# Qualitative Tier 2 Assessment

## Isotridecanol, ethoxylated

In accordance with the Chemical Risk Assessment Framework (CRAF), chemicals assigned a Tier 2 designation require a hazard assessment and qualitative assessment of risk.

Consistent with National Industrial Chemicals Notification and Assessment Scheme (NICNAS), the human health hazards for each chemical are characterised by analysing the toxicokinetics (the absorption, distribution, metabolism and excretion of the chemical in humans or laboratory animals), acute toxicity, irritation and corrosivity, repeat dose toxicity, genotoxicity, carcinogenicity, reproductive toxicity, and other health effects. The environmental hazards for each chemical are characterized by analysing the environmental fate properties (such as mobility, persistence, bioavailability and bioaccumulation), acute toxicity and chronic toxicity. In support of the hazard assessment, a risk assessment dossier is prepared for each of the chemicals included in the assessment.

The qualitative assessment of risk evaluates exposure to the vendor chemical that may occur during activities that do not intentionally result in a release to the environment, but where a potential release may occur. For this evaluation, these potential releases primarily are focused on the vendor chemical transported to the well pad site or water management facility (WMF), chemicals utilised in drilling fluid systems that may impact groundwater, residual chemicals that may be present in hydraulic flowback and workover fluids and chemicals and chemicals and residues of chemicals that may be present in water undergoing treatment or beneficially re-used.

Potentially complete exposure pathways (in that a source, a migration pathway, a mechanism for exposure, and a potential receptor are present) are assessed herein to determine the potential for risk (an incomplete pathway precludes an exposure occurring and an associated potential risk). In this context, site setting and management protocols associated with the action are evaluated. Key controls limiting the potential for exposure include:

- Engineering controls (including fencing and secondary containment);
- Storage (drums, totes and storage tanks) constructed in accordance with Australian standards and managed and monitored in accordance with regulatory requirements;
- Maintenance of access control restrictions during site activities that will preclude access by the public, livestock and large native fauna; and,
- Australia SafeWork Place and Santos Occupational Safety Guidance used to minimise human health exposure.

As a result, the assessment for this Tier 2 chemical includes the following components: completing the screening; developing a risk assessment dossier and Predicted No Effect Concentrations (PNECs) for water and soil; and, providing a qualitative discussion of risk. Each of these components is detailed within this memorandum.

## Background

Isotridecanol, ethoxylated is a chemical in a product used in drilling and completion activities, including workovers. The workover process is designed to remove any solids from the well and facilitate placement of the pump. As part of this process, fluids and some coal fines are removed from the well and transported to produced water ponds for management within the produced water stream. Once the well has been placed and commissioned, produced water is discharged into the water gathering pipelines and conveyed to the water ponds/water treatment facilities for treatment and beneficial use (such as dust suppression, construction, operational use and stock water for cattle).

The purpose and maximum quantity for this chemical is summarized in **Table 1**.

**Table 1 Initial and Underbalance Workover Fluid Chemicals**

| Chemical Name | CAS No. | Use | Quantity[1] |
|---|---|---|---|
| Isotridecanol, ethoxylated- | 69011-36-5 | Activators, Emulsifiers and Neutralisers | NA |

[1] Volume Percent in Treatment (%)
CAS No = Chemical Abstracts Service Number
NA = quantity used varies

The assessment of toxicity of this chemical was used to evaluate human health exposure scenarios and is presented in **Attachment 1**. There are no carcinogenicity studies on isotridecanol, ethoxylated. The alcohol ethoxylates $C_{12\text{-}13}AE_{6.5}$ and $C_{14\text{-}15}AE_{7}$ were not carcinogenic to rats in a two-year dietary study. Thus, a cancer reference value was not derived and, as a result, only a non-carcinogenic oral reference dose (RfD) was calculated. A detailed discussion of the derivation of the oral RfD and drinking water guideline values is presented in the attachment. **Table 2** provides a summary of the derivation.

**Table 2 Oral Reference Doses and Derived Drinking Water Guidelines**

| Constituent (CAS No.) | Study | Critical Effect/ Target Organ(s) | NOAEL (mg/kg-day) | Uncertainty Factors | Oral Reference Dose (mg/kg-day) | Drinking Water Guideline (mg/L) |
|---|---|---|---|---|---|---|
| Isotridecanol, ethoxylated (69011-36-5) | 2-year dietary study in rats | Increased organ weight | 50 | 100 | 0.5 | 1.8 |

Refer to **Attachment 1** for information on the key studies selected for oral reference dose and drinking water level development.
CAS = Chemical Abstracts Service
mg/kg-day = milligram per kilogram-day
mg/L = milligram per litre
NOAEL = No observed adverse effect level

For ecological receptors, the assessment utilises the information presented in the dossiers on the relative toxicity of the aquatic and terrestrial flora and fauna to the chemical. This assessment focuses on the aquatic invertebrate and fish species within the surface water resources and the soil flora and fauna associated with releases to the soil.

The determination of toxicological reference values (TRVs) was conducted according to the PNEC guidance in the *Environmental Risk Assessment Guidance Manual for Industrial Chemicals* prepared by the Australian Environmental Agency (AEA, 2009). PNECs for freshwater and sediment were developed to assess aquatic receptors, and PNECs for soil were developed for terrestrial receptors.

**Table 3** present the chemical, the endpoint, no observable effects concentration (NOEC) (milligrams per litre [mg/L]), assessment factor, and the aquatic PNEC (mg/L). PNECs for sediment and soil are detailed in **Tables 4** and **5,** respectively. Refer to **Attachment 1** for the development of PNECs, or the rational for PNECs that do not have a calculated PNEC.

**Table 3 PNECs Water – Tier 2 Chemicals**

| Constituents | Endpoint | $EC_{50}$ or NOEC (mg/L) | Assessment Factor | $PNEC_{water}$ (mg/L) |
|---|---|---|---|---|
| Isotridecanol, ethoxylated (69011-36-5) | - | - | - | 0.140[a] |

[a] $PNEC_{water}$ for isotridecanol, ethoxylated is the ANZG Water Quality Guideline – Freshwater Trigger Value for Alcohol Ethoxylates (AE).
$EC_{50}$ = effects concentration – 50%
mg/L = milligram per litre
NOEC = no observable effects concentration
PNEC = predicted no effect concentration
Refer to **Attachment 1** for information on the development of PNECs listed above.

