Setting Air Quality Guidelines for the Long Term Effects of Halogens, Hydrogen Halides, Metals and Metalloids

Stephen T Holgate (Chair) & Roy Harrison (Deputy Chair),

Expert Panel on Air Quality Standards

The Defra Expert Panel on Air Quality Standards

The Expert Panel on Air Quality Standards (EPAQS) was set up in 1991 to provide independent advice on air quality issues, in particular the levels of pollution at which no or minimal health effects are likely to occur.

Published EPAQS reports

1. Ozone (May 1994 - ISBN 011 752873 0)
2. Benzene (February 1994 - ISBN 011 752859 5)
3. 1,3-Butadiene (December 1994 - ISBN 011 753034 4)
4. Carbon Monoxide (December 1994 - ISBN 011 753035 2)
5. Sulphur Dioxide (September 1995 - ISBN 011 753135 9)
6. Particles (November 1995 - ISBN 011 753199 5)
7. Nitrogen Dioxide (December 1996 - ISBN 011 753352 1)
8. Lead (May 1998 - ISBN 011 753447 1)
9. Polycyclic Aromatic Hydrocarbons (July 1999 - ISBN 011 753503 6)
10. Airborne Particles: What is the appropriate measurement on which to base a standard? (April 2001 - ISBN 011 753599 0)
11. 1,3-Butadiene - Second Report (February 2002 - ISBN 0 85521 010 9)
12. Guidelines for halogens and hydrogen halides in ambient air for protecting human health against acute irritancy effects (2006)

All reports are available from www.defra.gov.uk/e

Guidelines for halogens and hydrogen halides in ambient air for protecting human health against acute irritancy effects

February 2006.

- EPAQS recommended guideline values for six substances: chlorine, bromine, hydrogen chloride, hydrogen bromide, hydrogen fluoride and hydrogen iodide.
- The values recommended represent a level at which no significant health effects would be expected to occur over the short-term, specifically guarding against the effects of acute irritancy

Hydrogen Iodide (HI)

- No atmospheric measurements of hydrogen iodide in the UK have been identified.
- The main source of hydrogen iodide in the United Kingdom is coal-fired power stations.
- Concentrations of particle-bound iodide measured at Chilton (Oxfordshire), Styrupp (Nottinghamshire) and Warymires (Cumbria) between 1996 and 2001 range from 0.8-2.0 x 10^{-6} mg/m^3.
- The average global total iodine/iodide concentration in ambient air has been reported by the United States Agency for Toxic Substances and Disease Registry (ATSDR, 2004) to range between 1-2 x 10^{-5} mg/m3

The Panel recommends that a concentration of hydrogen iodide gas or mass equivalent aerosol not exceeding 0.1 ppm (0.52 mg/m^3) over a 1-hour averaging period should protect against irritant and inflammatory effects on the skin, eye and breathing airways.

Hydrogen Fluoride (HF)

- Very limited number of recent ambient measurements of HF have been made in the UK in the vicinity of three industrial plants.

- The largest sources of HF in the atmosphere in the UK are coal-fired power stations emission sector in the United Kingdom) and aluminium smelters.

- Brickworks are a known source of fluoride emissions - 1984 and 1986 in the Marston Vale region of Bedfordshire monthly mean of gaseous fluorides of 4.9×10^{-5} to 10.5×10^{-4} ppm and daily mean fluoride concentrations of up to 2.7×10^{-3} ppm.

- In the United Kingdom emissions of hydrogen fluoride fell by 73% between 1970 and 2000 as a result of the decline in coal use and, since 1993, the installation of flue gas desulphurisation at Drax and Ratcliffe power stations.

The Panel recommended that a concentration of HF gas or mass equivalent aerosol not exceeding 0.2 ppm (0.16 mg/m³) over a 1-hour averaging period should protect against irritant and inflammatory effects on the eyes, skin and breathing airways.

