NRT Quick Reference Guide: Phosphine; Aluminum, Magnesium, and Zinc Phosphide QRGs are intended for Federal OSC/RPMs

For references, please see Key References Cited/Used in National Response Team (NRT) Quick Reference Guides (QRGs) for Toxic Industrial Chemicals

Agent Characteristics

Agent Classification: Pesticide/Toxic Industrial Chemical/Chemical Threat Agent

Chemical	CAS	Formula	Molecular Weight	Pesticide Type	Physical Description	Pesticide Registration Status / Synonyms and Trade Names (examples)
Industrial Chemical and Restricted Use Pesticide (applied only by or under direct supervision of specially trained and certified applicators)						
Phosphine	7803-51-2	PH_3	34.0	Insecticide/fumigant	Colorless gas	• Registered for use in enclosed empty spaces (structures or containers) or enclosed spaces containing listed raw agricultural commodities, processed foods, stored tobacco, animal feeds, and nonfood products • ECO$_2$FUME® – cylindered compressed gas containing 2% phosphine by weight (2.6% by volume) and 98% carbon dioxide • VAPORPH$_3$OS® – 99.3% phosphine gas for on-site blending with registered/food-grade carbon dioxide or forced air
Restricted Use Pesticides: phosphine generated through chemical reaction						
Aluminum Phosphide	20859-73-8	AlP	57.95	Insecticide/fumigant; Rodenticide: fumigant for burrowing pests	Dark gray or dark yellow crystalline solid	• Available as pellets/tablets, gas bags, granules, rope • Registered for use to control listed insects on stored commodities, and for control of burrowing vertebrate pests (especially rodents) • Fumitoxin®, Phosotoxin®, Gastoxin®, Weevil-cide®, Quick Phlo-R®, Detiaphos®, Detia®, Killz-All®
Magnesium Phosphide	12057-74-8	Mg_3P_2	134.9	Insecticide/fumigant; Rodenticide: fumigant for burrowing pests	White crystalline solid	• Available as pellets/tablets, gas bags, granules, strip • Registered for use to control listed insects on stored commodities, and for control of burrowing vertebrate pests (especially rodents) • Degesch®, Magnophos®, Magtoxin®, Fumi-Strip®
General Use Pesticide and Restricted Use Pesticide at >2% active ingredient: phosphine generated through chemical reaction						
Zinc Phosphide	1314-84-7	Zn_3P_2	258.1	Rodenticide	Dark gray granular solid, powder or paste	• Available as baits, pellets, powders; also as concentrate (registered by USDA) • Bonide®, ZP®, Wilco®, ProZap®, Force's®
Other metal phosphide chemicals not used as pesticides include: calcium phosphide (Ca_3P_2, red-brown crystals to gray granular lumps); potassium phosphide (K_3P and others, white crystalline or powdered solid); sodium phosphide (Na_3P, red solid); stannic phosphide (PSn, silver-white mass or lump solid).						

Description:
Phosphine is a colorless gas with a disagreeable odor of fish or garlic, when used as a pesticide. Pure phosphine is odorless and is used in manufacture of flame retardants and incendiaries. Other names include hydrogen phosphide and phosphorus trihydride. Phosphine is very toxic by inhalation at extremely low concentrations. Phosphine is typically transported as a liquefied compressed gas, but also is produced by the reaction of aluminum, magnesium, or zinc phosphide (also used as pesticides) with water or atmospheric moisture. **Phosphine gas is extremely flammable and can ignite spontaneously in air. Phosphine has a lower explosive limit (LEL) of 1.6% v/v; explosive potential is severe in the presence of heat, flame, oxygen, oxidizing compounds (chlorine, nitrogen oxides) and many other compounds.** Upper Explosive Limit (UEL) is 98% (est). Phosphine gas is heavier than air and may travel along the ground to an ignition source. When phosphine is heated to decomposition, it produces highly toxic fumes of phosphorus oxides. Prolonged heating may cause containers to explode violently and rocket. A harmful concentration of phosphine gas in the air will be reached very quickly on loss of containment. Phosphine gas can also be produced during active methamphetamine (meth) cooking in clandestine meth labs using the Red Phosphorus method.
Persistence: Phosphine gas is considered "non-persistent." Vapor: minutes to hours; liquid: rapidly evaporates at ambient temperatures and pressures. Persistence will depend upon amount and purity of the agent, method of release, environmental conditions, and the types of surfaces and materials impacted.

