急性曝露ガイドライン濃度 (AEGL)

Zinc phosphide (1314-84-7)
リン化亜鉛

Table　AEGL 設定値

Zinc Phosphide　1314-84-7　(Final)					
ppm					
	10 min	30 min	60 min	4 hr	8 hr
AEGL 1	NR	NR	NR	NR	NR
AEGL 2	2.0	2.0	1.0	0.25	0.13
AEGL 3	3.6	3.6	1.8	0.45	0.23

NR: データ不十分により推奨濃度設定不可

設定根拠(要約):

ホスフィンは無色の気体で、貯蔵穀物を食害する昆虫やげっ歯類に対し燻蒸剤として使用される。駆除剤は、金属リン化物の形で使用されることが一般的であり、水分と反応してホスフィンガスを遊離する。ホスフィンは半導体産業でも使用される。ホスフィンのヒトへの曝露に関するデータは、曝露の時間と濃度が正確に報告されていないため、AEGL 値の導出に使用するには限りがある。一方、動物については、適切なデータは豊富にあるものの、AEGL-1 値の定義に合致するデータが得られていない。したがって、AEGL-1 値は、データ不十分のため導出しなかった。

AEGL-2 値は、Newton ら(1993)の試験で、10 ppm のホスフィンに 6 時間曝露した Fischer 344 ラットにおいて、赤色の粘液性鼻汁が認められたことに基づいた。ラット、マウス、ウサギ、およびモルモットの 45 分間～30 時間の致死データ(死亡までの時間)から、種差はほとんどないことが示唆されるため(Figure 10-2 を参照)、種間変動に関する不確実係数として 3 を適用した。ホスフィンへの曝露濃度が同じであると推定される場合、小児は成人よりもホスフィンに対する感受性が高いことが、ヒトにおけるデータから示唆されるため、種内変動に関する不確実係数として 10 を適用した。したがって、総不確実係数は 30 となる。全身に作用する刺激性の蒸気とガスの多くは、曝露濃度−曝露時間関係を $C^n \times t = k$ の式で表すことができ、指数 n は 0.8～3.5 の範囲の値をとる(ten Berge et al. 1986)。ホスフィンについて、30 分間、1 時間、4 時間、8 時間の各曝露時間の AEGL 値をスケーリングするため、指数 n には、経験に基づいて導出した 1 の値を適用した。また、指数 n の導出には、ラットにおける 1～6 時間の致死データを使用した。6 時間から 10 分間への外挿に係る不確実性が加わるため、AEGL-2 の 30 分間値を 10 分間値としても採用した。

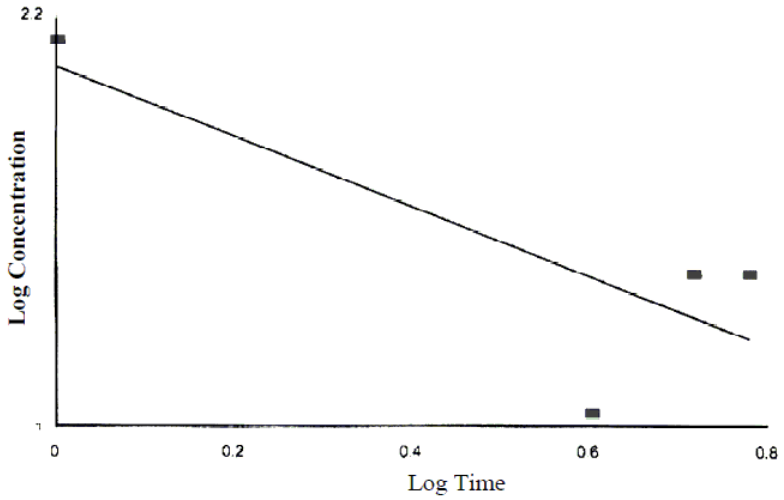

FIGURE 10-2 Best-fit concentration (ppm phosphine) × time (exposure duration in hours) curve. Linear regression of rat lethality data.