Addendum to Guidelines for Halogens and Hydrogen Halides in Ambient Air

"For hydrogen fluoride (HF) and hydrogen Iodide (HI) health effects resulting from the long term exposure cannot be ruled out"

Provisional Guideline for Hydrogen Iodide for Protecting Human Health Against Chronic Systemic Effects

- Iodine is an essential element required for the synthesis of thyroid hormones – thyroxine (T4) & triodothyronine (T3).
- A feed back loop involving the hypothalamic release of TRH and pituitary release of TSH.
- Excess iodine intake can cause hypothyroidism in elderly women and children (0.2% UK population).
- Lowest level of dietry iodine supplementation to affect thyroid function is 0.5 mgm/day. This is equivalent to an adult inhaling air containing HI at a concentration of 25 μg/m3 or 5ppb.

The Panel recommended a guideline value of inhaled HI of 0.1 mgm/m^{3}day (1ppb) to take account of those with subclinical hypothyroidism and children.

Provisional Guideline for Hydrogen Fluoride for Protecting Human Health Against Chronic Systemic Effects

- HF – Dental and skeletal fluorosis. Intake 0.01-0.13 mg/kg body weight (water & food).
- Those living close to industrial sources maybe exposed to higher levels.
- In the absence of a threshold for dental fluorosis, meta-analysis used in relation to water fluoridation.
- At an air concentration <0.016 mg/m^3, no risk of fluorosis.

The Panel recommended that concentrations of HF not exceeding 0.02 ppm (0.016 mgm/m^3) should protect against the systemic effects of fluoride on tooth enamel.

A monthly average air monitoring period is recommended.

Guidelines for Metals and Metalloids in Ambient Air for the Protection of Human Health

- 2nd report by EPAQS in advising EA on priority substances it is responsible for regulating.
- Guideline values for arsenic (As), nickel (Ni), chromium (Cr) and berylium (Be).
- Present in ambient air in chemical different forms with varying oxidation states that determine reactivity.
- Good quality epidemiological as primary source of evidence, if available (rarely!), occupational exposures and animal experiments.
- Safety factors used to take account of continued exposure (x10), animal→human (x10) and susceptible groups e.g. children, asthma, elderly (x10)

Arsenic (As)

- Exists in 4 oxidation states. Atmospheric particles containing As_2O_3
- Sources: coal-fired and oil-fuelled power stations and industries.
- Ambient concentrations in 2005 – rural: 0.1-0.4 ng/m^3, urban 0.8-1.4 ng/m^3.
- 30-fold reduction over 30 years
- In USA inhaled exposure 0.3-0.4 ng/day (0.5% total daily exposure).

Arsenic (As)

- As is methylated in liver to mono- and di-methyl arsenic acids excreted mostly in urine.
- Inhibits oxidative phosphorylation acutely and is a genotoxic carcinogen by binding to DNA and chromatin.
- Increased risk of lung cancer in smelters in Sweden (As <250-2000 $\mu g/m^3$ years, midpoint 125 $\mu g/m^3$ years) & Chile (202 $\mu g/m^3$ years) - equivalent to ~3 $\mu g/m^3$/year over 40 years working life.
- Based on EPAQS PAH standard: x10 as LOEL→ 0.3 $\mu g/m^3$ notional NOEL (carcinogen), x10 greater exposure of public across a lifetime & x10 for susceptible groups.

Based on occupational exposure-responses: Panel recommended a guideline value in ambient air as 3ng/m³ total inorganic arsenic in the PM_{10} fraction as an annual mean, but also recommends a progressive reduction below this guideline value.

Nickel (Ni)

- Exists as several oxidation states – divalent form dominates as sulphate salt and oxide.
- Essential trace element (reproduction).
- Source: oil fired power stations and metal industries.
- Ambient concentrations in 2005 – rural: 0.3-1.5 ng/m^3, urban 1.9-4.5 ng/m^3 & 2.3-19.6 close to metal industries.
- 20-fold reduction over 30 years.
- Exposure – tobacco smoke, occupational (coal burning, refining & mining).
- 40% of inhaled Ni retained in deep lung, the remainder excreted in urine as histidine salt.