**Table 4 PNECs Sediment – Tier 2 Chemicals**

| Constituents | Endpoint | $EC_{50}$ or NOEC (mg/kg wet wt) | Assessment Factor | $PNEC_{sed}$ (mg/kg wet wt) |
|---|---|---|---|---|
| Isotridecanol, ethoxylated (69011-36-5) | [a] | - | - | 0.71 |

[a] Calculated using equilibrium partitioning method
$EC_{50}$ = effects concentration – 50%
mg/kg wet wt = milligram per kilogram wet weight
NOEC = no observable effects concentration
PNEC = predicted no effect concentration
Refer to **Attachment 1** for information on the development of PNECs listed above.

**Table 5 PNECs Soil – Tier 2 Chemicals**

| Constituents | Endpoint | $EC_{50}$ or NOEC (mg/kg dry wt) | Assessment Factor | $PNEC_{soil}$ (mg/kg dry wt) |
|---|---|---|---|---|
| Isotridecanol, ethoxylated (69011-36-5) | [a] | - | - | 0.56 |

[a] Calculated using equilibrium partitioning method
$EC_{50}$ = effects concentration – 50%
mg/kg dry wt = milligram per kilogram dry weight
NOEC = no observable effects concentration
PNEC = predicted no effect concentration
Refer to **Attachment 1** for information on the development of PNECs listed above.

A detailed assessment of the risks posed by this TIer 2 chemical is provided in the following sections.

## General Overview

Alcohol ethoxylates (AE) are a class of non-ionic surfactants that have the basic structure $C_{x-y}AE_n$. The subscript (x-y) following the 'C' indicates the range of carbon chain units. The hydrocarbon chain can be either linear or branched. AEs also contain an ethylene oxide (E) chain attached to the alcohol. The degree of ethylene oxide polymerisation is indicated by the subscript (n) which indicates the average number of ethylene oxide units. Isotridecanol, ethoxylated has an average number of 1 to 2.5 moles of ethylene oxide (EO) units.

Isotridecanol, ethoxylated is a substance of unknown or variable composition, complex reaction products or biological materials (UVCB). A representative molecular structure of an AE is presented in **Figure 1**.

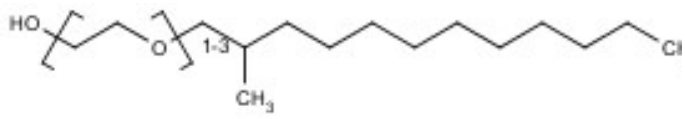


**Figure 1 Representative Molecular Structure of Isotridecanol, ethoxylated[1]**

Isotridecanol, ethoxylated is readily biodegradable. It has a low potential for bioaccumulation and a moderate potential for absorption to soil and sediment.

The Persistent, Bioaccumulative and Toxic (PBT) assessment for isotridecanol, ethoxylated is included in the dossier provided in **Attachment 1**. Based on physico-chemical properties and screening data detailed below, the overall conclusion was that the chemical is not a PBT substance.

[1] Source https://echa.europa.eu/brief-profile/-/briefprofile/100.105.729

## Human Health Hazards

The acute toxicity of isotridecanol, ethoxylates is low by the oral and dermal routes. The skin irritation rabbit studies on isotridecanol, ethoxylated and similar alcohol ethoxylates show that the degree of irritation depends on the testing conditions and length of the exposure period. Human patch studies on these alcohol ethoxylates do not support a skin irritant classification. Isotridecanol, ethoxylated with EO units of 1 to <2.5 are not irritating to the eyes of rabbits. Isotridecanol, ethoxylated is not a skin sensitiser.

Repeated dose toxicity studies on alcohol ethoxylates similar to isotridecanol, ethoxylates in rats do not indicate any target organ effects. These alcohol ethoxylates are not genotoxic or carcinogenic and have a low potential for reproductive and developmental toxicity.

A two-year dietary study in rats has been conducted on a similar alcohol ethoxylate ($C_{12\text{-}13}AE_{6.5}$) (HERA, 2009). The no observed adverse effects level (NOAEL) from this study is 50 milligrams per kilogram-day (mg/kg-day) based on increased organ weights. The NOAEL was used to derive the oral RfD and the drinking water guidance value (1.8 milligrams per litre [mg/L]) (see **Table 2**). Description of the oral RFD and calculation of the drinking water guideline value is included in the dossier provided in **Attachment 1**.

The lifecycle of chemicals, including isotridecanol, ethoxylates, used during the drilling, completion and workover of wells includes the following general categories: transportation of chemicals; drilling, completion and workover operations; and, treatment, recycling, disposal and beneficial reuse. Without management controls in place, there is the potential for human receptors to be exposed to workover chemicals that contain isotridecanol, ethoxylates during drilling, completion and workover operations and management of workover fluids during beneficial reuse. Based on an assessment of land use and an understanding of the project description provided in the Environmental Impact Statement (EIS) (URS, 2014) and the CRAF developed for the GFD Project Area, potential human receptors include:

1. Workers at the well lease involved with blending, storage, transfer, reuse, recovery and recycling of drilling fluids, workover fluids and cuttings; recycling, reuse or disposal of recovered materials including beneficial reuse activities such as land applications of drilling materials and dust suppression; and, mitigating releases at the well lease or along the transport or conveyance routes.
2. Agricultural workers or residents in irrigation areas.
3. Landholders that have access to the water supply from a bore hydraulically downgradient of the well lease.

In terms of risks associated with transport of chemicals and wastes, this risk is considered to be managed to a level as low as reasonably practicable. This is because the potential for a release is controlled through implementation of traffic management principles including use of designated trucking routes, vehicle signage, vehicle management systems (to manage speed and driving behaviour/habits) and, in the unlikely event of a vehicular accident, implementation of incident and spill response procedures. Given the highly regulated nature of transportation of chemicals (at both a Commonwealth and State level), transport-related scenarios are not evaluated further in this assessment. However, the outcome of the assessment should be used to inform emergency response actions.

Exposure of workers to drilling fluid and workover chemicals is possible via inadvertent spills and leaks, during the recycling and beneficial reuse of recovered materials (e.g., drilling fluids and cuttings), and during application of the recovered material to land. However, chemical exposures to workers are controlled through engineering, management controls and personal protective equipment, which are focused on elimination and mitigation of the potential for dermal contact and potential for incidental ingestion. In addition, Australia SafeWork Place and Santos Occupational Safety Guidance are used to minimise human health exposure. As a result, petroleum workers, are also excluded from assessment. No potentially complete exposure pathways were identified.