AEGL-3 値は、ホスフィンに 6 時間曝露した Sprague Dawley ラットにおいて、死亡が認められなかった濃度(18 ppm)に基づいた。種差はほとんどないことが、ラット、マウス、ウサギ、モルモットの致死データから示唆されるため、種間変動に関する不確実係数として 3 を適用した。ホスフィンの曝露濃度が同じであると推定される場合、小児は成人よりもホスフィンに対する感受性が高いことが、ヒトにおけるデータから示唆されるため、種内変動に関する不確実係数として 10 を適用した。したがって、総不確実係数は 30 となる。全身に作用する刺激性の蒸気やガスの多くは、曝露濃度−曝露時間関係を $C^n \times t = k$ の式で表すことができ、指数 n は 0.8〜3.5 の範囲の値をとる(ten Berge et al. 1986)。ホスフィンについては、30 分間、1 時間、4 時間、8 時間の各曝露時間の AEGL 値をスケーリングするため、指数 n には、経験に基づいて導出した 1 の値を適用した。指数 n の導出には、ラットにおける 1〜6 時間の致死データを使用した。6 時間から 10 分間への外挿する不確実性が加わるため、AEGL-3 の 30 分間値を 10 分間値としても採用した。Table に、導出した AEGL 値を示す。

Appendix D に、8 種類の金属リン化物の AEGL 値を示す。

APPENDIX D

AEGL Values for Selected Metal Phosphides
Aluminum Phosphide (AlP)
Potassium Phosphide (K_3P)
Sodium Phosphide (Na_3P)
Zinc Phosphide (Zn_3P_2)
Calcium Phosphide (Ca_3P_2)
Magnesium Phosphide (Mg_3P_2)
Strontium Phosphide (Sr_3P_2)
Magnesium Aluminum Phosphide (Mg_3AlP_3)

SUMMARY

Metal phosphides are solids and are typically used as fumigants against insects and rodents in stored grain. The metal phosphides react rapidly with water and moisture in the air or stored grain to produce phosphine gas. It is the phosphine gas that is responsible for acute toxicity, and the rate of phosphine generation is dependent on ambient temperature and humidity and the chemical structure of the phosphide (Anger et al. 2000).

In the absence of appropriate chemical-specific data for the metal phosphides considered in this appendix, the AEGL-2 and AEGL-3 values for phosphine were used to obtain AEGL-2 and AEGL-3 values, respectively, for the metal phosphides. The use of phosphine as a surrogate for the metal phosphides is deemed appropriate because qualitative (clinical signs) and quantitative (phosphine blood level) data suggest that the phosphine hydrolysis product is responsible for acute toxicity from metal phosphides. The phosphine AEGL-2 and AEGL-3 values were used as target values for calculating the concentrations of metal phosphide needed to generate the phosphine AEGL values.

Because AEGL-1 values for phosphine are not recommended (due to insufficient data), AEGL-1 values for the metal phosphides considered in this appendix are also not recommended. The calculated values are listed in Table D-1 below.

D.I. INTRODUCTION

Metal phosphides are solids and are typically used as fumigants against insects and rodents in stored grain. The metal phosphides react rapidly with water and moisture in the air or stored grain to produce phosphine gas. It is the phosphine gas which is responsible for acute toxicity, and the rate of phosphine generation is dependent on ambient temperature and humidity and the chemical structure of the phosphide (Anger et al. 2000).

TABLE D-1 AEGL Values for Metal Phosphides[a]

