

## 4. CHEMICAL AND PHYSICAL INFORMATION

### 4.1 CHEMICAL IDENTITY

Information concerning the chemical identity of elemental zinc and zinc compounds is listed in Table 4-1.

Zinc is a naturally occurring element found in the earth's surface rocks. Because of its reactivity, zinc metal is not found as the free element in nature. There are approximately 55 mineralized forms of zinc. The most important zinc minerals in the world are sphalerite ( $ZnS$ ), smithsonite ( $ZnCO_3$ ), and hemimorphite ( $Zn_4Si_2O_7(OH_2)H_2O$ ). Zinc appears in Group IIB of the periodic table and has two common oxidation states,  $Zn(0)$  and  $Zn(+2)$ . Zinc forms a variety of different compounds, such as zinc chloride, zinc oxide, and zinc sulfate (Goodwin 1998; Ohnesorge and Wilhelm 1991; WHO 2001).

### 4.2 PHYSICAL AND CHEMICAL PROPERTIES

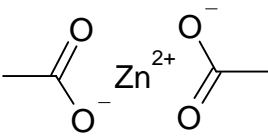
Information regarding the physical and chemical properties of elemental zinc and zinc compounds is located in Table 4-2.

Zinc is a lustrous, blue-white metal that burns in air with a bluish-green flame. It is stable in dry air, but upon exposure to moist air, it becomes covered with a film of zinc oxide or basic carbonate (e.g.,  $2ZnCO_3 \cdot 3Zn(OH)_2$ ) isolating the underlying metal and retarding further corrosion. Bonding in zinc compounds tends to be covalent, as in the sulfide and oxide (Goodwin 1998). In solution, four to six ligands can be coordinated with the zinc ion. Zinc has a strong tendency to react with acidic, alkaline, and inorganic compounds. Since zinc is amphoteric (i.e., capable of reacting chemically either as an acid or a base), it also forms zincates (e.g.,  $[Zn(OH)_3H_2O]^-$  and  $[Zn(OH)_4]^{2-}$ ) (Goodwin 1998; Ohnesorge and Wilhelm 1991; WHO 2001).

In humans and animals, zinc is an essential nutrient that plays a role in membrane stability, in over 300 enzymes, and in the metabolism of proteins and nucleic acids (WHO 2001).

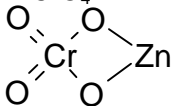
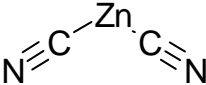
## 4. CHEMICAL AND PHYSICAL INFORMATION

**Table 4-1. Chemical Identity of Zinc and Selected Compounds<sup>a</sup>**

Characteristic	Zinc	Zinc acetate	Zinc chloride
Synonyms	Zinc dust; zinc powder	Acetic acid, zinc salt; acetic acid, zinc(II) salt; dicarbomethoxyzinc; octan zinecnaty [Czech]; zinc diacetate; zinc(II) acetate	Butter of zinc; chlorure de zinc (French); zinc (Chlorure de) (French); zinc butter; zinc chloride (ZnCl <sub>2</sub> ); zinc dichloride; zinco (cloruro di) (Italian); zinkchlorid (German); zinkchloride (Dutch)
Registered trade name(s)	Asarco; L 15; Blue powder; CI 77945; CI pigment Metal 6; Emanay zinc dust; Granular zinc; JASAD; Merrillite; PASCO	No data	Tinning flux (DOT) <sup>b</sup> ; AI3-0440; Zintrace
Chemical formula	Zn	Zn(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>	ZnCl <sub>2</sub>
Chemical structure	Zn		Cl-Zn-Cl
Identification numbers:			
CAS registry	7440-66-6	557-34-6 (anhydrous) 5970-45-6 (dihydrate)	7646-85-7
NIOSH RTECS	ZG8600000	AK1500000 (anhydrous) ZG8750000 (dihydrate)	ZH1400000
EPA hazardous waste	No data	No data	No data
OHM/TADS	7216955	No data	7216957
DOT/UN/NA/IMCO shipping	Zinc, powder or dust, UN 1436; zinc, powder or dust, zinc ashes, IMO4.3; zinc ashes, UN 1435	Zinc acetate, environmental hazardous substance, solid, NOS, UN 3077	Zinc chloride, anhydrous, UN 2331; zinc chloride, solution, UN 1840; zinc chloride, anhydrous, solution, IMO 8.3
HSDB	1344	1043	1050
NCI	No data	No data	No data