The management of chemicals and wastes will be conducted at the well lease using drums, totes and engineered tanks designed to contain the fluids. In the unlikely event of a release to ground, the potential for exposures (other than workers) is limited. Releases on the well pad would be of limited volumes and the well pad sites are fenced and access is controlled, which limits access to the public. If drilling fluid chemicals are spilled to ground then investigation, remediation and rehabilitation activities would be implemented to address soil impacts.

On-lease storage may utilise tanks or pits and there is the possibility that a containment failure could result in the release of the materials to the well lease and the surrounding environment. Releases on the well pad would be of limited volumes and as such these products would not be anticipated to migrate a significant distance off lease to the surrounding environment, including proximal water bodies.

The potential for a significant drilling fluid loss during drilling is rare, particularly given the volumes used and the management controls in place during drilling. Where lost circulation is identified during drilling, a lost circulation fluid (i.e. cellulose) is used to plug the interval and prevent further loss of fluids. Despite the limited potential for large scale losses during drilling, EHS Support (2015) completed modelling of how a conservative tracer or highly soluble organic constituents could migrate in the subsurface to assess the potential effects of potential loss of drilling muds on groundwater systems. The BIOSCREEN model was utilized to facilitate assessment of organic constituent mobility with and without biodecay. The modelling indicated that the potential for impact on ground water quality is limited even under a worst-case scenario utilising conservative assumptions.

Exposure of potential receptors (other than workers) is also possible to residual chemicals in areas adjacent to the well lease that have been used for the application of materials for beneficial reuse. The primary land use within the development area is agricultural (grazing on improved or unimproved pastures), and it is sparsely populated. There may be potential for human receptors such as residents and agricultural workers to be exposed to residual chemicals in recovered materials via direct contact (ingestion and dermal) and inhalation pathways. Relative potential exposure to agricultural workers/residents is considered low due to the remote location of the well leases and the sparse population. In addition, activities are undertaken in operational and controlled areas of the well lease.

However, Environmental Authority (EA) or Beneficial Use Approval conditions regulate project reuse. A plan for the beneficial reuse of materials has been developed by a Suitably Qualified Person (SQP) in accordance with the EA conditions which require materials of a certain quality and controls the maximum volumes that can be applied to land. In addition, the application techniques and location of application are controlled with specific monitoring required. Irrigation areas are designed to manage the risk of pooling and runoff with a general deficit irrigation strategy employed; and, are

fitted with monitoring bores to manage the risk of vertical and horizontal migration. Additional details regarding mitigation and management controls are discussed in the CRAF.

As a result, potential exposures during the drilling, completion and workover process are low due to the employment of mechanical equipment/processes, engineering controls (including secondary containment) and other mitigation and management strategies. Finally, the probability of any surface related discharge infiltrating subsurface soils and migrating to groundwater is very low.

## Environmental Hazards

In standard aquatic toxicity tests, isotridecanol, ethoxylated is of moderate toxicity concern to aquatic organisms. Acute toxicity towards fish, aquatic invertebrates and algae is of the same order of magnitude (ECHA).

Isotridecanol, ethoxylated is biodegradable and does not persist in the environment. The chemical also has a low potential for bioaccumulation.

PNECs for isotridecanol, ethoxyland are provided in **Tables 3-5**. Isotridecanol, ethoxylated is an alcohol ethoxylate (AE). ANZG has established a water quality guideline (ANZG, 2018) with a freshwater trigger value of 0.14 mg/L for AE. This value was derived using data normalised to an alkyl chain length of C13.3 and EO of 8.2 using the statistical distribution method with 95% protection.

There are no toxicity data for sediment-dwelling organisms or soil organisms. Therefore, PNECs for sediment and soil were calculated using the equilibrium partitioning method. PNEC calculations and assumptions are included in the dossier provided in **Attachment 1**.

During the drilling, completion and workover process, there is the potential for environmental receptors to be exposed to workover fluid chemicals such as isotridecanol, ethoxylated. Pipelines (where treated water is conveyed) can transect sensitive ecological areas (including Matters of National Environmental Significance [MNES]). There is the concern of wildlife (terrestrial and aquatic receptors) and livestock in the vicinity of the well leases to have adverse effects from potential exposures. Potential environmental receptors include:

1. Wildlife and livestock accessing the well lease and areas adjacent to a well lease, including surface water features, that have received runoff from an accidental release during drilling, completion and workover operations or loss of containment.
2. Wildlife and livestock accessing areas of the well lease where materials have been applied as well as accessing stored materials in lined pits or storage ponds.
3. Aquatic flora and fauna within a proximal surface water body that has received runoff from an accidental release during drilling, completion and workover activities or loss of containment, or from beneficial reuse applications.
4. Wildlife including livestock that have access to the water supply from a bore hydraulically downgradient of the well lease.

The potential for exposure of sensitive receptors (including MNES) is considered low. The drilling, completion and workover activities occur over a short duration and are conducted in controlled/operational areas within a perimeter fence. Further, the activity level, noise, etc. will be a disincentive for wildlife and livestock to access the lease through gaps in the fencing or unsecured gates.

Based on the engineering and management controls described in the previous section (Human Health Hazards), there is a low potential for ecological receptors exposed to surface water bodies that may receive runoff from an accidental release. There is also concern that recovered material applied to the land surface could migrate to groundwater or surface water, and therefore result in adverse effects to the environment (e.g., uptake by aquatic receptors). Due to EA conditions regulating land application techniques, the remote nature of the well leases, vertical separation of groundwater and distances to watercourses, the ephemeral nature of the watercourses and the physical and chemical properties of the residual chemicals post treatment or beneficial reuse, these potential exposures are also low.

## References

Australian and New Zealand Guidelines (ANZG). (2018). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra, ACT, Australia. https://www.waterquality.gov.au/anz-guidelines.

Australian Environmental Agency (AEA). (2009). Environmental Risk Assessment Guidance Manual for Industrial Chemicals, Commonwealth of Australia.

ECHA. ECHA REACH database: http://echa.europa.eu/information-on-chemicals/registered-substances

EHS Support. (2015). Santos GLNG Upstream Hydraulic Fracturing Risk Assessment Compendium of Assessed Fluid Systems. Revision 1. 23 November 2015.

Human and Environmental Risk Assessment (HERA) on Ingredients of Household Cleaning Products: Alcohol Ethoxylates. (2009). http://www.heraproject.com.