Physical Properties

Physical properties are listed at/near STP unless otherwise indicated. Conversion Factors for phosphine (PH_3) gas: ppm = mg/m^3 x 0.72; mg/m^3 = ppm x 1.39. NA= not available.

Chemical	Vapor Density	Vapor Pressure (mm Hg)	Volatility	Boiling Point	Melting/ Freezing Point	Flash Point / Explosive Range	Specific Gravity	Aqueous Solubility (mg/L)	Non-aqueous Solubility
Phosphine	1.17 (air = 1)	2.93x10^4 mm Hg at 25°C	NA (very high)	-126°F/-87.7°C	-209°F/-133°C	Flammable Gas LEL = 1.6% UEL= 98% (est)	1.185	Slightly soluble in cold water; Insoluble in hot water	Soluble in alcohol, ether
Aluminum Phosphide	NA	NA	NA	Evaporation at 20°C is negligible	>1832°F/1000°C	NA	2.85	Decomposes on contact with water, producing phosphine gas	NA
Magnesium Phosphide	NA	NA	NA	Evaporation at 20°C is negligible	>1382°F/750°C	NA	2.1	Decomposes on contact with water, producing phosphine gas	NA
Zinc Phosphide	NA	NA	NA	2012°F/1100°C	788°F/420°C	NA	4.55	Decomposes on contact with water, producing phosphine gas	Slightly soluble in carbon disulfide, benzene; practically insoluble in alcohols

Release Scenarios

AIR RELEASE SCENARIOS ARE ASSUMED MOST PROBABLE; HOWEVER, OTHER RELEASE SCENARIOS AND EXPOSURE ROUTES SHOULD BE CONSIDERED.
General Statement: Aluminum, magnesium and zinc phosphides can easily react with moisture and generate phosphine gas. Phosphine gas can also be produced during active methamphetamine (meth) cooking in clandestine labs using the Red Phosphorus method. Industrial processes that use red phosphorus, or other phosphorus species, may release phosphine gas under certain conditions. Phosphine gas, more than the solid phosphides, represents the greatest threat in a release scenario.
Open Areas: Phosphine gas is easy to disperse, and the primary release/attack scenario is an airborne release. Phosphine gas is expected to disperse or to degrade by reaction with encountered surfaces/materials. Phosphine gas is reactive, extremely flammable and may ignite combustible materials. Phosphine gas is heavier than air and can accumulate in lower terrains.

Release Scenarios (continued)

Water/Water Systems: Solid phosphides released into natural waters or water systems will generate phosphine gas, which can result in an inhalation hazard. Phosphine gas is non-reactive with and only slightly soluble in water, so if released into natural waters or water systems, it is expected to volatilize from the water and could result in an inhalation hazard. Introduction of phosphine gas or solid phosphides to water/water systems is an unlikely release scenario.

Indoor Facility: Due to its volatility, phosphine gas could potentially be dispersed inside a building or facility; HVAC systems could be impacted. Explosive vapors can be formed. Phosphine gas is heavier than air and can accumulate in lower levels or utility corridors inside the building.

Other: Routine fumigation of food, produce, grain, etc. does not contaminate the product being fumigated with phosphine. If solid phosphides are mixed with the product, generation of phosphine gas may be possible under certain conditions, e.g., residually moist products. Contamination of agricultural products is an unlikely scenario. There have been reports of phosphine gas exposure from the emesis (vomit) of humans and animals who have ingested solid phosphide pesticides. Also see above **General Statement**.

