CHEMICAL UPDATE WORKSHEET

Chemical Name:	**Mercury, elemental**
CAS #:	**7439-97-6**
Revised By:	RRD Toxicology Unit
Revision Date:	August 26, 2015

(A) Chemical-Physical Properties

	Part 201 Value	Updated Value	Reference Source	Comments
Molecular Weight (g/mol)		200.59	EPI	EXP
Physical State at ambient temp		Inorganic	MDEQ	
Melting Point (˚C)		-38.80	PP	EXP
Boiling Point (˚C)		356.619	CRC	EXP
Solubility (ug/L)		60	PP	EXP
Vapor Pressure (mmHg at 25˚C)		1.96E-03	PP	EXP
HLC (atm-m^3/mol at 25˚C)		1.14E-02	SSG	EXP
Log Kow (log P; octanol-water)		0.62	SCDM	EST
Koc (organic carbon; L/Kg)		3.449	EPI	EST
Ionizing Koc (L/kg)		NR	NA	NA
Diffusivity in Air (Di; cm^2/s)		7.09E-02	W9	EST
Diffusivity in Water (Dw; cm^2/s)		3.01E-05	W9	EST
Soil Water Partition Coefficient (Kd; inorganics)		NA	NA	NA

	Part 201 Value	Updated Value	Reference Source	Comments
Flash Point (˚C)		NA	NA	NA
Lower Explosivity Level (LEL; unitless)		NA	NA	NA
Critical Temperature (K)		1.75E+03	EPA2004	EXP
Enthalpy of Vaporization (cal/mol)		1.41E+04	EPA2004	EXP
Density (g/mL, g/cm^3)		13.534	PC	EXP
EMSOFT Flux Residential 2 m (mg/day/cm^2)	ID	2.81E-05	EMSOFT	EST
EMSOFT Flux Residential 5 m (mg/day/cm^2)	ID	6.88E-05	EMSOFT	EST
EMSOFT Flux Nonresidential 2 m (mg/day/cm^2)	ID	4.47E-05	EMSOFT	EST
EMSOFT Flux Nonresidential 5 m (mg/day/cm^2)	ID	1.09E-04	EMSOFT	EST

(B) Toxicity Values/Benchmarks

	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
Reference Dose (RfD) (mg/kg/day)	--	6.0E-5	MDEQ, 1995	
RfD details	Previous worksheet had not been filled out.	**Tier 3 Source:** **MDEQ:** **Basis:** No RfD values specific to the elemental form mercury were identified among the other Tier 3 data sources evaluated. The MDEQ/WRD-derived RfD value considers elemental mercury along with other chemical forms of mercury and therefore represents best available information at this time. **Tier 1 and 2 Sources:** **IRIS (06/01/1995):** Per IRIS, no RfD value is available at this time. **PPRTV:** No PPRTV file available at this time. **MRL:** Per MRL (3/1999) no oral value is available at this time. **Tier 3 Sources**: **MDEQ:** **Per DEQ-CCD/WRD** (3/23/1995), RfD = 6.0E-5 mg/kg/day. The RfD for mercury (including methylmercury) is based on a LOAEL of 3 µg/kg/day identified for neurological effects in humans estimated from an Iraqi study and other human studies (Great Lakes Initiative, 1995). An uncertainty factor of 50 was used (10 for LOAEL-to-NOAEL extrapolation and 5 for intraspecies differences). **Per DEQ-CCD/RRD** (1/16/1988) RfD = 3.0E-4 mg/kg/day. RfD based on IRIS file for mercuric chloride. RfD is back-calculated from DWEL = 0.010 mg/L x 2 L/day/70 Kg BW = 0.0003 mg/kg/day (= 3E-4 mg/kg/day). Critical effect = autoimmune glomerulonephritis. EPA 1987. **USEPA Regional Screening Level website:** Not available.		Complete
Oral Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$)	--	NA	MDEQ, 2015	
CSF details		**Carcinogen Weight-of-Evidence (WOE) Class**: D Classification. Not classifiable as to human carcinogenicity.		Complete

