



CHEMICAL UPDATE WORKSHEET

Chemical Name:	Tetrachloroethylene
CAS #:	127-18-4
Revised By:	RRD Toxicology Unit
Revision Date:	August 19, 2015

(A) Chemical-Physical Properties

	Part 201 Value	Updated Value	Reference Source	Comments
Molecular Weight (g/mol)	165.83	165.83	EPI	EXP
Physical State at ambient temp	Liquid	Liquid	MDEQ	
Melting Point (°C)	---	-22.30	EPI	EXP
Boiling Point (°C)	121.3	121.30	EPI	EXP
Solubility (ug/L)	2.0E+5	206000	EPI	EXP
Vapor Pressure (mmHg at 25°C)	18.24	1.85E+01	EPI	EXP
HLC (atm-m³/mol at 25°C)	1.84E-2	1.77E-02	EPI	EXP
Log Kow (log P; octanol-water)	2.67	3.40	EPI	EXP
Koc (organic carbon; L/Kg)	156	94.94	EPI	EST
Ionizing Koc (L/kg)		NR	NA	NA
Diffusivity in Air (Di; cm²/s)	0.072	5.05E-02	W9	EST
Diffusivity in Water (Dw; cm²/s)	8.2E-6	9.46E-06	W9	EST
Soil Water Partition Coefficient (Kd; inorganics)	NR	NR	NA	NA

	Part 201 Value	Updated Value	Reference Source	Comments
Flash Point (°F)	NA	NA	NA	NA
Lower Explosivity Level (LEL; unitless)	NA	NA	NA	NA
Critical Temperature (K)		6.20E+02	EPA2004	EXP
Enthalpy of Vaporization (cal/mol)		8.29E+03	EPA2004	EXP
Density (g/mL, g/cm ³)		1.623	CRC	EXP
EMSOFT Flux Residential 2 m (mg/day/cm ²)	2.63E-05	2.78E-05	EMSOFT	EST
EMSOFT Flux Residential 5 m (mg/day/cm ²)	6.19E-05	6.70E-05	EMSOFT	EST
EMSOFT Flux Nonresidential 2 m (mg/day/cm ²)	3.73E-05	4.42E-05	EMSOFT	EST
EMSOFT Flux Nonresidential 5 m (mg/day/cm ²)	8.66E-05	1.06E-04	EMSOFT	EST

(B) Toxicity Values/Benchmarks

	Part 201 Value	Updated Value	Source/Reference/Date	Comments/Notes/Issues
Reference Dose (RfD) (mg/kg/day)	1.0E-2	6.0E-3	IRIS, 2012	
RfD details	6-week mouse gavage study. NOAEL = 20 mg/kg, adjusted to 14 mg/kg for gavage schedule; LOAEL = 100 mg/kg (adjusted to 71 mg/kg); Critical effect = hepatotox in mice and weight gain in rats. UF = 1000 (Buben & O'Flaherty, 1985); CCD/RRD date: 9/17/1987	<p>Tier 1 Source: IRIS: Basis: IRIS is a Tier 1 source. IRIS tetrachloroethylene RfD= 6.0E-3 mg/kg/day. Critical Studies: 1) Echeverria, D; White, RF; Sampaio, C. (1995). A behavioral evaluation of PCE exposure in patients and dry cleaners: A possible relationship between clinical and preclinical effects. J Occup Environ Med 37: 667-680. 2) Cavalleri, A; Gobba, F; Paltrinieri, M; Fantuzzi, G; Righi, E; Aggazzotti, G. (1994). Perchloroethylene exposure can induce color vision loss. Neurosci Lett 179: 162-166. http://dx.doi.org/10.1016/0304-3940(94)90959-8. Methods: Candidate RfDs were developed through a route-to-route extrapolation. The oral exposure POD equivalent to the continuous inhalation exposure NOAELs or LOAELs was estimated via PBPK modeling. The candidate RfDs ranged from 2.6 × 10⁻³ to 9.7 × 10⁻³ mg/kg-day. The RfD of 6.0E-3 mg/kg-day is the midpoint of this range. Critical effect: 1) neurotoxicity (reaction time, cognitive effects) in occupationally-exposed adults, and 2) neurotoxicity (color vision) in occupationally-exposed adults End point or Point of Departure (POD): 1) LOAEL = 9.7 mg/kg-day; 2) LOAEL = 2.6 mg/kg-day Uncertainty Factors: UF = 1, 000 (10 each for interspecies variability, LOAEL to NOAEL extrapolation and database deficiencies) Source and date: IRIS, Last revision date - 02/10/2012. An IRIS Toxicological Review is available.</p> <p>Tier 2 Sources: PPRTV: No PPRTV record available at this time. MRL: Per ATSDR (10/2014), a DRAFT chronic oral MRL = 8.0E-3 mg/kg-day is</p>	IRIS, 2012	Complete



