

## **NICKEL**

### **Characteristics**

Nickel (Ni) is an element that exhibits valencies of 0, +1, +2, and +3. Metallic nickel is not commonly found in nature but nickel is found in many minerals. Nickel is used primarily in the manufacturing of stainless steel and other alloys due to its properties of hardness, corrosion-resistance, heat-resistance, and strength. Examples of alloys include copper-nickel alloys and nickel-chromium alloys. Nickel is also used as a catalyst, in plating, coins, batteries, electrodes, electrical contact, spark plugs, and machinery parts.

Natural sources of nickel to the atmosphere include soil dust, forest fires, particle releases from vegetation, sea salt, and meteoric dust. Anthropogenic sources of nickel released to the atmosphere are primarily from fossil fuel (oil and coal) combustion, high-temperature metallurgical operations, nickel primary production operations, and municipal waste incineration. Other sources include coke ovens, cement manufacturing, asbestos mining/milling, and cooling towers. In Canada, the most important anthropogenic sources of nickel to air are the primary base metal smelter and refineries, followed by fossil fuel combustion.

Nickel in air is mainly in the particulate form, with particle sizes ranging from 0.1 to 2  $\mu\text{m}$ . Nickel associated with these particles is mainly in the form of nickel sulphate, nickel chloride, nickel nitrate, and nickel oxide, the sulphates resulting from the oxidation of nickel by sulphur dioxide. The processes governing the fate of nickel in the atmosphere are the same processes that govern the transport and removal of these small particles from the atmosphere. The detection limit for ambient air monitoring (dichotomous sampling technique for particulate matter – 24-hour collection once every 6 days according to the predefined National Air Pollution Surveillance (NAPS) schedule) is 0.000011  $\mu\text{g m}^{-3}$ . From 1993 to 2003, the Edmonton Central air quality monitoring station (10225 104 St.) recorded 24-hour average nickel concentrations ranging from 0.00001  $\mu\text{g m}^{-3}$  to 0.01800  $\mu\text{g m}^{-3}$ , with an average of 0.00267  $\mu\text{g m}^{-3}$ .

### **Effects**

The adverse health effects of nickel are associated with inhalation of the inorganic form. Due to the lack of data on health effects of individual nickel compounds, the health effects summarized are associated with inorganic nickel compounds as a group.

The respiratory system is the prime target of nickel inhalation toxicity in both animals and humans. Nickel inhalation has also been reported to affect the immune and renal systems. Short-term exposures of animals to nickel are reported to cause: laboured breathing, pneumonia, degeneration of nasal airway surfaces and atrophy of the nasal smell receptor tissue, significant decreases in body weight, chronic active inflammation of the lungs, and death.

Air concentrations associated with these effects ranged from 200 to 6,700  $\mu\text{g m}^{-3}$  for exposure periods ranging from 12 days to 13 weeks (on an intermittent basis). Short-term exposure to high concentrations (383,000  $\mu\text{g m}^{-3}$ ) of nickel compounds was fatal in one man. Death was due to severe respiratory tract damage.

Long-term human inhalation exposures to nickel can produce: asthma, chronic bronchitis, emphysema, reduced vital capacity, and lung and nasal cancers. Occupational exposures to nickel ( $> 10,000 \mu\text{g m}^{-3}$ ) have been demonstrated to be carcinogenic, causing an increased risk of lung and nasal cancer in exposed workers. Occupational exposure to concentrations of 750  $\mu\text{g m}^{-3}$  is reported to cause increased urinary excretion of proteins in women, suggesting tubular dysfunction in the kidneys. Nickel refinery dust has been classified as a class A human carcinogen by the US Environmental Protection Agency. Long-term animal inhalation exposure is reported to be extremely toxic to the respiratory tract and significant mortality was reported in rats, guinea pigs, and mice. Air concentrations associated with these effects range from 60 to 2,000  $\mu\text{g m}^{-3}$  for exposure periods ranging from 24 to 31 months (on an intermittent basis).

## Objectives in Other Jurisdictions

The majority of the existing air quality objectives are derived from either the US Environmental Protection Agency inhalation unit risk factor 0.00024 per  $\mu\text{g m}^{-3}$ , the American Conference of Governmental Industrial Hygienists 8-hour Threshold Limit Value (1  $\text{mg m}^{-3}$ ), or the National Institute for Occupational Safety and Health relative exposure level of 0.015  $\mu\text{g m}^{-3}$ . The US Agency for Toxic Substances and Disease Registry adopted a minimal risk level of 0.2  $\mu\text{g m}^{-3}$ . The World Health Organization derived a risk specific concentration of 0.026  $\mu\text{g m}^{-3}$  corresponding to 1 in 100,000 risk and an inhalation unit risk factor of 0.00038 per  $\mu\text{g m}^{-3}$  for nickel. Agencies reviewed in the assessment report have set a variety of objectives: 0.15 to 23.8  $\mu\text{g m}^{-3}$  for 1-hour; 0.006 to 3.57  $\mu\text{g m}^{-3}$  for 24-hour; and 0.002 to 2.38  $\mu\text{g m}^{-3}$  for annual.

## Alberta Ambient Air Quality Objectives

Alberta ambient air quality objectives are issued by Alberta Environment, under Section 14 (1), the *Environmental Protection and Enhancement Act, 1992* (EPEA). Based upon the available information, Alberta hereby adopts:

- From California, an Alberta Ambient Air Quality Objective for nickel of 6  $\mu\text{g m}^{-3}$  (2.5 ppb) as a 1-hour average concentration.
- From California, an Alberta Ambient Air Quality Objective for nickel of 0.05  $\mu\text{g m}^{-3}$  (0.021 ppb) as an annual average concentration.

## Reference

WBK & Associates Inc., 2004: *Assessment Report on Nickel for Developing Ambient Air Quality Objectives*. Prepared for Alberta Environment. Edmonton, Alberta, Canada. 83 pp.