Occupational Exposure Levels for Manganese (OEL)

This fact sheet covers Occupational Exposure Levels for Manganese & its inorganic compounds. Recent reviews by occupational standard setting committees have recommended lower occupational exposure limits (OELs) than those described in the 2004 Criteria Document (the CD recommended –0.1 mg/m³ for the respirable fraction and 0.5 mg/m³ for inhalable). These reviews have endorsed the continued use of sub-clinical neurological effects as the key health endpoint for long-term occupational exposure to low levels of manganese. The methodologies used by the committees for deriving these OELs are extremely variable but the approach employed by the European Commission’s Scientific Committee on Occupational Exposure Limits (SCOEL) appears to be the most robust – leading to the recommendation of 8 hour time-weighted averages (TWAs) of 0.05 mg Mn/m³ for the respirable fraction and 0.2 mg Mn/m³ for the inhalable fraction.

1. Introduction

World-wide annual production of manganese ore was estimated at 47 million tonnes in 2010. Iron and steel production accounts for approximately 90% of the use of manganese with most of the rest being used in foundry and welding applications. Workplace exposure to manganese occurs during mining, in the production of alloys, from welding activities and in other sectors such as battery production. Exposure is primarily due to inhalation of particulate matter containing variable concentrations of manganese. Assessment of workplace exposure therefore relies on the comparison of measured levels of manganese in airborne particulates to OELs that are considered to protect workers from any possible adverse health effects all through their working life.

2. Why have the OELs changed?

Since the CD was produced in 2004 more studies have been published on the toxicology of manganese and on assessment of occupational exposure and there have also been advances in exposure assessment methodology. These studies have been considered in conjunction with the existing evidence base by SCOEL, the American Conference of Governmental Industrial Hygienists (ACGIH) and the German MAK Commission. All three of these authoritative bodies have proposed different OELs for manganese due the absence of a standardised methodology for deriving OELs for inorganic compounds.

3. What are the potential health effects of workplace exposure to manganese?

Long term exposure to high levels of manganese is known to result in severe neurotoxic symptoms, some of which resemble idiopathic Parkinson’s disease; this condition known as ‘manganism’ seems to be of a historic nature as physiological changes associated to this condition are no longer seen because workplace exposure has significantly decreased since the 1970s. However, chronic low level occupational exposure to some manganese-based substances has resulted in subtle sub-clinical neurological effects. These effects include slight deteriorations in motor function and co-ordination that are measured by specialised neurofunctional tests. These tests have been seen in recent studies to be very sensitive and subjective in some cases. Some but not all of these sub-clinical effects have been found to be reversible when occupational exposure to manganese stops and question marks remain over the clinical relevance of these sub-clinical effects. However, these sub-clinical effects leading to subtle neurobehavioural changes have become the basis for OEL derivation for manganese & its inorganic compounds.

The carcinogenic/mutagenic potential of manganese and reproductive and developmental health effects have also been considered for health-based recommendations. However, SCOEL concluded that data on the carcinogenicity, mutagenicity and genotoxicity of manganese are inconclusive and endorsed the view expressed in the CD that there is little evidence for reproductive or developmental toxicity. There is conflicting evidence of workplace exposure to manganese causing cardiovascular and respiratory effects but these would only occur at much higher exposure levels than those inducing the subtle neurological effects that are the basis of the OELs. The OELs are therefore considered protective of all potential health effects potentially caused by workplace exposure to manganese.
4. OELs for respirable and inhalable fractions?
The sub-clinical neurological effects used to assess potential health impacts from occupational exposure to manganese are systemic in nature (i.e. they occur following distribution of manganese around the body) rather than occurring at the principal point of entry to the body, the lungs. For manganese the respirable fraction of airborne particulate matter is considered to be the best measure of systemic availability. A small proportion of particles in the inhalable fraction will reach the respiratory tract but the vast majority will enter the gastrointestinal tract where absorption of manganese is much lower and better controlled via homeostasis. There is little evidence of manganese toxicity following dietary exposure but this exposure pathway may become significant in the workplace if there are high concentrations of inhalable particles. OELs are therefore recommended for both respirable and inhalable fractions to ensure that workers are protected from exposure to both fine and coarse particles containing manganese.

There have also been studies using biomonitoring techniques (i.e. measurement of manganese in blood, urine, etc), but it has not yet been possible to quantitatively relate these types of measurement to occupational exposure. Concentrations of airborne particulates are therefore still considered to be the most appropriate method of setting OELs.

5. Summary
The knowledge base on the toxicology of manganese and the relating of workplace exposure to observable effects has improved in recent years but considerable gaps remain. Subtle sub-clinical neurological effects are still considered the critical endpoint for assessing potential health effects. OELs based on observation of these effects in workers exposed to manganese & its inorganic compounds have been recommended by a number of organisations – all of which have used different derivation methodologies. The approach used by the SCOEL produced respirable and inhalable recommended values of 0.05 mg Mn/m$^3$ and 0.2 mg Mn/m$^3$, respectively, as 8 hour TWAs with no requirement for a short-term exposure limit.

Further information:

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1 SCOEL(2011) Recommendation from the Scientific Committee on Occupational Exposure Limits for manganese and inorganic manganese compounds. SCOEL/SUM/127. Published June 2011.
3 List of MAK and BAT Values 2013: Maximum Concentrations and Biological Tolerance Values at the Workplace.