Compound	Classification	10-min	30-min	1-hr	4-hr	8-hr
Aluminum Phosphide	AEGL-1	NR	NR	NR	NR	NR
	AEGL-2	9.5 mg/m^3	9.5 mg/m^3	4.7 mg/m^3	1.2 mg/m^3	0.59 mg/m^3
	AEGL-3	17 mg/m^3	17 mg/m^3	8.5 mg/m^3	2.1 mg/m^3	1.1 mg/m^3
Potassium Phosphide	AEGL-1	NR	NR	NR	NR	NR
	AEGL-2	24 mg/m^3	24 mg/m^3	12 mg/m^3	3.0 mg/m^3	1.5 mg/m^3
	AEGL-3	44 mg/m^3	44 mg/m^3	22 mg/m^3	5.5 mg/m^3	2.7 mg/m^3
Sodium Phosphide	AEGL-1	NR	NR	NR	NR	NR
	AEGL-2	16 mg/m^3	16 mg/m^3	8.2 mg/m^3	2.0 mg/m^3	1.0 mg/m^3
	AEGL-3	29 mg/m^3	29 mg/m^3	15 mg/m^3	3.7 mg/m^3	1.8 mg/m^3
Zinc Phosphide	AEGL-1	NR	NR	NR	NR	NR
	AEGL-2	21 mg/m^3	21 mg/m^3	11 mg/m^3	2.6 mg/m^3	1.3 mg/m^3
	AEGL-3	38 mg/m^3	38 mg/m^3	19 mg/m^3	4.8 mg/m^3	2.4 mg/m^3
Calcium Phosphide	AEGL-1	NR	NR	NR	NR	NR
	AEGL-2	15 mg/m^3	15 mg/m^3	7.5 mg/m^3	1.9 mg/m^3	0.93 mg/m^3
	AEGL-3	27 mg/m^3	27 mg/m^3	13 mg/m^3	3.4 mg/m^3	1.7 mg/m^3
Magnesium Phosphide	AEGL-1	NR	NR	NR	NR	NR
	AEGL-2	11 mg/m^3	11 mg/m^3	5.5 mg/m^3	1.4 mg/m^3	0.69 mg/m^3
	AEGL-3	20 mg/m^3	20 mg/m^3	9.9 mg/m^3	2.5 mg/m^3	1.2 mg/m^3
Strontium Phosphide	AEGL-1	NR	NR	NR	NR	NR
	AEGL-2	27 mg/m^3	27 mg/m^3	13 mg/m^3	3.3 mg/m^3	1.7 mg/m^3
	AEGL-3	48 mg/m^3	48 mg/m^3	24 mg/m^3	6.0 mg/m^3	3.0 mg/m^3
Magnesium Aluminum Phosphide	AEGL-1	NR	NR	NR	NR	NR
	AEGL-2	11 mg/m^3	11 mg/m^3	5.3 mg/m^3	1.3 mg/m^3	0.66 mg/m^3
	AEGL-3	19 mg/m^3	19 mg/m^3	9.5 mg/m^3	2.4 mg/m^3	1.2 mg/m^3

[a]These airborne concentrations will produce the equivalent AEGL values for phosphine.
Note: Absence of an AEGL-1 does not imply that exposure below the AEGL-2 is without adverse effects.
NR, not recommended.

Aluminum Phosphide (CAS No. 20859-73-8), Potassium Phosphide (CAS No. 20770-41-6), and Sodium Phosphide (CAS No. 12058-85-4): One mole of aluminum phosphide, potassium phosphide, or sodium phosphide will react rapidly with water or moisture to produce a maximum of 1 mole of phosphine gas as follows:

$$AlP + 3H_2O \rightarrow PH_3 + Al(OH)_3$$

$$K_3P + 3H_2O \rightarrow PH_3 + 3KOH$$

$$Na_3P + 3H_2O \rightarrow PH_3 + 3NaOH$$

Zinc Phosphide (CAS No. 1314-84-7), Calcium Phosphide (CAS No. 1305-99-3), Magnesium Phosphide (CAS No. 10257-74-8), and Strontium Phosphide (CAS No. 12504-13-1): One mole of zinc phosphide, calcium phosphide, magnesium phosphide or strontium phosphide will react rapidly with water or moisture to produce a maximum of 2 moles of phosphine gas as follows:

$$Zn_3P_2 + 6H_2O \rightarrow 2PH_3 + 3Zn(OH)_2$$

$$Ca_3P_2 + 6H_2O \rightarrow 2PH_3 + 3Ca(OH)_2$$

$$Mg_3P_2 + 6H_2O \rightarrow 2PH_3 + 3Mg(OH)_2$$

$$Sr_3P_2 + 6H_2O \rightarrow 2PH_3 + 3Sr(OH)_2$$

Magnesium Aluminum Phosphide (CAS No. None): One mole of magnesium aluminum phosphide will react rapidly with water or moisture to produce a maximum of 3 moles of phosphine gas as follows:

$$Mg_3AlP_3 + 9H_2O \rightarrow 3PH_3 + Al(OH)_3 + 3Mg(OH)_2$$

Aluminum phosphide is a gray or yellow crystalline solid prepared from red phosphorus and aluminum powder (O'Neil et al. 2001). Commercial aluminum phosphide sachets contain 70% aluminum phosphide and 30% aluminum carbonate (Bajaj et al. 1988). Calcium phosphide is a red-brown or gray solid prepared by heating calcium phosphate with aluminum or carbon by passing phosphorus vapors over metallic calcium. In addition to its use as a rodenticide, calcium phosphide is also used in signal fires and pyrotechnics and in the purification of copper and copper alloys (HSDB 2007a). Zinc phosphide is a gray solid and may be produced by passing phosphine through a solution of zinc sulfate (HSDB 2007b). Manufacturing information on the other metal phosphides considered in this appendix was not located. Available physico-chemical data for the metal phosphides are shown in Tables D-2 through D-9.

TABLE D-2 Physicochemical Data for Aluminum Phosphide

Parameter	Description/Value	Reference
Synonyms (commercial product)	Celphos, Phostoxin, Quickphos	O'Neil et al. 2001
CAS Registry No.	20859-73-8	O'Neil et al. 2001
Chemical formula	AlP	O'Neil et al. 2001
Molecular weight	57.96	O'Neil et al. 2001
Physical state	Solid, gray of yellow crystals	O'Neil et al. 2001

(Continued)

TABLE D-2 Continued

Parameter	Description/Value	Reference
Relative density (water = 1)	2.9	IPCS 1989
Melting point	>1350°C	IPCS 1989
Solubility in water	Reactive produces phosphine gas	IPCS 1989

TABLE D-3 Physicochemical Data for Potassium Phosphide

Parameter	Description/Value	Reference
CAS Registry No.	20770-41-6	ChemIDPlus 2005a
Chemical formula	K_3P	ChemIDPlus 2005a
Molecular weight	148.3	ChemIDPlus 2005a

TABLE D-4 Physicochemical Data for Sodium Phosphide

Parameter	Description/Value	Reference
Synonyms	Trisodium phosphide	ChemIDPlus 2005b
CAS Registry No.	12058-85-4	ChemIDPlus 2005b
Chemical formula	Na_3P	ChemIDPlus 2005b
Molecular weight	99.94	Lewis 1996a
Physical state	Solid, red crystals	Lewis 1996a
Melting point	Decomposes	Lewis 1996a
Solubility in water	Reacts violently	Lewis 1996a

TABLE D-5 Physicochemical Data for Zinc Phosphide

Parameter	Description/Value	Reference
Synonym	Trizinc diphosphide	IPCS 1989
CAS Registry No.	1314-84-7	IPCS 1989
Chemical formula	Zn_3P_2	IPCS 1989
Molecular weight	258.1	IPCS 1989
Physical state	Solid, gray powder or crystals	O'Neil et al. 2001
Relative density (water = 1)	4.55	O'Neil et al.2001
Melting point	Sublimes	IPCS 1989
Solubility in water	Insoluble, reacts	IPCS 1989

TABLE D-6 Physicochemical Data for Calcium Phosphide

Parameter	Description/Value	Reference
Synonyms (commercial product)	Calcium photophor, photophor	O'Neil et al. 2001
CAS Registry No.	1305-99-3	O'Neil et al. 2001
Chemical formula	Ca_3P_2	O'Neil et al. 2001

(Continued)

TABLE D-6 Continued

Parameter	Description/Value	Reference
Molecular weight	182.18	O'Neil et al. 2001
Physical state	Solid, red-brown crystals or gray lumps	O'Neil et al. 2001
Relative density (water = 1)	2.51	O'Neil et al. 2001
Melting point	1600°C	O'Neil et al. 2001
Solubility in water	Decomposes	O'Neil et al. 2001

