



# Maximum acceptable concentrations of perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) in drinking water

## What are PFOS and PFOA?

Perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) are members of a chemical group known as perfluorinated chemicals (PFCs). PFCs are extremely heat stable and have a number of industrial uses. Given this stability, they are also environmentally resistant.

## What are the guidelines for PFOS and PFOA in drinking water?

The Health Protection Agency (HPA) advises that the maximum acceptable concentration of perfluorooctane sulfonate (PFOS) in drinking water is 0.3 microgrammes per litre ( $\mu\text{g/l}$ ), and that the maximum acceptable concentration of perfluorooctanoic acid (PFOA) in drinking water is 10 microgrammes per litre ( $\mu\text{g/l}$ ). This follows a request for advice from the Drinking Water Inspectorate for England and Wales (DWI). The advice incorporates a recent review of toxicological evidence by the UK Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT), an independent scientific committee that gives advice to government departments and agencies. It also takes note of a recent study of dietary intakes by the Food Standards Agency (FSA).

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## HPA advice

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## Introduction

In the wake of the explosions and fires on 11 December 2005 at the Buncefield oil storage and transfer depot in Hemel Hempstead (England), and in the context of the potential for large volumes of water contaminated with PFOS (an additive which aids the spreading properties of firefighting foam) to affect sources of drinking water, the HPA was asked by the DWI to advise on an 'acceptable' level of PFOS in drinking water.

At that time, the COT, that provides advice to the FSA, the Department of Health and other government departments and agencies on matters concerning the toxicity of chemicals, was evaluating the toxicity of PFOS, and the FSA had commissioned analyses of the 2004 Total Diet Study samples for PFOS. In the absence of estimates of dietary intakes of PFOS, and on the basis of the preliminary COT discussions, the HPA advised the DWI in March 2006 that 'It appears unlikely that a lifetime's consumption of drinking water containing concentrations up to three microgrammes (of PFOS) per litre would harm human health' and that 'drinking water concentrations of PFOS should not exceed three microgrammes per litre'. The HPA undertook to review its advice when the COT had finalised its assessment of PFOS.

In June 2006, the FSA published Food Survey Information Sheet 11/06 (FSIS) 'Fluorinated chemicals – UK dietary intakes' (at [www.food.gov.uk/multimedia/pdfs/fsis1106.pdf](http://www.food.gov.uk/multimedia/pdfs/fsis1106.pdf)). The FSIS includes estimates of dietary intakes of a range of perfluoroalkyl substances (PFAS), including PFOS and PFOA. In October 2006, the FSA published Statement 2006/09 'COT statement on the Tolerable Daily Intake for perfluorooctane sulfonate' (at [www.food.gov.uk/multimedia/pdfs/cotstatementpfos200609.pdf](http://www.food.gov.uk/multimedia/pdfs/cotstatementpfos200609.pdf)) and Statement 2006/10 'COT statement on the Tolerable Daily Intake for perfluorooctanoic acid' (at [www.food.gov.uk/multimedia/pdfs/cotstatementpfoa200610.pdf](http://www.food.gov.uk/multimedia/pdfs/cotstatementpfoa200610.pdf)).

The DWI has asked the HPA not only to review its advice on PFOS, but also to advise on an 'acceptable' level of PFOA in drinking water.

## **PFOS**

The COT has recommended (paragraph 98 of its statement) that a Tolerable Daily Intake (TDI) of 0.3 microgrammes per kilogram body weight (0.3 µg/kg.d) be provisionally proposed for PFOS. The TDI is an estimate of the amount of contaminant, expressed on a body weight basis, that can be ingested daily over a lifetime without appreciable health risk. The COT considered that on the basis of available information this provisional TDI is adequate to protect against the range of identified effects. The COT suggested that the basis for the provisional TDI is 'probably conservative' (paragraph 48 of its statement).

This provisional TDI is lower than the initial proposal for a TDI of 1 µg/kg.d suggested by COT at an earlier stage of its deliberations. The HPA advice in March 2006 was based on that initial proposal, and noted that 'It appears unlikely that the COT will wish to recommend a higher TDI. It must be acknowledged that a somewhat lower TDI may be favoured.'

The FSIS provides estimates of dietary intake of PFOS for 'average' and 'high-level' consumers, for age groups from 1.5 to 2.5 years upwards; no estimates of dietary intake of PFOS for younger children are available. The estimates are presented as ranges from the 'lower bound' (which assumes that PFOS is absent for those food groups in which PFOS is present at concentrations below the reporting limit [limit of detection]) to the 'upper bound' (which assumes that PFOS is present at the reporting limit for those food groups in which PFOS is present at concentrations below the reporting limit [limit of detection]). If the limit of detection had been zero (a theoretical ideal which cannot be achieved), the ranges would have narrowed to point estimates which would lie somewhere in the interval between these current lower and upper bounds. The COT noted the 'considerable uncertainties in the dietary intake estimates' (paragraph 99 of its statement). For these data, the ratio between upper bound and lower bound estimates is generally about 5 (range 3 to 10).

