire cleaner spray (64742-96-7)	Population: Adult (19+ years) Weight fraction: 1.0 (SDS 2015i) *Dermal* Spraying: Product amount on skin: 0.021 g (based on release duration and contact rate) Release duration: 28 s (default for all-purpose cleaner spray, RIVM 2018)

	Contact rate: 46 mg/min (default for all-purpose cleaner spray, RIVM 2018) Wiping down: Product amount on skin: 0.25 g (assuming contact with one palm, using surface area for half of one hand/palm of 227.5 cm^2, Health Canada [modified 2022]) Total product amount on skin from spraying + rubbing in = 0.27 g *Inhalation* Exposure duration: 60 min (professional judgment; assumed spraying, leaving on, and wiping down four tires) Product amount: 22 g (based on default released mass for all-purpose cleaner, RIVM 2018) Room volume: 90 m^3 (garage; changed ConsExpo default of 34 m^3 to 90 m^3 as per estimate of a two car garage. 90 m^3 is the default garage volume used in US EPA Consumer Exposure Model v.2.1 (2019) and is consistent with values in Batterman et al. (2007); this garage size allows sufficient space to work on, and move around, an automobile) Ventilation rate: 1.5/hr (garage, RIVM 2014) Release area: 2 m^2 (professional judgment) Application duration: 15 min (professional judgment)
Spray paint (metallic) (68477-31-6)	Population: Adult (19+ years) Weight fraction: 0.01 (SDS 2015j) *Dermal* Product amount on skin: 1.5 g (based on release duration and contact rate) Release duration: 15 min (default for spraying paint with a spray can, RIVM 2007) Contact rate: 100 mg/min (default for spraying paint with a spray can, RIVM 2007) *Inhalation* Exposure duration: 20 min (default for spraying paint with a spray can, RIVM 2007) Product amount: 340 g (whole can, default for spraying paint with a spray can, RIVM 2007) Room volume: 34 m^3 (garage, RIVM 2014) Ventilation rate: 1.5/hr (garage, RIVM 2014)

Abbreviation: N/A, not applicable

Appendix E. Exposure estimates and MOEs from products available to consumers

Table E-1. Relevant oral exposure estimates and resulting MOEs for subgroup 1 substances in cosmetics

Exposure scenario (CAS RN)	Oral exposure (mg/kg bw/day)	MOE for oral exposure[a]
Lipstick or lip balm (64742-46-7)	0.27 to 0.66	1700 to 4100
Lipstick or lip balm (64742-47-8)	0.18 to 0.44	2500 to 6200

Abbreviation: MOE, margin of exposure

[a] The critical health effect level used for these oral exposures is an adjusted lowest observed adverse effect level (LOAEL) of 1116 mg/kg bw/day identified on the basis of the impaired learning and memory observed in a rat inhalation developmental neurotoxicity study in which dams were exposed to dearomatized white spirit from gestational day 7 to 20. This adjusted LOAEL was calculated by converting the lowest observed adverse effect concentration of 4679 mg/m^3 from the inhalation developmental neurotoxicity study into an internal dose that accounted for animal inhalation rate (m^3/day), body weight (kg), and time adjustment factors (hours of exposure/24; days of exposure in a week/7). Animal inhalation rates were determined using the equation provided in Bide et al. (2000). Animal body weights were derived from the study report if available; a default value as presented in Meek et al. (1994) was used otherwise. Target MOE = 1000 (x10 for interspecies variation; x10 for intraspecies variation; x10 for the use of a LOAEL).

Table E-2. Relevant dermal and inhalation exposure estimates and resulting MOEs for subgroup 1 substances in cosmetics

Exposure scenario (CAS RN)	Dermal exposure (mg/kg bw/day)	MOE for dermal exposure[a]	Inhalation exposure (mg/kg bw/day)	MOE for inhalation exposure[b]
Face moisturizer (64742-46-7)	11 to 19	11 to 18	0.23 to 0.27	4 100 to 4 900
Hand moisturizer (64742-46-7)	1.3 to 2.9	69 to 150	0.068 to 0.11	10 000 to 16 000
Body moisturizer (64742-46-7)	68 to 159	1 to 3	0.39 to 0.85	1300 to 2900
Deodorant/antiperspirant (solid/roll-on) (64742-46-7)	1.0 to 1.8	110 to 200	Minimal[c]	N/A
Facial foundation (liquid) (64742-46-7)	0.91 to 2.0	99 to 220	0.050 to 0.078	14 000 to 22 000
Hair conditioner, leave-on (cream or semi-solid	0.48 to 1.0	200 to 420	0.11 to 0.16	6900 to 10 000

