Australian Government
Department of Health and Aged Care
Australian Industrial Chemicals Introduction Scheme

Cycloalkane, polyfluoro, trifluoromethyl- Cyclohexane, polyfluoro-bis(trifluoromethyl)- Cyclohexane, polyfluoro-tris(trifluoromethyl)- Cycloalkane, polyfluoro-5-(trifluoromethyl)- Pentane, polyfluoro, (1,1,2,2,2-pentafluoroethyl) substituted, (trifluoromethyl) substituted

Assessment statement (CA09690/CA09840/CA09841/CA09842/CA09843)

09 November 2023

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AICIS assessment (CA09690/CA09840/ CA09841/CA09842/CA09843)

Chemicals in this assessment

AICIS Approved Chemical Name (AACN)	Application No.
Cycloalkane, polyfluoro, trifluoromethyl-	CA09690
Cyclohexane, polyfluoro-bis(trifluoromethyl)-	CA09840
Cyclohexane, polyfluoro-tris(trifluoromethyl)-	CA09841
Cycloalkane, polyfluoro-5-(trifluoromethyl)-	CA09842
Pentane, polyfluoro, (1,1,2,2,2-pentafluoroethyl) substituted, (trifluoromethyl) substituted	CA09843

Reason for the assessment

Applications for assessment certificates under section 31 of the *Industrial Chemicals Act 2019* (the Act).

Certificate Application type

AICIS received assessment certificate applications for the five chemicals in a Health and Environment Focus type. The chemicals in this assessment meet the similar chemical and same end use criteria.

Defined scope of assessment

The chemicals have been assessed as:

- imported into Australia individually for a combined volume of 2 tonnes per year for five chemicals
- imported in a neat form for use as such or at 10% concentration in fully finished products for industrial use only
- for use as tracer chemicals in interwell tracer injection and for inflow production monitoring for both onshore and offshore oil and gas wells

Summary of assessment

Summary of introduction, use and end use

The assessed chemicals will not be manufactured or reformulated in Australia. The assessed chemicals will be imported into Australia either in neat form for use as such or at 10%

concentration in fully finished products in an inert plastic polymer matrix rod. There will be no repackaging in Australia. The assessed chemicals either as neat or contained within inert plastic polymer matrix rod will be either directly distributed to the customers or stored for further distribution to the customers.

The assessed chemicals will be used only for industrial purposes as tracer chemicals in interwell tracer injection and for inflow production monitoring for both onshore and offshore oil and gas wells.

Human health

Summary of health hazards

The applicant has not submitted toxicological studies for the assessed chemicals or for suitable analogues. However, the applicant has submitted information on the toxicity of perfluorocarbons as a read-across for the assessed chemicals (F2 reports, 2012).

Based on the data submitted on perfluorocarbons (F2 reports, 2012), the assessed chemicals are:

- of low acute oral, dermal, and inhalation toxicity
- not irritating to skin and eye
- not considered to be skin sensitisers
- not considered to be genotoxic
- not likely to cause systemic health effects following repeated oral exposure (up to 1,000 mg/kg bw/day in rats)

The assessed chemicals are Flammable Liquids (Category 3), based on the calculated flash points ≥ 23 °C and ≤ 60 °C (UNECE 2017) (see **Supporting information**).

Hazard classifications relevant for worker health and safety

The assessed chemicals individually satisfy the criteria for classification according to the *Globally Harmonized System of Classification and Labelling of Chemicals* (GHS) (UNECE 2017) for hazard classes relevant for worker health and safety as follows. This does not consider classification of environmental hazards.

Physical hazards	Hazard category	Hazard statement
Flammable liquids	Category 3	H226 – Flammable liquid and vapour

Summary of health risk

Public

The assessed chemicals will not be available for use by the public. When introduced and used in the proposed manner, it is unlikely that the public will be exposed to the assessed chemicals.

This assessment does not identify any risks to public health that would require specific risk management measures.

Workers

Workers may experience dermal, ocular or inhalation exposure to the assessed chemicals in neat form (at > 90% concentration) during handling and application/injection of the chemicals. However, as the use of closed system of transferring the assessed chemicals from container to injection unit's calibration tank and to the well, there is a minimum handling of assessed chemicals and limited exposure during this process. The exposure will be further minimised by the use of personnel that have undergone training and workers wearing protective glasses and gloves and carrying out the processes in well-ventilated area when transferring the assessed chemicals.