URS. (2014). Santos GLNG Project: Gas Field Development Project Environmental Impact Statement. Available online at: http://www.santosglng.com/environment-and-water/gas-field-development-project-eis.aspx

# Attachment 1 Risk Assessment Dossier

**ETHOXYLATED BRANCHED C13 ALCOHOL**
**[ISOTRIDECANOL, ETHOXYLATED]**

This dossier on isotridecanol, ethoxylated presents the most critical studies pertinent to the risk assessment of isotridecanol, ethoxylated in its use in coal seam gas extraction activities. This dossier does not represent an exhaustive or critical review of all available data. The information presented in this dossier was obtained primarily from the Human & Environmental Risk Assessment on Ingredients of European Household Cleaning Products: Alcohol Ethoxylates (HERA, 2009). Where possible, study quality was evaluated using the Klimisch scoring system (Klimisch *et al.*, 1997).

Screening Assessment Conclusion – Isotridecanol, ethoxylated was not identified in chemical databases used by NICNAS as an indicator that the chemical is of concern and is not a PBT substance. Isotridecanol, ethoxylated was assessed as a tier 2 chemical for acute and chronic toxicity. Therefore, this substance is classified overall as a **tier 2** chemical and requires a hazard assessment and qualitative assessment of risk.

## 1 BACKGROUND

Alcohol ethoxylates (AE) are a very widely used class of non-ionic surfactants. Significant quantities of AE are converted to alcohol ethoxysulphates (AES) with the remaining AE used primarily in household laundry detergents. AE have many desirable characteristics such as rapid biodegradation, low to moderate foaming ability, superior cleaning of man-made fibres and tolerance of water hardness. AE are also used in lesser quantities in household cleaners, institutional and industrial cleaners, cosmetics, agriculture and in textile, paper, oil and other process industries.

Isotridecanol, ethoxylated is readily biodegradable. It has a low potential for bioaccumulation and a moderate potential for adsorption to soil and sediment.

The acute toxicity of isotridecanol, ethoxylates is low by the oral and dermal routes. The skin irritation rabbit studies on isotridecanol, ethoxylated and similar alcohol ethoxylates show that the degree of irritation depends on the testing conditions and length of the exposure period. Human patch studies on these alcohol ethoxylates do not support a skin irritant classification. Isotridecanol, ethoxylated with EO units of 1 to <2.5 are not irritating to the eyes of rabbits. Isotridecanol, ethoxylated is not a skin sensitiser. Repeated dose toxicity studies on alcohol ethoxylates similar to isotridecanol, ethoxylates in rats do not indicate any target organ effects. These alcohol ethoxylates are not genotoxic, carcinogenic and have a low potential for reproductive and developmental toxicity. Isotridecanol, ethoxylated has moderate chronic toxicity concern to aquatic life.

## 2 CHEMICAL NAME AND IDENTIFICATION

**Chemical Name (IUPAC):** Isotridecanol, ethoxylated
**CAS RN:** 69011-36-5
**Molecular formula:** Not available (UVCB substance)
**Molecular weight:** Not available (UVCB substance)

**Synonyms:** Isotridecanol, ethoxylated; C13 ethoxylated alcohol; Alcohol C13 ethoxylated; ethoxylated branched C13 alcohol

## 3 PHYSICO-CHEMICAL PROPERTIES

Alcohol ethoxylates (AE) are a class of non-ionic surfactants that have the basic structure $C_{x-y}AE_n$. The subscript (x-y) following the 'C' indicates the range of carbon chain units. The hydrocarbon chain can be either linear or branched. AEs also contain an ethylene oxide (E) chain attached to the alcohol. The degree of ethylene oxide polymerisation is indicated by the subscript (n) which indicates the average number of ethylene oxide units. Isotridecanol, ethoxylated (CAS No. 69011-36-5) has an average number of 1 to 2.5 moles of ethylene oxide units.

Key physical and chemical properties for the substance are shown in Table 1.

**Table 1 Overview of the Physico-chemical Properties of Isotridecanol, ethoxylated (1 to 2.5 moles ethoxylated)**

| Property | Value | Klimisch score | Reference |
|---|---|---|---|
| Physical state at 20°C and 101.3 kPa | Clear liquid with a rancid odour | 2 | ECHA |
| Melting Point | -11.6°C @ 101.3 kPa | 1 | ECHA |
| Boiling Point | >280°C @ 101.3 kPa | 1 | ECHA |
| Density | 907 kg/$m^3$ @ 20°C | 1 | ECHA |
| Vapour Pressure | <5 Pa @ 20°C | 2 | ECHA |
| Partition coefficient (log $K_{ow}$) | 4.9* (calculated) @25 °C | 2 | ECHA |
| Water Solubility | 0.02-0.029 g/L @ 21°C | 1 | ECHA |
| Dissociation Constant (pKa) | Not applicable | - | ECHA |
| Viscosity | 38.2 $mm^2$/s (static) @ 20°C | 1 | ECHA |

*Weight-averaged log $K_{oc}$ of whole substance based on normalised composition.

## 4 DOMESTIC AND INTERNATIONAL REGULATORY INFORMATION

A review of international and national environmental regulatory information was undertaken (Table 2). This chemical is listed on the Australian Inventory of Chemical Substances – AICS (Inventory). No conditions for its use were identified. No other specific environmental regulatory controls or concerns were identified within Australia and internationally for isotridecanol, ethoxylated.

**Table 2 Existing International Controls**

| Convention, Protocol or other international control | Listed Yes or No? |
|---|---|
| Montreal Protocol | No |
| Synthetic Greenhouse Gases (SGG) | No |
| Rotterdam Convention | No |
| Stockholm Convention | No |
| REACH (Substances of Very High Concern) | No |
| United States Endocrine Disrupter Screening Program | No |
| European Commission Endocrine Disruptors Strategy | No |

## 5 ENVIRONMENTAL FATE SUMMARY

### A. Summary

Isotridecanol, ethoxylated is readily biodegradable. It has a low potential for bioaccumulation and a moderate potential for adsorption to soil and sediment.

### B. Partitioning

Abiotic degradation like hydrolysis and photolysis is not an important process in case of alcohol ethoxylates due to the chemical structure of these substances (ECHA).

### C. Biodegradation

Isotridecanol, ethoxylated is readily biodegradable. In an OECD 301B test, degradation was 75% in 28 days (ECHA) [Kl. score = 2].

If a chemical is found to be readily biodegradable, it is categorised as Not Persistent since its half-life is substantially less than 60 days (DoEE, 2017).

### D. Environmental Distribution

Using KOCWIN v2.00, the following calculated $K_{oc}$ values were obtained: 441.7 for alcohol, C13, branched; 359.3 for alcohol ethoxylate, C13, branched, 1 EO; and 237.8 for alcohol ethoxylate, C13, branched, 3 EO (ECHA) [Kl. Score = 2]. The average of the $K_{oc}$ values for the C13 ethoxylated alcohols, which is 298.6 L/kg, will be used to calculate the PNEC values for sediment and soil.

