



## CHEMICAL UPDATE WORKSHEET

<b>Chemical Name:</b>	<b>Molybdenum</b>
<b>CAS #:</b>	<b>7439-98-7</b>
<b>Revised By:</b>	RRD Toxicology Unit
<b>Revision Date:</b>	September 16, 2015

### (A) Chemical-Physical Properties

	<b>Part 201 Value</b>	<b>Updated Value</b>	<b>Reference Source</b>	<b>Comments</b>
<b>Molecular Weight (g/mol)</b>	95.94	95.94	EPI	EXP
<b>Physical State at ambient temp</b>	Inorganic	Inorganic	MDEQ	
<b>Melting Point (°C)</b>	---	2622.00	PP	EXP
<b>Boiling Point (°C)</b>	5560	4639.00	CRC	EXP
<b>Solubility (ug/L)</b>	NA	NA	NA	NA
<b>Vapor Pressure (mmHg at 25°C)</b>	NA	NR	NA	NA
<b>HLC (atm-m<sup>3</sup>/mol at 25°C)</b>	NR	NR	NA	NA
<b>Log Kow (log P; octanol-water)</b>	NR	NR	NA	NA
<b>Koc (organic carbon; L/Kg)</b>	NR	NR	NA	NA
<b>Ionizing Koc (L/kg)</b>		NR	NA	NA
<b>Diffusivity in Air (Di; cm<sup>2</sup>/s)</b>	NR	NR	NA	NA
<b>Diffusivity in Water (Dw; cm<sup>2</sup>/s)</b>	NR	NR	NA	NA
<b>Soil Water Partition Coefficient (Kd; inorganics)</b>	NA	NA	NA	NA

	Part 201 Value	Updated Value	Reference Source	Comments
Flash Point (°C)	NA	NA	NA	NA
Lower Explosivity Level (LEL; unitless)	NA	NA	NA	NA
Critical Temperature (K)		NR	NA	NA
Enthalpy of Vaporization (cal/mol)		NR	NA	NA
Density (g/mL, g/cm <sup>3</sup> )		NR	NA	NA
EMSOFT Flux Residential 2 m (mg/day/cm <sup>2</sup> )	NA	NR	EMSOFT	NA
EMSOFT Flux Residential 5 m (mg/day/cm <sup>2</sup> )	NA	NR	EMSOFT	NA
EMSOFT Flux Nonresidential 2 m (mg/day/cm <sup>2</sup> )	NA	NR	EMSOFT	NA
EMSOFT Flux Nonresidential 5 m (mg/day/cm <sup>2</sup> )	NA	NR	EMSOFT	NA

**(B) Toxicity Values/Benchmarks**

	Part 201 Value	Updated Value	Source/Reference/Date	Comments/Notes/Issues
Reference Dose (RfD) (mg/kg/day)	5.0E-3	5.0E-3	IRIS, 1993	
RfD details	Human 6-year to Lifetime Dietary Exposure Study; LOAEL = 0.14 mg/kg-d; Critical effect = increased uric acid levels. UF = 30. (Koval'skiy et al., 1961).	<p><b>Tier 1 Source:</b>  <b>IRIS:</b>  <b>Basis:</b> IRIS is a Tier 1 source.  <b>Critical Study:</b> Koval'skiy, V.V., G.A. Yarovaya and D.M. Shmavonyan. 1961. Changes of purine metabolism in man and animals under conditions of molybdenum biogeochemical provinces. Zh. Obshch. Biol. 22:179-191. (Russian trans.)  <b>Methods:</b> In a cross-sectional epidemiology study in a Morich geoprovince of Armenia, Koval'skiy et al. (1961) correlated the dietary intake of molybdenum with serum uric acid levels, several biochemical endpoints, and with a gout-like sickness affecting the adult population in two settlements, Ankava village and a smaller adjoining settlement. This particular region was selected for two reasons: high molybdenum content in the soil and plants (38 and 190 times that of the control area) and low content of copper (Cu). Based on these figures and dietary estimates, the average adult person in the Ankava settlement received 10-15 mg of molybdenum and 5-10 mg of copper. This intake corresponds to molybdenum doses of 0.14- 0.21 mg/kg-day for a 70-kg adult.  <b>Critical effect:</b> Increased uric acid levels.  <b>End point or Point of Departure (POD):</b> NOAEL = none; LOAEL = 0.14 mg/kg-day.  <b>Uncertainty Factors:</b> UF = 30; An uncertainty factor of 3 is used for protection of sensitive human populations and a factor of 10 for the use of a LOAEL, rather than a NOAEL, from a long-term study in a human population.  <b>Source:</b> IRIS, 08/01/1993</p> <p><b>Tier 2 Sources:</b>  <b>PPRTV:</b> No PPRTV record available at this time.  <b>MRL:</b> No MRL record available at this time.</p>		Complete