	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
		IRIS WOE Basis: Based on inadequate human and animal data. Epidemiologic studies failed to show a correlation between exposure to elemental mercury vapor and carcinogenicity; the findings in these studies were confounded by possible or known concurrent exposures to other chemicals including human carcinogens, as well as lifestyle factors (e.g., smoking). Findings from genotoxicity tests are severely limited and provide equivocal evidence that mercury adversely affects the number or structure of chromosomes in human somatic cells. **Source and Date**: IRIS 05/01/1995. **Tier 1 and 2 Source:** **IRIS:** Per IRIS (5/1/1995), an oral CSF is not available. **PPRTV:** No PPRTV record available at this time. **MRL:** NA; MRLs are for non-cancer effects only. **Tier 3 Source:** **MDEQ:** Per DEQ-CCD no value at this time.		
Reference Concentration (RfC) or Initial Threshold Screening Level (ITSL) (µg/m³)		3.0E-1	IRIS, 1995	
RfC/ITSL details		**Tier 1 Source:** **IRIS:** **Basis:** IRIS is a Tier 1 source. **IRIS** RfC = 3.0E-4 mg/m^3 **Critical Studies**: 1. Fawer, R.F., U. DeRibaupierre, M.P. Guillemin, M. Berode and M. Lobe. 1983. Measurement of hand tremor induced by industrial exposure to metallic mercury. J. Ind. Med. 40: 204-208. 2. Piikivi, L. and U. Tolonen. 1989. EEG findings in chlor-alkali workers subjected to low long term exposure to mercury vapor. Br. J. Ind. Med. 46: 370-375. 3. Piikivi, L. and H. Hanninen. 1989. Subjective symptoms and psychological		Complete

	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
		performance of chlorine-alkali workers. Scand. J. Work Environ. Health. 15: 69-74. 4. Piikivi, L. 1989. Cardiovascular reflexes and low long-term exposure to mercury vapor. Int. Arch. Occup. Environ. Health. 61: 391-395. 5. Ngim, C.H., S.C. Foo, K.W. Boey and J. Jeyaratnam. 1992. Chronic neurobehavioral effects of elemental mercury in dentists. Br. J. Ind. Med. 49: 782-790. 6. Liang, Y-X., R-K. Sun, Y. Sun, Z-Q. Chen and L-H. Li. 1993. Psychological effects of low exposure to mercury vapor: Application of a computer-administered neurobehavioral evaluation system. Environ. Res. 60: 320-327. **Method(s)**: Human occupational inhalation studies 1. Fawer et al. (1983) used a sensitive objective electronic measure of intention tremor (tremors that occur at the initiation of voluntary movements) in 26 male workers (mean age of 44 years) exposed to low levels of mercury vapor in various occupations: fluorescent tube manufacture (n=7), chloralkali plants (n=12), and acetaldehyde production (n=7). Controls (n=25; mean age of 44.6 years) came from the same factories but were not exposed occupationally. Personal air samples (two per subject) were used to characterize an average exposure concentration of 0.026 mg/m^3. It should be noted that it is likely that the levels of mercury in the air varied during the period of exposure and historical data indicate that previous exposures may have been higher. Exposure measurements for the control cohort were not performed. The average duration of exposure was 15.3 years. 2. Piikivi and Tolonen (1989) used EEGs to study the effects of long-term exposure to mercury vapor in 41 chloralkali workers exposed for a mean of 15.6 +/- 8.9 years as compared with matched referent controls. They found that the exposed workers, who had mean blood Hg levels of 12 ug/L and mean urine Hg levels of 20 ug/L, tended to have an increased number of EEG abnormalities when analyzed by visual inspection only. 3. Piikivi and Hanninen (1989) studied the subjective symptoms and psychological performances on a computer-administered test battery in 60 chloralkali workers exposed to mercury vapor for a mean of 13.7 ± 5.5 years		

	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
		as compared with matched referent controls. The exposed workers had mean blood Hg levels of 10 ug/L and mean urine Hg levels of 17 ug/L. Both subjective and objective symptoms of autonomic dysfunction were investigated in 41 chloralkali workers exposed to mercury vapor for a mean of 15.6 ± 8.9 years as compared with matched referent controls (Piikivi, 1989). 4. Ngim et al. (1992) assessed neurobehavioral performance in a cross-sectional study of 98 dentists (38 female, 60 male; mean age 32, range 24-49 years) exposed to TWA concentrations of 0.014 mg/m^3 (range 0.0007 to 0.042 mg/m^3) versus 54 controls (27 female, 27 male; mean age 34, range 23-50 years) with no history of occupational exposure to mercury. Air concentrations were measured with personal sampling badges over typical working hours (8-10 hours) and converted to an 8-hour TWA. 5. Liang et al. (1993) investigated workers in a fluorescent lamp factory with a computer-administered neurobehavioral evaluation system and a mood inventory profile. The exposed cohort (mean age 34.2 years) consisted of 19 females and 69 males exposed to ninterruptedly for at least 2 years prior to the study. Exposure was monitored with area samplers and ranged from 0.008 to 0.085 mg/m^3 across worksites. No details on how the exposure profiles to account for time spent in different worksites were constructed. The average exposure was estimated at 0.033 mg/m^3 (range 0.005 to 0.19 mg/m^3). The average duration was of working was 15.8 years for the exposed cohort. **Critical effect**: Hand tremor, increases in memory disturbance, slight subjective and objective evidence of autonomic dysfunction **End point or Point of Departure (POD):** 1. The TWA of 0.025 mg/m^3 was designated a LOAEL. Using the TWA and adjusting for occupational ventilation rates and workweek, the resultant LOAEL (HEC) is 0.009 mg/m^3. 2. The authors extrapolated an exposure level associated with these EEG changes of 0.025 mg/m^3 from blood levels based on the conversion factor calculated by Roels et al. (1987). 3. The authors extrapolated an exposure level associated with these subjective		