All of the lower bound estimates are below the provisional TDI, but the upper bound estimates of average dietary intake for the age groups 1.5 to 2.5 years, 2.5 to 3.5 years, and 4 to 6 years, are all close to the provisional TDI, and the upper bound estimates of high level intake for all five age groups from 1.5 to 10 years exceed or equal the provisional TDI.

Other related PFAS were also detected. The COT noted (in paragraph 96 of its statement) that PFOS can be formed by degradation from a large group of related perfluorinated substances, but also that the significance to the exposure assessment of detecting a number of other fluorinated chemicals in different food groups is currently uncertain.

Although the upper bound estimates are likely to be overestimates, the data for age groups from 1.5 to 10 years do not exclude the possibility that some children's dietary intakes of PFOS already exceed the provisional TDI, perhaps for prolonged periods. It is prudent to base the drinking-water limit on consideration of this group. Ideally, therefore, additional exposure to PFOS via drinking water should be kept as low as reasonably practicable. It is also desirable, however, to propose a concentration above which action should be taken. It seems a reasonable precaution to limit this 'maximum acceptable' intake of PFOS from children's drinking water to some fraction of the provisional TDI. The choice of fraction is arbitrary, but 10% seems appropriate. Allocation of 10% of the provisional TDI to 1 litre of drinking water consumed daily by a one-year-old child weighing 10 kg yields a 'maximum acceptable' concentration of 0.3 µg/l of PFOS.

At a drinking-water concentration of 0.3 µg/l, the estimated total PFOS intakes (from diet and water, but taking no account of other related PFAS) would be lower than the provisional TDI for all other age groups for which dietary intake estimates are available. Estimated PFOS intakes (from water only, and taking no account of other related PFAS) for children younger than 1.5 years (including bottle-fed children) would also be lower than the provisional TDI.

**The revised recommended 'maximum acceptable' concentration of PFOS in drinking-water is 0.3 µg/l.**

## **PFOA**

The COT has recommended (paragraph 84 of its statement) that a TDI of 3 microgrammes per kilogram body weight (3 µg/kg bw/day) be established, based on the range of effects on the liver, kidney, haematological (blood) and immune systems. The COT considered that the TDI is adequate to protect against other potential effects, such as cancer.

The FSIS provides estimates of dietary intake of PFOA for age groups from 1.5 to 2.5 years upwards; no estimates of dietary intake of PFOA for younger children are available. All of the estimates are below the TDI.

The COT statement does not suggest that there is evidence that children are more susceptible to adverse effects of PFOA, other than noting (in paragraph 38) that newborn rats were more sensitive to PFOA than weanlings and adult animals (in tests of the lethality of very high doses). Nevertheless, it is a reasonable precaution to seek to limit children's intake of PFOA from food and drinking water to the TDI. Since no estimates of dietary intake of PFOA for children younger than 1.5 years of age are available, it is necessary to make some arbitrary assumption. The default procedure normally followed by the World Health Organization (WHO) in its Guidelines for Drinking-Water Quality (at [www.who.int/water\\_sanitation\\_health/dwq/gdwq0506\\_8.pdf](http://www.who.int/water_sanitation_health/dwq/gdwq0506_8.pdf)), when suitable estimates of dietary intake are unavailable, is to allow for sources other than drinking water to provide up to 90% of the TDI in adults, and hence to allocate 10% of the TDI to drinking water for adults. This approach (with standard assumptions about the consumption of drinking water) implies allocation of 30% of the TDI to drinking water for the one-year-old child, and 45% of the TDI to drinking-water for the bottle-fed baby. Rounding up, it seems reasonable, therefore, to allocate 50% of the TDI to 0.75 l of drinking water consumed daily by a bottle-fed baby weighing 5 kg; this is the procedure chosen by WHO to generate a guideline value for lead in drinking water (at [www.who.int/water\\_sanitation\\_health/dwq/chemicals/lead/en/](http://www.who.int/water_sanitation_health/dwq/chemicals/lead/en/)).

For PFOA, the result is a 'maximum acceptable' concentration of 10 microgrammes PFOA per litre (10 µg/l).

At a drinking-water concentration of 10 µg/l, the estimated total PFOA intakes (from diet and water) would be lower than the TDI for all groups for which dietary intake estimates are available. Estimated PFOA intakes (from water only) for children younger than 1.5 years would also be lower than the TDI.

**The recommended 'maximum acceptable' concentration of PFOA in drinking-water is 10 µg/l.**

## **Future review**

Recommendations such as these are always subject to review in the light of new information. The COT statements indicate in particular the need for more precise estimates of the dietary intake of PFOS, consideration of the impact of other perfluorinated chemicals in the diet on total PFOS exposure, better understanding of the way the body handles PFOS and PFOA, and clarification of the mechanism by which PFOA at high doses causes tumours in the liver and pancreas in rats. The need for estimates of the dietary intakes in children below 1.5 years of age is also noted.