3. CHEMICAL AND PHYSICAL INFORMATION

3.1 CHEMICAL IDENTITY

The chemical identities of lead and several of its compounds are given in Table 3-1.

3.2 PHYSICAL AND CHEMICAL PROPERTIES

The physical properties of lead and several of its compounds are listed in Table 3-2. Lead readily tarnishes in the atmosphere but is one of the most stable fabricated metals because of its corrosive resistance to air, water, and soil (Howe 1981). A waste that contains lead or lead compounds may (or may not) be characterized a hazardous waste following testing by the Toxicity Characteristic Leaching Procedure (TCLP) as prescribed by the Resource Conservation and Recovery Act (RCRA) regulations.

Divalent lead can interfere with the action of other divalent cations, such as Ca^{+2}, in biological systems.

Under the authority of the RCRA, a solid waste would be defined as hazardous if it exhibits any of the four (ignitability, corrosivity, reactivity, and toxicity) characteristics used to identify hazardous wastes.

A solid waste containing lead or lead compounds may be defined as a hazardous waste if it exhibits the characteristic of toxicity. The waste is said to exhibit the toxicity characteristic if the lead concentration in the extract obtained by subjecting a sample of the waste to the TCLP exceeds 5.0 mg/L. Tetraethyl and tetraethyl lead are combustible. If they are in sufficient quantity in a waste, tetraethyl lead may show an ignitability characteristic. More details on the regulatory requirements are presented in Chapter 7.

Table 3-1. Chemical Identity of Lead and Compounds

Characteristic	Lead[a]	Lead acetate[a]	Lead azide[b]	Lead bromide[c]
Synonym(s)	*Lead metal; plumbum;* olow (Polish); pigment metal	*Lead(2+) acetic acid;* plumbous acetate	*Initiating explosive (lead* azide, dextrinated type only)	*Lead (II) bromide* [d]
Registered trade name(s)	CI77575	Salt of Saturn; sugar of lead; Unichem PBA	No data	No data
Chemical formula[b]	Pb	$PbC_4H_6O_4$	PbN_6	$PbBr_2$
Chemical structure	Pb	$[CH_3COO]^-Pb^{2+}[CH_3COO]^-$	$N_3^-Pb^{2+}N_3^-$	$Br^-Pb^{2+}Br^-$
Identification numbers:				
CAS registry	7439-92-1	301-04-2	13424-46-9	10031-22-8
NIOSH RTECS	OF7525000	AI5250000	OF8650000	No data
EPA Hazardous Waste	D008	U144, D008	No data	No data
OHM/TADS	7216776	7217255	No data	No data
DOT/UN/NA/IMO Shipping	NA	UN 1616, IMO 6.1	UN 0129	No data
HSDB	231	1404	No data	No data
NCI	No data	No data	No data	No data

Table 3-1. Chemical Identity of Lead and Compounds (continued)

Characteristic	Lead chloride[a]	Lead chromate[a]	Lead fluoroborate[a]	Lead iodide[a]
Synonym(s)	Lead(2+) chloride; lead (II) chloride; plumbous chloride	Chromic acid (H_2CrO_4) lead(2+) salt; lead chromate (VI); phoenicochroite; and others	Borate(1-), tetrafluoro, lead(2+); lead borofluoride; lead boron fluoride; lead tetrafluoroborate	Lead diiodide; lead(II) iodide; plumbous iodide
Registered trade name(s)	No data	Canary Chrome Yellow 40-2250; Cologne Yellow; King's Yellow	No data	No data
Chemical formula[b]	$PbCl_2$	$PbCrO_4$	$Pb(BF_4)_2$	I_2Pb
Chemical structure	$Cl^-Pb^{2+}Cl^-$	$Pb^{2+}[CrO_4]^{2-}$	$[BF_4]^-Pb^{2+}[BF_4]^-$	$I^-Pb^{2+}I^-$
Identification numbers:				
CAS registry	7758-95-4	7758-97-6	13814-96-5	10101-63-0
NIOSH RTECS	OF9450000[b]	GB2975000	ED2700000	OG1515000
EPA Hazardous Waste	No data	D007, D008	D008	D008
OHM/TADS	7217256	No data	7217378	No data
DOT/UN/NA/IMO Shipping	NA 2291	No data	NA 2291; 1MO 6.1	NA 2811
HSDB	6309	1650	1991	636
NCI	No data	No data	No data	No data

Table 3-1. Chemical Identity of Lead and Compounds (continued)