TABLE D-7 Physicochemical Data for Magnesium Phosphide

Parameter	Description/Value	Reference
Synonyms	Trimagnesium diphosphide	IPCS 1989
CAS Registry No.	12057-74-8	IPCS 1989
Chemical formula	Mg_3P_2	IPCS 1989
Molecular weight	134.87	IPCS 1989
Physical state	Solid, gray or bright yellow crystals	IPCS 1989
Relative density (water = 1)	2.1	IPCS 1989
Melting point	>750°C	IPCS 1989
Solubility in water	Moisture sensitive, reacts	IPCS 1989

TABLE D-8 Physicochemical Data for Strontium Phosphide

Parameter	Description/Value	Reference
CAS Registry No.	12504-13-1	Lewis 1996b
Chemical formula	Sr_3P_2	Lewis 1996b
Molecular weight	324.9	Lewis 1996b
Physical state	Solid	Lewis 1996b

TABLE D-9 Physicochemical Data for Magnesium Aluminum Phosphide

Parameter	Description/Value	Reference
CAS Registry No.	None	ChemIDPlus 2005c
Chemical formula	Mg_3AlP_3	ChemIDPlus 2005c
Molecular weight	192.8	—
Physical state	Solid	ChemIDPlus 2005c

D.II. SPECIAL CONSIDERATIONS

Metabolism and Disposition

Solid metal phosphides deposited on moist respiratory tract surfaces may hydrolyze and release absorbable phosphine. However, a more likely scenario would involve atmospheric hydrolysis of metal phosphides to phosphine gas.

Chan et al. (1983) detected phosphine in postmortem stomach, blood, and liver specimens from a 27-year-old man who had ingested aluminum phosphide tablets. The phosphine was released from the samples after acid treatment. Similarly, Anger et al. (2000) identified phosphine in postmortem brain, liver, and kidneys of a 39-year-old man who had committed suicide by ingestion of aluminum phosphide tablets.

Chugh et al. (1996) measured blood phosphine levels in patients with severe (n = 30), mild (n = 10), or minimal (n = 5) toxicity due to aluminum phosphide ingestion. Patients with severe toxicity had ingested "fresh" aluminum phosphide compound and were in a state of shock. Those with mild toxicity had ingested "old" aluminum phosphide compound and presented with hypotension and gastrointestinal symptoms. Patients with minimal toxicity ingested some powder from the aluminum phosphide tablets and presented with only nausea and occasional vomiting. Blood phosphine levels were positively correlated with severity of clinical signs and to dose of pesticide. At admission, blood phosphine levels were 71% higher ($p < 0.001$) in patients in the severe toxicity group than in the mild toxicity group of patients; blood phosphine was not detected in the minimal toxicity group of patients. Blood phosphine levels were also correlated to mortality; patients having blood phosphine levels $\leq 1.067 \pm 0.16$ mg% survived, whereas those with blood phosphine above this apparent threshold died (6 of 30 in the severe toxicity group).

Garry et al. (1993) described a fatality from inhalation of aluminum phosphide aerosol In this case report, blood aluminum concentration was used as a marker of exposure (see Section 2.1.1).

Mechanism of Toxicity

Metal phosphides react rapidly with moisture in air to produce phosphine gas. It is the phosphine gas that is responsible for acute inhalation toxicity from metal phosphide exposure. The rate of phosphine generation is dependent on ambient temperature and humidity (Anger et al. 2000) in addition to the chemical structure of the metal phosphide. The hydrolysis reactions and phosphine evolution rates (OECD 2001) of the metal phosphides considered in this appendix are summarized in Table D-10.

D.III. RATIONALE AND AEGL-1

Summary of Human Data Relevant to AEGL-1

No human data are available for the derivation of AEGL-1 for the metal phosphides considered in this appendix.