	Part 201 Value	Updated Value	Source/Reference/Date	Comments/Notes/Issues
		<p><b>Tier 3 Source:</b>  <b>MDEQ:</b> Per DEQ-CCD-WRD 04/14/1997. RfD = 0.005 mg/kg/day. A LOAEL of 0.14 mg/kg/d was found in an epidemiology study of 300 Armenians exposed to molybdenum via their diet for 6 years to a lifetime. People exposed to this dose developed gout-like symptoms (an uncertainty factor of 10x was used for LOAEL to NOAEL extrapolation and 3x was used to protect sensitive members of the human population). This was consistent with the IRIS database.</p>		
<b>Oral Cancer Slope Factor (CSF) (mg/kg-day)<sup>-1</sup></b>	--	NA	MDEQ, 2015	
<b>CSF details</b>	--	<p><b>Tier 1 and 2 Sources:</b>  <b>IRIS:</b> Per IRIS (08/01/1993), this substance has not undergone a complete evaluation and determination under US EPA's IRIS program for evidence of human carcinogenic potential.  <b>PPRTV:</b> No PPRTV record available at this time  <b>MRL:</b> NA; MRLs are for non-cancer effects only.</p> <p><b>Tier 3 Source:</b>  <b>MDEQ:</b> Per DEQ-CCD no value at this time.</p>		Complete
<b>Reference Concentration (RfC) or Initial Threshold Screening Level (ITSL) (µg/m³)</b>	NA	3.0E+1	MDEQ, 2009	
<b>RfC/ITSL details</b>	--	<p><b>Tier 3 Source:</b>  <b>MDEQ:</b>  <b>Basis:</b> RIVM (2001) value (12 µg/m³) is based on an adjusted NOAEC of 12 mg/m³ from an NTP (1997) rat and mouse inhalation study. A total UF of 1,000 was applied to the adjusted NOAEC. ECHA (REACH) derived a higher value (3.3E+3) using the same study but the NOAEC was not adjusted for continuous exposure; the UF value was not specified. MDEQ arrived at a higher number and is the preferred value. See details below.</p>		Complete