Characteristic	Lead molybdenum chromate[b]	Lead nitrate[a]	Lead oxide[a]	Lead phosphate[a]
Synonym(s)	Chromic acid, lead and molybdenum salt; lead chromate, sulphate and molybdate; molybdenum-lead chromate; molybdenum orange	Lead dinitrate; nitric acid lead(2+) salt; lead (II) nitrate; plumbous nitrate	Lead(2+) oxide; lead monoxide; litharge; massicot	Lead(2+) phosphate; Phosphoric acid lead(2+) salt;
Registered trade name(s)	C.I. Pigment Red 104	No data	CI 77577; CI Pigment Yellow 46	Perlex Paste 500; Perlex Paste 600A; CI 77622
Chemical formula	$25PbCrO_4 \cdot 4PbMoO_4 \cdot PbSO_4$ [e]	PbN_2O_{64}	PbO	$Pb_3(PO_4)_2$
Chemical structure	No data	$[NO_3]^- Pb^{2+} [NO_3]^-$	Pb=O	$[PO_4]^{3-}$ $Pb^{2+} Pb^{2+} Pb^{2+} [PO_4]^{3-}$
Identification numbers:				
CAS registry	12709-98-7	10099-74-8	1317-36-8	7446-27-7
NIOSH RTECS	OG1625000	OG2100000	OG1750000	No data
EPA Hazardous Waste	No data	D008	D008	D008, U145
OHM/TADS	No data	7217257	No data	No data
DOT/UN/NA/IMCO Shipping	No data	UN 1469, IMO 5.1	No data	No data
HSDB	No data	637	638	2637
NCI	No data	No data	No data	No data

Table 3-1. Chemical Identity of Lead and Compounds (continued)

Characteristic	Lead styphnate[b]	Lead sulfate[a]	Lead sulfide[a]	Tetraethyl lead[a]
Synonym(s)	Initiating explosive lead styphnate; lead trinitroresorcinate; styphnate of lead	Sulfuric acid lead(2+) salt; lead (II) sulfate	Lead monosulfide; lead(2+) sulfide; Lead (II) sulfide; plumbous sulfide; natural galena	Lead tetraethide; TEL; tetraethyllead; tetraethylplumbane
Registered trade name(s)	No data	CI 77630; Fast White; Lead Bottoms; Mulhouse White	No data	No data
Chemical formula	$C_6H(NO_2)_3(O_2Pb)$ [c]	$PbSO_4$	PbS	$C_8H_{20}Pb$
Chemical structure	No data	$Pb^{2+}[SO_4]^{2-}$	$Pb^{2+}S^{2-}$	$(CH_3CH_2)_4Pb$
Identification numbers:				
CAS registry	63918-97-8	7446-14-2	1314-87-0	78-00-2
NIOSH RTECS	OG6425000	OG4375000 [b]	OG4550000	TP4550000
EPA Hazardous Waste	No data	No data	D008	P110; D008
OHM/TADS	No data	No data	7800071	7216922
DOT/UN/NA/IMCO Shipping	UN 0130	UN 1794; NA 1794; IMO 8.0	NA 2291; IMO 6.1	NA 1649; IMO 6.1
HSDB	No data	6308	639	841
NCI	No data	No data	No data	C54988

[a]HSDB 1996
[b]RTECS 1996
[c]Lewis 1993
[d]Lenga 1988
[e]USPATFULL 1997

CAS = Chemical Abstracts Services; DOT/UN/NA/IMO = Department of Transportation/United Nations/North America/International Maritime Dangerous Goods Code; EPA = Environmental Protection Agency; HSDB = Hazardous Substances Data Bank; NCI = National Cancer Institute; NIOSH = National Institute for Occupational Safety and Health; OHM/TADS = Oil and Hazardous Materials/Technical Assistance Data System; RTECS = Registry of Toxic Effects of Chemical Substances