If released to soil, the average $K_{oc}$ values for the C13 ethoxylated alcohols indicate a moderate potential for both adsorption and mobility. If released to water, based on these $K_{oc}$ values and slight solubility, this substance may have moderate adsorption to suspended solids or sediment.

### E. Bioaccumulation

The BCF values for alcohol ethoxylates in fathead minnows have been reported to range from <5 to 387.5 (Toll et al., 2000). The uptake rates varied from 330 to 1660 (L x kg/d) and elimination rates varied from 3.3 to 59 per day (Toll et al., 2000). The high concentrations in fish are thought to be prevented by an efficient biotransformation of the alcohol ethoxylates, leading to a high elimination rate. Thus, it can be stated that bioaccumulation of alcohol ethoxylates is regarded to be negligible as the surfactants will be rapidly metabolised (ECHA).

## 6 HUMAN HEALTH HAZARD ASSESSMENT

### A. Summary

The acute toxicity of isotridecanol, ethoxylates is low by the oral and dermal routes. The skin irritation rabbit studies on isotridecanol, ethoxylated and similar alcohol ethoxylates show that the degree of irritation depends on the testing conditions and length of the exposure period. Human patch studies on these alcohol ethoxylates do not support a skin irritant classification. Isotridecanol, ethoxylated with EO units of 1 to <2.5 are not irritating to the eyes of rabbits. Isotridecanol,

ethoxylated is not a skin sensitiser. Repeated dose toxicity studies on alcohol ethoxylates similar to isotridecanol, ethoxylates in rats do not indicate any target organ effects. These alcohol ethoxylates are not genotoxic, carcinogenic and have a low potential for reproductive and developmental toxicity.

**B. Acute Toxicity**

The oral $LD_{50}$ in rats for $C_{12\text{-}13}AE_{6.5}$ is 2,100 mg/kg (HERA, 2009) [Kl. score = 2]. The oral $LD_{50}$ in rats for $C_{12\text{-}15}AE_7$ is 1,700 mg/kg (HERA, 2009) [Kl. score = 2].

An OECD Guideline 403 (Acute Inhalation Toxicity) study was conducted using Sprague Dawley rats exposed to 1600 mg/$m^3$ over a four hour period. The $LC_{50}$ for this test was determined to be > 1 600 mg/$m^3$ (ECHA)[Kl Score = 2].

An acute dermal $LD_{50}$ values of >2,000 mg/kg were determined for $C_{12\text{-}14}AE_3$ and $C_{12\text{-}14}AE_6$ in two separate studies (HERA, 2009) [Kl. score = 2]. The acute dermal $LD_{50}$ of $C_{12\text{-}15}AE_7$ is >2,000 mg/kg (HERA, 2009) [Kl. score = 2].

**C. Irritation**

<u>Skin</u>

Application of 0.5 mL isotridecanol, ethoxylated (3 EO) to the skin of rabbits for 4 hours under occlusive conditions was considered irritating (ECHA) [Kl. score = 2].

Application of 0.5 mL isotridecanol, branched, ethoxylated (3-4 EO) to the skin of rabbits for 24 hours under occlusive conditions was considered irritating (ECHA) [Kl. score = 2].

Application of 0.5 mL isotridecanol, ethoxylated (3 EO) to the skin of rabbits for 4 hours under semi-occlusive conditions was not considered irritating (ECHA) [Kl. score = 2].

Application of 0.5 mL $C_{12\text{-}13}AE_{<2.5}$ (CAS No. 66455-14-9) to the skin of rabbits for 24 hours under occlusive conditions was considered irritating (ECHA) [Kl. score = 2].

Application of 0.5 mL alcohols C12-13, branched and linear, <2.5 EO to the skin of rabbits for 4 hours under occlusive conditions was not considered irritating (ECHA) [Kl. score = 2].

In a 24-hour human patch test, there was some short-lived redness in some individuals from the application of $C_{12\text{-}14}AE_3$, but there was no scaling or oedema in any subjects (HERA, 2009) [Kl. score = 2].

In a standard 4-hour human patch test, the irritation potential of $C_{12\text{-}15}AE_5$ and $C_{12\text{-}15}AE_5$ were compared to 20% sodium dodecyl sulfate (which is classified a skin irritant under GHS). The results showed that neither alcohol ethoxylate should be classified as a skin irritant (Basketter et al., 2004) [Kl. score = 2].

Eye

Instillation of 0.1 mL isotridecanol, ethoxylated (3 EO) (CAS No. 69011-36-5) into the eyes of rabbits was severely irritating. The means of the 24, 48 and 72-hour scores were: 1.6 for corneal opacity; 0.6 for iridial lesions; 2.2 for conjunctival redness; and 0.7 for chemosis. The effects were not fully reversible within 21 days (ECHA) [Kl. score = 2].

Instillation of 0.1 mL isotridecanol, branched, ethoxylated (3-4 EO) (CAS No. 24938-91-8) into the eyes of rabbits was severely irritating. The means of the 24, 48, and 72-hour scores were: 1.0 for corneal opacity; 0.1 for iridial lesions; 1.7 for conjunctival redness; and 0.6 for chemosis. The effects were not fully reversible within 8 days (ECHA) [Kl. score = 2].

Instillation of 0.1 mL alcohols C12-13, branched and linear, <2.5 EO (CAS No. 160901-19-9) into the eyes of rabbits was not irritating. The means of the 24, 48, and 72-hour scores were: 0.00 for corneal opacity; 0.00 for iridial lesions; 0.83 for conjunctival redness; and 0.50 for chemosis (ECHA) [Kl. score = 2].

Instillation of 0.1 mL $C_{12\text{-}13}AE_{<2.5}$ (CAS No. 66455-14-9) into the eyes of rabbits was not irritating. The mean of the 24, 48, and 72-hour scores were: 0.00 for all endpoints (ECHA) [Kl. score = 2].

**D. Sensitisation**

No sensitisation studies are available on isotridecanol, ethoxylated.

In a guinea pig maximisation test, $C_{12\text{-}13}AE_{<2.5}$ (CAS No. 66455-14-9) was not considered a skin sensitiser (ECHA) [Kl. score = 2].

**E. Repeated Dose Toxicity**

Oral

No repeated dose toxicity studies are available on isotridecanol, ethoxylated.