Exposure scenario (CAS RN)	Dermal exposure (mg/kg bw/day)	MOE for dermal exposure[a]	Inhalation exposure (mg/kg bw/day)	MOE for inhalation exposure[b]
cream) (64742-46-7)				
Hair oil or serum (64742-46-7)	0.34	590	0.044 to 0.076	15 000 to 25 000
Hair styling product (for example, pomade, balm, cream or putty) (64742-46-7)	0.75 to 2.8	71 to 270	0.16 to 0.37	3 000 to 7 000
After hair-removal wipe (64742-46-7)	1.2 to 2.1	93 to 164	0.016 to 0.025	45 000 to 70 000
Hairspray (aerosol) (64742-46-7)	0.32 to 0.85	235 to 625	0.019 to 0.036	31 000 to 59 000
Facial make-up remover (for example, biphasic oil and water) (64742-46-7)	1.2 to 3.3	61 to 167	0.026 to 0.052	21 000 to 43 000
Face mask (64742-46-7)	3.9 to 4.7	43 to 51	0.00010 to 0.00013	8.6 million to 11 million
Massage oil (64742-46-7)	13 to 86	2 to 15	0.038 to 0.081	14 000 to 29 000
Spray perfume/eau de toilette (64742-46-7)	0.62 to 1.9	110 to 320	0.0037 to 0.0065	170 000 to 300 000
Face spray (anti-aging) (64742-46-7)	2.3	88	0.013	86 000
Hair conditioner, wash-off (64742-46-7)	0.48 to 1.0	200 to 420	0.011 to 0.016	70 000 to 100 000
Temporary hair dye (64742-46-7)	0.47 to 1.5	130 to 430	0.0030 to 0.0047	240 000 to 370 000
Eye shadow (64742-46-7)	0.029 to 0.078	2 600 to 6 900	0.0013 to 0.0030	370 000 to 860 000

Exposure scenario (CAS RN)	Dermal exposure (mg/kg bw/day)	MOE for dermal exposure[a]	Inhalation exposure (mg/kg bw/day)	MOE for inhalation exposure[b]
Shampoo (64742-46-7)	0.050 to 0.19	1 000 to 4 000	0.00093 to 0.0021	530 000 to 1.2 million
Face moisturizer (64742-47-8)	7.3 to 12	16 to 28	0.37 to 0.63	1 800 to 3 000
Hand moisturizer (64742-47-8)	1.3 to 2.9	69 to 160	0.069 to 0.11	10 000 to 16 000
Body moisturizer (64742-47-8)	27 to 63	3 to 7	0.15 to 0.33	3 400 to 7 400
Spray perfume / eau de toilette (64742-47-8)	1.8 to 5.6	36 to 110	0.011 to 0.019	59 000 to 100 000
Hair conditioner, leave-on (cream or semi-solid cream) (64742-47-8)	4.8 to 10	20 to 42	1.1 to 1.6	700 to 1000
Hair oil or serum (64742-47-8)	0.42	480	0.052 to 0.087	13 000 to 21 000
Hair styling product (for example, pomade, balm, cream or putty) (64742-47-8)	0.86 to 3.2	63 to 230	0.18 to 0.42	2 700 to 6 200
Genital product (64742-47-8)	2.0	99	Minimal[c]	N/A
Permanent hair dye (64742-47-8)	8.2 to 9.7	21 to 24	0.053 to 0.066	17 000 to 21 000
Semi-permanent hair dye (64742-47-8)	2.2 to 2.6	78 to 93	0.052 to 0.063	18 000 to 21 000
Hairspray (aerosol) (64742-47-8)	1.9 to 5.1	39 to 110	0.11 to 0.21	5 300 to 10 000
Waterless hand cleaner (64742-47-8)	10	20	0.52	2 100
Massage oil (64742-47-8)	0.83 to 5.5	36 to 240	0.019 to 0.038	29 000 to 59 000
Foot moisturizer	5.6 to 6.6	30 to 36	Minimal[c]	N/A

