

## PER-FLUOROALKYL AND POLY-FLUOROALKYL SUBSTANCES (PFAS)

CAS NUMBERS 1763-23-1 (PFOS), 335-67-1 (PFOA), 355-46-4 (PFHxS)

### GUIDELINE

***Based on human health considerations, the sum of the concentrations of perfluorooctane sulfonate (PFOS) and perfluorohexane sulfonate (PFHxS) in drinking water should not exceed 70 nanograms per litre (ng/L), which is equivalent to 0.07 micrograms per litre (µg/L).***

***Based on human health considerations, the concentration of perfluorooctanoic acid (PFOA) in drinking water should not exceed 560 ng/L, which is equivalent to 0.56 µg/L.***

### GENERAL DESCRIPTION

Per- and poly-fluoroalkyl substances (PFAS) are manufactured chemicals that do not occur naturally in the environment. PFAS chemicals include perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS) amongst a large group of other compounds. PFAS are persistent in the environment, show the potential for bioaccumulation and biomagnification, and are toxic in animal studies (potential developmental, reproductive and systemic toxicity).

Due to PFAS water and heat resistance, they have been used in a wide range of consumer products including surface treatments such as non-stick cookware, and notably in aqueous film forming foam used to extinguish fires. While the import of some PFAS in Australia has been reduced since 2002 (Environmental Health Standing Committee, 2017), historical use in firefighting foams has resulted in detections of PFAS at a number of sites including airports, firefighting training facilities and federal government sites. PFAS has also been found in groundwater, surface water, sewage treatment plant effluents and landfill leachates in international studies (Ahrens et al., 2016; Banzhaf et al., 2017).

Humans can be exposed to PFAS present in food, consumer products, dust and drinking water (Health Canada, 2016a; Health Canada, 2016b). The major sources of PFAS are expected to be food and consumer products, including solution-treated carpeting and treated apparel (Tittlemier et al., 2007); however, the proportion of exposure from drinking water can increase in individuals living in areas with drinking water containing PFAS (Health Canada, 2016a; Health Canada, 2016b). Exposure to PFOS and PFOA from both inhalation and dermal routes during showering and bathing is considered negligible (Health Canada, 2016a; Health Canada, 2016b).

### LEVEL DETECTED IN AUSTRALIAN WATER

While some water that is in proximity to contaminated sites has been monitored for PFAS, this has not been done routinely for Australian drinking water supplies.

Low concentrations of PFAS have been reported in water supplies not impacted by contaminated sites; however, these are unlikely to be of human health concern. A study of drinking water collected from 34 sampling locations around Australia found that levels of PFOS and PFOA were not quantifiable in approximately half the samples (limit of quantification (LOQ) of 0.66 ng/L and 0.5 ng/L, respectively), and PFHxS was not quantifiable in more than 70% of samples (LOQ 0.92 ng/L). Concentrations ranged from <0.66 to 16 ng/L for PFOS, <0.92 to 14 ng/L for PFHxS and <0.5 to 9.7 ng/L for PFOA (Thompson et al., 2011a).

## TREATMENT OF DRINKING WATER

Standard water treatment technologies including coagulation followed by physical separation, aeration, chemical oxidation, UV irradiation, and disinfection have little or no effect on PFOS or PFOA concentrations (Dickenson and Higgins, 2016; Health Canada, 2016).

Granular activated carbon (GAC) and anion exchange (AIX) can remove many PFAS but are less effective at removing shorter chain PFAS, and may only be effective for a limited time. Reverse osmosis is likely to remove shorter chain PFAS (Thompson et al., 2011b). Disposal or treatment of the membrane concentrate stream needs to be considered (WRF, 2016; Dickenson and Higgins, 2016). Researchers are still investigating the most effective and efficient approach to treating PFAS in drinking water and therefore available resources should be taken into consideration during water treatment.

## MEASUREMENT

PFAS can be measured by solid phase extraction followed by a liquid chromatograph coupled to electrospray ionization tandem mass spectrometry (MS/MS) operated in negative ion mode (National Measurement Institute (NMI), 2017; Health Canada, 2016). In drinking water the limit of reporting for this analysis is below the guideline values for these chemicals (NMI, 2017). Other methods may be available (for example, time-of-flight mass spectrometry and ion trap mass analysers). Complementary techniques such as oxidative conversion may be used to determine the presence of precursor compounds, which are capable of biotransforming in the environment to form stable chemicals (e.g. PFOS and PFOA) (Houtz and Sedlak, 2012). As with all analytical chemistry, it is essential to ensure a method limit of detection sensitive enough for the level at which the guideline value is set.

Appropriate sampling, storage and transportation are critical for analysis. The potential for sample contamination during both sample collection and analysis is very high due to PFAS being used in other products, including waterproof sample labels, and therefore should be carried out by trained personnel.

A laboratory measurement uncertainty of +/- 20-30% was shown in water samples tested for PFOS and PFOA in the NMI's Proficiency Test Report AQA 16-06 PFOS/PFOA in Fish, Soil and Water (2016). Robust averages were calculated using the procedure set out in ISO13528:2015(E). Reported or estimated uncertainties should be considered carefully when comparing results (NMI, 2016).