Health Effects

Onset: Onset of symptoms is dose and route dependent. Symptoms may occur within seconds after exposure to phosphine gas (severe respiratory irritation) or liquid (frostbite, or skin/eye burns). Symptoms from phosphine gas may also be delayed for several hours after inhalation exposure. For zinc phosphide, after oral ingestion either intentionally or from food contaminated with zinc phosphide, onset of systemic (affects the whole body) symptoms may be delayed for several hours.

Signs/Symptoms: Appearance and severity of symptoms will vary depending upon exposure route, concentration and duration. However, the following is a general list of possible symptoms. Symptoms can be delayed by several hours.

Mild: Headache, cough, tightness and pain in the chest, shortness of breath, dizziness, and lethargy.

Moderate: In addition to mild symptoms, symptoms can also include dyspnea (breathing difficulty), muscle pain, chills, tremors, incoordination, seizures, and coma. Gastrointestinal symptoms include nausea, vomiting, abdominal pain, and diarrhea.

Severe: Pulmonary (lung) edema and cardiac arrhythmias. Impaired kidney and liver function may occur. Exposure above the OEL may result in unconsciousness or death.

Caution: Zinc phosphide is very toxic when ingested, because it reacts with water and acid in the stomach causing severe irritation. Severe symptoms of vascular collapse and extensive liver and kidney damage may result in death after about 30 hours.

Exposure Routes:

Inhalation: The primary route of exposure is inhalation of phosphine gas. Phosphides can be absorbed into the body by inhalation of their vapors or aerosols, and dusts.

Skin: Contact with phosphides, especially aluminum phosphide, can irritate the skin and mucous membranes. Phosphides are toxic when absorbed into the body through the skin and mucous membranes. Contact with liquid phosphine can cause frostbite or skin burns.

Eyes: Contact with phosphides, especially aluminum phosphide, can irritate the eyes. Contact with liquid phosphine can cause frostbite or burn the eyes.

Ingestion: Phosphides can be absorbed into the body by ingestion, and can result in acute systemic toxicity after ingestion, see **Caution** in above section.

Effect Levels

Air: Acute Exposure Guideline Levels (AEGLs) for general population one-time exposure emergency scenarios (complete definitions are available in Key References Cited/Used in NRT Quick Reference Guides for Toxic Industrial Chemicals). It should be noted that some AEGL-1 values are not recommended (NR) due to insufficient data. **In the AEGLs table below: PH_3=phosphine, AlP=aluminum phosphide, Mg_3P_2=magnesium phosphide, Zn_3P_2=zinc phosphide.**

AEGL Level in ppm, at various exposure durations	**10 min.**	**30 min.**	**1 hr.**	**4 hr.**	**8 hr.**
AEGL 1: Threshold mild effects	**PH_3** = NR **AlP** = NR **Mg_3P_2** = NR **Zn_3P_2** = NR	NR NR NR NR	NR NR NR NR	NR NR NR NR	NR NR NR NR
AEGL 2: Potentially irreversible effects or impaired ability to escape	**PH_3** = 4 **AlP** = 4 **Mg_3P_2** = 2 **Zn_3P_2** = 2	4 4 2 2	2 2 1 1	0.5 0.5 0.25 0.25	0.25 0.25 0.13 0.13
AEGL 3: Threshold for severe effects/medical needs/increasing potential for lethality	**PH_3** = 7.2 **AlP** = 7.2 **Mg_3P_2** = 3.6 **Zn_3P_2** = 3.6	7.2 7.2 3.6 3.6	3.6 3.6 1.8 1.8	0.9 0.9 0.45 0.45	0.45 0.45 0.23 0.23

Exposure Guidelines

Phosphine (PH_3) Gas (NA = not available)		
NIOSH IDLH = 50 ppm	**NIOSH STEL** = 1 ppm (1 mg/m^3)	**Soil:** see table below
NIOSH REL = 0.3 ppm TWA (0.4 mg/m^3)	**OSHA PEL** = 0.3 ppm TWA (0.4 mg/m^3)	**Drinking Water:** see table below
ACGIH TLV-TWA = 0.05 ppm; 0.15 ppm (ceiling) as STEL	**Inhalation RfC** = 0.0003 mg/m^3	**Oral RfD** = 0.00025 mg/kg/day
AIHA ERPG-1 = NA	**AIHA ERPG-2** = 0.5 ppm	**AIHA ERPG-3** = 5 ppm