Limited exposure is also expected for inflow production monitoring purpose where the assessed chemicals are embedded in the inert plastic polymer rods. The assessed chemicals will slowly leak out of the polymer matrix rods when in contact with the hydrocarbon phase and these rods will never be removed from the well after monitoring.

This assessment does not identify any risks to the health of workers that would require specific risk management measures.

Environment

Summary of environmental hazard characteristics

According to domestic environmental hazard thresholds and based on the available data the assessed chemicals are:

- Persistent (P)
- Not Bioaccumulative (Not B)
- Not Toxic (Not T)

Environmental hazard classification

Based on the physical and chemical properties and ecotoxicological information available for the assessed chemicals, they are not expected to bioaccumulate in aquatic organisms or be toxic or harmful to aquatic life. Therefore, the assessed chemicals are not formally classified under the *Globally Harmonized System of Classification and Labelling of Chemicals* (GHS) for acute and chronic aquatic toxicities (UNECE 2017).

Summary of environmental risk

The assessed chemicals will be introduced as oil and gas tracers for use in inflow and interwell applications, for both onshore and offshore oil and gas extraction.

When introduced into the well, the assessed chemicals are expected to partition to the hydrocarbon phase where they will be refined and incorporated into the end oil and gas products. All the assessed chemicals are expected to be recovered for inflow applications. Up to 80% of the assessed chemicals is expected to remain in the well during interwell applications, where they will be persistent. However, they are not expected to be exposed to organisms or the atmosphere.

Recovery of the oil and gas may result in the release of small amounts of the assessed chemicals to aquatic compartments during processing. In these compartments, the assessed chemicals are expected to ultimately volatilise and partition to the air compartment, where they will be persistent.

The refined products containing the assessed chemicals will eventually be combusted during use.

The assessed chemicals are not readily degradable and are persistent in the water and air compartments.

The assessed chemicals are hydrophobic (log Kow ≥ 4) and have the potential for bioaccumulation. However, the assessed chemicals are highly volatile from water and log Kow values are not considered to be environmentally relevant. Correspondingly, the assessed chemicals are not considered to be bioaccumulative.

Acute toxicity data indicates the assessed chemicals are not harmful or toxic to aquatic organisms.

The assessed chemicals will undergo long range transport and have a high global warming potential with 100-year GWP values greater than 6500.

Ultimately, releases of the assessed chemicals are expected to be minimal based on the assessed use patterns. Based on the limited exposure from the assessed use patterns, rapid partitioning of any releases to the air compartment and demonstrated acute toxicity values showing no effects, the environmental risk from the assessed chemicals can be managed.

Means for managing risk

Workers

The information in this statement, including recommended hazard classifications, should be used by a person conducting a business or undertaking at a workplace (such as an employer) to determine the appropriate controls under the relevant jurisdiction Work Health and Safety laws.

Recommendation to Safe Work Australia

- It is recommended that Safe Work Australia (SWA) update the *Hazardous Chemical Information System* (HCIS) to include classifications relevant to work health and safety (see **Hazard classifications relevant for worker health and safety**).

Information relating to safe introduction and use

- The storage of the assessed chemicals should be in accordance with the Safe Work Australia *Code of Practice for Managing Risks of Hazardous Chemicals in the Workplace* (SWA, 2012) or relevant State or Territory Code of Practice.

- A copy of the Safety Data Sheet (SDS) should be easily accessible to workers.

Conclusions

The conclusions of this assessment are based on the information described in this statement.

Considering the means of managing risks, the Executive Director is satisfied that when each of the assessed chemicals is introduced and used in accordance with the terms of the corresponding assessment certificate the human health and environment risks can be managed within existing risk management frameworks. This is provided that:

- all requirements are met under environmental, workplace health and safety and poisons legislation as adopted by the relevant state or territory,
- the means for managing the risks identified during this assessment are implemented.

Note: Obligations to report additional information about hazards under section 100 of the *Industrial Chemicals Act 2019* apply.

Supporting information

Grouping rationale

All five assessed chemicals are considered as a group for the purpose of the risk assessment. They are all perfluoro alkanes (C6 to C9) of relatively low molecular weights ranging from 300 to 450 g/mol, having same functional group (C-F), and same end use.

Perfluorocarbons contain only two types of bonds. Carbon-fluorine bonds, and carbon-carbon bonds.

