



## CHEMICAL UPDATE WORKSHEET

<b>Chemical Name:</b>	<b>Strontium(DD)</b>
<b>CAS #:</b>	<b>7440-24-6</b>
<b>Revised By:</b>	RRD Toxicology Unit
<b>Revision Date:</b>	July 31, 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>	87.62	87.62	EPI	EXP
<b>Physical State at ambient temp</b>	Inorganic	Inorganic	MDEQ	
<b>Melting Point (°C)</b>	765	777.00	Phys Prop	EXP
<b>Boiling Point (°C)</b>	NA	1377.00	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	NR	NA
EMSOFT Flux Residential 5 m (mg/day/cm <sup>2</sup> )	NA	NR	NR	NA
EMSOFT Flux Nonresidential 2 m (mg/day/cm <sup>2</sup> )	NA	NR	NR	NA
EMSOFT Flux Nonresidential 5 m (mg/day/cm <sup>2</sup> )	NA	NR	NR	NA

**(B) Toxicity Values/Benchmarks**

	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
<b>Reference Dose (RfD) (mg/kg/day)</b>	6.3E-1	6.0E-1	IRIS, 1996	
<b>RfD details</b>	<p>Critical effect = "rachitic bone" in young female rats administered Sr carbonate in-feed at doses of 380 mg/Kg and higher (Storey, 1961). NOAEL = 190 mg/kg/day. UF = 300 (10x species to species, 10x incomplete database (retained even though not typically used by RRD toxicologists because critical effect more pronounced in young animals; potential prenatal developmental effects, 3x sensitive subpopulations). For more details contact RRD for</p>	<p><b>Tier 1 Source:</b> <b>IRIS:</b> <b>Basis:</b> IRIS is a Tier 1 source. IRIS (1994) chronic RfD = 6.0E-1 mg/kg-day. ATSDR (2004) intermediate oral MRL = 2.0 mg/kg-day. The IRIS value is a chronic value and based on 3 studies while the MRL is for subchronic exposure and based on only one study; therefore, the IRIS RfD is selected. <b>Critical Studies:</b> 1) Storey, E. 1961. Strontium "rickets": bone calcium and strontium changes. Austral. Ann. Med. 10: 213-222.; 2) Marie, P.J., M.T. Garba, M. Hott and L. Miravet. 1985. Effect of low doses of stable Sr on bone metabolism in rats. Miner. Electrolyte Metab. 11: 5-13.; and 3) Skoryna, S.C. 1981. Effects of oral supplementation with stable strontium. Can. Med. Assoc. J. 125(7): 703-712. <b>Methods:</b> 1) Storey (1961) fed young (40-60 g) and adult (200-250 g) female rats (strain unspecified) diets with adequate calcium (1.6%), phosphorous (0.9%) and vitamin D for 20 days. Strontium (as strontium carbonate) in diet was given to both adult and young rats: 0.19, 0.38, 0.75, 1.0 (young rats only), 1.5 and 3.0% (corresponding to 190, 380, 750, 1000, 1500 and 3000 mg/kg-day for young rats and 95, 190, 375, 750 and 1500 mg/kg-day for adult rats). 2) Marie et al. (1985) exposed weanling male Sprague-Dawley rats (8/group) to 0, 0.19, 0.27, 0.34 and 0.40% of SrCl<sub>2</sub> in distilled water for 9 weeks. The diet contained 0.5% calcium. The authors estimated strontium intakes are 0, 316, 425, 525 and 633 mg/kg-day. 3) Skoryna (1981) fed rats (12/group) ad libitum with a standard laboratory diet exposed them to 0.002, 900, 1900 or 3400 ppm strontium chloride (55% strontium) in drinking water for 3 years. At water consumption rate of 49 mL/day, the estimated doses were 70, 147 and 263 mg/kg Sr/day. The control and experimental groups received adequate amounts of calcium (0.35 ppm) and magnesium (0.0682 ppm) in their drinking water. <b>Critical effect:</b> rachitic bone defects (rickets) in young rats</p>	IRIS, 1996	Complete

	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
	<p>the TSD. RRD Calculation date: 6/23/1992</p>	<p><b>End point or Point of Departure (POD):</b> NOAEL = 190 mg/kg/day (0.19% Sr as SrCO<sub>3</sub>). LOAEL = 380 mg/kg/day).</p> <p><b>Uncertainty Factors:</b> UF = 300 (10 each for interspecies extrapolation and database deficiencies, and 3 for intraspecies variability- a factor of 10 not warranted because the critical study was performed in young animals).</p> <p><b>Source and date:</b> IRIS, Last revision date - 12/01/1996</p> <p><b>Tier 2 Sources:</b>  <b>PPRTV:</b> No PPRTV record is available at this time.  <b>MRL:</b> Per ATSDR (10/2004), no oral chronic MRL at this time. Oral intermediate MRL = 2.0 mg/kg-day is available:  <b>Critical Study:</b> Storey E. 1961. Strontium 'rickets': Bone calcium and strontium changes. Austral Ann Med 10:213-222.  <b>Methods:</b> Groups of five young (40–60 g) and three adult (200–250 g) female rats were fed a diet containing 1.6% calcium, 0.9% phosphorus, and 0, 0.19, 0.38, 0.75, 1.0 (young only), 1.5, or 3% strontium as strontium carbonate for 20 days. The strontium intakes were calculated to be 0, 140, 550, 1,080, 1,460, 2,220, or 4,975 mg strontium/kg/day in young rats, and 0, 170, 350, 690, 1,370, or 2,750 mg strontium/kg/day in adult rats.  <b>Critical effect:</b> skeletal toxicity in young rats  <b>End point or Point of Departure (POD):</b> NOAEL = 140 mg/kg/day  <b>Uncertainty Factors:</b> UF = 90 (10 for interspecies extrapolation and 3 each for database deficiencies and modifying factor)  <b>Source and date:</b> ATSDR, 10/2004. A Toxicological Profile is available.</p> <p><b>Tier 3 Source:</b>  <b>MDEQ:</b> Per DEQ-CCD/RRD (6/23/1992), RfD = 6.3 E-1 mg/kg-day. See Part 201 Value RfD details.  Per DEQ-CCD/WRD (6/10/1998), a ballpark HNV was derived using data presented in IRIS. It was based on a 3 year study in rats which found a dietary NOAEL of 0.19% (190 mg/kg/d). The compound was administered as SrCO<sub>3</sub>. (UF=30; 3x for intraspecies extrapolation) (Storey, 1961; Marie et al., 1985; Skoryna, 1981).</p>		