Rats were given in their diet 0%, 0.0313%, 0.0625%, 0.125%, 0.25%, 0.5% or 1.0% $C_{12\text{-}15}AE_7$ for 90 days. The animals in the $\geq$0.25% groups showed significantly reduced body weight gain, which was associated with marked decreases in food and water consumption. Relative liver weights were significantly increased in the $\geq$0.5% male rats and $\geq$0.25% females. Histopathologic examination showed hepatocytic enlargement in the $\geq$0.125% groups, suggesting increased liver metabolism on the basis of increased alkaline phosphatase activity at the higher dose levels. The NOAEL was established at 0.0625% in the diet or 102 mg/kg-day (HERA, 2009) [Kl. score = 2].

Rats were fed $C_{12\text{-}14}AE_7$ in the diet at concentrations of 0%, 0.0313%, 0.0625%, 0.125%, 0.25%, 0.5% and 1.0% for 90 days. The animals in the $\geq$0.25% groups showed significantly reduced body weight gain, which was associated with marked decreases in food and water consumption. Relative liver weights were significantly increased in the $\geq$0.5% male rats and $\geq$0.25% females. Histopathologic examination showed hepatocytic enlargement in the $\geq$0.125% groups, suggesting increased liver metabolism on the basis of increased alkaline phosphatase activity at the higher dose levels. The NOAEL was established at 0.0625% in the diet or 110 mg/kg-day (HERA, 2009) [Kl. score = 2].

Rats were given in their diet 0%, 0.1%, 0.5% or 1% $C_{12-13}AE_{6.5}$ for two years. Body weight gain was reduced in the 1% males and ≥0.5% females, which was likely due to the reduced food consumption in these animals. At study termination, organ to body weight ratios were increased in the ≥0.5% females (liver, kidney and brain), 1% females (heart), and 1% males (liver). A dose-related focal myocarditis was observed in males. While focal myocarditis is commonly observed in non-treated aging rats, the incidence in the treated animals were higher than in the controls. The NOAEL was established at 0.1% or 50 mg/kg-day (HERA, 2009) [Kl. score = 2].

Inhalation

No studies are available.

Dermal

No adequate studies are available.

**F. Genotoxicity**

In Vitro Studies

The genotoxicity studies conducted on alcohol ethoxylates are reviewed in HERA (2009). The results of few of the *in vitro* studies on similar alcohol ethoxylates to isotridecanol, ethoxylated are presented in Table 3.

**Table 3 *In Vitro* Genotoxicity Studies on Selected Alcohol Ethoxylates**

| Test Substance | Test System | Results* | | Klimisch Score | References |
|---|---|---|---|---|---|
| | | -S9 | +S9 | | |
| $C_{14-15}AE_7$ | Bacterial reverse mutation (*S. typhimurium* strains) | - | - | 2 | HERA, 2009 |
| $C_{14-15}AE_7$ | Bacterial reverse mutation (*S. typhimurium* strains) | - | - | 2 | HERA, 2009 |
| $C_{14}AE_{12}$ | Chromosomal aberrations (CHO cells) | - | - | 2 | HERA, 2009 |

*+, positive; -, negative

In Vivo Studies

In two separate studies, CD-1 mice were given an intraperitoneal dose of 0, 50, or 100 mg/kg $C_{12-15}AE_3$ or $C_{12-14}AE_9$. There were no increases in the frequency of micronuclei in the bone marrow cells (Talmage, 1994) [Kl. score = 2].

Male and female Tunstall rats were given a single oral gavage dose of 0, 250, 500, or 1,000 mg/kg $C_{14-15}AE_7$. There were no increases in chromosomal aberrations in the bone marrow cells (HERA, 2009) [Kl. score = 2].

## G. Carcinogenicity

No studies are available on isotridecanol, ethoxylated.

Male and female Sprague-Dawley rats were given in their diet $C_{12\text{-}13}AE_{6.5}$ in the diet at doses up to 1% (500 mg/kg-day). Reduced food consumption was noted at the higher dose levels (*i.e.*, 0.5% and 1% for females and 1% for males), resulting in a lower body weight gain compared to the control group. No treatment-related histopathology was found and no increase in tumour incidence was observed (HERA, 2009) [Kl. score = 2].

Male and female Charles River rats were given in their diet 0, 0.1, 0.5 or 1% $C_{14\text{-}15}AE_7$ for two years. There were no treatment-related changes in general behaviour and appearance. The survival rate of the test animals was comparable if not better than the controls. Body weights of the 0.5% females and the 1% males and females had significantly lower weight gains than the control. There were no treatment-related effects on organ weights and tumour incidence (HERA, 2009) [Kl. score = 2]

Male and female Sprague-Dawley rats were given in their diet $C_{14\text{-}15}AE_7$ at 0.1%, 0.5% and 1% for two years. A treatment-related body weight depression was observed in females at the two highest treatment levels and in males at the 1% dose level, probably due to the poor palatability of the diet. There was no evidence for any carcinogenic activity (HERA, 2009) [Kl. score = 2].

## H. Reproductive Toxicity

No studies are available on isotridecanol, ethoxylated.

CD rats were given in their diet 0%, 0.05%, 0.1% or 0.5% (approximately 0, 25, 50 or 250 mg/kg-day) $C_{12}AE_6$ in a two-generation reproductive toxicity study. There were no treatment related effects in the parents or pups on general behaviour, appearance or survival. At 0.5%, there was reduced weight gain in both the parental animals and the pups compared to the controls. Fertility was unaffected by treatment. The NOAEL for reproductive toxicity is 0.5% in the diet, which corresponds to 250 mg/kg-day (HERA, 2009) [Kl. score = 2].

In a two-generation developmental and teratogenicity study, CD rats were given in their diet 0%, 0.05%, 0.1% or 0.5% $C_{14\text{-}15}AE_7$ (approximately 0, 25, 50 or 250 mg/kg-day). Three of the treated groups were given the test substance continuously throughout the study; in the other three groups the females received the test substance on GD 6-15 and the males were untreated. None of the deaths of parental rats during the study was considered to be compound-related. There were no treatment-related changes in behaviour or appearance in the parental rats or pups. Slightly lower body weight gain was noted in the 0.5% continuously treated females. Food consumption was similar for control and treated rats. Fertility, gestation and viability indices were similar across groups. The average 21-day body weights for the 0.5% continuous treated pups were significantly lower than that of the control. Relative liver weights of the 0.5% continuously treated $F_1$ parental animals were increased at the 91-day sacrifice; relative liver weights of the 0.5% continuously treated males were also increased at the 60-day and caesarean section sacrifices. There were no treatment-related histopathological lesions in any of the tissues from the $F_0$ and $F_1$ generations. The NOAEL for reproductive toxicity is 0.5% in the diet or 250 mg/kg-day (HERA, 2009) [Kl. score = 2].

