Fluoride health monitoring guidelines
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**Substance:** Fluoride  
**Chemical formula:** NaF – sodium fluoride (CAS no. 7681-49-4)  
CaF₂ – calcium fluoride (fluorspar) (CAS no. 7789-75-5)  
Na₃AlF₆ – sodium aluminium fluoride (cryolite) (CAS no. 13775-53-6)  
H₂SiF₆ – fluosilicic acid (CAS no. 16961-83-4)

**Exposure standards:** 2.5 mg/m³ (TWA)**(1)**

Main uses/occupations at risk

**Uses of fluoride and means of industrial exposure**

<table>
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<th>Occupation</th>
<th>How used</th>
<th>Route of exposure</th>
<th>Compounds</th>
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<td>Electrolyte bath</td>
<td>Inhalation Ingestion if hands contaminated</td>
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<td>Water treatment</td>
<td>Treatment plant operator</td>
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<tr>
<td>Electroplating</td>
<td>Electroplater</td>
<td>Electrolyte bath</td>
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</table>

Other uses  
*Sodium fluoride* - as a wood preservative, pesticide, insecticide, fungicide, rodenticide; also used in the manufacture of vitreous enamels, casein glues, coated papers and toothpaste.  
*Calcium fluoride* - is used as a flux in steel, glass and enamel production.  
*Hydrogen fluoride* – in motor fuel, refrigerants, cleaning and etching glass and tanning leather  
*Sodium fluorosilicate* - is used in aluminium and beryllium refining and as laundry soap.  
*Magnesium fluorosilicate* - is a concrete hardener and a waterproofing and moth-proofing agent.  
*Copper fluoride* - is used in high-energy batteries.  
*Stannous fluoride and sodium monofluorophosphate* - are used as toothpaste additives  
*Uranium hexafluoride* - in the enrichment of uranium.  
*Zinc fluoride* - in impregnating timber.
*Time weighted average (8-hour day)

Figure 1: Adding sodium fluoride at water treatment plant

**Non-occupational sources**
Drinking water, sea-water, food especially fish, tea, mouthwash and dental products.

**Target organ/effect**
- **Bone** – skeletal fluorosis
- **Joints** – arthritis, stiffness of the back, hands, feet, knees
- **Respiratory tract** – irritation
- **Eyes** – irritation

**Type of health monitoring required**
- Pre-shift urinary fluorides – preferably after a two-day break (e.g. weekend).
- Post-shift urinary fluorides – end of work day.

50 ml spot urine sample collected in a plastic (not glass) urine specimen jar. Refrigerate sample if any delay in sending it to the laboratory. Worker is to be showered and changed before taking sample to avoid contamination of specimen from fluoride dust on clothing or hands.
Frequency of monitoring

- Annual urine testing as a minimum.

Biological occupational exposure limit (BOEL)

*Fluoride in urine (creatinine corrected)*

| Pre-shift | 2 mg/g (105 μmol/L)\(^{(2)}\) |
| Post-shift | 3 mg/g (158 μmol/L)\(^{(2)}\) |

**Action level**

Post-shift urinary fluorides > 158 μmol/L (or > 3 mg/L)

Review work practices and repeat urinary fluoride in one week (worker should avoid tea for 48 hours prior to urine collection).

Note that increased consumption of tea, salt water fish, taking fluoride tablets and using some mouthwashes can all increase the pre-shift fluoride levels in urine.

Absorption/excretion pharmacology

Fluorides occur naturally in some foods, ground water and sea water. Tea contains high levels as do some seafoods. Fluoridated toothpaste is a source of absorbed fluorides.

The main route of absorption in an industrial setting is by inhalation of the dust. However, small quantities can be ingested from smoking or eating on the job with contaminated hands. Soluble fluorides (e.g. sodium fluoride) are more easily absorbed (90 to 97 percent uptake) compared with sparingly soluble salts, e.g. calcium fluoride (62 percent absorption of an ingested dose).\(^{(2)}\)

The main route of excretion is the kidney, but fluoride is also eliminated through faeces, sweat and breast milk. About half the absorbed amount of fluoride is excreted very rapidly in urine with a biological half-life of two and nine hours and the rest is deposited in bone from where it is eliminated very slowly (half-life between eight and twenty years). This slow excretion from the bone facilitates accumulation of fluorides in the body (fluorosis) in cases of chronic over-exposure.\(^{(2)}\)