	Part 201 Value	Updated Value	Source/Reference/Date	Comments/Notes/Issues
		Appears to be based on the IRIS RfD. No CAS search was conducted.		
<b>Oral Cancer Slope Factor (CSF) (mg/kg-day)<sup>-1</sup></b>	--	NA	MDEQ, 2015	
<b>CSF details</b>	NA	<p><b>Tier 1 and 2 Sources:</b>  <b>IRIS:</b> Per IRIS (12/01/1996), no value at this time. IRIS has not evaluated strontium for evidence of human carcinogenic potential.  <b>PPRTV:</b> No PPRTV record is 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/m<sup>3</sup>)</b>	--	NA	MDEQ, 2015	
<b>RfC/ITSL details</b>	NA	<p><b>Tier 1 and 2 Sources:</b>  <b>IRIS:</b> Per IRIS (12/01/1996), no value at this time.  <b>PPRTV:</b> No PPRTV record is available at this time.  <b>MRL:</b> Per ATSDR List (12/2014), no value at this time.</p> <p><b>Tier 3 Source:</b>  <b>MDEQ:</b> Per DEQ-CCD/AQD (7/23/2015), no value at this time; AQD has an AQD Footnote # 26, which states: "This toxic air contaminant (TAC) is reasonably anticipated to exist as a particle in the ambient air. A toxicological review has determined that, in lieu of setting a screening level, the primary NAAQS for particulate matter (PM) are reasonable and appropriate health protective levels for the particulate".</p>		Complete
<b>Inhalation Unit Risk Factor (IURF) ((µg/m<sup>3</sup>)<sup>-1</sup>)</b>	--	NA	MDEQ, 2015	



	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
IURF details	NA	<p><b>Tier 1 and 2 Sources:</b>  <b>IRIS:</b> Per IRIS (12/01/1996), no value at this time. IRIS has not evaluated strontium for evidence of human carcinogenic potential.  <b>PPRTV:</b> No PPRTV record is 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
Mutagenic Mode of Action (MMOA)? (Y/N)	--	NO	USEPA, 2015	
MMOA Details	--	NA Not listed as a carcinogen with mutagenic MOA in the USEPA OSWER List.		
Developmental or Reproductive Effector? (Y/N)	No	YES-oral. The RfD is based on a reproductive-developmental effect. Oral Exposure Pathways- Full Term Exposure	MDEQ, 2015	
Developmental or Reproductive Toxicity Details	NA	<p><b>Basis:</b> Per IRIS, young animals are more sensitive than adult animals to excessive strontium intakes because bones in young animals are actively growing.  <b>Critical effect:</b> rachitic bone defects (rickets) in young rats  <b>Critical Studies:</b> 1) Storey, E. 1961. Strontium "rickets": bone calcium and strontium changes. Austral. Ann. Med. 10: 213-222.; 2) Marie, P.J., M.T. Garba, M. Hott and L. Miravet. 1985. Effect of low doses of stable Sr on bone metabolism in rats. Miner. Electrolyte Metab. 11: 5-13.; and 3) Skoryna, S.C. 1981. Effects of oral supplementation with stable strontium. Can. Med. Assoc. J. 125(7): 703-712.</p>		
State Drinking Water Standard (SDWS) (ug/L)	--	NO	SDWA, 1976	
SDWS details	NA	MI Safe Drinking Water Act (SDWA) 1976 PA 399		
Secondary Maximum Contaminant Level (SMCL) (ug/L)	--	NO	SDWA, 1976 and USEPA SMCL List	

	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
<b>SMCL details</b>	NA	MI Safe Drinking Water Act (SDWA) 1976 PA 399 and USEPA SMCL List, 2015		
<b>Is there an aesthetic value for drinking water? (Y/N)</b>	NO	Not evaluated.	NA	
<b>Aesthetic value (ug/L)</b>	NA	NA	NA	
<b>Aesthetic Value details</b>	NA	NA		
<b>Phytotoxicity Value? (Y/N)</b>	NO	Not evaluated.	NA	
<b>Phytotoxicity details</b>	NA	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> )		0.2	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>	21,000
<b>Updated GSI value (µg/L)</b>	21,000
<b>Rule 57 Drinking Water Value (µg/L)</b>	21,000

	<b>Rule 57 Value (µg/L)</b>	<b>Verification Date</b>
<b>Human Non-cancer Values- Drinking water source (HNV-drink)</b>	ID* (21,000)	8/1998
<b>Human Non-Cancer Values- Non-drinking water sources (HNV-Non-drink)</b>	ID* (21,000)	8/1998
<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>	21,000	6/2008
<b>Aquatic maximum value (AMV)</b>	40,000	6/2008
<b>Final Acute Value (FAV)</b>	81,000	6/2008

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>	5,000	MDEQ, 2015
<b>Target Detection Limit – Water (<math>\mu\text{g}/\text{L}</math>)</b>	1,000	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 OEHHHA	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