Phosphide (NA = not available)	**NIOSH IDLH**	**NIOSH REL**	**OSHA PEL**	**ACGIH TLV-TWA**
AlP	NA	NA	NA	NA
Mg_3P_2	NA	NA	NA	NA
Zn_3P_2	NA	NA	NA	NA

Regional Screening Levels (RSLs) May 2018, where: Target Cancer Risk (TR) = 1 x 10^{-6}, Target Hazard Quotient (THQ) = 1.0. THQ may vary depending on remediation versus removal activities and chemical complexity of incident. (NA = not available)

Phosphide/Phosphine	**RSL Residential Soil (mg/kg)**	**RSL Industrial Soil (mg/kg)**	**Tap Water (ug/L)**
AlP	31	470	8.0
Mg_3P_2	NA	NA	NA
Zn_3P_2	23	350	6.0
PH_3	23	350	0.57

Personnel Safety

Note: Personal Protective Equipment (PPE) selection (levels A-D), medical surveillance requirements, First Aid options and personnel decontamination may vary depending upon the amount and purity of agent, site conditions and the release scenario. Additional information on personnel safety and PPE selection criteria can be found at: www.cdc.gov/niosh/ershdb. We also recommend that responders check their own internal procedures (i.e., SOPs), if applicable.

Medical: **Pre-incident:** Annual physical and respiratory function exams. **During Incident:** Conduct periodic on-site medical monitoring, observe for any signs and symptoms as per Health Effects section above and treat accordingly as per First Aid section below.

First Aid: Immediately remove person from affected area and remove contaminated clothing and articles. **Compressed liquid:** Observe and treat for frostbite and chemical burns. Wash bare skin immediately with water, or warm, soapy water if available, at normal household pressures (~50-60 psi) for three minutes, ensure thorough soaking. Rinse eyes exposed to liquid agent with potable water for 15 minutes. **Gas**: Observe and treat for respiratory distress and maintain clear airway. **Caution:** When performing CPR, or artificial respiration, use pocket mask with a one-way valve or other proper respiratory medical device (not mouth-to-mouth) to prevent accidental exposure to responder from potential off-gassing of phosphine gas from affected person. **Antidote: THERE IS NO ANTIDOTE**. Send person for follow-up medical attention and evaluation. If cleared to resume work, continue to monitor for signs/symptoms and treat accordingly. **Post Incident:** Post-incident medical surveillance is highly recommended.

Personal Protective Equipment (PPE):
GENERAL INFORMATION: NIOSH-approved Self Contained Breathing Apparatus (SCBA), NIOSH-approved Air Purifying Respirators (APR) or Powered Air Purifying Respirators (PAPR), full-face masks, and protective clothing should be used. Pre-incident training and exercises on the proper use of PPE are recommended.

CAUTION: Phosphine is a flammable gas that can be pyrophoric (spontaneously igniting in air). Phosphine may form mixtures with air that do not ignite spontaneously, but are flammable or explosive at ambient temperatures. Ignited phosphine gas may cause thermal burn risks. Chemical-resistant PPE may ignite and melt on skin, and may contribute to severity of burn injuries from short-duration thermal hazards.