Chemical identity

Chemical identity of CA09690

AACN	Cycloalkane, polyfluoro, trifluoromethyl-

Chemical identity of CA09840

AACN	Cyclohexane, polyfluoro-bis(trifluoromethyl)-

Chemical identity of CA09841

AACN	Cyclohexane, polyfluoro-tris(trifluoromethyl)-

Chemical identity of CA09842

AACN	Cycloalkane, polyfluoro-5-(trifluoromethyl)-

Chemical identity of CA09843

AACN	Pentane, polyfluoro, (1,1,2,2,2-pentafluoroethyl) substituted, (trifluoromethyl) substituted

Relevant physical and chemical properties

The following physical and chemical properties represent the properties of the perfluoroalkane chemicals.

AACN (CA09690)	Cycloalkane, polyfluoro, trifluoromethyl-
Physical form	Colourless liquid at 20 °C and 101.3 kPa
Melting point	-44.7 °C
Boiling point	76.3 °C
Density	1.7994 g/cm^3 at 20 °C 101.3 kPa
Vapour pressure	14.9 kPa at 25 °C (calculated)

Flash point	4.2 ± 19.1 °C (calculated)
Molecular weight (g/mol)	350
Water solubility	1.7 x 10^{-7} g/L at 25 °C
Ionisable in the environment?	No
log K_{ow}	5.49 at 35 °C and pH 7

AACN (CA09840)	Cyclohexane, polyfluoro-bis(trifluoromethyl)-
Physical form	Colourless liquid at 20 °C and 101.3 kPa
Melting point	-56 °C
Boiling point	101.5 °C
Density	1.8672 g/cm^3 at 20 °C 101.3 kPa
Vapour pressure	5.4 kPa at 25 °C (calculated)
Flash point	14.2 ± 19.1 °C (calculated)
Molecular weight (g/mol)	400
Water solubility	2.5 x 10^{-10} g/L at 25 °C
Ionisable in the environment?	No
log K_{ow}	6.02 at 35 °C and pH 7

AACN (CA09841)	Cyclohexane, polyfluoro-tris(trifluoromethyl)-
Physical form	Colourless liquid at 20 °C and 101.3 kPa
Melting point	NA
Boiling point	125 °C
Density	1.9025 g/cm^3 at 20 °C 101.3 kPa
Vapour pressure	13.6 kPa at 25 °C (calculated)
Flash point	18.6 ± 19.1 °C (calculated)
Molecular weight (g/mol)	450
Water solubility	2.4 x 10^{-12} g/L at 25 °C

Ionisable in the environment?	No
log K_{ow}	6.66 at 35 °C and pH 7

AACN (CA09842)	Cycloalkane, polyfluoro-5-(trifluoromethyl)-
Physical form	Colourless liquid at 20 °C and 101.3 kPa
Melting point	45 °C
Boiling point	48 °C
Density	1.72 g/cm^3 at 20 °C 101.3 kPa
Vapour pressure	71.2 kPa at 25 °C (calculated)
Flash point	-12.7 ± 19.1 °C (calculated)
Molecular weight (g/mol)	300
Water solubility	1.8 x 10^{-6} g/L at 25 °C
Ionisable in the environment?	No
log K_{ow}	4.86 at 35 °C and pH 7.98

AACN (CA09843)	Pentane, polyfluoro, (1,1,2,2,2-pentafluoroethyl) substituted, (trifluoromethyl) substituted
Physical form	Colourless liquid at 20 °C and 101.3 kPa
Melting point	NA
Boiling point	69 °C
Density	1.691 g/cm^3 at 20 °C 101.3 kPa
Vapour pressure	4.35 kPa at 25 °C (calculated)
Flash point	30.1 ± 10.2 °C (calculated)
Molecular weight (g/mol)	438
Water solubility	2.5 x 10^{-8} g/L at 25 °C
Ionisable in the environment?	No
log K_{ow}	6.39 at 35 °C and pH 8.01

Human exposure

Workers

There will be no manufacturing, reformulation or repackaging of the assessed chemicals in Australia. The assessed chemicals will be imported either as neat form or in fully finished inert plastic polymer matrix rod containing 10% of assessed chemicals. The amount of gas tracer used is minimal and the normal dose rate is 0.01 ppm for each assessed chemical, which gives a probable scale of use per installation of 2 kg/year/chemical.

