Air Guidance Values
Site Assessment and Consultation Unit
Environmental Health Division
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Air Toxicological Summary for: Manganese (Mn) and Manganese Compounds

CAS: 7439-96-5

Example compounds: Manganese(II) Carbonate (CAS 598-62-9), Manganese(II) Acetate (CAS 638-38-0), Manganese(IV) Oxide (Manganese dioxide, CAS 1313-13-9), Manganese(III) Oxide (CAS 1317-34-6), Manganese(II,III) Oxide (CAS 1317-35-7), Manganese(II) Oxide (CAS 1344-43-0), Manganese(II) Silicate (CAS 7759-00-4), Manganese(II) Chloride (CAS 7773-01-5), Manganese(II) Sulfate (CAS 7785-87-7), Manganese(II) Nitrate (CAS 10377-66-9), Iron Manganese Oxide (CAS 11115-91-6), Manganese(II) Phosphate (CAS 14154-09-7), Manganese Dihydrogen Phosphate (CAS 18718-07-5); Ferromanganese Oxide (CAS 75864-23-2), Methylcyclopentadienyl manganese tricarbonyl (MMT, CAS 12108-13-3).

Exceptions: The Risk Assessment Advice (RAA) developed in this summary does not apply to permanganate compounds or other compounds in the Mn(VII) oxidation state.

NOTES: The Risk Assessment Advice (RAA) developed in this summary applies to the µg/m^3 air concentration of elemental manganese (Mn), or the µg/m^3 air concentration of the compound, reported as Mn. This can be determined as follows:

$$\text{Compound air concentration, as elemental Mn:} = \text{compound air concentration } (\mu g/m^3) \times \left(\frac{molecular\ weight\ of\ Mn}{molecular\ weight\ of\ compound}\right)$$

MDH reviewed manganese at the request of the Minnesota Pollution Control Agency as a result of their identification of manganese as a risk driver in air toxics evaluations. Manganese Risk Assessment Advice for the chronic air exposure duration ($RAA_{Chronic}$) was developed using an expedited review process in order to update the existing manganese value in a timely manner.

Chronic Non-Cancer Risk Assessment Advice ($RAA_{Chronic}$) = 0.1 µg/m³

$$= \frac{\text{(Point of Departure } (POD_{TWA}),\ \mu g/m^3)}{\text{(Uncertainty Factors (UF))}}$$

$$= \frac{(32.2\ \mu g/m^3)}{(300)}$$

= **0.1 µg/m³** (0.11 rounded to 1 significant figure)

Reference Concentration:	POD/Total UF = 32.2 µg/m³ ÷ 300 = 0.11 µg/m³
Source of toxicity value:	Determined by MDH 2025, based on Roels et al. 1992 (occupational human study)
POD and Critical Effect:	$BMCL_{10}$ = 90.2 µg/m³; neurological effects (eye-hand coordination)
Time Weighted Average (TWA):	POD_{TWA} = 32.2 µg/m³ (90.2 µg/m³ x (10 m³/20 m³) x (5 days/7 days))
Total uncertainty factor:	300
Uncertainty factor allocation:	3 for subchronic to chronic study extrapolation, 10 for intraspecies variability, and 10 for database uncertainty.

Cancer Risk Assessment Advice = Not Applicable

Cancer classification:	Classification D - not classifiable as to human carcinogenicity. (EPA IRIS 1993)

Volatile: No

Summary of Guidance Value History:

MDH previously developed a Health Risk Value (HRV) for Mn of 0.2 µg/m³ in 2002, applying a logistic regression equation published in an occupational epidemiology study of workers exposed to manganese through welding fumes (Roels et al., 1992). For this update, MDH searched the scientific literature for toxicological and epidemiological studies published since the most recent substantive evaluation that included external peer review (ATSDR 2012). Although many epidemiological studies were published between 2012 through 2025 observing similar subtle neurological effects with longer term occupational and environmental exposure to manganese, the Roels et al. (1992) paper remains the best data set available to determine a chronic air guidance value. As such, MDH utilized the most recent version of benchmark dose software at the 10% extra risk interval ($BMDL_{10}$), as outlined above, to determine a chronic non-cancer health-based Risk Assessment Advice ($RAA_{Chronic}$) level of 0.1 µg/m³.