Exposure scenario (CAS RN)	Dermal exposure (mg/kg bw/day)	MOE for dermal exposure[a]	Inhalation exposure (mg/kg bw/day)	MOE for inhalation exposure[b]
(64742-47-8)				
Body pack (64742-47-8)	2.9	70	0.17	6 600
Sunless tanning lotion (64742-47-8)	1.4	150	0.028	40 000
Facial foundation (liquid) (64742-47-8)	0.66 to 1.5	140 to 300	0.036 to 0.056	20 000 to 31 000
Facial make-up remover (lotion) (64742-47-8)	0.52 to 0.95	210 to 390	0.010 to 0.016	70 000 to 110 000
Face mask (64742-47-8)	1.3 to 1.6	130 to 150	0.0030 to 0.0037	300 000 to 370 000
After hair-removal (body) (64742-47-8)	0.58 to 0.78	260 to 350	0.0072 to 0.0090	124 000 to 155 000
Heavy-duty hand cleaner (64742-47-8)	0.70	290	0.015	74 000
After sun (cream/milk) (64742-47-8)	0.49 to 1.8	110 to 410	0.0081 to 0.017	66 000 to 140 000
Shaving cream (face) (64742-47-8)	0.0092 to 0.015	13 000 to 22 000	0.00019 to 0.00029	3.8 million to 5.9 million
Shampoo (64742-47-8)	0.050 to 0.19	1 100 to 4 000	0.00092 to 0.0020	560 000 to 1.2 million
Mascara (64771-72-8)	0.0024 to 0.0078	26 000 to 83 000	1.4×10^{-4} to 3.2×10^{-4}	3.5 million to 8.0 million

Abbreviations: MOE, margin of exposure; N/A, not applicable

[a] The critical health effect level used for these dermal exposures is a lowest observed adverse effect level (LOAEL) of 200 mg/kg bw/day identified on the basis of the hematological effects in male rabbits and increased spleen and adrenal weights in female rabbits after dermal exposure to undiluted kerosene in a 28-day study. Target MOE = 1000 (x10 for interspecies variation; x10 for intraspecies variation; x10 for the use of a LOAEL).

[b] The critical health effect level used for these inhalation exposures is an adjusted lowest observed adverse effect level (LOAEL) of 1116 mg/kg bw/day identified on the basis of the impaired learning and memory observed in a rat inhalation developmental neurotoxicity study in which dams were exposed to dearomatized white spirit from gestational day 7 to 20. This adjusted LOAEL was calculated by converting the lowest observed adverse effect concentration of 4679 mg/m^3 from the inhalation developmental neurotoxicity study into an internal dose that accounted for animal inhalation rate (m^3/day), body weight (kg), and time adjustment factors (hours of exposure/24; days of exposure in a week/7). Animal inhalation rates were determined using the equation provided in Bide et al. (2000). Animal body weights were derived from the study report if available; a default value as presented in Meek et

al. (1994) was used otherwise. Target MOE = 1000 (x10 for interspecies variation; x10 for intraspecies variation; x10 for the use of a LOAEL).
[c] The applied skin surface area is occluded or obstructed, thereby limiting volatilization of the substance from the applied skin surface to room air and inhalation exposure.

Table E-3. Relevant dermal and inhalation exposure estimates and resulting MOEs for subgroup 1 substances in NHPs

Exposure scenario (CAS RN)	Dermal exposure (mg/kg bw/day)	MOE for dermal exposure[a]	Inhalation exposure (mg/kg bw/day)	MOE for inhalation exposure[b]
Sunscreen (64742-46-7)	6.3 to 28	7 to 32	0.12 to 0.28	4 000 to 9 300
Liquid foundation with SPF (64742-46-7)	0.60 to 0.84	240 to 330	0.032 to 0.040	28 000 to 35 000
Facial cleanser (64742-46-7)	0.034 to 0.047	4 300 to 5 900	4.8×10^{-4} to 7.4×10^{-4}	1.5 million to 2.3 million
Body moisturizer (64742-46-7)	5.4 to 7.3	27 to 37	0.056 to 0.067	17 000 to 20 000
Sunscreen (64742-47-8)	10 to 46	4 to 20	0.20 to 0.45	2500 to 5600

Abbreviations: MOE, margin of exposure; NHP, Natural Health Product
[a] The critical health effect level used for these dermal exposures is a lowest observed adverse effect level (LOAEL) of 200 mg/kg bw/day identified on the basis of the hematological effects in male rabbits and increased spleen and adrenal weights in female rabbits after dermal exposure to undiluted kerosene in a 28-day study. Target MOE = 1000 (x10 for interspecies variation; x10 for intraspecies variation; x10 for the use of a LOAEL).
[b] The critical health effect level used for these inhalation exposures is an adjusted LOAEL of 1116 mg/kg bw/day identified on the basis of the impaired learning and memory observed in a rat inhalation developmental neurotoxicity study in which dams were exposed to dearomatized white spirit from gestational day 7 to 20. This adjusted LOAEL was calculated by converting the lowest observed adverse effect concentration (LOAEC) of 4679 mg/m^3 from the inhalation developmental neurotoxicity study into an internal dose that accounted for animal inhalation rate (m^3/day), body weight (kg), and time adjustment factors (hours of exposure/24; days of exposure in a week/7). Animal inhalation rates were determined using the equation provided in Bide et al. (2000). Animal body weights were derived from the study report if available; a default value as presented in Meek et al. (1994) was used otherwise. Target MOE = 1000 (x10 for interspecies variation; x10 for intraspecies variation; x10 for the use of a LOAEL).

