8. REGULATIONS, ADVISORIES, AND GUIDELINES

MRLs are substance specific estimates intended to serve as screening levels used by ATSDR health assessors and other responders to identify contaminants and potential health effects that may be of concern at hazardous waste sites.

An acute-duration inhalation MRL of 0.07 ppm was derived for hydrogen sulfide. This MRL is based on a minimal LOAEL of 2 ppm for a >30% alteration in two measures of lung function that are suggestive of bronchial obstruction (airway resistance and specific airway conductance) in 2 out of 10 persons with asthma (Jappinen et al. 1990). The MRL was derived by dividing the unadjusted LOAEL by an uncertainty factor of 27 (3 for the use of a minimal LOAEL, 3 for human variability, and 3 for database deficiencies). Further details on the derivation of this MRL can be found in the MRL worksheets in Appendix A of this profile.

An intermediate-duration inhalation MRL of 0.02 ppm was derived for hydrogen sulfide. This MRL is based on a NOAEL of 10 ppm and a LOAEL of 30 ppm for olfactory neuron loss in rats exposed to hydrogen sulfide 6 hours/day, 7 days/week for 10 weeks (Brenneman et al. 2000). The MRL was derived by dividing the human equivalent concentration of the NOAEL by an uncertainty factor of 30 (3 for extrapolation from animals to humans with dosimetric adjustments and 10 for human variability). Further details on the derivation of this MRL can be found in the MRL worksheets in Appendix A of this profile.

EPA has derived a chronic inhalation reference concentration (RfC) for chronic exposure to hydrogen sulfide. The RfC of 0.002 mg/m^3 (0.001 ppm) is based on a NOAEL of 13.9 mg/m^3 (10 ppm) and a LOAEL of 41.7 mg/m^3 (30 ppm) for nasal lesions of the olfactory mucosa in rats (Brenneman et al. 2000). The $NOAEL_{HEC}$ of 0.64 mg/m^3 (0.46 ppm) was divided by an uncertainty factor of 300 (3 for interspecies extrapolation with dosimetric adjustment from rat to human, 10 for sensitive populations, and 10 for subchronic exposure) (IRIS 2003).

EPA has not derived an oral reference dose (RfD) or an inhalation RfC for chronic exposure to carbonyl sulfide (IRIS 2002).

The international and national regulations, advisories, and guidelines regarding hydrogen sulfide and carbonyl sulfide in air, water, and other media are summarized in Tables 8-1 and 8-2.

Table 8-1. Regulations and Guidelines Applicable to Hydrogen Sulfide

Agency	Description	Information	Reference
INTERNATIONAL			
Guidelines:			
IARC	Carcinogenicity classification	No data	IARC 2013
WHO	Air quality guidelines	No data	WHO 2010
	Drinking water quality guidelines	No data[a]	WHO 2011
NATIONAL			
Regulations and Guidelines:			
a. Air			
ACGIH	TLV (8-hour TWA)	1 ppm	ACGIH 2012b
	STEL	5 ppm	
AIHA	ERPG-1[b,c]	0.1 ppm	AIHA 2011
	ERPG-2	30 ppm	
	ERPG-3	100 ppm	
DOE	PAC-1[d]	0.51 ppm	DOE 2012
	PAC-2	27 ppm	
	PAC-3	50 ppm	
EPA	AEGL-1[e]		EPA 2013a
	10-minutes	0.75 ppm	
	30-minutes	0.60 ppm	
	60-minutes	0.51 ppm	
	4-hours	0.36 ppm	
	8-hours	0.33 ppm	
	AEGL-2		
	10-minutes	41 ppm	
	30-minutes	32 ppm	
	60-minutes	27 ppm	
	4-hours	20 ppm	
	8-hours	17 ppm	
	AEGL-3		
	10-minutes	76 ppm	
	30-minutes	59 ppm	
	60-minutes	50 ppm	
	4-hours	37 ppm	
	8-hours	31 ppm	
	NAAQS	No data	EPA 2013d
NIOSH	REL (10-minute ceiling)	10 ppm	NIOSH 2011
	IDLH	100 ppm	