	Part 201 Value	Updated Value	Source/Reference/Date	Comments/Notes/Issues
		<p>derived as follows. From 4/2015 MRL list.</p> <p>Critical Studies:</p> <p>1) Cavalleri A; Gobba F; Paltrinieri M; et al. 1994. Perchloroethylene exposure can induce color vision loss. <i>Neurosci Lett</i> 179:162-166.</p> <p>2) Gobba F; Righi E; Fantuzzi G; et al. 1998. Two-year evolution of perchloroethylene-induced color-vision loss. <i>Arch Environ Health</i> 53:196-198.</p> <p>Method(s): Color vision was evaluated in 35 tetrachloroethylene-exposed workers (22 dry cleaners and 13 ironers) with an average of 106 months of exposure. Concentrations were measured in the breathing zone by personal passive samplers. The TWA concentrations for all workers ranged from 0.38–31.19 ppm, with mean exposures of 6.23, 7.27, and 4.80 ppm for all workers, dry cleaners, and ironers, respectively. Controls included an equal number (35) of workers without occupational exposure to solvents, and were matched for sex, age, alcohol consumption, and cigarette smoking. The subjects were reexamined 2 years later using the same test; results were reported by Gobba et al. (1998).</p> <p>Critical effect: increased CCI scores (decreased color vision)</p> <p>End point or Point of Departure (POD): LOAEL = 7.3 ppm. Converted to equivalent continuous exposure LOAEL = 1.7 ppm (7.3ppm x 8/24hrs x 5/7 days). Based on simulations of the Chiu and Ginsberg (2011) model, a continuous inhalation exposure to 1.7 ppm yields the same 24-hour AUC as a continuous oral dose of 2.3 mg/kg/day.</p> <p>Uncertainty Factors: UF = 100 (10 each for interspecies variability and use of a LOAEL); MF = 3 for database deficiencies</p> <p>Source and date: ATSDR, 3/2015 from 4/2015 MRL list.</p> <p>Tier 3 Source:</p> <p>MDEQ: Per DEQ-CCD (9/17/1987), RfD = 1.0E-2 mg/kg-day. See Part 201 Value RfD details.</p>		
Oral Cancer Slope Factor (CSF) (mg/kg-day) ⁻¹	2.6E-2	2.1E-3	IRIS, 2012	



	Part 201 Value	Updated Value	Source/Reference/Date	Comments/Notes/Issues
CSF details	Per RD: Increased incidence of hepatocellular carcinomas in B6C3F1 female mice exposed via gavage for 78 weeks followed by a 12 week observation period. Metabolized doses were used in the cancer model. The male mouse data resulted in a higher potency but the female data were used for criteria development because a clearer dose-response pattern was observed. Revised species scaling factor of (BWh/BWa) to the 0.25 power used for q* calculation. RD calculation date: 1/27/00.	<p>Tier 1 Source: IRIS: Basis: IRIS is a Tier 1 source. IRIS tetrachloroethylene CSF= 2.1E-3 (mg/kg-day)⁻¹. Critical Study: JISA (Japan Industrial Safety Association). (1993). Carcinogenicity study of tetrachloroethylene by inhalation in rats and mice. Hadano, Japan. Methods: 1) <i>Dose response data: Tumor Type</i> - Hepatocellular adenomas or carcinomas; <i>Test Species</i> - Male Crj:BDF1 mice; <i>Route</i> - inhalation 2) <i>Extrapolation method:</i> Multistage model (with linear extrapolation from the point of departure (BMDL10), followed by route-to-route extrapolation to the oral route and interspecies extrapolation using the PBPK model of Chiu and Ginsberg (2011) Carcinogen Weight-of-Evidence (WOE) Class: “likely to be carcinogenic in humans by all routes of exposure.” IRIS WOE Basis: based on suggestive evidence of carcinogenicity in epidemiologic studies and conclusive evidence that the administration of tetrachloroethylene, either by ingestion or by inhalation to sexually mature rats and mice, increases tumor incidence. Source and Date: IRIS, Last revision date - 02/10/2012. An IRIS Toxicological Review is available.</p> <p>Tier 2 Sources: PPRTV: No PPRTV record available at this time. MRL: NA; MRLs are for non-cancer effects only.</p> <p>Tier 3 Source: MDEQ: Per DEQ-CCD/RRD, CSF = (2.6E-2 mg/kg-day)⁻¹. See Part 201 Value CSF details.</p>	IRIS, 2012	Complete
Reference Concentration (RfC) or Initial	--	4.0E+1	IRIS, 2012	