When used for interwell injection, the assessed chemicals will be transferred through pumps from the imported containers to the injection unit‘s calibration tank. The assessed chemicals will be then injected to the wells. This is a closed system and there will be no direct exposure to workers. Up to 15 kg of each assessed chemical is used per injection per well. For this type of application, up to 80% of the assessed chemicals remain in the well.

The assessed chemicals will also be used as tracers for inflow production monitoring purposes. For inflow application, the assessed chemicals embedded in polymer rods are placed within screen completion equipment. The assessed chemicals within the inert plastic polymer matrix rods will hence be run in hole along with the rest of the completion and the gas tracers will slowly leak out of the polymer matrix rods when in contact with the hydrocarbon phase. The polymer rods will stay within the screen and will not be removed from the well after monitoring, but the rods will be depleted in tracer concentration through time, typically reaching non-measurable concentrations in 1-3 years. Typically, 100-500 grams of assessed chemicals per zone of a production well are used (one time use per tracer per production well). The assessed chemicals are expected to be entirely recovered when used for inflow applications.

Workers may be exposed via dermal, ocular and or inhalation routes to the assessed chemicals during handling, and application/injection of the chemicals and during quality control, equipment maintenance and cleaning up processes. However, there is a minimum handling of assessed chemicals and very limited operational exposure to assessed chemicals. Only personnel that have undergone training will be transferring the assessed chemicals from container to injection unit’s calibration tank and from there to a closed system leading to the well. The applicant has stated that it is mandatory to wear protective gear such as protective glasses and gloves. In addition, there is a requirement to conduct operations under well-ventilated area when transferring chemicals.

Health hazard information

The applicant has not submitted toxicological studies for the assessed chemicals or for suitable analogues. However, the applicant has submitted information on the toxicity of perfluorocarbons as a read-across for the assessed chemicals (F2 reports, 2012).

As per this report, perfluorocarbon exclusively means a fully saturated chemical compound that contains only carbon and fluorine. They are also known (perhaps more technically) as perfluoroalkanes and perfluorocycloalkanes (depending on structure), or (perhaps less technically) as fluorocarbons.

The F2 report indicate that perfluorocarbons were of low acute oral (LD50 > 2,000 mg/kg bw), dermal (LD50 > 2,000 mg/kg bw) and inhalation (LC50 6 hours > 3,000 mg/L) toxicity in rats.

The perfluorocarbons are not irritating to the skin, as per the testing of perfluorocarbons (n = 8) for skin irritation potentials in rabbits. In addition, perfluoro-2-methylpentane has been the subject of a 48-hour patch test with human subjects in human repeat insult patch test (HRIPT) (no concentration was indicated). None of the 50 test subjects who completed the test, had experienced any reaction. Similarly, the perfluorocarbons are not irritating to the eye, as per the testing of perfluorocarbons (n = 9) for eye irritation potential in rabbits. Skin sensitisation tests on several perfluorocarbons (n = 4) showed negative results.

The F2 report stated that several perfluorocarbons (perfluoroperhydrofluorene and perfluoroperhydrophenanthrene) had been tested in 90-day repeated dose oral toxicity studies (NOAEL > 1,000 mg/kg bw/day). No additional information was provided on these studies.

In an inhalation toxicity study, rats were exposed to perfluorobutane up to 5% (v/v) in air for six hours a day, five days a week for 90 days. While some haematological parameters had some significant variation, there were no deaths and no signs of clinical toxicity. Food consumption was normal, and no ophthalmological or biochemical changes were observed. No additional information was provided on this study. In another study, rats (n = 10/sex) were exposed to perfluoro-n-hexane at 5% concentration v/v in air for six hours/day, five days/week for two weeks. No effects were observed.

Based on the above information and given the wide use of perfluorocarbons in numerous medical applications, the F2 report concluded that perfluorocarbons as a class of chemicals exhibit no repeated dose toxicity, whether by inhalation, orally or dermally.

In addition to the above information, the F2 report also provides a summary of toxicity testing by F2 Chemicals Ltd as below:

Perfluoro-2-methylhexane: The chemical was negative for skin and eye irritation and for mutagenicity test. The chemical was also negative for HRIPT (48-hour patch test). Perfluoro-2,4-dimethyl-3-ethylpentane: The chemical was negative for skin and eye irritation. Perfluoro-1,3,5-trimethylcyclohexane: the chemical was of low acute oral toxicity.