	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
		<p><b>Tier 1 and 2 Sources:</b>  <b>IRIS:</b> Per IRIS 08/01/1993 no value was reported.  <b>PPRTV:</b> No PPRTV record available at this time.  <b>MRL:</b> No MRL record available at this time.</p> <p><b>Tier 3 Sources:</b>  <b>MDEQ:</b> ITSL = 30 µg/m<sup>3</sup>. This value is based on molybdenum disulfide (CAS# 1317-33-5) Molybdenum metal is considered insoluble and therefore the screening level is based on an 8 hour averaging time. Insoluble molybdenum compounds are relatively less reactive and therefore less toxic than soluble molybdenum. The screening level for insoluble molybdenum compounds is 30 ug/m3 based on a TLV.                      Note: The screening level for molybdenum trioxide (1313-27-5) is 5 µg/m<sup>3</sup> based on a TLV. This value is assigned to soluble molybdenum.                      Source: MDEQ-AQD, 4/6/2009</p> <p><b>RIVM:</b> Maximum Permissible Risk (MPR) = 12 µg/m<sup>3</sup>.                      Basis:                      Key study: NTP. 1997. Toxicology and carcinogenesis studies of molybdenum trioxide in F344/N rats and B6C3F1 mice (inhalation studies). NIH Publication, NTP.TR462, US Dep of Health &amp; Human Services.                      Method:                      NOAEC: 100 mg of molybdenum trioxide per m<sup>3</sup> is equivalent to a NOAEC of 12 mg/m<sup>3</sup> for continuous exposure.                      UF: 1,000 (100 for interspecies extrapolation and intraspecies variability and 10 for semi chronic to chronic exposure)                      Source: Re-evaluation of human-toxicological maximum permissible risk levels. RIVM report no. 711701025 2001</p> <p><b>ECHA (REACH):</b> Derived No Effect Level (DNEL) = 3.33 mg/m<sup>3</sup> (3.3E+3 µg/m<sup>3</sup>                      Basis: DNEL for molybdenum (CAS#7439-98-7)</p>		

	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
		<p>Adjustment factors: no information is available                      Key study unnamed publication, 1997                      Guideline: OECD Guideline 413 (Sub chronic Inhalation Toxicity: 90-Day)                      Method: B6C3F1 mouse (10/sex/dose) were exposed by whole body inhalation to 0, 1, 3,10, 30 and 100 mg/m<sup>3</sup> molybdenum trioxide dust for 6.5 hrs./day, 5 days/wk. for 13 weeks. The doses were selected based on a 14 day inhalation study with mice. Exposure of mice to molybdenum trioxide for 14 days at concentrations of 0, 3, 10, 30, 100, or 300 mg/m<sup>3</sup> had no effect on survival or clinical findings. However, final mean body weights of male and female mice exposed to 300 mg/m<sup>3</sup> were significantly lower than those of the control group.                      NOAEC: &gt;100 mg/m<sup>3</sup> air (nominal)                      Critical effect: No treatment-related effects on mortality, clinical signs, final mean body weights, organ weights, and epididymis weights, sperm count, or motility.                      No treatment-related gross or microscopic lesions were observed but increases in liver copper concentrations in females exposed to 30 mg/m<sup>3</sup>.</p> <p><b>Other Tier 3:</b> No value is available at this time from these Tier 3 sources/databases: HEAST, NTP ROC, health and environmental agencies of California, Massachusetts, Minnesota, New Jersey, New York, and Texas, WHO (IARC), WHO (IPCS/INCHEM), Canada and OECD HPV.</p>		
<b>Inhalation Unit Risk Factor (IURF) ((µg/m<sup>3</sup>)<sup>-1</sup>)</b>	--	NA	MDEQ, 2015	
<b>IURF details</b>	--	<p><b>Tier 1 and 2 Sources:</b>  <b>IRIS (08/01/1993):</b> This substance/agent has not undergone a complete evaluation and determination under US EPA's IRIS program for evidence of human carcinogenic potential.  <b>PPRTV:</b> No PPRTV record available at this time.  <b>MRL:</b> NA; MRLs are for non-cancer effects only.</p> <p><b>Tier 3 Source:</b>  <b>MDEQ:</b> Per DEQ-CCD-AQD no value reported.</p>		Complete



