



CHEMICAL UPDATE WORKSHEET

Chemical Name:	Phosphorous, White (DD)
CAS #:	7723-14-0 (this CAS is used by IRIS and ATSDR for white phosphorous)
Revised By:	RRD Toxicology Unit
Revision Date:	November 30, 2015

(A) Chemical-Physical Properties

	Part 201 Value	Updated Value	Reference Source	Comments
Molecular Weight (g/mol)	123.9	34	EPI	EXP
Physical State at ambient temp	Inorganic	Inorganic	MDEQ	
Melting Point (°C)	---	44.10	EPI	EXP
Boiling Point (°C)	---	280.00	EPI	EXP
Solubility (ug/L)	NA	3300	EPI	EXP
Vapor Pressure (mmHg at 25°C)	NA	NR	NA	NA
HLC (atm-m³/mol at 25°C)	NR	2.44E-02	PP	EST
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; cm²/s)	NR	NR	NA	NA
Diffusivity in Water (Dw; cm²/s)	NR	NR	NA	NA
Soil Water Partition Coefficient (Kd; inorganics)	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 ³)		NR	NA	NA
EMSOFT Flux Residential 2 m (mg/day/cm ²)	NA	NR	NR	EST
EMSOFT Flux Residential 5 m (mg/day/cm ²)	NA	NR	NR	EST
EMSOFT Flux Nonresidential 2 m (mg/day/cm ²)	NA	NR	NR	EST
EMSOFT Flux Nonresidential 5 m (mg/day/cm ²)	NA	NR	NR	EST

(B) Toxicity Values/Benchmarks

	Part 201 Value	Updated Value	Source/Reference/Date	Comments/Notes/Issues
Reference Dose (RfD) (mg/kg/day)	1.5E-5	2.0E-5	IRIS, 1993	
RfD details	<p>One-generation reproductive study in rats, NOAEL = 0.015 mg/kg-d; UF = 1000; Critical effects = parturition mortality, forelimb hair loss (Condray, 1985). *RfD changed to 2 significant figures.</p> <p>CCD/RRD date: 5/17/1990</p>	<p>Tier 1 Source: Basis: IRIS is selected because it is a Tier 1 source and conducted around the same time as the ATSDR MRL. It is the same value and based on the same study as ATSDR. ATSDR (9/1997) intermediate oral MRL = 0.0002 (2.0E-4) mg/kg-day. An additional UF = 10 is applied to account for database deficiencies (incomplete reproductive/developmental data and a less than adequate lifetime study). Per ATSDR, the EPA RfD is based on the same NOAEL of 0.015 mg/kg/day and the same study (IRDC 1985) used for deriving the MRL. Critical Study: International Research and Development Corporation (IRDC) 1985 Methods: A one generation reproduction study was conducted in rats. Charles River COBS CD rats (15 male and 30 female rats/group) were exposed to 0.005, 0.015 and 0.075 mg/kg/day elemental phosphorus at a dose volume of 5 ml/kg. Test and control materials (corn oil) were administered 80 days prior to mating. The F0 generation was mated twice to produce “a” and “b” offspring. In males, dosing continued until sacrifice. Dosing of females was continued through gestation and weaning of the pups. Critical effect: reproductive effects (increased mean number of stillborn pups, parturition effect, and decreased mean number of viable pups at birth) End point or Point of Departure (POD): NOAEL = 0.015 mg/kg/day Uncertainty Factors: UF = 1000 (10 each for intraspecies variability, interspecies extrapolation, and incomplete reproductive/developmental data and less than lifetime study) Source and date: ATSDR, 9/1997</p> <p>Tier 1 and 2 Sources: IRIS: IRIS (2/01/1993) RfD = 2.0E-5 mg/kg-day. Critical Study: Condray JR. 1985. Elemental yellow phosphorus one-generation reproduction study in rats. IR-82-215; IRD No. 401-189. Monsanto Company, St. Louis, MO. [This study and IRDC 1985 are the same studies.]</p>		Complete