A Summary of toxicity testing by other companies (Rhone-Poulenc/RTZ/ISC) indicated that the perfluorocarbons are of low acute oral, dermal, and inhalation toxicity and not eye and skin irritants and not sensitising to skin and negative for Ames test.

Moreover, the reports provided by the applicant (F2 reports, 2012) noted that several perfluorocarbons have been used in various medical applications where the liquid comes into direct contact with the human body. The reports added that some of the perfluorocarbons are routinely used in eye surgery (estimating over half a million operations worldwide), in which a perfluorocarbon is injected directly into the eye. In addition, several different perfluorocarbons have been used in a wide variety of medical applications (such as in Blood extender, Eye surgery, Nasal spray, Imaging agent, Organ storage, Liquid breathing, and Ulcer treatment).

Environmental exposure

The assessed chemicals will be imported into Australia either in a neat formulation or contained in an inert polymer matrix for use as tracer chemicals in both onshore and offshore oil and gas extraction. No manufacture or reformulation is expected to occur in Australia.

When used for interwell monitoring, the assessed chemicals are manually transferred into a pumping unit which will then inject the assessed chemicals into the gas well. This is a closed system designed to prevent further environmental release.

The assessed chemicals will also be used as tracers for inflow production monitoring purposes. During this process the assessed chemicals are contained in an inert polymer matrix which will be deployed into the oil or gas well during the initial completion. No releases of the assessed chemicals are expected during the initial installation. In the well, the assessed chemicals will leach out from the polymer matrix when in contact with the hydrocarbon phase.

The majority of the chemicals used in inflow applications are expected to remain in the oil or gas phases as they are volatile and readily soluble in the hydrocarbon phase. The assessed chemicals produced with the oil or gas phase will share the fate of the oil or gas and will be sent to refineries. Typically, up to 500 grams of the each assessed chemical may be employed for each production zone of an injection well.

Up to 15 kilograms of each assessed chemical may be used per oil reservoir for interwell applications. Up to 80% of the assessed chemicals used in interwell applications are expected to remain in the oil reservoir, the remainder will be extracted and share the fate of the produced oil or gas and is to be sent to refineries (Eriksen et al., 2005). Release from the well is considered unlikely given the industry standard processes and assuming the standards are followed (DoE, 2014).

When used in onshore and offshore applications, a minor portion of the assessed chemicals may be released to aquatic compartments (Wood, 2021). Once released, the assessed chemicals are expected to rapidly volatilise out of the water compartment and partition to the atmosphere.

Releases of the assessed chemicals during the refining process are expected to be limited by standard control measures in place at the oil refineries, including floating roofs and vapour recovery systems. It is expected that the majority of the assessed chemicals will be incorporated into the refined oil and gas products.

The assessed chemicals will be incorporated into and share the fate of the refined oil and gas products, which will eventually be combusted during use.

Some of the assessed chemicals may be extracted during the clean-up phase of the extraction process. Any of the assessed chemicals produced during this process will be burned according to the environmental protection conditions of the operating oil company. Any unburned assessed chemicals will be released directly to the atmosphere.

During combustion and burning processes, the assessed chemicals are expected to be degraded to CO_2, H_2O and fluoride. Information indicates that approximately 99.6% of the each assessed chemical in the final products will be destroyed (Eriksen et al., 2005).

Ultimately, any releases of the assessed chemicals, which are not destroyed, will eventually partition to the atmosphere and contribute to global levels of perfluorocarbons.

Environmental fate

Partitioning

The assessed chemicals are insoluble in water and have moderate to high log Kow values (log Kow > 4.2). Available literature indicates that perfluorocarbons similar to the assessed chemicals have high mobility in moist soils, comparable to sulphur hexafluoride (Zhong et al., 2014). Additionally, perfluorocarbons similar to the assessed chemicals are highly volatile with Henry's law constant values > 0.17 mol/ m^3Pa (Sander, 2015).

Therefore, if the assessed chemicals are released into the environment, they are not expected to sorb to soils or sediments and will be highly mobile before ultimately partitioning out of water, soil or sediments into the air compartment.

Degradation

Based on half-lives > 2 days in air and > 2 months in seawater the assessed chemicals are persistent.

Degradation studies in seawater indicate that the assessed chemicals are not readily biodegradable. Biodegradation studies conducted to OECD test guideline 306 for the assessed chemicals demonstrated limited degradation over 28 days.