The elimination of fluoride is decreased by increased intake of magnesium and calcium (antacids such as Gaviscon\textsuperscript{TM} contain magnesium, and Dexsal Antacid Liquid\textsuperscript{TM} contains calcium). Fluoride elimination is increased in persons with an increased intake of iron.\(^{(2)}\)

Pre-shift urinary fluoride is therefore a measure of fluoride accumulated in the body over a long time, regardless of the source of exposure and route of absorption. Such measurements are an indicator of skeletal burden.

Post-shift urinary fluoride indicates the magnitude of recent exposure.
Summary of toxicology

Acute effects
Most cases of acute poisoning in humans have been associated with suicidal or accidental ingestion of fluoride-containing insecticides and other products in the home. Acute fluoride poisoning is manifested by vomiting, diarrhoea, abdominal pain, cyanosis, severe weakness, dyspnoea, muscle spasms, paresis and paralyses, cardiovascular disorders including ventricular fibrillation, convulsions, coma and death. Fluoride kills by blocking normal cellular metabolism. Fluoride inhibits enzymes, particularly metallo-enzymes involved in essential processes, causing vital functions such as the initiation and transmission of nerve impulses to cease. The strong affinity of fluoride for calcium leads to hypocalcaemia.\(^\text{(3)}\)

The first manifestations of fluoride poisoning (nausea, vomiting) are seen with the ingestion of 140 mg to 210 mg of fluoride per 70 kg body weight. The lethal dose is 32 mg to 64 mg fluoride/kg body weight.\(^\text{(3)}\)

Chronic effects
Occupational skeletal fluorosis has been reported mainly from aluminium production, magnesium foundries, fluorspar processing and superphosphate manufacture.\(^\text{(3)}\)

Osteofluorosis can be asymptomatic in its early phases, appearing radiologically as an increase in bone density of the vertebrae and the pelvis. With increasing fluoride, radiological changes show increasing bone density, bone contours and trabeculae become uneven and blurred, the bones of the extremities show thickening of the compact bone and irregular periosteal growth (exostoses and osteophytes), and there is increasing evidence of calcification in ligaments, tendons and muscle insertions. It should be noted that bone density changes could be caused by other diseases such as Paget’s disease or osteoblastic metastases.\(^\text{(3)}\)

With increased radiological density, clinical signs and symptoms become more severe, especially pain in the joints of hands, feet, knees and spine. With increasing severity, the pain increases and movement of the vertebral column and lower limbs becomes limited. Finally ossification of the ligaments and outgrowths of bony spurs in joints may result in fusion of the spine (‘poker back’) and contractures of the hips and knees. This severe stage of crippling fluorosis has been associated with heavy industrial fluoride exposure.\(^\text{(3)}\)

Endemic skeletal fluorosis has been reported in countries such as India, China and South Africa with a hot climate and high water fluoride levels generally in excess of 8 mg/L.\(^\text{(3)}\) In Queensland surface waters tend to have naturally low levels of fluoride at around 0.5 mg/L. Water supplies treated with fluoride are maintained at levels between 0.5 and 0.9 mg/L.\(^\text{(4)}\)

Summary of epidemiology
A study of 1242 employees in an aluminium smelter using the Soderberg process, found clinical musculoskeletal effects occurred before skeletal fluorosis was evident radiologically. However, this group of workers were also exposed to other chemicals and had ergonomic problems, for example lifting and moving pot doors.\(^\text{(3)}\)
Workers in a magnesium foundry containing fluoride concentration above 10 mg/m³ reported nosebleeds. A group of cryolite workers reported gastrointestinal, circulatory, respiratory and nervous symptoms, skin rashes and muscle, joint and bone complaints. Pot room workers in an aluminium smelter developed fluorosis after 10 years exposure to fluorides in air of 2.4 to 6.0 mg/m³.(5)

Community studies have found that adults could consume water containing 5 ppm fluoride without ill effect. In one study it was reported that a drinking water supply containing 8 ppm of fluoride would result in a 10% incidence of osteosclerosis. Other studies have found effects at lower levels of fluoride in the water supply.(5)

Reference list