	Part 201 Value	Updated Value	Source/Reference/Date	Comments/Notes/Issues
		<p>Methods: Elemental yellow (white) phosphorus in corn oil was administered orally by gavage to groups of 15 males and 30 female Sprague-Dawley rats at doses of 0, 0.005, 0.015, or 0.075 mg/kg/day beginning at 80 days prior to mating and continuing through weaning of two complete reproductive cycles.</p> <p>Critical effect: Parturition mortality (maternal toxicity); forelimb hair loss</p> <p>End point or Point of Departure (POD): NOAEL = 0.015 mg/kg-day (maternal toxicity)</p> <p>Uncertainty Factors: UF = 1,000 (10 each for intraspecies variability, interspecies extrapolation, and database deficiencies (incomplete reproductive/developmental data and a less than adequate lifetime study)).</p> <p>Source and date: IRIS, Last revision date - 2/01/1993. An EPA screening-level review in 2003 did not identify any critical new studies.</p> <p>PPRTV: No PPRTV record is available at this time.</p> <p>MRL: Per ATSDR (9/1997), no chronic oral MRL at this time.</p> <p>Tier 3 Source: MDEQ: Per DEQ-CCD (5/17/1990), RfD =1.5E-5 mg/kg/day based on IRIS but differs from IRIS RfD in that two significant figures are presented. See Part 201 RfD details.</p>		
Oral Cancer Slope Factor (CSF) (mg/kg-day ⁻¹)	--	NA	MDEQ, 2015	
CSF details	NA	<p>Carcinogen Weight-of-Evidence (WOE) Class: D – not classifiable as to human carcinogenicity</p> <p>IRIS WOE Basis: no data in humans or animals</p> <p>Source and Date: IRIS, Last revision date - 2/01/1993</p> <p>Other Sources: IRIS: Per IRIS (2/01/1993), no value at this time. PPRTV: No PPRTV record is available at this time. MRL: NA; MRLs are for non-cancer effects only.</p>		Complete



	Part 201 Value	Updated Value	Source/Reference/Date	Comments/Notes/Issues
		Tier 3 Source: MDEQ: Per DEQ-CCD, no value at this time.		
Reference Concentration (RfC) or Initial Threshold Screening Level (ITSL) ($\mu\text{g}/\text{m}^3$)	--	2.0E-1	ATSDR, 1997/MDEQ, 2015	
RfC/ITSL details	NA	<p>Basis: Based on ATSDR (9/1997) acute inhalation MRL = $0.02 \text{ mg}/\text{m}^3$ ($2.0\text{E}+1 \mu\text{g}/\text{m}^3$). MDEQ applied additional UFs of 100 to account for acute to chronic extrapolation (10x) and database deficiency (10x) to derive a chronic RfC of $0.2 \mu\text{g}/\text{m}^3$. The MDEQ/AQD (2015) ITSL = $1.8 \mu\text{g}/\text{m}^3$ is based on an extrapolated oral endpoint.</p> <p>Tier 1 and 2 Source: IRIS: Per IRIS (2/01/1993), no value at this time. PPRTV: No PPRTV record is available at this time. MRL: Per ATSDR (9/1997), no chronic or intermediate inhalation MRL at this time.</p> <p>Acute MRL: ATSDR (9/1997) acute inhalation MRL = $0.02 \text{ mg}/\text{m}^3$ ($2.0\text{E}+1 \mu\text{g}/\text{m}^3$). Critical Study: White SA, Armstrong GC. 1935. White phosphorus smoke: It's irritating concentration for man and its toxicity for small animals for one-hour exposures. E.A.T.P. 190, Project A 5.2-I. Methods: In two acute-duration exposure studies, respiratory effects have been reported by men inhaling white phosphorus smoke for 2-15 minutes. At the lowest concentration tested ($187 \text{ mg phosphorus pentoxide equivalents}/\text{m}^3$ [$258 \text{ mg orthophosphoric acid equivalents}/\text{m}^3$] for 5 minutes), throat irritation during talking was reported. At higher concentrations $\geq 514 \text{ mg phosphorus pentoxide equivalents}/\text{m}^3$ [$709 \text{ mg orthophosphoric acid equivalents}/\text{m}^3$] for 15 minutes), coughing and nose irritation were reported Critical effect: throat irritation, coughing and headache End point or Point of Departure (POD): NOAEL = $187 \text{ mg}/\text{m}^3$ Uncertainty Factors: UF = 30 (10 for intraspecies variability and 3 for use of a</p>		Complete