## 4. CHEMICAL AND PHYSICAL INFORMATION

**Table 4-1. Chemical Identity of Zinc and Selected Compounds<sup>a</sup>**

Characteristic	Zinc chromate	Zinc cyanide
Synonyms	Basic zinc chromate; chromic acid, zinc salt(1:1); chromic acid, zinc salt; chromium zinc oxide; zinc chrome yellow; zinc chromate; zinc chromate AM; zinc chromate C; zinc chromate O; zinc chromate Z; zinc chromate(VI) hydroxide; zinc chrome; zinc chrome (anti-corrosion); zinc chromium oxide; zinc hydroxychromate; zinc tetraoxychromate	Cyanure de zinc (French); zinc dicyanide
Registered trade name(s)	Pigment yellow 36; buttercup yellow; zinc tetraoxychromate 76A; zinc tetraoxychromate 780B; zinc yellow; ZTO; zincro ZTO	No data
Chemical formula	ZnCrO <sub>4</sub>	Zn(CN) <sub>2</sub>
Chemical structure		
Identification numbers:		
CAS registry	13530-65-9	557-21-1
NIOSH RTECS	GB3290000	ZH1575000
EPA hazardous waste	No data	P121; an acute hazardous waste when a discarded commercial chemical product or manufacturing chemical intermediate or an off-specification commercial chemical product or a manufacturing chemical intermediate. D003; a waste containing zinc cyanide may (or may not) be characterized a hazardous waste following testing for the reactivity characteristics as prescribed by RCRA regulations
OHM/TADS	No data	No data
DOT/UN/NA/IMCO shipping	No data	Zinc cyanide, UN 1713; Zinc cyanide, IMO 6.1
HSDB	6188	1051
NCI	77955	No data

## 4. CHEMICAL AND PHYSICAL INFORMATION

**Table 4-1. Chemical Identity of Zinc and Selected Compounds<sup>a</sup>**

Characteristic	Zinc hydroxide	Zinc oxide
Synonyms	Zinc dihydroxide	Zinc monoxide; zincum oxydatum; zinci oxydum; zinci oxicum; cynku tlenek (Polish)
Registered trade name(s)	No data	Actox 14; Actox 16; Actox 216; AI3-00277; Akro-Zinc Bar85 <sup>b</sup> ; Amalox; Amaloz; Azo 22; Azodox; Blanc de Zinc; Cadox XX 78; Caswell No 920; Chinese White; CI 77947; CI Pigment White 4; Electrox 2500; Emanay Zinc Oxide; Emar; Felling Zinc Oxide; Flores de Zinci; Flowers of Zinc; GIAP 10; Green Seal-8; Hubbuck's White; Kadox 15; Kadox-25; Kadox 72; Outmine; Ozide; Ozlo; Permanent White; Philosopher's Wool; Powder Base 900; Protox 166; Protox 168; Protox 169; Protox Type 166; Protox Type 167; Protox Type 168; Protox Type 169; Protox Type 267; Protox Type 268; Red Seal; Red seal-9; Snow White; Unichem ZO; Vandem VAC; Vandem VOC; Vandem VPC; C-Weiss 8 (German); White Seal-7; XX 78; XX 203; XX 601; Zinca 20; Zinc White; Zincoid; Zn 0701T; Calamine <sup>b</sup> ; Zincite <sup>b</sup>
Chemical formula	Zn(OH) <sub>2</sub>	ZnO
Chemical structure	HO—Zn—OH	Zn=O
Identification numbers:		
CAS registry	20427-58-1	1314-13-2
NIOSH RTECS	ZH3853000	ZH4810000
EPA hazardous waste	No data	No data
OHM/TADS	No data	No data
DOT/UN/NA/IMCO shipping	No data	No data
HSDB	No data	5024
NCI	No data	No data