Per NIOSH guidance –
LEVEL A: Recommended for the initial response to a phosphine incident. Level A provides the greatest level of skin (fully encapsulating suit), respiratory (SCBA), and eye protection when the contaminant identity or concentration is unknown. Select Level A when the phosphine concentration is unknown or above the IDLH or AEGL-2, and when there is a potential of ocular or dermal exposure.
LEVEL B: Provides the highest level of respiratory protection (SCBA) when a lesser level of skin protection is required. Select Level B when the phosphine concentration is unknown or above the IDLH or AEGL-2 and dermal exposure is less of a risk. Level B differs from Level A in that it typically incorporates a non-encapsulating, splash-protective, chemical-resistant outer suit that provides protection against most liquids but is not vapor tight.
LEVEL C: Select Level C when the contaminant identity and concentration are known and the respiratory protection criteria factors for the use of APR or PAPR (i.e., < IDLH, warning properties) are met. Level C may be appropriate when decontaminating personnel or equipment. **Note: Phosphine may have limited inhalation warning properties due to olfactory fatigue; use APR/PAPR with caution.**
LEVEL D: Select Level D when the contaminant is known and the concentration is below the appropriate occupational exposure limits for the stated duration times. **Note:** AEGL-1 values are not available for phosphine; therefore, other exposure values such as ACGIH TLV must be used.
Downgrading PPE levels can be considered only when the identity and concentration of the contaminant and risks of dermal exposure are known, and must be accompanied by on-site monitoring.

Field Detection

Real-time field screening tools (results not confirmatory or quantitative): Caution should be given to equipment that has not been properly evaluated. False positive and false negatives may occur in the presence of interferents common in the environment. Follow manufacturers' standards for any applicable correction factors. The following is a summary of minimum screening concentration ranges or levels for equipment procured by many EPA and HAZMAT response teams. Other screening tools may be used by these teams and other agencies and responders, some with similar capabilities and limitations.
CAUTION: Phosphide pesticides decompose on contact with water and moisture in air, producing phosphine (PH$_3$) gas; monitoring for phosphine gas is highly recommended for phosphide pesticides.

NOTE: Detection equipment does not measure contaminant levels. Rather, they detect the presence of phosphine gas at levels as low as listed below.

Minimum Screening Ranges/ Levels for Air	Dräger Tubes (Phosphine Tube 0.01a)	Dräger Sensors XS/XXS – PH$_3$	MultiRAE (PH$_3$ sensor)	MultiRAE (PID)	ppbRAE (PID)	Honeywell SPM (Hydrides)		Screening Levels for Water as Phosphates – Total, ortho-/meta	Colorimetric (HACH, various)
ppm	0.01	0.01	0.1	1	0.001	0.03			0.1 mg/L
mg/m^3	0.014	0.014	0.14	1.4	0.0014	0.04			

Sampling

Note: This section on sampling contains general guidelines and does not replace the need for a site-specific sampling plan (See Key References Cited/Used)
Sampling Concerns: Detection, sampling equipment and procedures, and analytical techniques will be site-specific and depend on: 1) physical state of the agent; 2) type of surfaces contaminated (e.g., porous vs. non-porous); 3) the purpose of sampling (e.g., characterization, decontamination efficacy and clearance); and 4) specific laboratory requirements. **Because phosphine gas and solid phosphide pesticides are reactive and volatile, field detection of reaction by-products (non-volatile oxyacids of phosphorous and inorganic phosphates) may suffice to achieve sampling goals in specific matrices, i.e., waters and soils.**
CAUTION: To avoid risk of severe personal injury, care must be taken when handling and preparing solid phosphide pesticide samples (e.g., tablets, pellets, dust) for analysis since phosphine gas may be released and/or buildup of flammable/explosive concentrations of phosphine gas in sampling containers can occur (even a closed plastic bag). Unreacted, or partially spent solid phosphide pesticide sampling residues must be handled and treated to reduce the above risks.
The U.S. Environmental Protection Agency (EPA) has set up mobile and fixed labs and analytical assets for chemical agent analysis of environmental samples under their Environmental Response Laboratory Network (ERLN), see ANALYSIS section below (www2.epa.gov/emergency-response/environmental-response-laboratory-network). **For sampling questions, call EPA/HQ-EOC at 202-564-3850. Concurrent air sampling is recommended during all sampling activities.**