	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
		measures of memory disturbance of 0.025 mg/m^3 from blood levels based on the conversion factor calculated by Roels et al. (1987). 4. The authors extrapolated an exposure level associated with these subjective and objective measures of autonomic dysfunction of 0.030 mg/m^3 from blood levels based on the conversion factor calculated by Roels et al. (1987). 5. These neurobehavioral effects are consistent with central and peripheral neurotoxicity and the TWA is considered a LOAEL. Using the TWA and adjusting for occupational ventilation rates and the reported 6-day workweek, the resultant LOAEL (HEC) is 0.006 mg/m^3. 6. Based on these neurobehavioral effects, the TWA of 0.033 mg/m^3 is designated as LOAEL. Using the TWA and adjusting for occupational ventilation rates and workweek, the resultant LOAEL (HEC) is 0.012 mg/m^3. CONCLUSION: The TWA level of 0.025 mg/m^3 was used to represent the exposure for the synthesis of the studies described above. Using this TWA and taking occupational ventilation rates and workweek into account results in a LOAEL (HEC) of 0.009 mg/m^3. **Uncertainty Factors**: UF = 30; An uncertainty factor of 10 was used for the protection of sensitive human subpopulations (including concern for acrodynia - see Additional Comments section) together with the use of a LOAEL. An uncertainty factor of 3 was used for lack of database, particularly developmental and reproductive studies. **Source and date:** IRIS, 06/01/1995. **Tier 2 Sources:** **PPRTV:** No PPRTV record available at this time. **MRL:** Per ATSDR, March 1999, MRL = 0.0002 mg/m^3 (= 0.2 µg/m^3). **Critical Study:** Fawer RF, de Ribaupierre Y, Guillemin MP, et al. 1983. Measurement of hand tremor induced by industrial exposure to metallic mercury. British Journal of Industrial Medicine 40:204-208. **Methods:** Hand tremors were measured in 26 male workers exposed to metallic mercury and 25 control males working in the same facilities but not exposed to mercury. Workers had been exposed to mercury through the manufacture of		

	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
		fluorescent tubes, chloralkali, or acetaldehyde. Hg-exposed workers ha a duration of exposure of 15.3 ± 2.6 years, blood mHg of 41.3 ± micromoles Hg/L, and urinary Hg of 11.3 ± 1.2 micromoles Hg/mole of creatinine. Mean Hg level measured using personal air monitors was 0.026± 0.0926 ± 0.004 mg/m^3 (3 subjects were exposed to greater than 0.05 mg/m^3.) **Critical Effects:** Increased frequency of tremors **End Point or Point of Departure:** LOAEL = 0.026 mg/m^3 (= 2.6E+1 µg/m^3). **Uncertainty Factors:** UF = 30; 3 for use of a minimal LOAEL; 10 for human variability. **Tier 3 Source:** **MDEQ:** Per DEQ-CCD-AQD, 05/28/2015. ITSL = 0.3 ug/m^3. Annual AT. (AIR): The chronic ITSL is the same as the EPA RfC and is based on neurological effects and several epidemiological studies. The acute ITSL is based on the ATSDR/MDHHS action level for re-occupancy of homes following mercury spills, which is primarily based on the lowest neurological TD-LO from the key epidemiology studies utilized by EPA in deriving the RfC. AQD Footnote #7 Besides the assessment of mercury ambient air impacts in comparison to the ITSLs, larger individual sources of mercury emissions undergoing permit review (e.g., greater than 5 to 10 lbs/yr.) may be evaluated on a case-by-case basis to address concerns for deposition and bioaccumulation, taking into account site-specific factors such as the presence of nearby recreational fisheries and realistic exposure scenarios.		
Inhalation Unit Risk Factor (IURF) ((µg/m^3)$^{-1}$)	--	NA	MDEQ, 2015	
IURF details		**Carcinogen Weight-of-Evidence (WOE) Class**: Class D; not classifiable as to human carcinogenicity. **IRIS WOE Basis**: Based on inadequate human and animal data. Epidemiologic studies failed to show a correlation between exposure to elemental mercury vapor and carcinogenicity; the findings in these studies were confounded by possible or known concurrent exposures to other chemicals, including human carcinogens, as well as lifestyle (e.g., smoking). Findings from genotoxicity tests		Complete