TABLE D-10 Hydrolysis of Metal Phosphides

Metal Phosphide	Hydrolysis Reaction	Maximum Number of moles of phosphine produced per mole of metal phosphide hydrolyzed	Phosphine evolution rate at 20°C and 1 atm (mL/kg• min)
Aluminum Phosphide	$AlP + 3H_2O \rightarrow PH_3 + Al(OH)_3$	1	2069.7
Potassium Phosphide	$K_3P + 3H_2O \rightarrow PH_3 + 3KOH$	1	807.6
Sodium Phosphide	$Na_3P + 3H_2O \rightarrow PH_3 + 3NaOH$	1	997.8
Zinc Phosphide	$Zn_3P_2 + 6H_2O \rightarrow 2PH_3 + 3Zn(OH)_2$	2	929.9
Calcium Phosphide	$Ca_3P_2 + 6H_2O \rightarrow 2PH_3 + 3Ca(OH)_2$	2	1274.6
Magnesium Phosphide	$Mg_3P_2 + 6H_2O \rightarrow 2PH_3 + 3Mg(OH)_2$	2	1781.4
Strontium Phosphide	$Sr_3P_2 + 6H_2O \rightarrow 2PH_3 + 3Sr(OH)_2$	2	737.1
Magnesium Aluminum Phosphide	$Mg_3AlP_3 + 9H_2O \rightarrow 3PH_3 + Al(OH)_3 + 3Mg(OH)_2$	3	1865.2

Summary of Animal Data Relevant to AEGL-1

No animal data are available for the derivation of AEGL-1 for the metal phosphides considered in this appendix.

Derivation of AEGL-1

No human or animal data are consistent with the effects defined by AEGL-1. Data were also insufficient for derivation of AEGL-1 values for phosphine; thus phosphine cannot be used as a surrogate. Therefore, AEGL-1 values for the metal phosphides considered in this appendix are not recommended (Table D-11).

D.IV. RATIONALE AND AEGL-2

Summary of Human Data Relevant to AEGL-2

No human data are available for the derivation of AEGL-2 for the metal phosphides considered in this appendix.

TABLE D-11 AEGL-1 Values for Metal Phosphides

Compound	10 min	30 min	1 h	4 h	8 h
Aluminum Phosphide	NR	NR	NR	NR	NR
Potassium Phosphide	NR	NR	NR	NR	NR
Sodium Phosphide	NR	NR	NR	NR	NR
Zinc Phosphide	NR	NR	NR	NR	NR
Calcium Phosphide	NR	NR	NR	NR	NR
Magnesium Phosphide	NR	NR	NR	NR	NR
Strontium Phosphide	NR	NR	NR	NR	NR
Magnesium Aluminum Phosphide	NR	NR	NR	NR	NR

NR: not recommended. Absence of an AEGL-1 does not imply that exposure below the AEGL-2 is without adverse effects.

Summary of Animal Data Relevant to AEGL-2

No animal data are available for the derivation of AEGL-2 for the metal phosphides considered in this appendix.

Derivation of AEGL-2

In the absence of appropriate chemical-specific data for the metal phosphides considered in this appendix, the AEGL-2 values for phosphine will be used to obtain AEGL-2 values for the metal phosphides. The use of phosphine as a surrogate for the metal phosphides is deemed appropriate because qualitative (clinical signs) and quantitative (phosphine blood level) data suggest that the phosphine hydrolysis product is responsible for acute toxicity from metal phosphides. The phosphine AEGL-2 values will be used as target values for calculating the concentrations of metal phosphide needed to generate the phosphine AEGL values. Calculations were done using the methodology in NRC (2001) and are for 25 degrees C and 760 mm Hg. The metal phosphide values for AEGL-2 are given in Table D-12.

D.V. RATIONALE AND AEGL-3

Summary of Human Data Relevant to AEGL-3

No human data are available for the derivation of AEGL-3 for the metal phosphides considered in this appendix.

Summary of Animal Data Relevant to AEGL-3

No animal data are available for the derivation of AEGL-3 for the metal phosphides considered in this appendix.