Table 3-2. Physical and Chemical Properties of Lead and Compounds

Property	Lead[a]	Lead acetate[a]	Lead azide[b]	Lead bromide[b]
Molecular weight	207.20	325.28	291.25	367.04
Color	Bluish-gray	White	White	White
Physical state	Solid	Solid	Needles or powder	Crystalline powder
Melting point	327.4 °C	280 °C	No data	373 °C
Boiling point	1,740 °C	Decomposes above 200 °C	Explodes at 350 °C	916 °C[c]
Density	11.34 g/cm^3 at 20 °C	3.25 g/cm^3 at 20 °C	No data	6.66 g/cm^3 [d]
Odor	None	Slightly acetic	No data	No data
Odor threshold	No data	No data	No data	No data
Solubility:				
Water	Insoluble	2,210,000 mg/L at 50 °C	230 mg/L at 18 °C	8,441 mg/L at 20 °C[c]
Nitric acid	Soluble	No data	No data	No data
Hot conc. sulfuric acid	Soluble	No data	No data	No data
Organic solvent(s)	Insoluble	Soluble in glycerol, very slight in alcohol	Acetic acid[c]	Insoluble in alcohol
Partition coefficients:				
Log K_{ow}	No data	No data	No data	No data
Log K_{oc}	No data	No data	No data	No data
Vapor pressure	1.77 mm Hg at 1,000 °C 10 mm Hg at 1,162 °C 100 mm Hg at 1,421 °C 400 mm Hg at 1,630 °C	No data	No data	1 mmHg at 513 °C 100 mm Hg at 745 °C[c]
Henry's law constant	No data	No data	No data	No data
Autoignition temperature	No data	No data	No data	No data
Flashpoint	No data	No data	No data	No data
Flammability limits	No data	No data	Not flammable	No data
Conversion factors:				
Air	None[e]	None[e]	None[e]	None[e]
Water	1 ppm(w/v) = 1 mg/L = 1 1 µg/mL	1 ppm(w/v) = 1 mg/L = 1 µg/mL	1 ppm(w/v) = 1 mg/L = 1 µg/mL	1 ppm(w/v) = 1 mg/L = 1 µg/mL
Solid	1 ppm(w/w) = 1 mg/kg = 1 1 µg/g	1 ppm(w/w) = 1 mg/kg = 1 µg/g	1 ppm(w/w) = 1 mg/kg = 1 µg/g	1 ppm(w/w) = 1 mg/kg = 1 µg/g
Explosive limits	No data	Lead acetate-lead bromate double salt is explosive	No data	No data
Valence state	0, +2, +4[f]	+2	+2	+2

Table 3-2. Physical and Chemical Properties of Lead and Compounds (continued)

Property	Lead chloride[a]	Lead chromate[a]	Lead fluoroborate[b]	Lead iodide[a]
Molecular weight	278.11	323.22	380.81	461.01
Color	White	(Orange-)yellow	Colorless	Bright or golden yellow
Physical state	Solid	Solid	Crystalline powder	Hexagonal crystals; powder
Melting point	501 °C	844 °C	No data	402 °C
Boiling point	950 °C	Decomposes[c]	No data	954 °C[c]
Density	5.85 g/cm^3 at 20 °C[d]	6.12 g/cm^3 at 15 °C	1.75 g/cm^3 at 20 °C[d]	6.16 g/cm^3 at 20 °C
Odor	No data	Faint odor (solution)	Odorless	No data
Odor threshold	No data	No data	No data	No data
Solubility:				
Water	9,900 mg/L at 20 °C[c]	0.2 mg/L	No data	630 mg/L at 20 °C
Nitric acid	No data	Soluble in dilute acid	No data	No data
Hot concentrated sulfuric acid	No data	No data	No data	No data
Organic solvent(s)	Insoluble in alcohol[c]	Insoluble in acetic acid	Decomposes in alcohol[c]	Insoluble in alcohol[b]
Partition coefficients				
Log K_{ow}	No data	No data	No data	No data
Log K_{oc}	No data	No data	No data	No data
Vapor pressure	1 mmHg at 547 °C	No data	No data	1 mmHg at 479 °C
Henry's law constant	No data	No data	No data	No data
Autoignition temperature	No data	No data	No data	No data
Flashpoint	No data	No data	No data	No data
Flammability limits	No data	Flammable with combustible organic or other oxidizable materials	Not ignited readily	Not flammable
Conversion factors:				
Air	None[e]	None[e]	None[e]	None[e]
Water	1 ppm(w/v) = 1 mg/L = 1µg/mL	1 ppm(w/v) = 1 mg/L = 1 µg/mL	No data	No data
Solid	1 ppm(w/w) = 1 mg/kg = 1µg/g	1 ppm(w/w) = 1 mg/kg = 1 µg/g	No data	No data
Explosive limits	No data	No data	No data	No data
Valence state	+2	+2	+2	+2

Table 3-2. Physical and Chemical Properties of Lead and Compounds (continued)