Summary of toxicity testing for health effects identified in the Health Standards Statute (144.0751):

Even if testing for a specific health effect was not conducted for this chemical, information about that effect might be available from studies conducted for other purposes. MDH has considered the following information in developing health protective guidance.

	Endocrine	Immunotoxicity	Development	Reproductive	Neurotoxicity	Respiratory
Tested for specific effect?	Yes	Yes	Yes	Yes	Yes	Yes
Effects observed?	Yes[1]	Yes[2]	Yes[3]	Yes[4]	Yes[5]	Yes[6]

Comments on extent of testing or effects:

[1] Elevated serum cortisol and prolactin were observed in a population occupationally exposed to manganese dusts/fumes at a level of 0.15 mg/m^3. In further analysis of this data, serum prolactin levels were found to be significantly elevated when 1997 prolactin levels were compared to 1992 levels as well as both years' levels when compared to the non-exposed control group. Manganese exposures during that timeframe remained consistent, so it is unclear whether prolactin levels reflect current or cumulative exposure (ATSDR 2012).

[2] An early EPA study noted observing monocytic and lymphocytic infiltration of the myocardium of exposed Rhesus monkeys and not in controls. However, there was not enough evidence to link manganese exposure as the causative agent. Increased susceptibility to lung infection by bacterial pathogens following inhalation of manganese dusts at a concentration of 69 mg/m^3 has been noted in acute animal studies. Studies in other animal models indicate that injection or consumption of manganese compounds can cause significant changes in the functioning of several cell types of the immune system, but additional studies are needed to learn whether these effects also occur after inhalation exposure (ATSDR 2012).

[3] Multiple epidemiological studies that have detected altered behavioral and cognitive performance among children
exposed to excess levels of manganese, however, these studies have uncertainties that preclude the establishment of causal relationships between the observed effects and manganese exposure (also see neurotoxicity[5] section below). The one developmental study involving inhalation exposure identified in an ATSDR literature search had many complications, and additional studies involving neurobehavioral effects in animals following gestational and postnatal exposure to airborne manganese are necessary (ATSDR 2012). These points are reflected in the database uncertainty factor (UF_{DB}) of 10 being chosen for the MDH $Mn_{chronic}$ RAA.

[4] Men exposed to manganese dust in the workplace at a concentration of 0.97 mg/m^3 reported decreased libido and impotency and additional studies have reported decreased sperm and semen quality (ATSDR 2012).

[5] Repeated manganese inhalation exposure is associated with adverse neurological effects, as studied in multiple case studies and epidemiological studies of occupationally and environmentally exposed populations as well as animal inhalation studies. The lowest estimated points of departure reported from studies with acceptable data sets range from 0.03 to 0.07 mg/m^3 of respirable or total Mn dust (ATSDR 2012). The MDH $RAA_{chronic}$ for Mn and

Mn Compounds is based on one of these occupational health epidemiological studies. **This is the most sensitive effect and is therefore protective of all the other health effects noted in this section**.

[6] Workers exposed to approximately 1 mg/m^3 of manganese salts and oxides over a 1-19 year timespan reported cough and decreased lung function. Rhesus monkeys exposed to 1.5 mg/m^3 as manganese sulfate developed lesions in the lower respiratory tract (mild subacute bronchiolitis, alveolar duct inflammation, and proliferation of bronchus-associated lymphoid tissue). These lesions were determined to be transient as they were not found 45 days after the end of exposure. It is thought that inflammation of respiratory tissues from high-level exposure to inhaled manganese particulates is likely a consequence of the inhaled particulate matter (ATSDR 2012).

Resources Consulted During Review:

Agency for Toxic Substances and Disease Registry (ATSDR). 2012. Toxicological Profile for Manganese

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Roels HA, Ghyselen P, Buchet JP, et al. 1992. Assessment of the permissible exposure level to manganese in workers exposed to manganese dioxide dust. *Br J Ind Med.* 49:25-34.

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