The exposure from the use of the one approved NPD (sunscreen) containing CAS RN 64742-47-8 at 4% is considered to be within the same range as the natural health product sunscreen (dermal and inhalation) because of its similarity in concentration and use. It would also be expected to have similar MOEs (for example, <1000 for dermal).

Table E-4. Relevant dermal and/or inhalation exposure estimates and resulting MOEs for subgroup 1 substances in other products available to consumers

Exposure scenario (CAS RN)	Dermal exposure (mg/kg bw/day)	MOE for dermal exposure[a]	Inhalation exposure (mg/kg bw/day)	MOE for inhalation exposure[b]
Engine cleaner spray	0.20	1 000	0.35	3 200

Exposure scenario (CAS RN)	Dermal exposure (mg/kg bw/day)	MOE for dermal exposure[a]	Inhalation exposure (mg/kg bw/day)	MOE for inhalation exposure[b]
(8008-20-6)				
Penetrating lubricant spray (8008-20-6)	0.81	250	2.30	490
Engine cleaner spray (64741-77-1)	0.57	350	1.0	1 100
Automotive interior detailer/cleaner spray (64741-44-2)	0.50	400	0.34	3 300
Firearm cleaner (64741-91-9)	5.3	38	0.00044	2.5 million
Automotive wax (64742-14-9)	2.9	69	N/A	N/A
Automotive interior detailer/cleaner (64742-46-7)	2.9	69	2.1	530
Construction adhesive (64742-46-7)	0.18	1 100	6.5	170
Countertop polish/cleaner (64742-46-7)	1.1	180	1.1	1 000
Furniture polish liquid (64742-46-7)	7.6	26	85	13
Furniture polish spray (64742-46-7)	6.1	33	76	15
Leather protectant spray (64742-46-7)	0.49	410	1.7	660
Adhesive spray – automotive (64742-47-8)	0.11	1 800	0.49	2 300
Adhesive remover liquid – larger scale project	97	2	290	4

Exposure scenario (CAS RN)	Dermal exposure (mg/kg bw/day)	MOE for dermal exposure[a]	Inhalation exposure (mg/kg bw/day)	MOE for inhalation exposure[b]
(64742-47-8)				
Adhesive remover spray – smaller scale project (64742-47-8)	0.041	4 900	0.40	2 800
Automotive polish (64742-47-8)	4.9	41	N/A	N/A
Air freshener – nebula diffuser for home (64742-47-8)	N/A	N/A	0.33 to 1.2	930 to 3 400
Automotive interior detailer/cleaner (64742-47-8)	7.5	27	6.2	180
Automotive metal polish (64742-47-8)	3.7	54	0.62	1 800
Automotive spray paint (64742-47-8)	5.1	39	5.5	200
Fabric waterproofing spray (64742-47-8)	0.32	630	18	62
Floor paste wax (64742-47-8)	1.4	140	11	100
Furniture polish spray (64742-47-8)	6.7	30	82	14
Interior paint primer (64742-47-8)	15	13	160	7
Lamp oil (64742-47-8)	0.0022	91 000	0.0012	930 000[c]
Paint thinner – cleaning brushes (64742-47-8)	28	7	0.40	2 800
Penetrating lubricant spray (64742-47-8)	2.2	91	6.2	180

Exposure scenario (CAS RN)	Dermal exposure (mg/kg bw/day)	MOE for dermal exposure[a]	Inhalation exposure (mg/kg bw/day)	MOE for inhalation exposure[b]
Portable heater fuel (64742-47-8)	0.037	5 400	0.00048	2.3 million[c]
Silicone lubricant spray (64742-47-8)	0.18	1100	3.1	360
Stainless steel polish spray (64742-47-8)	0.7	290	0.61	1 800
Rust paint (64742-47-8)	3.6 (small scale) 34 (large scale)	56 (small scale) 6 (large scale)	0.62 (small scale) 110 (large scale)	1 800 (small scale) 10 (large scale)
Wood paste varnish – furniture (64742-47-8)	6.2	32	3.6	310
Wood stain – floor (64742-47-8)	25	8	68	16
Wood stain – furniture (64742-47-8)	2.3 (small scale) 21 (large scale)	87 (small scale) 10 (large scale)	0.57 (small scale) 36 (large scale)	2 000 (small scale) 31 (large scale)
Fabric waterproofing liquid (64742-81-0)	31	6	N/A	N/A
Fabric waterproofing spray (64742-81-0)	0.91	220	52	21
Tire cleaner spray (64742-96-7)	3.6	56	0.98	1 100