Table 8-1. Regulations and Guidelines Applicable to Hydrogen Sulfide

Agency	Description	Information	Reference
NATIONAL *(cont.)*			
OSHA	PEL (8-hour TWA) for general industry	No data	OSHA 2013b 29 CFR 1910.1000, Table Z-2
	Acceptable ceiling concentration	20 ppm	
	Acceptable maximum peak above the acceptable ceiling concentration for an 8-hour shift	50 ppm for 10 minutes once only if no other measured exposure occurs	
	Highly hazardous chemicals (threshold quantity)	1,500 pounds	OSHA 2013a 29 CFR 1910.119, Appendix A
b. Water			
EPA	Designated as hazardous substances in accordance with Section 311(b)(2)(A) of the Clean Water Act	Yes	EPA 2012c 40 CFR 116.4
	Drinking water contaminant candidate list	No data	EPA 2009a 74 FR 51850
	Drinking water standards and health advisories	No data	EPA 2012d
	National primary drinking water standards	No data	EPA 2009b
	National recommended water quality criteria		EPA 2009c
	Freshwater (criterion continuous concentration)	2.0 µg/L	
	Saltwater (criterion continuous concentration)	2.0 µg/L	
	Reportable quantities of hazardous substances designated pursuant to Section 311 of the Clean Water Act	100 pounds	EPA 2012a 40 CFR 117.3
c. Food			
FDA	EAFUS[f]	Yes	FDA 2013
d. Other			
ACGIH	Carcinogenicity classification	No data	ACGIH 2012b
EPA	Carcinogenicity classification	Data inadequate for assessment	IRIS 2003
	RfC	$2x10^{-3}$ mg/m^3	
	RfD	No data	
	Identification and listing of hazardous waste	U135	EPA 2012b 40 CFR 261, Appendix VIII
	Inert pesticide ingredients in pesticide products approved for nonfood use only	No data	EPA 2013c
	Master Testing List	No data	EPA 2013a

Table 8-1. Regulations and Guidelines Applicable to Hydrogen Sulfide

Agency	Description	Information	Reference
NATIONAL *(cont.)*			
	RCRA waste minimization PBT priority chemical list	No data	EPA 1998 63 FR 60332
EPA	Standards for owners and operators of hazardous waste TSD facilities; groundwater monitoring list	No data	EPA 2012e 40 CFR 264, Appendix IX
	Superfund, emergency planning, and community right-to-know		
	Designated CERCLA hazardous substance and reportable quantity pursuant to Section 311(b)(2) of the Clean Water Act and Section 3001 of RCRA	100 pounds	EPA 2012f 40 CFR 302.4
	Effective date of toxic chemical release reporting	01/01/1994	EPA 2012g 40 CFR 372.65
	Extremely hazardous substances and its threshold planning quantity[g]		EPA 2012h 40 CFR 355, Appendix A
	Reportable quantity	100 pounds	
	Threshold planning quantity	500 pounds	
	TSCA chemical lists and reporting periods	No data	EPA 2012i 40 CFR 712.30
	TSCA health and safety data reporting	No data	EPA 2012j 40 CFR 716.120
NTP	Carcinogenicity classification	No data	NTP 2011

[a]A guideline value was not established for hydrogen sulfide because it occurs in drinking-water at concentrations well below those of health concern; although it may affect acceptability of drinking water (WHO 2011).
[b]ERPG-1: maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odor; ERPG-2: maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action; ERPG-3: is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects (AIHA 2011).
[c]Odor should be detectable near ERPG-1.
[d]PAC-1: mild, transient health effects; PAC-2: irreversible or other serious health effects that could impair the ability to take protective action; PAC-3: life-threatening health effects (DOE 2012).
[e]AEGL-1: is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic, nonsensory effects; however, these effects are not disabling and are transient and reversible upon cessation of exposure; AEGL-2: is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting, adverse health effects or an impaired ability to escape; AEGL-3: is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening adverse health effects or death (EPA 2013a).
[f]The EAFUS list of substances contains ingredients added directly to food that FDA has either approved as food additives or listed or affirmed as GRAS.
[g]Hydrogen sulfide does not meet the toxicity criteria but because of its acute lethality, high production volume, or known risk it is considered a chemical of concern.