Test chemical	% degradation after 28 days
Cycloalkane, polyfluoro, trifluoromethyl-	13%
Cyclohexane, polyfluoro-bis(trifluoromethyl)-	5%
Cyclohexane, polyfluoro-tris(trifluoromethyl)-	1%
Cycloalkane, polyfluoro-5-(trifluoromethyl)-	5%
Pentane, polyfluoro, (1,1,2,2,2-pentafluoroethyl) substituted, (trifluoromethyl) substituted	6%

In the atmosphere, the assessed chemicals are expected to have very long lifetimes. Structurally similar perfluorocarbons have lifetimes in the range of thousands of years (WMO, 2019).

Bioaccumulation

No bioaccumulation information was provided for the assessed chemicals. Measured partition coefficients of the assessed chemicals were provided by the applicant, which exceed the domestic bioaccumulation threshold of log Kow = 4.2 (EPHC, 2009).

Test chemical	Measured log Kow value
Cycloalkane, polyfluoro, trifluoromethyl-	5.49
Cyclohexane, polyfluoro-bis(trifluoromethyl)-	6.02
Cyclohexane, polyfluoro-tris(trifluoromethyl)-	6.66
Cycloalkane, polyfluoro-5-(trifluoromethyl)-	4.86
Pentane, polyfluoro, (1,1,2,2,2-pentafluoroethyl) substituted, (trifluoromethyl) substituted	6.39

While the assessed chemicals exceed the domestic threshold for bioaccumulation based on log Kow, these results are not considered to be relevant for risk assessment purposes as the assessed chemicals are highly volatile from water and are not expected to reach meaningful concentrations in aquatic compartments under environmentally relevant conditions.

Additionally, information was provided which indicates that perfluorocarbons with high vapour pressure are rapidly expelled from air breathing organisms. As the assessed chemicals have high vapour pressures (> 5,399 Pa), they are unlikely to bioaccumulate in air breathing organisms.

Environmental transport

Volatile perfluorocarbons similar to the assessed chemicals have been used for atmospheric transport and dispersion studies (Watson et al., 2007) based on their inherent stability. Therefore, the assessed chemicals are expected to undergo long range transport if released to the environment.

Predicted environmental concentration (PEC)

A PEC was not calculated as the proposed use patterns do not allow for a quantitative exposure assessment. Any releases of the assessed chemicals are expected to ultimately partition to the atmosphere based on their physico-chemical properties.

Environmental effects

Effects on the atmosphere

There are no standard ecotoxicological endpoints for evaluating effects in the atmospheric compartment. Generally, the effects assessment for this compartment involves the evaluation of the long-range transport potential, global warming potential (GWP) and ozone depleting potential (ODP).

While the assessed chemicals are not listed as synthetic greenhouse gases under Annex A of the Kyoto Protocol, the GWP of the assessed chemicals relative to carbon dioxide (CO_2) on a 100-year time horizon are expected to be extremely high. Supplied information on the assessed chemicals demonstrates GWP values > 6,500.

The assessed chemicals are not expected to contribute to stratospheric ozone depletion because they do not contain chlorine or bromine. The assessed chemicals are not controlled substances listed in Annexes to the Montreal Protocol or the Ozone Protection and Synthetic Greenhouse Gas Management Act 1989.

Effects on aquatic Life

Acute toxicity

The following measured median lethal concentration (LC50) for fish were supplied by the applicant:

Test chemical	Endpoint	Method
Cycloalkane, polyfluoro, trifluoromethyl-	96 h LC50 > 1,000 mg/L (WAF)	*Cyprindon variegatus* (Sheepshead minnow) Mortality OECD TG 203 Semi-static conditions Nominal concentration

Cyclohexane, polyfluoro-bis(trifluoromethyl)-	96 h LC50 > 1,000 mg/L (WAF)	*Cyprindon variegatus* (Sheepshead minnow) Mortality OECD TG 203 Semi-static conditions Nominal concentration
Cyclohexane, polyfluoro-tris(trifluoromethyl)-	96 h LC50 > 10,000 mg/L (WAF)	*Cyprindon variegatus* (Sheepshead minnow) Mortality OECD TG 203 Semi-static conditions Nominal concentration
Cycloalkane, polyfluoro-5-(trifluoromethyl)-	96 h LC50 > 10,000 mg/L (WAF)	Cyprindon variegatus (Sheepshead minnow) Mortality OECD TG 203 Semi-static conditions Nominal concentration
Pentane, polyfluoro, (1,1,2,2,2-pentafluoroethyl) substituted, (trifluoromethyl) substituted	96 h LC50 > 1,000 mg/L (WAF)	*Cyprindon variegatus* (Sheepshead minnow) Mortality OECD TG 203 Semi-static conditions Nominal concentration