## I. Developmental Toxicity

No studies are available on isotridecanol, ethoxylated.

In a two-generation reproductive toxicity study, Charles River rats were given in their diet 0, 0.05, 0.1 or 0.5% (about 0, 25, 50 or 250 mg/kg-day) $C_{12}AE_6$. General behaviour, appearance and survival were unaffected by treatment. At the 0.5% dose level, adults and pups gained less weight than the control rats. In the 0.5% dose group, there was a statistical increase in embryo lethality and soft tissue anomalies, and at the 0.1% there was a statistical decrease in mean foetal liver weight. Neither of these effects was considered to be treatment-related by the authors as they showed no dose response characteristics. The NOAEL for maternal toxicity is 50 mg/kg-day. The NOAEL for developmental and teratogenicity is 0.1% in the diet or 50 mg/kg-day (HERA, 2009) [Kl. score = 2].

Pregnant rabbits were given by oral gavage 0, 50, 100 or 200 mg/kg $C_{12}AE_6$ from gestational days 2 to 16. Nine control rabbits and 31 treated rabbits died during the study. Surviving rabbits at the 200 mg/kg dose group generally showed slight losses of body weight. At 100 and 200 mg/kg, ataxia and a slight decrease in body weight was observed in the pregnant animals. In seven treated and two control rabbits, early deliveries were recorded. There were no treatment-related effects on corpora lutea, implantations, number of live foetuses and spontaneous abortions. The NOAEL for maternal toxicity is 50 mg/kg-day; the NOAEL for developmental toxicity is 200 mg/kg-day (HERA, 2009) [Kl. score = 2].

## J. Derivation of Toxicological Reference and Drinking Water Guidance Values

The toxicological reference values developed for isotridecanol, ethoxylated follow the methodology discussed in enHealth (2012). The approach used to develop drinking water guidance values is described in the Australian Drinking Water Guidelines (ADWG, 2011).

**Non-Cancer**

Oral

A two-year dietary study in rats has been conducted on $C_{12\text{-}13}AE_{6.5}$ (HERA, 2009). The NOAEL from this study is 50 mg/kg-day based on increased organ weights. The NOAEL of 50 mg/kg-day will be used to derive an oral reference dose and drinking water guidance value for isotridecanol, ethoxylated.

Oral Reference Dose (oral RfD)

Oral RfD = NOAEL / ($UF_A$ x $UF_H$ x $UF_L$ x $UF_{Sub}$ x $UF_D$)

Where:
$UF_A$ (interspecies variability) = 10
$UF_H$ (intraspecies variability) = 10
$UF_L$ (LOAEL to NOAEL) = 1
$UF_{Sub}$ (subchronic to chronic) = 1
$UF_D$ (database uncertainty) = 1

Oral RfD = 50/(10 x 10 x 1 x 1 x 1) = 50/100 = 0.5 mg/kg-day

Drinking water guidance value

Drinking water guidance value = (animal dose) x (human weight) x (proportion of intake from water) / (volume of water consumed) x (safety factor)

Using the oral RfD,

Drinking water guidance value = (oral RfD) x (human weight) x (proportion of water consumed) / (volume of water consumed)

Where:
Human weight = 70 kg (ADWG, 2011)
Proportion of water consumed = 10% (ADWG, 2011)
Volume of water consumed = 2L (ADWG, 2011)

Drinking water guidance value = (0.5 x 70 x 0.1)/2 = 1.8 mg/L

**Cancer**

The alcohol ethoxylates $C_{12\text{-}13}AE_{6.5}$ and $C_{14\text{-}15}AE_{7}$ were not carcinogenic to rats in a two-year dietary study. Thus, a cancer reference value was not derived.

### K. Human Health Hazard Assessment of Physico-Chemical Properties

Isotridecanol, ethoxylated does not exhibit the following physico-chemical properties:

- Explosivity
- Flammability
- Oxidising potential

## 7 ENVIRONMENTAL EFFECTS SUMMARY

### A. Summary

Isotridecanol, ethoxylated has moderate chronic toxicity concern to aquatic life.

### B. Aquatic Toxicity

In developing a water quality guideline for alcohol ethoxylates ANZG (2018), the toxicity data was normalised for a specific alkyl chain length or a specific number of ethoxylate (EO) groups. The NOECs listed below were normalised to an alkyl chain length of C13.3 and EO of 8.2.

Freshwater fish: 2 species, 720 to 1,500 μg/L.

Freshwater crustaceans: 2 species, 590 to 860 μg/L.

Freshwater rotifers: 1 species, *Brachionus calyciflorus*, 1,300 μg/L

Freshwater algae, diatoms and blue-green algae: 6 species, 200 to 8,700 μg/L.

Freshwater mesocosms: 4 NOEC data for multiple species tests were 80, 80, 320, and 330 μg/L, although replication was insufficient to meet OECD (1992) requirements. Normalised data were 380, 380, 320, and 1,520 μg/L.

**C. Terrestrial Toxicity**

No studies are available.

**D. Calculation of PNEC**

$PNEC_{water}$: The ANZG water quality guideline (2018) for freshwater is: "A high reliability trigger value of 140 μg/L was derived for AE (normalised data) using the statistical distribution method with 95% protection."

For the purposes of calculating the PNEC values for sediment and soil, the $PNEC_{water}$ will be 0.14 mg/L.

PNEC sediment

There are no toxicity data for sediment-dwelling organisms. Therefore, the $PNEC_{sed}$ was calculated using the equilibrium partitioning method. The $PNEC_{sed}$ is 0.71 mg/kg sediment wet weight.

The calculations are as follows:

$PNEC_{sed} = (K_{sed\text{-}water}/BD_{sed}) \times 1000 \times PNEC_{water}$
$= (6.53/1280) \times 1000 \times 0.14$
$= 0.71$ mg/kg

Where:
$K_{sed\text{-}water}$ = suspended matter-water partition coefficient ($m^3/m^3$)
$BD_{sed}$ = bulk density of sediment ($kg/m^3$) = 1,280 [default]
$PNEC_{water}$ = predicted no effect concentration in water

$K_{sed\text{-}water} = 0.8 + [0.2 \times (Kp_{sed}/1000) \times BD_{solid}]$
$= 0.8 + [0.2 \times (11.94/1000) \times 2400]$
$= 6.53\ m^3/m^3$

And:

$Kp_{sed}$ = solid-water partition coefficient (L/kg).

