CHEMICAL UPDATE WORKSHEET

Chemical Name:	**Aluminum (DD)**
CAS #:	**7429-90-5**
Revised By:	RRD Toxicology Unit
Revision Date:	August 12, 2105

(A) Chemical-Physical Properties

	Part 201 Value	Updated Value	Reference Source	Comments
Molecular Weight (g/mol)	26.982	30.01	EPI	EXP
Physical State at ambient temp	Inorg	Inorganic	MDEQ	
Melting Point (˚C)	---	660.323	CRC	EXP
Boiling Point (˚C)	2467	2519	CRC	EXP
Solubility (ug/L)	NA	NA	NA	NA
Vapor Pressure (mmHg at 25˚C)	NA	NR	NA	NA
HLC (atm-m³/mol at 25˚C)	NR	NR	NA	NA
Log Kow (log P; octanol-water)	NR	NR	NA	NA
Koc (organic carbon; L/Kg)	NR	NR	NA	NA
Ionizing Koc (L/kg)		NR	NA	NA
Diffusivity in Air (Di; cm^2/s)	NR	NR	NA	NA
Diffusivity in Water (Dw; cm^2/s)	NR	NR	NA	NA
Soil Water Partition Coefficient (Kd; inorganics)	NA	NR	NA	NA

	Part 201 Value	Updated Value	Reference Source	Comments
Flash Point (˚C)	NA	NA	NA	NA
Lower Explosivity Level (LEL; unit less)	NA	NA	NA	NA
Critical Temperature (K)		NR	NA	NA
Enthalpy of Vaporization (cal/mol)		NR	NA	NA
Density (g/mL, g/cm^3)		NR	NA	NA
EMSOFT Flux Residential 2 m (mg/day/cm^2)	NA	NR	EMSOFT	NA
EMSOFT Flux Residential 5 m (mg/day/cm^2)	NA	NR	EMSOFT	NA
EMSOFT Flux Nonresidential 2 m (mg/day/cm^2)	NA	NR	EMSOFT	NA
EMSOFT Flux Nonresidential 5 m (mg/day/cm^2)	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)	3.3E-1	1.0E+0	ATSDR, 2008	
RfD details	LOAEL = 100 mg Al/Kg-day, UF = 1000. Critical effect = developmental neurotoxicity in mice. Review based on ECAO review. ECAO UF adjusted for consistency with ERD policy: a UF of 10 will be used to account for interspecies extrapolation, 10 for intraspecies variability, and 3 for use of a minimal LOAEL. All criteria are based on single exposure unadjusted for duration or pattern of exposure. EPB-CCD, 9/30/1996.	**Tier 2 Source:** **Basis:** ATSDR is a more recent source than PPRTV for RfD. **ATSDR** oral chronic MRL = 1.0 mg/kg-day based on neurological effects. **Critical Study**: Golub MS, Germann SL, Han B, et al. 2000. Lifelong feeding of a high aluminum diet to mice. Toxicology 150:107-117 **Methods**: Groups of 8 male and 10 female Swiss Webster mice were exposed to 7 or 1,000 µg Al/gdiet as aluminum lactate in diet. The investigators estimated adult doses of <1 and 100 mg/kg/day. The mice were exposed to aluminum from conception (via feeding the dams) through 24 months of age. In a companion study, groups of 6–9 male and female Swiss Webster mice or 7 male and female C57BL/6J mice (number per sex were not reported) were exposed to 7 or 1,000 µg Al/gdiet as aluminum lactate in diet (<1 and 100 mg/kg/day) from conception (via feeding the dams) through 24 months of age. **Critical effect**: decreased forelimb and hind limb grip strength and decreased thermal sensitivity. **End point or Point of Departure (POD):** LOAEL = 100 mg/kg-day **Uncertainty Factors**: UF = 300; (10 each for intraspecies variability and interspecies extrapolation, 3 for use of a LOAEL); Modifying Factor = 0.3 for possible differences in the bioavailability of the aluminum lactate used in the Golub and Germann (2001) study and the bioavailability of aluminum from drinking water and a typical U.S. diet. **Source and date:** ATSDR, 9/2008. From 12/2014 MRL list. **Tier 1 and 2 Sources:** **IRIS:** No IRIS file available at this time. **PPRTV:** Per PPRTV (10/23/2006), oral chronic RfD = 1.0 mg/kg-day **Critical Studies**: 1) Donald, J.M., M.S. Golub, M.E. Gershwin and C.L. Keen. 1989. Neurobehavioral effects in offspring of mice given excess aluminum in diet		Complete