It is noted that in the chemical Cycloalkane, polyfluoro, trifluoromethyl- and chemical Cyclohexane, polyfluoro-bis(trifluoromethyl)- acute fish toxicity studies, 100% mortality was observed after 24 hours in 10,000 mg/L (WAF) test groups, however no mortalities or adverse effects were observed in 1,000 mg/L (WAF) test groups.

The following measured median lethal concentration (EC50) for aquatic invertebrates were supplied by the applicant:

Test chemical	Endpoint	Method
Cycloalkane, polyfluoro, trifluoromethyl-	48 h EC50 > 1,000 mg/L (WAF)	*Acartia tonsa* (marine copepod) Immobility ISO 14669 Semi-static conditions Measured concentration
Cyclohexane, polyfluoro-bis(trifluoromethyl)-	48 h EC50 > 10,000 mg/L (WAF)	*Acartia tonsa* (marine copepod) Immobility ISO 14669 Semi-static conditions Measured concentration
Cyclohexane, polyfluoro-tris(trifluoromethyl)-	48 h EC50 > 10,000 mg/L (WAF)	Acartia tonsa (Marine copepod) Immobility ISO 14669 Semi-static conditions Measured concentration

Cycloalkane, polyfluoro-5-(trifluoromethyl)-	48 h EC50 > 10,000 mg/L (WAF)	*Acartia tonsa* (marine copepod) Immobility ISO 14669 Semi-static conditions Measured concentration
Pentane, polyfluoro, (1,1,2,2,2-pentafluoroethyl) substituted, (trifluoromethyl) substituted	48 h EC50 > 10,000 mg/L (WAF)	*Acartia tonsa* (marine copepod) Immobility ISO 14669 Semi-static conditions Measured concentration

The following measured median effect concentration (ErC50) for algae were supplied by the applicant:

Test chemical	Endpoint	Method
Cycloalkane, polyfluoro, trifluoromethyl-	72 h ErC50 > 3,198 mg/L (WAF)	*Skeletonema costatum* (unicellular algae) Growth rate ISO 10253 Static conditions Nominal concentration
Cyclohexane, polyfluoro-bis(trifluoromethyl)-	72 h ErC50 > 10,000 mg/L (WAF)	*Skeletonema costatum* (unicellular algae) Growth rate ISO 10253 Static conditions Nominal concentration
Cyclohexane, polyfluoro-tris(trifluoromethyl)-	72 h ErC50 > 10,000 mg/L (WAF)	*Skeletonema costatum* (unicellular algae) Growth rate ISO 10253 Static conditions Nominal concentration
Cycloalkane, polyfluoro-5-(trifluoromethyl)-	72 h ErC50 > 10,000 mg/L (WAF)	*Skeletonema costatum* (unicellular algae) Growth rate ISO 10253 Static conditions Nominal concentration
Pentane, polyfluoro, (1,1,2,2,2-pentafluoroethyl) substituted, (trifluoromethyl) substituted	72 h ErC50 > 10,000 mg/L (WAF)	*Skeletonema costatum* (unicellular algae) Growth rate ISO 10253 Static conditions Nominal concentration

Chronic toxicity

The following measured no effect concentration (NOErC) for algae were supplied by the applicant:

Test chemical	Endpoint	Method
Cycloalkane, polyfluoro, trifluoromethyl-	72 h NOErC = 1,000 mg/L (WAF)	*Skeletonema costatum* (unicellular algae) Growth rate ISO 10253 Static conditions Nominal concentration
Cyclohexane, polyfluoro-bis(trifluoromethyl)-	72 h NOErC = 10,000 mg/L (WAF)	*Skeletonema costatum* (unicellular algae) Growth rate ISO 10253 Static conditions Nominal concentration
Cyclohexane, polyfluoro-tris(trifluoromethyl)-	72 h NOErC = 10,000 mg/L (WAF)	*Skeletonema costatum* (unicellular algae) Growth rate ISO 10253 Static conditions Nominal concentration
Cycloalkane, polyfluoro-5-(trifluoromethyl)-	72 h NOErC = 10,000 mg/L (WAF)	*Skeletonema costatum* (unicellular algae) Growth rate ISO 10253 Static conditions Nominal concentration
Pentane, polyfluoro, (1,1,2,2,2-pentafluoroethyl) substituted, (trifluoromethyl) substituted	72 h NOErC = 10,000 mg/L (WAF)	*Skeletonema costatum* (unicellular algae) Growth rate ISO 10253 Static conditions Nominal concentration