## 4. CHEMICAL AND PHYSICAL INFORMATION

**Table 4-1. Chemical Identity of Zinc and Selected Compounds<sup>a</sup>**

Characteristic	Zinc phosphate	Zinc sulfate
Synonyms	Zinc ortho-phosphate; neutral zinc phosphate; tribasic zinc phosphate; trizinc diphosphate; zinc acid phosphate; zinc phosphate (3:2)	Sulfate de zinc (French); sulfuric acid zinc salt; sulfuric acid, zinc salt (1:1); white copperas; white vitriol; zinc sulfate; zinc vitriol; zinci sulfas; zincum sulfuricum
Registered trade name(s)	Bonderite 181; Bonderite 40; Bonderite 880; C.I. Pigment White 32; Delaphos; Delaphos 2M; Fleck's Extraordinary; Fleck's Extraordinary cement; Granodine 16NC; Granodine 80; Heucophos ZP 10; LF Bowsei PW 2; Man-Gill 51339; Man-Gill 51355; Microphos 90; Phoshinox PZ 06; Pigment White 32; Sicor ZNP/M; ZPF; Sicor ZNP/S; Virchem 931; Weather coat 1000; ZP-DL; ZP-SB	Bonazen <sup>b</sup> ; Medizinc; Bufopto Zinc sulfate; Op-thal-zin; Optraex; Solvenzink; Verazinc; zincate; Zincomed; Zinkosite; AI3-03967; Orazinc; Zinc-200; Zinklet; Neozin; Optised; Prefrin-Z; Visine-AC; Zin CFRin; Zink-Gro
Chemical formula	Zn <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>	ZnSO <sub>4</sub> <sup>c</sup>
Chemical structure		
Identification numbers:		
CAS registry	7779-90-0	7733-02-0
NIOSH RTECS	TD0590000	ZH5260000
EPA hazardous waste	No data	No data
OHM/TADS	No data	7216958
DOT/UN/NA/IMCO shipping	No data	NA 9161
HSDB	No data	1063
NCI	No data	No data

## 4. CHEMICAL AND PHYSICAL INFORMATION

**Table 4-1. Chemical Identity of Zinc and Selected Compounds<sup>a</sup>**

Characterstic	Zinc sulfide
Synonyms	Wurtzite (alpha) <sup>b</sup> ; sphalerite (beta) <sup>b</sup> ; zinc monosulfide; zinc blende; zinc sulphide
Registered trade name(s)	Albalith; Irtran Z; Irtran 2; CI Pigment White 7; Sachtolith; Sachtolith HD-S; Cleartran
Chemical formula	ZnS
Chemical structure	Zn=S
Identification numbers:	
CAS registry	1314-98-3
NIOSH RTECS	ZH5400000
EPA hazardous waste	D003
OHM/TADS	No data
DOT/UN/NA/IMCO shipping	UN 3077; Zinc sulfide, environmentally hazardous substance, solid, NO; UN 3082; zinc sulfide, environmentally hazardous substance, liquid, NOS
HSDB	5802
NCI	No data

<sup>a</sup>Unless otherwise specified, all data from Chemfinder 2003; ChemID 2003; HSDB 2003; NIOSH 1990; and RTECS 2003

<sup>b</sup>HSDB 1990

<sup>c</sup>O'Neil et al. 2001

CAS = Chemical Abstracts Service; DOT/UN/NA/IMCO = 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; RCRA = Resource Conservation and Recovery Act; RTECS = Registry of Toxic Effects of Chemical Substances