	Part 201 Value	Updated Value	Source/Reference/Date	Comments/Notes/Issues
Threshold Screening Level (ITSL) ($\mu\text{g}/\text{m}^3$)				
RfC/ITSL details	NA	<p>Tier 1 Source: IRIS: Basis: IRIS is a Tier 1 source. IRIS tetrachloroethylene RfC= 4.0E+1 $\mu\text{g}/\text{m}^3$. Critical Studies: 1) Echeverria, D; White, RF; Sampaio, C. (1995). A behavioral evaluation of PCE exposure in patients and dry cleaners: A possible relationship between clinical and preclinical effects. J Occup Environ Med 37: 667-680. 2) Cavalleri, A; Gobba, F; Paltrinieri, M; Fantuzzi, G; Righi, E; Aggazzotti, G. (1994). Perchloroethylene exposure can induce color vision loss. Neurosci Lett 179: 162-166. http://dx.doi.org/10.1016/0304-3940(94)90959-8. Methods: 1) Echeverria et al. (1995) examined 65 dry cleaners in Detroit, MI, using a standardized neurobehavioral battery. 2) Cavalleri et al. (1994) tested the color vision among 35 dry cleaning and laundry workers compared to 35 controls matched on age, alcohol consumption, and smoking. The candidate RfCs from these two studies ranged from 0.015 to 0.056 mg/m^3. The RfC, 0.04 mg/m^3, is the midpoint of this range rounded to one significant figure. Critical effect: 1) neurotoxicity (reaction time, cognitive effects) in occupationally-exposed adults, and 2) neurotoxicity (color vision) in occupationally-exposed adults End point or Point of Departure (POD): 1) $\text{LOAEL}_{\text{HEC}} = 56 \text{ mg}/\text{m}^3$, 2) $\text{LOAEL}_{\text{HEC}} = 15 \text{ mg}/\text{m}^3$ Uncertainty Factors: UF = 1, 000 (10 each for interspecies variability, LOAEL to NOAEL extrapolation and database deficiencies) Source and date: IRIS, Last revision date - 02/10/2012. An IRIS Toxicological Review is available.</p> <p>Tier 2 Sources:</p>		Complete



	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
		<p>PPRTV: No PPRTV record available at this time.</p> <p>MRL: MRL: Per ATSDR List (12/2014), a DRAFT chronic inhalation MRL = 6.0E-3 ppm is derived as follows.</p> <p>Critical Studies:</p> <p>1) Cavalleri A; Gobba F; Paltrinieri M; et al. 1994. Perchloroethylene exposure can induce color vision loss. Neurosci Lett 179:162-166.</p> <p>2) Gobba F; Righi E; Fantuzzi G; et al. 1998. Two-year evolution of perchloroethylene-induced color-vision loss. Arch Environ Health 53:196-198.</p> <p>Methods: Color vision was evaluated in 35 tetrachloroethylene-exposed workers (22 dry cleaners and 13 ironers) with an average of 106 months of exposure. Concentrations were measured in the breathing zone by personal passive samplers. The TWA concentrations for all workers ranged from 0.38–31.19 ppm, with mean exposures of 6.23, 7.27, and 4.80 ppm for all workers, dry cleaners, and ironers, respectively. Controls included an equal number (35) of workers without occupational exposure to solvents, and were matched for sex, age, alcohol consumption, and cigarette smoking. The subjects were reexamined 2 years later using the same test; results were reported by Gobba et al. (1998).</p> <p>Critical effect: increased CCI scores (decreased color vision)</p> <p>End point or Point of Departure (POD): LOAEL = 1.7 ppm. The 7.3 ppm concentration was multiplied by 8/24 hours and 5/7 days to yield an equivalent continuous exposure concentration of 1.7 ppm.</p> <p>Uncertainty Factors: UF = 100 (10 each for interspecies variability and use of a LOAEL); MF = 3 for database deficiencies</p> <p>Source and date: ATSDR, 3/2015 draft from 4/2015 MRL list.</p> <p>Tier 3 Source:</p> <p>MDEQ: Per DEQ-CCD (3/28/2012), AQD adopted the IRIS RfC. On 20-March, 2013 an acute ITSL of 1400 µg/m³ with 24-hr averaging time was created based on ATSDR MRL of 0.2 ppm.</p>		
<p>Inhalation Unit Risk Factor (IURF) ((µg/m³)⁻¹)</p>	<p>5.8E-7</p>	<p>3.0E-7</p>	<p>IRIS, 2012</p>	