Effects on sediment dwelling life

The following measured LC50 values for crustaceans were supplied by the applicant:

Test chemical	Endpoint	Method
Cycloalkane, polyfluoro, trifluoromethyl-	10 d LC50 > 322 mg/kg dw	*Corophium volutator* (European mud scud) OSPAR protocols 2005 Nominal concentration
Cyclohexane, polyfluoro-bis(trifluoromethyl)-	10 d LC50 > 12,800 mg/kg dw	*Corophium volutator* (European mud scud) OSPAR protocols 2005 Nominal concentration

Cyclohexane, polyfluoro-tris(trifluoromethyl)-	10 d LC50 > 12,900 mg/kg dw	*Corophium volutator* (European mud scud) OSPAR protocols 2005 Nominal concentration
Cycloalkane, polyfluoro-5-(trifluoromethyl)-	10 d LC50 > 13,000 mg/kg dw	*Corophium volutator* (European mud scud) OSPAR protocols 2005 Nominal concentration
Pentane, polyfluoro, (1,1,2,2,2-pentafluoroethyl) substituted, (trifluoromethyl) substituted	10 d LC50 > 13,800 mg/kg dw	*Corophium volutator* (European mud scud) OSPAR protocols 2005 Nominal concentration

It should be noted that that the tests were conducted in open vessels with air blown through the test set up and that the assessed chemicals are highly volatile. It is likely that the animals were not exposed to the reported nominal concentrations of the test chemicals.

Predicted no-effect concentration (PNEC)

A PNEC was not calculated as the assessed chemicals have no acute effects on aquatic or sediment dwelling species up to 322 mg/kg.

Categorisation of environmental hazard

The categorisation of the environmental hazards of the assessed chemicals according to domestic environmental hazard thresholds is presented below:

Persistence

Persistent (P). Based on available measured degradation studies and literature, the assessed chemicals are categorised as Persistent.

Bioaccumulation

Not bioaccumulative (Not B). While the assessed chemicals exceed the domestic log Kow threshold for bioaccumulation potential, the assessed chemicals are not expected to bioaccumulate in air breathing organisms or be bioavailable under environmentally relevant conditions based on their rapid volatilisation from water.

Toxicity

Not Toxic (Not T). Based on available ecotoxicity values above 1 mg/L, the assessed chemicals are categorised as Not Toxic.

Environmental risk characterisation

The assessed chemicals used as oil and gas tracers are largely expected to be incorporated into the produced petroleum products. These products will eventually be combusted as a function of their use, during which the assessed chemicals will be destroyed.

The assessed chemicals are expected to be entirely recovered when used for inflow applications. The unrecovered portion of the assessed chemicals used in interwell monitoring are expected to remain in the oil reservoir where they will be persistent but are not expected to be exposed to organisms or the atmosphere. Release from the well is considered unlikely given the industry standard processes and assuming the standards are followed (DoE, 2014).

If released into the environment, the assessed chemicals are expected to volatilise and partition into the atmospheric compartment where they are expected to be extremely persistent, undergo long range transport and have high global warming potentials.

A risk quotient (PEC/PNEC) for the aquatic compartment has not been calculated. However, release of the assessed chemicals is expected to be minimal based on the assessed use patterns. Additionally, while the assessed chemicals have the potential for bioaccumulation, they are expected to partition to air and not be available for bioaccumulation under environmentally relevant conditions. The assessed chemicals are also not expected to exhibit acute toxic effects on aquatic organisms based on the supplied data.

Therefore, while the assessed chemicals are persistent and can contribute to GWP, considering the minimal exposure from the assessed use patterns, minimal opportunity to bioaccumulate and lack of ecotoxicity, the environmental risk from the assessed chemicals can be managed.

As the environmental and toxic effects of PFCs is an area of ongoing research, re-assessment or evaluation may be required if information becomes available that indicates the assessed chemicals or their degradants have greater hazards than those considered in this assessment.

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