TABLE D-12 AEGL-2 Values For Metal Phosphides[a]

Compound	10-min	30-min	1-hr	4-hr	8-hr
Aluminum Phosphide	9.5 mg/m^3	9.5 mg/m^3	4.7 mg/m^3	1.2 mg/m^3	0.59 mg/m^3
Potassium Phosphide	24 mg/m^3	24 mg/m^3	12 mg/m^3	3.0 mg/m^3	1.5 mg/m^3
Sodium Phosphide	16 mg/m^3	16 mg/m^3	8.2 mg/m^3	2.0 mg/m^3	1.0 mg/m^3
Zinc Phosphide	21 mg/m^3	21 mg/m^3	11 mg/m^3	2.6 mg/m^3	1.3 mg/m^3
Calcium Phosphide	15 mg/m^3	15 mg/m^3	7.4 mg/m^3	1.9 mg/m^3	0.93 mg/m^3
Magnesium Phosphide	11 mg/m^3	11 mg/m^3	5.5 mg/m^3	1.4 mg/m^3	0.69 mg/m^3
Strontium Phosphide	27 mg/m^3	27 mg/m^3	13 mg/m^3	3.3 mg/m^3	1.7 mg/m^3
Magnesium Aluminum Phosphide	11 mg/m^3	11 mg/m^3	5.3 mg/m^3	1.3 mg/m^3	0.66 mg/m^3

[a]These airborne concentrations will produce the equivalent AEGL values for phosphine.

Derivation of AEGL-3

In the absence of appropriate chemical-specific data for the metal phosphides considered in this appendix, the AEGL-3 values for phosphine will be used to obtain AEGL-3 values for the metal phosphides. The use of phosphine as a surrogate for the metal phosphides is deemed appropriate because qualitative (clinical signs) and quantitative (phosphine blood level) data suggest that the phosphine hydrolysis product is responsible for acute toxicity from metal phosphides. The phosphine AEGL-3 values will be used as target values for calculating the concentrations of metal phosphide needed to generate the phosphine AEGL values. Calculations were done using the methodology in NRC (2001) and are for 25 degrees C and 760 mm Hg. The metal phosphide values for AEGL-3 are given in Table D-13.

D.VI. Comparison with Other Standards and Criteria

No other exposure criteria or guidelines were located for the metal phosphides.

TABLE D-13 AEGL-3 Values for Metal Phosphides[a]

Compound	10-min	30-min	1-hr	4-hr	8-hr
Aluminum Phosphide	17 mg/m^3	17 mg/m^3	8.5 mg/m^3	2.1 mg/m^3	1.1 mg/m^3
Potassium Phosphide	44 mg/m^3	44 mg/m^3	22 mg/m^3	5.5 mg/m^3	2.7 mg/m^3
Sodium Phosphide	29 mg/m^3	29 mg/m^3	15 mg/m^3	3.7 mg/m^3	1.8 mg/m^3
Zinc Phosphide	38 mg/m^3	38 mg/m^3	19 mg/m^3	4.8 mg/m^3	2.4 mg/m^3
Calcium Phosphide	27 mg/m^3	27 mg/m^3	13 mg/m^3	3.4 mg/m^3	1.7 mg/m^3
Magnesium Phosphide	20 mg/m^3	20 mg/m^3	9.9 mg/m^3	2.5 mg/m^3	1.2 mg/m^3
Strontium Phosphide	48 mg/m^3	48 mg/m^3	24 mg/m^3	6.0 mg/m^3	3.0 mg/m^3
Magnesium Aluminum Phosphide	19 mg/m^3	19 mg/m^3	9.5 mg/m^3	2.4 mg/m^3	1.2 mg/m^3

[a]These airborne concentrations will produce the equivalent AEGL values for phosphine.

注：本物質の特性理解のため、参考として国際化学物質安全性カード（ICSC）および急性曝露ガイドライン濃度（AEGL)の原文のURLを記載する。

日本語ICSC

https://www.ilo.org/dyn/icsc/showcard.display?p_lang=ja&p_card_id=0602&p_version=2

AEGL（原文）

https://www.epa.gov/sites/default/files/2014-11/documents/phosphine_metal_phosphides_final_volume6_2007_0.pdf