	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
		are severely limited and provide equivocal evidence that mercury adversely affects the number of structure of chromosomes in human somatic cells. **Source and Date**: IRIS, 05/01/1995. **Tier 1 and 2 Sources**: **IRIS:** Per IRIS (5/1/1995), no IURF value at this time. **PPRTV:** No PPRTV record available at this time. **MRL:** NA; MRLs are for non-cancer effects only. **Tier 3 Source:** **MDEQ:** Per DEQ-CCDAQD, no value at this time.		
Mutagenic Mode of Action (MMOA)? (Y/N)	--	No	USEPA, 2015	
MMOA Details	--	Not listed as a carcinogen with mutagenic MOA in the USEPA OSWER List.		
Developmental or Reproductive Effector? (Y/N)	No	NO	MDEQ, 2015	
Developmental or Reproductive Toxicity Details	NA	No for inhalation at this time. The RfC is not based on a reproductive-developmental effect.		
State Drinking Water Standard (SDWS) (µg/L)	--	2.0E+0 **(inorganic mercury)**	SDWA, 1976	
SDWS details	NA	MI Safe Drinking Water Act (SDWA) 1976 PA 399		
Secondary Maximum Contaminant Level (SMCL) (µg/L)	--	NO	SDWA, 1976 and USEPA SMCL List	
SMCL details	NA	MI Safe Drinking Water Act (SDWA) 1976 PA 399 and USEPA SMCL List, 2015		
Is there an Aesthetic Value? (Y/N)	NO	Not evaluated.	NA	

	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
Aesthetic value details	NA	NA		
Is there a Phytotoxicity Value? (Y/N)	NO	Not evaluated.	NA	
Phytotoxicity details	NA	NA		
Others:				

(C) Chemical-specific Absorption Factors

	Part 201 Value	Update	Source/Reference/ Dates	Comments/Notes /Issues
Gastrointestinal absorption efficiency value (ABSgi)	---	1.0	MDEQ, 2015/USEPA RAGS-E, 2004	
ABSgi details		RAGS E (USEPA, 2004) Default Value		
Skin absorption efficiency value (AEd)	---	NA	MDEQ, 2015	
AEd details				
Ingestion Absorption Efficiency (AEi)		NA	MDEQ, 2015	
AEi Details				
Relative Source Contribution for Water (RSC_W)		NA	MDEQ, 2015	
Relative Source Contribution for Soil (RSC_S)		NA	MDEQ, 2015	
Relative Source Contribution for Air (RSC_A)		1.0	MDEQ, 2015	
Others				

(D) Rule 57 Water Quality Values and GSI Criteria

Current GSI value (µg/L)	0.0013
Updated GSI value (µg/L)	0.0013
Rule 57 Drinking Water Value (µg/L)	0.0018

	Rule 57 Value (µg/L)	Verification Date
Human Non-cancer Values- Drinking water source (HNV-drink)	0.0018	7/1997
Human Non-Cancer Values- Non-drinking water sources (HNV-Non-drink)	0.0018	7/1997
Wildlife Value (WV)	0.0013	7/1997
Human Cancer Values for Drinking Water Source (HCV-drink)	NA	NA
Human Cancer values for non-drinking water source (HCV-Non-drink)	NA	NA
Final Chronic Value (FCV)	0.77^{D} D = value is expressed as dissolved	7/1997
Aquatic maximum value (AMV)	1.4^{D} D = value is expressed as dissolved	7/1997
Final Acute Value (FAV)	2.8^{D} D = value is expressed as dissolved	7/1997

Sources:

1. MDEQ Surface Water Assessment Section Rule 57 website
2. MDEQ Rule 57 table

(E) Target Detection Limits (TDL)

	Value	Source
Target Detection Limit – Soil (μg/kg)	50	MDEQ, 2015
Target Detection Limit – Water (μg/L)	0.001	MDEQ, 2015
Target Detection Limit – Air (ppbv)	NA	MDEQ, 2015
Target Detection Limit – Soil Gas (ppbv)	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