Table 8-1. Regulations and Guidelines Applicable to Hydrogen Sulfide

Agency	Description	Information	Reference

ACGIH = American Conference of Governmental Industrial Hygienists; AEGL = acute exposure guideline levels; AIHA = American Industrial Hygiene Association; CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act; CFR = Code of Federal Regulations; DOE = Department of Energy; EAFUS = Everything Added to Food in the United States; EPA = Environmental Protection Agency; ERPG = emergency response planning guidelines; FDA = Food and Drug Administration; FR = Federal Register; GRAS = generally recognized as safe; IARC = International Agency for Research on Cancer; IDLH = immediately dangerous to life or health; IRIS = Integrated Risk Information System; NAAQS = National Ambient Air Quality Standards; NIOSH = National Institute for Occupational Safety and Health; NTP = National Toxicology Program; OSHA = Occupational Safety and Health Administration; PAC = protective action criteria; PBT = persistent, bioaccumulative, and toxic; PEL = permissible exposure limit; RCRA = Resource Conservation and Recovery Act; REL = recommended exposure limit; RfC = inhalation reference concentration; RfD = oral reference dose; STEL = short-term exposure level; TLV = threshold limit values; TSCA = Toxic Substances Control Act; TSD = treatment, storage, and disposal; TWA = time-weighted average; USC = United States Code; WHO = World Health Organization

Table 8-2. Regulations and Guidelines Applicable to Carbonyl Sulfide

Agency	Description	Information	Reference
INTERNATIONAL			
Guidelines:			
IARC	Carcinogenicity classification	No data	IARC 2013
WHO	Air quality guidelines	No data	WHO 2010
	Drinking water quality guidelines	No data	WHO 2011
NATIONAL			
Regulations and Guidelines:			
a. Air			
ACGIH	TLV (8-hour TWA)	5 ppm	ACGIH 2012a
AIHA	ERPG-1, -2, -3	No data	AIHA 2011
DOE	PAC-1[a]	5 ppm	DOE 2012
	PAC-2	55 ppm	
	PAC-3	150 ppm	
EPA	AEGL-1[b]	Not recommended due to lack of warning properties	EPA 2013b
	AEGL-2		
	10-minutes	69 ppm	
	30-minutes	69 ppm	
	60-minutes	55 ppm	
	4-hours	34 ppm	
	8-hours	23 ppm	
	AEGL-3		
	10-minutes	190 ppm	
	30-minutes	190 ppm	
	60-minutes	150 ppm	
	4-hours	95 ppm	
	8-hours	48 ppm	
	Hazardous air pollutant	Yes	EPA 2009d 42 USC 7412
	NAAQS	No data	EPA 2013d
NIOSH	REL (10-hour TWA)	No data	NIOSH 2013
OSHA	PEL (8-hour TWA) for general industry	No data	OSHA 2013c 29 CFR 1910.1000, Table Z-1
	Highly hazardous chemicals	No data	OSHA 2013a 29 CFR 1910.119, Appendix A