	Part 201 Value	Updated Value	Source/Reference/Date	Comments/Notes/Issues
		minimal LOAEL) Calculation: $187 \text{ mg/m}^3 \times 5/60 \text{ min} \times 1/24 \text{ hr.} \times 1/30 \text{ UF} = 0.02 \text{ mg/m}^3$. Source and date: ATSDR, 9/1997 Tier 3 Source: MDEQ: Per DEQ-CCD (2/23/2015), ITSL = $1.8\text{E}+0 \text{ } \mu\text{g/m}^3$. Basis: The RfD value was derived from the NOAEL in the reproductive toxicity rat study (Condray, 1985). Critical Study: Condray JR. 1985. Elemental yellow phosphorus one-generation reproduction study in rats. IR-82-215; IRD No. 401-189. Monsanto Company, St. Louis, MO. [This study and IRDC 1985 are the same studies.] Method(s): Elemental yellow (white) phosphorus in corn oil was administered orally by gavage to groups of 15 males and 30 female Sprague-Dawley rats at doses of 0, 0.005, 0.015, or 0.075 mg/kg/day beginning at 80 days prior to mating and continuing through weaning of two complete reproductive cycles. Critical effect: Parturition mortality (maternal toxicity); fore limb hair loss End point or Point of Departure (POD): NOAEL = 0.015 mg/kg-day (maternal toxicity) Uncertainty Factors: UF = 30 (10 for intraspecies variability and 3 for interspecies extrapolation) Since the 1991 study gives more confidence to the key study, the incomplete database uncertainty factor of 10 was removed in the present assessment. Also, an uncertainty factor of 3 is recommended by EPA guidance for interspecies extrapolation. Source and date: MDEQ-CCD/AQD, 2/23/2015		
Inhalation Unit Risk Factor (IURF) ($\mu\text{g/m}^3$)⁻¹	--	NA	MDEQ, 2015	
IURF details	NA	Carcinogen Weight-of-Evidence (WOE) Class: D – not classifiable as to human carcinogenicity IRIS WOE Basis: no data in humans or animals Source and Date: IRIS, Last revision date - 2/01/1993 Other Sources:		Complete



	Part 201 Value	Updated Value	Source/Reference/Date	Comments/Notes/Issues
		<p>IRIS: Per IRIS (2/01/1993), no value at this time. PPRTV: No PPRTV record is available at this time. MRL: NA; MRLs are for non-cancer effects only.</p> <p>Tier 3 Source: MDEQ: Per DEQ-CCD, no value at this time.</p>		
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)	Yes	YES-oral, the RfD is based on a reproductive-developmental effect. Oral Exposure Pathways- Single Exposure	MDEQ, 2015	
Developmental or Reproductive Toxicity Details	NA	<p>Critical effect: reproductive effects (increased mean number of stillborn pups, parturition effect, and decreased mean number of viable pups at birth) Critical Study: International Research and Development Corporation (IRDC) 1985 Methods: A one generation reproduction study was conducted in rats. Charles River COBS CD rats (15 male and 30 female rats/group) were exposed to 0.005, 0.015 and 0.075 mg/kg/day elemental phosphorus at a dose volume of 5 ml/kg. Test and control materials (corn oil) were administered 80 days prior to mating. The F0 generation was mated twice to produce "a" and "b" offspring. In males, dosing continued until sacrifice. Dosing of females was continued through gestation and weaning of the pups.</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
SMCL details	NA	MI Safe Drinking Water Act (SDWA) 1976 PA 399 and USEPA SMCL List, 2015		
Is there an aesthetic value for drinking water? (Y/N)	NO	Not evaluated.	NA	
Aesthetic value (ug/L)	NA	NA	NA	
Aesthetic Value details	NA	NA		
Phytotoxicity Value? (Y/N)	NO	Not evaluated.	NA	
Phytotoxicity details	NA	NA	NA	
Others				

(C) Chemical-specific Exposure Factors

	Part 201 Value	Update	Source/Reference/ Dates	Comments/Notes /Issues
Gastrointestinal absorption efficiency value (ABS_{gi})	---	1.0	MDEQ, 2015/USEPA RAGS-E, 2004	
ABS_{gi} details		RAGS E (USEPA, 2004) Default Value		
Skin absorption efficiency value (AE_d)	---	0.1	MDEQ, 2015/USEPA RAGS-E, 2004	
AE_d details		RAGS E (EPA, 2004): There is no default value assigned for inorganics because the speciation of the compound is critical to the dermal absorption and there are too little data to extrapolate a reasonable default value.		
Ingestion Absorption Efficiency (AE_i)		0.5	MDEQ, 2015	
AE_i 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) Analytical Information

	Value	Source
Target Detection Limit – Soil ($\mu\text{g}/\text{kg}$)	1	MDEQ, 2015
Target Detection Limit – Water ($\mu\text{g}/\text{L}$)	0.005	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 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