	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
<b>Mutagenic Mode of Action (MMOA)? (Y/N)</b>	--	NO	USEPA, 2015	
<b>MMOA Details</b>	--	Not listed as a carcinogen with mutagenic MOA in the USEPA OSWER List.		
<b>Developmental or Reproductive Effector? (Y/N)</b>	--	NO	MDEQ, 2015	
<b>Developmental or Reproductive Toxicity Details</b>		The RfD is not based on a reproductive-developmental effect.		
<b>State Drinking Water Standard (SDWS) (µg/L)</b>	NA	NO	SDWA, 1976	
<b>SDWS details</b>	--	MI Safe Drinking Water Act (SDWA) 1976 PA 399		
<b>Secondary Maximum Contaminant Level (SMCL) (µg/L)</b>	NA	NO	SDWA, 1976 and USEPA SMCL List	
<b>SMCL details</b>	--	MI Safe Drinking Water Act (SDWA) 1976 PA 399 and USEPA SMCL List, 2015		
<b>Is there an Aesthetic Value? (Y/N)</b>	NO	Not evaluated.	NA	
<b>Aesthetic value details</b>	NA	NA		
<b>Is there a Phytotoxicity Value? (Y/N)</b>	NO	Not evaluated.	NA	
<b>Phytotoxicity details</b>	NA	NA		
<b>Others:</b>				

**(C) Chemical-specific Absorption Factors**

	Part 201 Value	Update	Source/Reference/ Dates	Comments/Notes /Issues
Gastrointestinal absorption efficiency value (ABS <sub>gi</sub> )	---	1.0	MDEQ, 2015/USEPA RAGS-E, 2004	
ABS <sub>gi</sub> details		RAGS E (USEPA, 2004) Default Value		
Skin absorption efficiency value (AE <sub>d</sub> )	---	0.01	MDEQ, 2015	
AE <sub>d</sub> details				
Ingestion Absorption Efficiency (AE <sub>i</sub> )		0.5	MDEQ, 2015	
AE <sub>i</sub> Details				
Relative Source Contribution for Water (RSC <sub>w</sub> )		0.4	MDEQ, 2015	
Relative Source Contribution for Soil (RSC <sub>s</sub> )		1.0	MDEQ, 2015	
Relative Source Contribution for Air (RSC <sub>A</sub> )		1.0	MDEQ, 2015	
Others				

**(D) Rule 57 Water Quality Values and GSI Criteria**

<b>Current GSI value (µg/L)</b>	3,200 (X)
<b>Updated GSI value (µg/L)</b>	3,200 (X)
<b>Rule 57 Drinking Water Value (µg/L)</b>	120

	<b>Rule 57 Value (µg/L)</b>	<b>Verification Date</b>
<b>Human Non-cancer Values- Drinking water source (HNV-drink)</b>	120	5/2006
<b>Human Non-Cancer Values- Non-drinking water sources (HNV-Non-drink)</b>	10,000	5/2006
<b>Wildlife Value (WV)</b>	NA	NA
<b>Human Cancer Values for Drinking Water Source (HCV-drink)</b>	NA	NA
<b>Human Cancer values for non-drinking water source (HCV-Non-drink)</b>	NA	NA
<b>Final Chronic Value (FCV)</b>	3,200	4/2006
<b>Aquatic maximum value (AMV)</b>	29,000	4/2006
<b>Final Acute Value (FAV)</b>	58,000	4/2006

Sources:

1. MDEQ Surface Water Assessment Section Rule 57 [website](#)
2. MDEQ Rule 57 [table](#)

**(E) Target Detection Limits (TDL)**

	<b>Value</b>	<b>Source</b>
<b>Target Detection Limit – Soil (<math>\mu\text{g}/\text{kg}</math>)</b>	1,000	MDEQ, 2015
<b>Target Detection Limit – Water (<math>\mu\text{g}/\text{L}</math>)</b>	50	MDEQ, 2015
<b>Target Detection Limit – Air (ppbv)</b>	NA	MDEQ, 2015
<b>Target Detection Limit – Soil Gas (ppbv)</b>	NA	MDEQ, 2015

**CHEMICAL UPDATE WORKSHEET ABBREVIATIONS:**

CAS # - Chemical Abstract Service Number.