Table 8-2. Regulations and Guidelines Applicable to Carbonyl Sulfide

Agency	Description	Information	Reference
NATIONAL *(cont.)*			
b. Water			
EPA	Designated as hazardous substances in accordance with Section 311(b)(2)(A) of the Clean Water Act	No data	EPA 2012c 40 CFR 116.4
	Drinking water contaminant candidate list	No data	EPA 2009a 74 FR 51850
	Drinking water standards and health advisories	No data	EPA 2012d
	National primary drinking water standards	No data	EPA 2009b
	National recommended water quality criteria	No data	EPA 2009c
	Reportable quantities of hazardous substances designated pursuant to Section 311 of the Clean Water Act	No data	EPA 2012a 40 CFR 117.3
c. Food			
FDA	EAFUS[c]	No data	FDA 2013
d. Other			
ACGIH	Carcinogenicity classification	No data	ACGIH 2012a
EPA	Carcinogenicity classification	No data	IRIS 2002
	RfC	No data	
	RfD	No data	
	Identification and listing of hazardous waste	No data	EPA 2012b 40 CFR 261, Appendix VIII
	Inert pesticide ingredients in pesticide products approved for nonfood use only	No data	EPA 2013c
	Master Testing List	Yes[d]	EPA 2013d
	RCRA waste minimization PBT priority chemical list	No data	EPA 1998b 63 FR 60332
	Standards for owners and operators of hazardous waste TSD facilities; groundwater monitoring list	No data	EPA 2012e 40 CFR 264, Appendix IX
	Superfund, emergency planning, and community right-to-know		
	Designated CERCLA hazardous substance and reportable quantity pursuant to Section 112 of the Clean Air Act	100 pounds	EPA 2012f 40 CFR 302.4
	Effective date of toxic chemical release reporting	01/01/1987	EPA 2012g 40 CFR 372.65
	Extremely hazardous substances and its threshold planning quantity	No data	EPA 2012h 40 CFR 355, Appendix A

Table 8-2. Regulations and Guidelines Applicable to Carbonyl Sulfide

Agency	Description	Information	Reference
NATIONAL *(cont.)*			
EPA	TSCA chemical lists and reporting periods	No data	EPA 2012i 40 CFR 712.30
	TSCA health and safety data reporting	No data	EPA 2012j 40 CFR 716.120
NTP	Carcinogenicity classification	No data	NTP 2011

[a]PAC-1: mild, transient health effects; PAC-2: irreversible or other serious health effects that could impair the ability to take protective action; PAC-3: life-threatening health effects (DOE 2012).
[b]AEGL-1: is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic, nonsensory effects; however, these effects are not disabling and are transient and reversible upon cessation of exposure; AEGL-2: is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting, adverse health effects or an impaired ability to escape; AEGL-3: is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening adverse health effects or death (EPA 2013a).
[c]The EAFUS list of substances contains ingredients added directly to food that FDA has either approved as food additives or listed or affirmed as GRAS.
[d]Testing action development underway for health effects including mutagenicity, acute and subchronic toxicity, neurotoxicity, developmental and reproductive toxicity, carcinogenicity and immunotoxicity.

ACGIH = American Conference of Governmental Industrial Hygienists; AEGL = acute exposure guideline levels; AIHA = American Industrial Hygiene Association; CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act; CFR = Code of Federal Regulations; DOE = Department of Energy; EAFUS = Everything Added to Food in the United States; EPA = Environmental Protection Agency; ERPG = emergency response planning guidelines; FDA = Food and Drug Administration; FR = Federal Register; GRAS = generally recognized as safe; IARC = International Agency for Research on Cancer; IRIS = Integrated Risk Information System; NAAQS = National Ambient Air Quality Standards; NIOSH = National Institute for Occupational Safety and Health; NTP = National Toxicology Program; OSHA = Occupational Safety and Health Administration; PAC = protective action criteria; PBT = persistent, bioaccumulative, and toxic; PEL = permissible exposure limit; RCRA = Resource Conservation and Recovery Act; REL = recommended exposure limit; RfC = inhalation reference concentration; RfD = oral reference dose; TLV = threshold limit values; TSCA = Toxic Substances Control Act; TSD = treatment, storage, and disposal; TWA = time-weighted average; USC = United States Code; WHO = World Health Organization