Property	Lead molybdenum chromate[a]	Lead nitrate[a]	Lead oxide[a]	Lead phosphate[a]
Molecular weight	9,852 (comples)[g]	331.23	223.21	811.54
Color	Red[h]	Colorless or white	Reddish-yellow; yellow (above 489 °C)	White
Physical state	No data	Solid	Solid	Solid
Melting point	No data	Decomposes at 470 °C	886 °C (Litharge); no data (Massicot)	1,014°C
Boiling point	No data	No data	Decomposes at 1,472 °C	No data
Density	No data	4.53 g/cm^3 at 20 °C	9.3 g/cm^3 (Litharge); 8.0 g/cm^3 (Massicot)[d]	6.9–7.3 g/cm^3 [d]
Odor	No data	Odorless	No data	No data
Odor threshold	No data	No data	No data	No data
Solubility:				
Water	No data	376,500 mg/L at 0 °C (Litharge: 23 mg/L at 23 °C (Massicot)	10 mg/L at 20 °C	0.14 mg/L at 20 °C[c]
Nitric acid	No data	Insoluble	Soluble (Litharge)	Soluble
Hot conc. sulfuric acid	No data	No data	No data	No data
Organic solvent(s)	No data	1 g in 2,500 mL absolute alcohol; 1 g in 75 mL absolute alcohol	Soluble in alkali chlorides; soluble in alkali (Massicot); insoluble in alcohol	Soluble in fixed alkali hydroxides; insoluble in alcohol
Partition coefficients:				
Log K_{ow}	No data	No data	No data	No data
Log K_{oc}	No data	No data	No data	No data
Vapor pressure	No data	No data	1 mmHg at 943 °C[c]	No data
Henry's law constant	No data	No data	No data	No data
Autoignition temperature	No data	No data	No data	No data
Flashpoint	No data	No data	No data	No data
Flammability limits	No data	Fire risk with organics	Not readily ignited	No data
Conversion factors:				
Air	No data	None[e]	None[e]	None[e]
Water	No data	1 ppm(w/v) = 1 mg/L = 1 μg/mL	1 ppm(w/v) = 1 mg/L = 1μg/mL	1 ppm(w/v) = 1 mg/L = 1μg/mL
Solid	No data	1 ppm(w/w) = 1 mg/kg = 1 μg/g	1 ppm(w/w) = 1 mg/kg = 1μg/g	1 ppm(w/w) = 1 mg/kg = 1μg/g
Explosive limits	No data	Explosive with easily oxidizable substances, and lead nitrate-lead hypophosphite double salt	2–3 drops 90% peroxyformic acid causes violent explosion	No data
Valence state	No data	+2	+2	+2

Table 3-2. Physical and Chemical Properties of Lead and Compounds (continued)

Property	Lead styphnate[i]	Lead sulfate[a]	Lead sulfide[a]	Tetraethyl lead[a]
Molecular weight	450.28[g]	303.26	239.26	323.45
Color	Orange-yellow	White	Black, blue, or silvery	Colorless (unless dyed)
Physical state	Crystals	Solid	Cubic or metallic crystals; powder	Oily liquid
Melting point	No data	1,170 °C	1,114 °C	-130 °C
Boiling point	No data	No data	1,281 °C (with sublimation)	200 °C; 227.7 °C (with decomposition)
Density	No data	6.2 g/cm^3 [d]	7.5 g/cm^3	1.653 g/cm^3 at 20 °C
Odor	No data	No data	Musty, pleasant, sweet	No data
Odor threshold	No data	No data	No data	No data
Solubility:				
Water	Insoluble	42.5 mg/L at 25 °C[c]	0.86 mg/L at 13 °C	0.29 mg/L at 25 °C
Nitric acid	No data	More than in water	Soluble	No data
Hot conc. sulfuric acid	No data	Slightly soluble[d]	Soluble (in acid)	No data
Organic solvent(s)	No data	Insoluble in alcohol	Nitric acid, hot diluted hydrochloric acid[b]; insoluble in alcohol[c]	Benzene, ethanol, diethyl ether, gasoline petroleum ether
Partition coefficients:				
Log K_{ow}	No data	No data	No data	No data
Log K_{oc}	No data	No data	No data	No data
	No data	No data	1 mmHg at 852 °C[c]	0.2 mm Hg at 20 °C
Henry's law constant	No data	No data	No data	No data
Autoignition temperature	No data	No data	No data	No data
Flashpoint	No data	No data	No data	93 °C (closed cup); 85 °C (open cup)
Flammability limits	Detonates at 260 °C	Not flammable	Noncombustible	1.8%
Conversion factors:				
Air	No data	None[e]	None[e]	No data
Water	No data	1 ppm(w/v) = 1 mg/L = 1 μg/mL	1 ppm(w/v) = 1 mg/L = 1μg/mL	No data
Solid	No data	1 ppm(w/w) = 1 mg/kg = 1 μg/g	1 ppm(w/w) = 1 mg/kg = 1μg/g	No data
Explosive limits	No data	No data	No data	Potentially, above 80 °C
Valence state	No data	+2	+2	No data

[a]HSDB 1996;[b]Merck 1989; [c]Lide 1996; [d]Temperature not specified; [e]Since these compounds exist in the particulate state, their concentrations are expressed as μg/m^3 only; [f]Howe 1981; [g]Molecular weight calculated from atomic weights; [h]USPATFULL 1997; [i]Lewis 1993