	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
		during gestation and lactation. Neurotoxicol.Teratol. 11:345-351 2) Golub, M.S., B. Han, C.L. Keen, M.E. Gershwin and R.P. Tarara. 1995. Behavioral performance of Swiss-Webster mice exposed to excess dietary aluminum during development or during development and as adults. Toxicol. Appl. Pharmacol. 133:64-72. **Method(s)**: 16 pregnant Swiss-Webster mice were fed 25, 500 or 1000 mg Al/kg diet as aluminum lactate throughout gestation and lactation. A neurobehavioral test battery was administered to six pups per litter at age 25 days (4 days post weaning), 39 days or age 21 and 35 days. **Critical effect**: minimal developmental neurotoxicity in the offspring of mice **End point or Point of Departure (POD):** LOAEL = 100 mg/kg-day **Uncertainty Factors**: UF = 100; (3 each for minimal LOAEL and intraspecies variability and 10 for interspecies extrapolation). **Source and date:** PPRTV, 10/23/2006 **MRL:** ATSDR (9/2008) also derived an oral intermediate MRL = 1.0 mg/kg-day based on neurological effects; **Critical Studies**: 1) Golub MS, Germann SL. 2001. Long-term consequences of developmental exposure to aluminum in a suboptimal diet for growth and behavior in Swiss Webster mice. Neurotoxicol Teratol 23:365-372. 2) Colomina MT, Roig JL, Torrente M, et al. 2005. Concurrent exposure to aluminum and stress during pregnancy in rats: effects on postnatal development and behavior of the offspring. Neurotoxicol Teratol 27:565-574. **Method(s)**: 1) Groups of pregnant Swiss Webster mice were exposed to 0, 100, 500, or 1,000 mg Al/kg diet on gestational days 0–21 and during lactation until day 21. On PND 21, one male and one female pup from each litter were placed on the same diet as the dam. The offspring were exposed until PND 35. The composition of the diet was modified from the National Research Council's recommendations; the investigators noted that the nutrients were reduced to correspond to the usual intake of these nutrients by young women. 2) female Sprague-Dawley rats were exposed to 0, 50, or 100 mg Al/kg/day		

	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
		aluminum nitrate nonahydrate in drinking water; citric acid (710, 355, and 710 mg/kg/day in the control, 50, and 100 ppm groups, respectively) was added to the drinking water to increase aluminum absorption. The adult rats were exposed to aluminum for 15 days prior to mating and the during gestation and lactation periods; after weaning, the pups were exposed to the same aluminum concentration as the mothers from postnatal day 21 through 68. The total aluminum doses were 3, 53, and 103 mg Al/kg/day. **Critical effect**: neurotoxicity in mice (latency to locate the platform following cue relocation in the water maze test) **End point or Point of Departure (POD):** NOAEL = 26 mg/kg-day **Uncertainty Factors**: UF = 100; (10 each for intraspecies variability and interspecies extrapolation); Modifying Factor = 0.3 for possible differences in the bioavailability of the aluminum lactate used in the Golub and Germann (2001) study and the bioavailability of aluminum from drinking water and a typical U.S. diet. **Source and date:** ATSDR, 9/2008. From 12/2014 MRL List **Tier 3 Source:** **MDEQ:** Per CCD/RRD (9/30/1996), RfD = 3.3E-1 mg/kg-day. **Critical Study**: Donald, J.M., M.S. Golub, M.E. Gershwin and C.L. Keen. 1989. Neurobehavioral effects in offspring of mice given excess aluminum in diet during gestation and lactation. Neurotoxicol. Teratol. 11:345-351 **Method(s)**: 16 Swiss Webster mice were exposed to aluminum lactate in the diet throughout gestation and lactation. **Critical Effect:** Functional developmental neurotoxicity in mice. **End point or Point of Departure (POD):** LOAEL = 100 mg Al/kg/day (maternal dose). **Uncertainty Factors**: Total UF = 300. **Source and Date:** EPA Superfund Technical Support Center, Environmental Criteria and Assessment Office (ECAO), 1994.		
Oral Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$)	--	NA	MDEQ, 2015	

	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
CSF details	NA	**Carcinogen Weight-of-Evidence (WOE) Class**: *"inadequate information to assess carcinogenic potential"*. **IRIS WOE Basis**: insufficient evidence in epidemiological/occupational studies, lack of demonstrated carcinogenicity or mutagenicity in available animal studies, lack of positive evidence of non-carcinogenicity and lack of mode of action data for aluminum **Source and Date**: PPRTV, 10/23/2006 **Tier 1 and 2 Sources:** **IRIS:** No IRIS file available at this time. **PPRTV:** Per PPRTV (10/23/2006), no value at this time. **MRL:** NA; MRLs are for non-cancer effects only. **Tier 3 Source:** **MDEQ:** Per DEQ-CCD, no value at this time.		Complete
Reference Concentration (RfC) or Initial Threshold Screening Level (ITSL) (µg/m³)	--	5.5E+0	PPRTV, 2006	
RfC/ITSL details	NA	**Tier 2 Source:** **PPRTV:** **Basis:** PPRTV is the only available value. **Critical Study**: Hosovski, E., Z. Mastelica, D. Suderic and D. Radulovic. 1990. Mental abilities of workers exposed to aluminum. Med. Lav. 81(2):119-123. **Method(s)**: occupational study, in which workers were exposed to presumed time-weighted average (TWA) concentrations of 4.6-11.5 mg Al/m3 magnitude for an average of 12 years. **Critical effect**: Psychomotor and cognitive impairment **End point or Point of Departure (POD):** LOAEL = 4.6 mg Al/m^3 adjusted for discontinuous exposure (10 m^3/20 m^3 and 5 days/7 days) to 1.64 mg/m^3 **Uncertainty Factors**: UF = 300 (10 each for intraspecies variability and LOAEL to		Complete