$BD_{solid}$ = bulk density of the solid phase ($kg/m^3$) = 2,400 [default]

$Kp_{sed} = K_{oc} \times f_{oc}$
= 298.6 x 0.04
= 11.94 L/kg

Where:

$K_{oc}$ = organic carbon normalised distribution coefficient (L/kg). The $K_{oc}$ for isotridecanol, ethoxylated is 298.6 L/kg.
$f_{oc}$ = fraction of organic carbon in sediment = 0.04 [default].

PNEC soil

There are no toxicity data for terrestrial or soil organisms. Therefore, the $PNEC_{soil}$ was calculated using the equilibrium partitioning method. The $PNEC_{soil}$ is 0.56 mg/kg soil dry weight.

The calculations are as follows:

$PNEC_{soil} = (Kp_{soil}/BD_{soil}) \times 1000 \times PNEC_{water}$
= (5.97/1500) x 1000 x 0.14
= 0.56 mg/kg

Where:
$Kp_{soil}$ = soil-water partition coefficient ($m^3/m^3$)
$BD_{soil}$ = bulk density of soil ($kg/m^3$) = 1,500 [default]
$PNEC_{water}$ = predicted no effect concentration in water

$Kp_{soil} = K_{oc} \times f_{oc}$
= 298.6 x 0.02
= 5.97 $m^3/m^3$

Where:
$K_{oc}$ = organic carbon normalised distribution coefficient (L/kg). The $K_{oc}$ for isotridecanol, ethoxylated is 298.6 L/kg.
$f_{oc}$ = fraction of organic carbon in soil = 0.02 [default].

## 8 CATEGORISATION AND OTHER CHARACTERISTICS OF CONCERN

### A. PBT Categorisation

The methodology for the Persistent, Bioaccumulative and Toxic (PBT) substances assessment is based on the Australian and EU REACH Criteria methodology (DEWHA, 2009; ECHA, 2017).

Isotridecanol, ethoxylated is readily biodegradable and thus does not meet the screening criteria for persistence.

The bioconcentration factors (BCF) in fish for ethoxylated alcohols (which includes isotridecanol, ethoxylated) have been reported to range from <5 to 387.5. Thus, isotridecanol, ethoxylated does not meet the screening criteria for bioaccumulation.

The chronic NOEC values for alcohols ethoxylates are >0.1 mg/L. Thus, isotridecanol, ethoxylated alcohol does not meet the criteria for toxicity.

The overall conclusion is that isotridecanol, ethoxylated is not a PBT substance.

**B. Other Characteristics of Concern**

No other characteristics of concern were identified for isotridecanol, ethoxylated.

## 9 SCREENING ASSESSMENT

| Chemical Name | CAS No. | Overall PBT Assessment [1] | Chemical Databases of Concern Assessment Step | | Persistence Assessment Step | | Bioaccumulative Assessment Step | Toxicity Assessment Step | | | Risk Assessment Actions Required[3] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Listed as a COC on relevant databases? | Identified as Polymer of Low Concern | P criteria fulfilled? | Other P Concerns | B criteria fulfilled? | T criteria fulfilled? | Acute Toxicity [2] | Chronic Toxicity[2] | |
| Isotridecanol, ethoxylated | 69011-36-5 | Not a PBT | No | No | No | No | No | No | 2 | 2 | 2 |

**Footnotes:**

1 - PBT Assessment based on PBT Framework.

2 - Acute and chronic aquatic toxicity evaluated consistent with assessment criteria (see Framework).

3 - Tier 2 - Hazard Assessment and Qualitative Assessment Only. Develop toxicological profile and PNECs for water and soil and provide qualitative discussion of risk.

**Notes:**

NA = not applicable

PBT = Persistent, Bioaccumulative and Toxic

B = bioaccumulative

P = persistent

T = toxic

## 10 REFERENCES, ABBREVIATIONS AND ACRONYMS

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## B. Abbreviations and Acronyms

| | |
|---|---|
| °C | degrees Celsius |
| ADWG | Australian Drinking Water Guidelines |
| AE | alcohol ethoxylates |
| AES | alcohol ethoxy sulphates |
| AICS | Australian Inventory of Chemical Substances |
| ANZG | Australian and New Zealand Environment Guidelines |
| ARMCANZ | Agriculture and Resource Management Council of Australia and New Zealand |
| BCF | bioconcentration factor |
| CAS | Chemical Abstracts Service |
| CHO | Chinese hamster ovary |
| COC | constituent of concern |
| DEWHAD | Department of Environment, Water, Heritage and the Arts |
| DoEE | Department of Environment and Energy |
| ECHA | European Chemicals Agency |
| EO | ethoxylate |
| EU | European Union |
| g/L | grams per litre |
| GD | gestational day |
| GHS | Globally Harmonized System of Classification and Labelling of Chemicals |
| HERA | Human and Environmental Risk Assessment |
| hPa | hectopascal |
| IUPAC | International Union of Pure and Applied Chemistry |
| kg/d | kilograms per day |
| $kg/m^3$ | kilograms per cubic metre |
| KI | Klimisch scoring system |
| KOCWIN™ | USEPA organic carbon partition coefficient estimation model |
| kPa | kilopascal |
| L | litre |
| L/kg | litres per kilogram |
| LC | lethal concentration |

| | |
|---|---|
| LD | lethal dose |
| LOAEL | lowest observed adverse effect level |
| $m^3$ | cubic metre |
| mg/kg | milligrams per kilogram |
| mg/kg-day | milligrams per kilogram per day |
| mg/L | milligrams per litre |
| $mg/m^3$ | milligrams per cubic metre |
| mL | millilitre |
| $mm^2/s$ | square millimetres per second |
| NICNAS | The National Industrial Chemicals Notification and Assessment Scheme |
| NOAEL | no observed adverse effect level |
| NOEC | no observed effect concentration |
| OECD | Organisation for Economic Co-operation and Development |
| Pa | pascal |
| PBT | Persistent, Bioaccumulative and Toxic |
| PNEC | Predicted No Effect Concentration |
| REACH | Registration, Evaluation, Authorisation and Restriction of Chemicals |
| SGG | Synthetic Greenhouse Gases |
| USEPA | United States Environmental Protection Agency |
| UVCB | Unknown or Variable Composition, Complex Reaction Products and Biological Materials |
| µg/L | micrograms per litre |