## HEALTH CONSIDERATIONS

Food Standards Australia New Zealand (FSANZ) conducted a review of the available literature for the purposes of determining Australian Tolerable Daily Intakes (TDIs) for PFOS, PFOA and PFHxS (2017b). FSANZ concluded that available human epidemiology data are not suitable to support the derivation of TDI for PFOS or PFOA, which is consistent with the findings of other regulatory agencies. Therefore, FSANZ has recommended TDIs based on extensive toxicological databases in laboratory animals (FSANZ, 2017).

The following summarises FSANZ findings:

- It is not possible to identify any causal associations between PFOS, PFOA and PFHxS and human health effects from epidemiological studies due to limitations in study design and inconsistency in study results (FSANZ, 2017).
- While there is evidence of associations with increased serum cholesterol and decreased body weights at birth, it is not possible to determine whether PFOS or PFOA cause the changes, or whether other factors are involved. As these are observational studies, FSANZ considers that the meaning and clinical significance of the associations for PFOS and PFOA for decreased birth weight and increased cholesterol in humans are uncertain and should be interpreted with caution (FSANZ, 2017).

NOTE: Important general information is contained in PART II, Chapter 6

- There are studies showing both negative and positive associations between increasing PFOS and PFOA concentrations and compromised antibody production in humans. However, to date there is no convincing evidence for increased incidence of infective disease associated with PFOS or PFOA effects on human immune function (FSANZ, 2017).
- Epidemiological studies have not provided convincing evidence of a correlation between PFOS and PFHxS and any cancer type in human beings. Although associations between PFOA and some human cancers have been suggested from some epidemiological studies, results have often been contradictory, and a causal relationship cannot be established with reasonable confidence (FSANZ, 2017). The International Agency for Research on Cancer (IARC) Monograph found that there is limited evidence of carcinogenicity in humans for PFOA and classified it as possibly carcinogenic to humans (Group 2B) (IARC, 2017).

## DERIVATION OF GUIDELINE

### **PFOS**

The health-based guideline value of 70 ng/L for PFOS was determined as follows:

$$70 \text{ ng/L equivalent to } 0.07 \text{ } \mu\text{g/L} = \frac{20 \text{ ng/kg body weight/day} \times 70 \text{ kg} \times 0.1}{2 \text{ L/day}}$$

where:

- A Tolerable Daily Intake (TDI) of 20 ng/kg bodyweight per day has been established by FSANZ on the basis of decreased parental and offspring body weight gains in a multigenerational reproductive toxicity study in rats.
- Because of the large differences observed in the half-lives of PFOS in humans compared to animals, pharmacokinetic modelling was applied to the serum PFOS concentrations measured in experimental animals at the no-observed-adverse-effect level (NOAEL) to calculate the human equivalent dose. The FSANZ TDI incorporates an uncertainty factor of 30, applied to the human equivalent dose (HED: A dose in humans anticipated to provide the same degree of effect as that observed in animals at a given dose), which includes a default factor of 3 to account for interspecies differences in toxicodynamics and a default factor of 10 for intraspecies differences in the human population.
- 70 kg is taken as the average weight of an adult.
- 0.1 is a proportionality factor based on the conservative assumption that drinking water accounts for 10% of the TDI.
- 2 L/day is the reference value of water consumed by an adult.
- The rounding conventions described in Chapter 6 have not been applied in the derivation of the health based guideline value for PFOS in order to align with guidance published by the Department of Health.

### **PFHxS**

FSANZ found that there was insufficient toxicological and epidemiological evidence to justify establishing a TDI for PFHxS. In the absence of a TDI, FSANZ concluded that it is reasonable to consider that the TDI for PFOS is likely to be conservative and protective of human health as an interim measure. Effectively this means that the guideline value for PFOS should apply to the sum of PFOS and PFHxS.

**PFOA**

The health-based guideline value of 560 ng/L for PFOA was determined as follows:

$$560 \text{ ng/L which is equivalent to } 0.56 \text{ } \mu\text{g/L} = \frac{160 \text{ ng/kg body weight/day} \times 70 \text{ kg} \times 0.1}{2 \text{ L/day}}$$

where:

- A Tolerable Daily Intake of 160 ng/kg bodyweight/day has been established by FSANZ on the basis of a NOAEL for foetal toxicity in a developmental and reproductive study in mice.
- Because of the large differences observed in the half-lives of PFOA in humans compared to animals, pharmacokinetic modelling was applied to the serum PFOA concentrations measured in experimental animals at the NOAEL and above to calculate the human equivalent dose. The FSANZ TDI incorporates an uncertainty factor of 30, applied to the HED, which includes a default factor of 3 to account for interspecies differences in toxicodynamics and a default factor of 10 for intraspecies differences in the human population.
- 70 kg is taken as the average weight of an adult.
- 0.1 is a proportionality factor based on the conservative assumption that drinking water accounts for 10% of the TDI.
- 2 L/day is the reference value of water consumed by an adult.
- The rounding conventions described in Chapter 6 have not been applied in the derivation of the health based guideline value for PFOA in order to align with guidance published by the Department of Health.

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