**Section (A) Chemical-Physical Properties****Reference Source(s):**

CRC	Chemical Rubber Company Handbook of Chemistry and Physics, 95th edition, 2014-2015
EMSOFT	USEPA Exposure Model for Soil-Organic Fate and Transport (EMSOFT) (EPA, 2002)
EPA2001	USEPA (2001) Fact Sheet, Correcting the Henry's Law Constant for Soil Temperature. Office of Solid Waste and Emergency Response, Washington, D.C.
EPA4	USEPA (2004) User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings. February 22, 2004.
EPI	USEPA's Estimation Programs Interface SUITE 4.1, Copyright 2000-2012
HSDB	Hazardous Substances Data Bank
MDEQ	Michigan Department of Environmental Quality
NPG	National Institute for Occupational Safety and Health Pocket Guide to Chemical Hazards
PC	National Center for Biotechnology Information's PubChem database
PP	Syracuse Research Corporation's PhysProp database
SCDM	USEPA's Superfund Chemical Data Matrix
SSG	USEPA's Soil Screening Guidance: Technical Background Document, Second Edition, 1996
USEPA/EPA	United States environmental protection agency's Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). July, 2004.

W9 USEPA's User Guide for Water9 Software, Version 2.0.0, 2001

**Basis/Comments:**

EST	estimated
EXP	experimental
EXT	extrapolated
NA	not available or not applicable
NR	not relevant

**Section (B) Toxicity Values/Benchmarks****Sources/References:**

ATSDR	Agency for Toxic Substances and Disease Registry
CALEPA	California Environmental Protection Agency
CAL DTSC	California Department of Toxic Substances Control
CAL OEHHA	CAEPA Office of Environmental Health Hazard Assessment
CCD	MDEQ Chemical Criteria Database
ECHA	European Chemicals Agency (REACH)
OECD HPV	Organization for Economic Cooperation and Development HPV Database
HEAST	USEPA's Health Effects Assessment Summary Tables
IRIS	USEPA's Integrated Risk Information System
MADEP	Massachusetts Department of Environmental Protection
MDEQ/DEQ	Michigan Department of Environmental Quality
DEQ-CCD/AQD	MDEQ Air Quality Division
DEQ-CCD/RRD	MDEQ Remediation and Redevelopment Division
DEQ-CCD/WRD	MDEQ Water Resources Division
MNDOH	Minnesota Department of Health

NJDEP	New Jersey Department of Environmental Protection
NYDEC	New York State Department of Environmental Conservation
OPP/OPPT	USEPA's Office of Pesticide Programs
PPRTV	USEPA's Provisional Peer Reviewed Toxicity Values
RIVM	The Netherlands National Institute of Public Health and the Environment
TCEQ	Texas Commission on Environmental Quality
USEPA	United States Environmental Protection Agency
USEPA OSWER	USEPA Office of Solid Waste and Emergency Response
USEPA MCL	USEPA Maximum Contaminant Level
WHO	World Health Organization
WHO IPCS	International Programme on Chemical Safety (IPCS/INCHEM)
WHO IARC	International Agency for Research on Cancers
NA	Not Available.
NR	Not Relevant.

**Toxicity terms:**

BMC	Benchmark concentration
BMCL	Lower bound confidence limit on the BMC
BMD	benchmark dose
BMDL	Lower bound confidence limit on the BMD
CSF	Cancer slope Factor
CNS	Central nervous system
IURF or IUR	Inhalation unit risk factor
LOAEL	Lowest observed adverse effect level
LOEL	Lowest observed effect level
MRL	Minimal risk level (ATSDR)
NOAEL	No observed adverse effect level
NOEL	No observed effect level

RfC	Reference concentration
RfD	Reference dose
p-RfD	Provisional RfD
aRfD	Acute RfD
UF	Uncertainty factor
WOE	Weight of evidence

**Section (C) Chemical-specific Absorption Factors**

MDEQ	Michigan Department of Environmental Quality
USEPA RAGS-E	United States Environmental Protection Agency's Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). July, 2004.

**Section (D) Rule 57 Water Quality Values and GSI Criteria**

GSI	Groundwater-surface water interface
NA	A value is not available or not applicable.
ID	Insufficient data to derive value
NLS	No literature search has been conducted