## 4. CHEMICAL AND PHYSICAL INFORMATION

**Table 4-2. Physical and Chemical Properties of Zinc and Selected Compounds<sup>a</sup>**

Property	Zinc	Zinc acetate	Zinc chloride
Molecular weight	65.38	183.48	136.29
Color	Bluish-white, lustrous	White granules	White granules <sup>b</sup>
Physical state	Solid metal	Solid	Solid
Melting point	419.5 °C	237 °C (decomposes)	290 °C
Boiling point	908 °C	No applicable	732 °C
Density (g/cm <sup>3</sup> )	7.14 at 25 °C	1.735	2.907 at 25 °C
Odor	No data	Faint acetous odor <sup>c</sup>	Odorless; fume has acrid odor <sup>c</sup>
Odor threshold:			
Water	No data	No data	No data
Air	No data	No data	No data
Solubility:			
Water	Insoluble <sup>d</sup>	4.0x10 <sup>4</sup> mg/L at 25 °C; 6.7x10 <sup>4</sup> mg/L at 100 °C <sup>c</sup>	4.32x10 <sup>6</sup> mg/L at 25 °C; 6.14x10 <sup>6</sup> mg/L at 100 °C
Other solvent(s)	Soluble in acetic acid and alkali	33 mg/L in alcohol	1 g/1.3 mL alcohol; 1 g/2 mL glyderol; 1 g/0.25 mL 2% hydrochloroacetic acid
Partition coefficients:			
K <sub>d</sub> (mL/g)	0.1–8,000 <sup>e</sup> ; 40 (average) <sup>f</sup> ; 39 in sandy loam soil; 12.2 in sandy soil <sup>g</sup>	No data	No data
K <sub>ow</sub>	No data	No data	No data
K <sub>oc</sub>	No data	No data	No data
Vapor pressure	1 mm Hg at 487 °C	Not data	Not data
Henry's law constant	Not applicable	Not applicable	Not applicable
Autoignition temperature	No data	No data	Not flammable <sup>h</sup>
Flashpoint	No data	No data	Not flammable <sup>h</sup>
Flammability limits	No data	No data	Not flammable <sup>h</sup>
Conversion factor	Not applicable	mg Zn(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> x 0.36 = mg Zn	mg ZnSO <sub>4</sub> x 0.40 = mg Zn
Explosive limits	No data	No data	No data

## 4. CHEMICAL AND PHYSICAL INFORMATION

**Table 4-2. Physical and Chemical Properties of Zinc and Selected Compounds<sup>a</sup>**

Property	Zinc chromate	Zinc cyanide	Zinc hydroxide
Molecular weight	181.37	117.42	99.40
Color	Lemon-yellow	White <sup>c</sup>	Colorless <sup>c</sup>
Physical state	Solid	Powder <sup>c</sup>	Solid <sup>c</sup>
Melting point	No data	800 °C (decomposes) <sup>c</sup>	Decomposes at 125 °C <sup>c</sup>
Boiling point	No data	Not applicable	Not applicable
Density (g/cm <sup>3</sup> )	3.40	1.852 <sup>c</sup>	3.053 <sup>c</sup>
Odor	Odorless	No data	No data
Odor threshold:			
Water	No data	No data	No data
Air	No data	No data	No data
Solubility:			
Water	Insoluble in cold water; sparingly soluble	Insoluble <sup>c</sup> ; 50 mg/L at 20 °C <sup>c</sup>	Almost insoluble <sup>c</sup>
Other solvent(s)	Soluble in acids, liquid ammonia; insoluble in acetone	Soluble in dilute mineral acids	No data
Partition coefficients:			
K <sub>d</sub> (mL/g)	No data	No data	No data
K <sub>ow</sub>	No data	No data	No data
K <sub>oc</sub>	No data	No data	No data
Vapor pressure	No data	No data	No data
Henry's law constant	Not applicable	Not applicable	Not applicable
Autoignition temperature	No data	No data	No data
Flashpoint	No data	No data	No data
Flammability limits	No data	No data	No data
Conversion factor	mg ZnCrO <sub>4</sub> x 0.36 = mg Zn	mg Zn(CN) <sub>2</sub> x 0.56 = mg Zn	mg Zn(OH) <sub>2</sub> x 0.66 = mg Zn
Explosive limits	No data	No data	No data