Abbreviations: MOE, margin of exposure; N/A, not applicable

[a] The critical health effect level used for these dermal exposures is a lowest observed adverse effect level (LOAEL) of 200 mg/kg bw/day identified on the basis of the hematological effects in male rabbits and increased spleen and adrenal weights in female rabbits after dermal exposure to undiluted kerosene in a 28-day study. Target MOE = 1000 (x10 for interspecies variation; x10 for intraspecies variation; x10 for the use of a LOAEL).

[b] The critical health effect level used for these inhalation exposures is an adjusted LOAEL of 1116 mg/kg bw/day identified on the basis of the impaired learning and memory observed in a rat inhalation developmental neurotoxicity study in which dams were exposed to dearomatized white spirit from gestational day 7 to 20. This adjusted LOAEL

was calculated by converting the lowest observed adverse effect concentration of 4679 mg/m^3 from the inhalation developmental neurotoxicity study into an internal dose that accounted for animal inhalation rate (m^3/day), body weight (kg), and time adjustment factors (hours of exposure/24; days of exposure in a week/7). Animal inhalation rates were determined using the equation provided in Bide et al. (2000). Animal body weights were derived from the study report if available; a default value as presented in Meek et al. (1994) was used otherwise. Target MOE = 1000 (x10 for interspecies variation; x10 for intraspecies variation; x10 for the use of a LOAEL).

[c] While there is some uncertainty with respect to volatilization of the fuel from the fuel tank post-filling (that is, prior to and during operation), it is expected that most of the substance undergoes combustion once the lamp or heater is lit and that the MOE resulting from the filling step is sufficiently large to account for this uncertainty.

Table E-5. Relevant dermal, inhalation and combined exposure estimates and resulting MOEs for subgroup 2 substances in other products available to consumers

Exposure Scenario[a] (CAS RN)	Dermal exposure (mg/kg bw/day)	Dermal MOE[b]	Inhalation exposure (mg/kg bw/day)[c]	Inhalation MOE[b]	Combined exposure (mg/kg bw/day)	Combined exposure MOE[b]
Automotive undercoating spray (64742-94-5)	0.61	290	0.15	1200	0.76	230
Engine cleaner spray (64742-94-5)	0.026	6800	0.059	3000	0.085	2100
Fabric waterproofing spray (64742-94-5)	0.026	6800	2.0	88	2.0	88
Lacquer spray paint (64742-94-5)	1.1	160	1.5	120	2.6	68
Shoe polish spray (64742-94-5)	2.9	61	0.66	270	3.6	49
Wood stain – floor (64742-94-5)	1.1	160	2.3	77	3.3	53
Wood stain – furniture (64742-94-5)	0.090 (small scale) 0.83 (large scale)	2000 (small scale) 210 (large scale)	0.022 (small scale) 0.96 (large scale)	8000 (small scale) 180 (large scale)	0.11 (small scale) 1.8 (large scale)	1600 (small scale) 98 (large scale)
Spray paint (68477-31-6)	0.15	1200	0.22	800	0.37	480

Abbreviation: MOE, margin of exposure

[a] Adult population (19+ years) considered

[b] The critical health effect level used for these dermal, inhalation and combined exposures is an adjusted lowest observed adverse effect level (LOAEL) of 176 mg/kg bw/day identified on the basis of the maternal and fetal toxicity in an inhalation prenatal developmental toxicity study in CD-1 mice exposed to high flash aromatic naphtha from

gestational day 6 to 15. This adjusted LOAEL was calculated by converting the lowest observed adverse effect concentration of 102 ppm from the inhalation prenatal developmental toxicity study into an internal dose that accounted for animal inhalation rate (m^3/day), body weight (kg), and time adjustment factors (hours of exposure/24; days of exposure in a week/7). Animal inhalation rates were determined using the equation provided in Bide et al. (2000). Animal body weights were derived from the study report if available; a default value as presented in Meek et al. (1994) was used otherwise. Target MOE = 1000 (x10 for interspecies variation; x10 for intraspecies variation; x10 for the use of a LOAEL).
[c] Internal dose (mg/kg bw/day) = mean air concentration on day of exposure (mg/m^3) × inhalation rate (m^3/day) / body weight (kg).