	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
		NOAEL, and 3 for inadequate database). **Source and date:** PPRTV, 10/23/2006 **Tier 1 and 2 Sources:** **IRIS:** No IRIS RfC available at this time. **MRL:** Per ATSDR (9/2008), no inhalation MRL value at this time. **Tier 3 Source:** **MDEQ:** Per DEQ-CCD, no value at this time.		
Inhalation Unit Risk Factor (IURF) ((µg/m^3)$^{-1}$)		NA	MDEQ, 2015	
IURF details		**Carcinogen Weight-of-Evidence (WOE) Class**: *"inadequate information to assess carcinogenic potential*". **IRIS WOE Basis**: insufficient evidence in epidemiological/occupational studies, lack of demonstrated carcinogenicity or mutagenicity in available animal studies, lack of positive evidence of non-carcinogenicity and lack of mode of action data for aluminum **Source and Date**: PPRTV, 10/23/2006 **Tier 1 and 2 Sources:** **IRIS:** No IRIS file available at this time. **PPRTV:** Per PPRTV (10/23/2006), no value at this time. **MRL:** NA; MRLs are for non-cancer effects only. **Tier 3 Source:** **MDEQ:** Per DEQ-CCD, no value at this time.		Complete
Mutagenic Mode of Action (MMOA)? (Y/N)	--	NO	USEPA, 2015	
MMOA Details	NA	NA Not listed as a carcinogen with mutagenic MOA in the USEPA OSWER List.		

	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
Developmental or Reproductive Effector? (Y/N)	No	YES-oral, the RfD is based on a reproductive-developmental effect. Oral Exposure Pathways- Single Exposure No-inhalation, the RfC is not based on a reproductive-developmental effect.	MDEQ, 2015	
Developmental or Reproductive Toxicity Details	NA	**Critical Study (ies)**: Golub MS, Germann SL, Han B, et al. 2000. Lifelong feeding of a high aluminum diet to mice. Toxicology 150:107-117 **Method(s)**: Groups of 8 male and 10 female Swiss Webster mice were exposed to 7 or 1,000 Ig Alig diet as aluminum lactate in diet. The investigators estimated adult doses of <1 and 100 mg/kg/day. The mice were exposed to aluminum from conception (via feeding the dams) through 24 months of age. In a companion study, groups of 6–9 male and female Swiss Webster mice or 7 male and female C57BL/6J mice (number per sex were not reported) were exposed to 7 or 1,000 Ig Alig diet as aluminum lactate in diet (<1 and 100 mg/kg/day) from conception (via feeding the dams) through 24 months of age. **Critical effect**: decreased forelimb and hind limb grip strength and decreased thermal sensitivity.		
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)	50	50	SDWA, 1976 and USEPA SMCL List	
SMCL details	SDWA, 1976	MI Safe Drinking Water Act (SDWA) 1976 PA 399 and USEPA SMCL List, 2015		
Is there an aesthetic value for drinking water? (Y/N)	Yes	**YES**		
Aesthetic value (ug/L)	50	50	USEPA, 2015 and SDWA, 1976	

	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
Aesthetic Value details		USEPA, 2015 and SDWA, 1976		
Phytotoxicity Value? (Y/N)	NO	Not evaluated.	NA	
Phytotoxicity details	NA	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		MDEQ, 2015/USEPA RAGS-E, 2004		
Skin absorption efficiency value (AEd)	---	0.01	MDEQ, 2015	
AEd details				
Ingestion Absorption Efficiency (AEi)		0.5	MDEQ, 2015	
AEi Details				
Relative Source Contribution for Water (RSC_W)		0.2	MDEQ, 2015	
Relative Source Contribution for Soil (RSC_S)		1.0	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)	NA
Updated GSI value (µg/L)	NA
Rule 57 Drinking Water Value (µg/L)	NA

	Rule 57 Value (µg/L)	Verification Date
Human Non-cancer Values- Drinking water source (HNV-drink)		
Human Non-Cancer Values- Non-drinking water sources (HNV-Non-drink)		
Wildlife Value (WV)		
Human Cancer Values for Drinking Water Source (HCV-drink)		
Human Cancer values for non-drinking water source (HCV-Non-drink)		
Final Chronic Value (FCV)		
Aquatic maximum value (AMV)		
Final Acute Value (FAV)		

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)	1,000	MDEQ, 2015
Target Detection Limit – Water (μg/L)	50	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