	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
IURF details	NA	<p>Tier 1 Source: IRIS: Basis: IRIS is a Tier 1 source. IRIS tetrachloroethylene IURF= 3.0E-7 (µg/m³)⁻¹ Critical Study (ies): JISA (Japan Industrial Safety Association). (1993). Carcinogenicity study of tetrachloroethylene by inhalation in rats and mice. Hadano, Japan. Method(s): 2-year (104-week) carcinogenicity study; F344DuCrj (Fischer) rats and Crj:BDF1 mice (400 rats and 400 mice) were used in a total of 4 groups, 3 study sample treatment groups and 1 control group, of 50 males and females each. Based on two-week and 13-week preliminary studies, the concentration was set at 600 ppm, 200 ppm and 50 ppm in rats and 250 ppm, 50 ppm, and 10 ppm in mice, and administered for 6 hours/day, 5 days a week for 104 weeks. 1) <i>Dose response data: Tumor Type</i> - Hepatocellular adenomas or carcinomas; <i>Test Species</i> - Male Crj:BDF1 mice; <i>Route</i> - inhalation 2) <i>Extrapolation method:</i> Multistage model (with linear extrapolation from the point of departure (BMCL₁₀), followed by extrapolations to humans using the PBPK model of Chiu and Ginsberg (2011) Carcinogen Weight-of-Evidence (WOE) Class: “likely to be carcinogenic in humans by all routes of exposure.” IRIS WOE Basis: based on suggestive evidence of carcinogenicity in epidemiologic studies and conclusive evidence that the administration of tetrachloroethylene, either by ingestion or by inhalation to sexually mature rats and mice, increases tumor incidence. Source and Date: IRIS, Last revision date - 02/10/2012. An IRIS Toxicological Review is available.</p> <p>Tier 2 Sources: PPRTV: No PPRTV record 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 (3/28/2012), AQD adopted IRIS value for IURF = 3E-7 ($\mu\text{g}/\text{m}^3$) ⁻¹ .		
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	No, the RfD is not based on a reproductive-developmental effect.	MDEQ, 2014	
Developmental or Reproductive Toxicity Details	NA	NA		
State Drinking Water Standard (SDWS) (ug/L)	5	5	SDWA, 1976	
SDWS details	SDWA, 1976	MI Safe Drinking Water Act (SDWA) 1976 PA 399		
Secondary Maximum Contaminant Level (SMCL) (ug/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 for drinking water? (Y/N)	NO	Not evaluated.	NA	
Aesthetic value (ug/L)	--	NA	NA	
Aesthetic Value details		NA		
Phytotoxicity Value? (Y/N)	NO	Not evaluated.	NA	

	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
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 (A _{Ed})	---	0.1	MDEQ, 2015	
A _{Ed} details				
Ingestion Absorption Efficiency (A _{Ei})		1.0	MDEQ, 2015	
A _{Ei} 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)	60 (X)
Updated GSI value (µg/L)	60 (X)
Rule 57 Drinking Water Value (µg/L)	11

	Rule 57 Value (µg/L)	Verification Date
Human Non-cancer Values- Drinking water source (HNV-drink)	320	5/1997
Human Non-Cancer Values- Non-drinking water sources (HNV-Non-drink)	1,800	5/1997
Wildlife Value (WV)	NA	NA
Human Cancer Values for Drinking Water Source (HCV-drink)	11	5/1997
Human Cancer values for non-drinking water source (HCV-Non-drink)	60	5/1997
Final Chronic Value (FCV)	190	8/2012
Aquatic maximum value (AMV)	1,400	8/2012
Final Acute Value (FAV)	2,900	8/2012

Sources:

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



(E) Analytical Information

	Value	Source
Target Detection Limit – Soil ($\mu\text{g}/\text{kg}$)	50	MDEQ, 2015
Target Detection Limit – Water ($\mu\text{g}/\text{L}$)	1	MDEQ, 2015
Target Detection Limit – Air (ppbv)	5.00E+00	MDEQ, 2015
Target Detection Limit – Soil Gas (ppbv)	1.70E+02	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