Nickel (Ni)

- Allergic sensitising agent of skin 2 weeks after first exposure. Common and occurs in up to 20% of population - jewellery.
- No direct evidence that Ni causes asthma.
- Possibly carcinogenic, animal LOEL for chronic inflammation in lung 0.06 mg/m^3.
- x10 animal → human, x5 for LOAL (non-carcinogen), animals exposed to 30 hrs/week → x6 for continuous exposure, x10 susceptible groups: 0.02 μg/m^3.

The Panel recommended a guideline vale for airborne total nickel of 0.02 μg/m^{3in} PM_{10} fraction as an annual mean.

Beryllium (Be)

- Main sources are from coal combustion and in UK, oil-based industries. 50 companies use beryllium in manufacture using Be alloys.

- Ambient air in Birmingham as roadside concentration 0.05 ng/m^3. Copper-beryllium used in electronics, aerospace, computers.

- Inhalation is the major pathway in humans.

Beryllium (Be)

- >90% of inhaled dose excreted. Residuum interferes with a number of intermediary enzymes.
- High concentrations → acute pneumonitis that can be lethal.
- Chronic exposure leads to a granulomatous lung disease similar to sarcoidosis . Involves immunological sensitisation with disease occurring up to 40 years after exposure & increases with duration of exposure.
- Also considered a Group 1 carcinogen. Controversial.
- Sensitisation occurs at lower concentrations – basis of guideline.
- NOEL of 0.02$\mu g/m^3$ for sensitisation and berylliosis, x10 for greater exposure of public and x10 for susceptible individuals → 0.2 ng/m^3.

The Panel recommended a guideline value for ambient air beryllium of 0.2 ng/m^3 in the PM_{10} fraction as annual average.

This value is close to highest roadside level → more extensive measurement needed.

Chromium (Cr)

- Exists in 5 oxidation states.
- Trivalent Cr most abundant and essential dietary element (Hb synthesis). Hexavalent Cr produced by industrial processes however in air mostly exists as CrO_3.
- Sources: chemicals and iron and steel industries and coal burning.
- Emissions declined by >80% in 30 years.
- Occupational exposures 0.04-0.5 ng/m^3.
- Any Cr reaching blood is taken up by RBCs.

Chromium (Cr)

- High doses cause irritant and inflammatory effects and is a sensitiser to cause inflammatory and fibrotic lung disease.
- Cr is a carcinogen especially lung cancer.
- Based on the safety factors we have used for other carcinogens taking safety factors into account:

The Panel recommended a guideline value of 0.2ng/m^3 in the Cr(VI) oxidation state in the Pm_{10} size fraction as an annual mean and a progressive reduction below this value.

REVIEW OF THE EXPERT PANEL ON AIR QUALITY STANDARDS

Departmental responsibility

We recommend that a combined body should ideally be constituted under the auspices of Defra. However, in our view, this is not essential, and it would be possible for a combined body to operate under the auspices of the Department of Health or the Health Protection Agency, provided Defra is able to contribute to the combined body's work program and supervision.

Expert Panel on Air Quality Standards

- Professor H Ross Anderson: St George's Hospital Medical School
- Dr Peter Baxter: University of Cambridge
- Dr Paul Cullinan: Imperial College (National Heart and Lung Institute)
- Professor Dick Derwent OBE: rdscientific
- Professor Jonathan Grigg: University of Leicester
- Professor Roy Harrison OBE: University of Birmingham
- Professor Frank J Kelly: King's College London
- Dr Geoffrey H Pigott: AH Marks & Co. Ltd
- Dr Alison Searl: Institute of Occupational Medicine, Edinburgh
- Mr John Stedman: NETCEN (part of AEA Technology plc)

EPAQS Secretariat

- Ms Ingrid Holmes Secretariat from September 2004 to May 2005: Defra
- Dr Sarah Honour: Defra
- Professor R L Maynard CBE: HPA
- Dr Martin Meadows: Secretariat to February 2005 Defra
- Dr Heather Walton: Secretariat to February 2005 HPA
- Dr Martin Williams: Defra Scretariat to February 2005
- Dr Tim Williamson: Secretariat from February 2005 Defra
- Dr Colin Pownsland EA