## 4. CHEMICAL AND PHYSICAL INFORMATION

**Table 4-2. Physical and Chemical Properties of Zinc and Selected Compounds<sup>a</sup>**

Property	Zinc oxide	Zinc phosphate	Zinc sulfate
Molecular weight	81.38	386.11	161.44
Color	White/yellowish-white	White <sup>c</sup>	Colorless <sup>i</sup>
Physical state	Solid	Powder <sup>c</sup>	Solid
Melting point	1975 °C	900 °C <sup>c</sup>	680 °C (decomposes)
Boiling point	Sublimes	No data	No applicable
Density (g/cm <sup>3</sup> )	5.607 at 20 °C	3.998 at 15 °C <sup>c</sup>	3.54 at 25 °C
Odor	Odorless	Odorless	Not determined
Odor threshold:			
Water	No data	No data	No data
Air	No data	No data	No data
Solubility:			
Water	1.6 mg/L at 29 °C <sup>i</sup>	Insoluble <sup>j</sup>	Soluble in cold and hot water <sup>i</sup> ; 4.19x10 <sup>5</sup> mg/L at 0 °C; 9.1x10 <sup>5</sup> mg/L at 70 °C
Other solvent(s)	Soluble in dilute acetic or mineral acids, ammonia, ammonium carbonate, fixed alkali hydroxide solution, and ammonium chloride <sup>i</sup> ; insoluble in alcohol <sup>i</sup>	Soluble in dilute mineral acids, ammonium hydroxide and alkali hydroxide solutions; insoluble in alcohol	Slightly soluble in alcohol; soluble in methanol and glycerol <sup>i</sup> ; 1 g/2.5 mL glycerol
Partition coefficients:			
K <sub>d</sub>	No data	No data	No data
K <sub>ow</sub>	No data	No data	No data
K <sub>oc</sub>	No data	No data	No data
Vapor pressure	Not data	No data	No data
Henry's law constant	Not applicable	No data	Not applicable
Autoignition temperature	Not flammable <sup>h</sup>	No data	Not flammable <sup>h</sup>
Flashpoint	Not flammable <sup>h</sup>	No data	Not flammable <sup>h</sup>
Flammability limits	Not flammable <sup>h</sup>	No data	Not flammable <sup>h</sup>
Conversion factor	mg ZnO x 0.80 = mg Zn	mg Zn <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> x 0.51 = mg Zn	mg ZnSO <sub>4</sub> x 0.40 = mg Zn
Explosive limits	No data	No data	No data

## 4. CHEMICAL AND PHYSICAL INFORMATION

**Table 4-2. Physical and Chemical Properties of Zinc and Selected Compounds<sup>a</sup>**

Property	Zinc sulfide (α)	Zinc sulfide (γ)
Molecular weight	97.45	97.45
Color	Colorless <sup>i</sup>	Colorless
Physical state	Solid	Solid
Melting point	1,700±20 °C	No data
Boiling point	1,185 °C at 1 atm	1,185 °C at 1 atm
Density (g/cm <sup>3</sup> )	3.98 at 20 °C <sup>i</sup> ; 4.087 at 25 °C	4.102 at 25 °C
Odor	No data	No data
Odor threshold:		
Water	No data	No data
Air	No data	No data
Solubility:		
Water	6.9 mg/L at 18 °C <sup>i</sup>	6.5 mg/L at 18 °C <sup>i</sup>
Organic solvents	Very soluble in alcohol; soluble in dilute mineral acids; insoluble in acetic acid; insoluble in alkalis	Very soluble in alcohol; soluble in dilute mineral acids; insoluble in alkalis
Partition coefficients:		
K <sub>d</sub>	No data	No data
K <sub>ow</sub>	No data	No data
K <sub>oc</sub>	No data	No data
Vapor pressure	No data	No data
Henry's law constant	Not applicable	Not applicable
Autoignition temperature	No data	No data
Flashpoint	No data	No data
Flammability limits	No data	No data
Conversion factor	mg ZnS x 0.67 = mg Zn	mg ZnS x 0.67 = mg Zn
Explosive limits	No data	No data

<sup>a</sup>Information obtained from O'Neil et al. (2001) except where noted.

<sup>b</sup>ACGIH 1991

<sup>c</sup>Lewis 1997

<sup>d</sup>HSDB 2003

<sup>e</sup>Baes and Sharp 1983

<sup>f</sup>Baes et al. 1984

<sup>g</sup>Gerritse et al. 1982

<sup>h</sup>Weiss 1986

<sup>i</sup>Weast 1988

<sup>j</sup>Goodwin 1998

Zn = zinc; Zn(C<sub>2</sub>H<sub>3</sub>O<sub>2</sub>)<sub>2</sub> = zinc acetate; ZnCl<sub>2</sub> = zinc chloride; ZnCrO<sub>4</sub> = zinc chromate; Zn(CN)<sub>2</sub> = zinc cyanide; Zn(OH)<sub>2</sub> = zinc hydroxide; ZnO = zinc oxide; Zn<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> = zinc phosphate; ZnS = zinc sulfide; ZnSO<sub>4</sub> = zinc sulfate