Sample Locations and Planning: Initially consider air monitoring to ensure worker safety and to determine if there is phosphine present that could impact other areas. Characterization sampling is initiated by targeted or judgmental sampling to identify "hot spots," potential agent flow paths, and media or objects potentially acting as sinks. Additional biased or random sampling can be used to determine the extent of potential contamination or to verify the efficacy of decontamination. More thorough probabilistic sampling (e.g., grid, statistical approach) may be required for the clearance phase or if there are large uncertainties about the area impacted or the amount released. Because phosphine is reactive and generally not persistent, air sampling for a variety of compounds along with phosphine to help to "clear areas" should be included in the sampling plan. **Concurrent air monitoring for phosphine is recommended during all sampling activities.**

Sampling (continued)

Note: Phosphine is highly volatile and reactive, so reaction by-products, mainly non-volatile oxyacids of phosphorous and inorganic phosphates, may be detected in the field and used as markers to determine the extent of contamination of the parent phosphine. Under specific reaction conditions, reaction by-products may form in many sample types. Samples should be analyzed for the presence of agent and its reaction by-products. See ANALYSIS section below to ensure sampling procedures are compatible with all analytes.

Types of Samples:
Air: Samples are collected using appropriate solid phase absorbent media at breathing zone level (~5 ft.) to assess inhalation exposure and at ground levels (~6 in.) to assess off gassing at surfaces.
Water: Water should be collected in appropriate containers with addition of appropriate preservatives. Concurrent air monitoring is recommended.
Soil: For localized hot spot areas where soil deposition may occur, surface soil samples should be taken from a non-vegetated area to a depth of less than one inch. Sub-surface soil samples are typically not necessary unless a large amount of liquid was poured on the ground, or if an underlying aquifer is endangered. Concurrent air monitoring is recommended.
Surface Wipes: Wipe samples may indicate absence of phosphide contamination on non-porous surfaces. Concurrent air monitoring is recommended.
Bulk: For hot spot areas where liquid phosphine deposition may occur on porous surfaces (e.g., concrete, asphalt), actual pieces or cores of contaminated surface may be obtained using appropriate tools (scabbling, coring or drills) for subsequent laboratory extraction analysis. Concurrent air monitoring is recommended.
Other Sample Matrices: Contact EPA/HQ-EOC at 202-564-3850 for sampling instructions.

Sample Packaging and Shipping: The packaging and shipping of samples are subject to strict regulations established by DOT, CDC, USPS, OSHA and IATA. Contact the sample-receiving laboratory to determine if they have additional packaging, shipping or labeling requirements.

Analysis

CAUTION: Many labs may not be able to perform analysis on all matrices (e.g., wipes and soil). The ERLN will use uniform, compatible sample prep and analytical methods. (See www2.epa.gov/emergency-response/environmental-response-laboratory-network). Phosphates and other phosphine pesticide breakdown products may be accurately determined in the field using available meters and field kits. **Care must be taken when handling and preparing samples for analysis since phosphine gas may be generated. Prepare samples under a fume hood using GLP**. **To avoid risks from explosion hazard, consider using portable blast shield inside fume hood.** For access to the nearest ERLN laboratory specially trained and equipped for analysis of phosphine pesticides and their reaction by-products, contact the EPA/HQ-EOC at 202-564-3850.

Decontamination/Cleanup

CAUTION: DO NOT PUT WATER OR ALLOW MOISTURE IN CONTACT WITH SOLID PHOSPHIDE CONTAINING PRODUCTS. Avoid use of oxidizers in presence of gaseous or liquid phosphine. Phosphine can explode in presence of powerful oxidizers.
Liquid phosphine will quickly dissipate from a leaking compressed gas container, Phosphine is so volatile and reactive that unless present in confined spaces it will either dissipate rapidly or be consumed by reaction with the atmosphere and/or surfaces/materials it encounters. Hence, most decontamination will not necessarily be for phosphine gas itself, but for reaction by-products, mostly non-volatile oxyacids of phosphorous and inorganic phosphates. Separate, long-term decontamination strategies will need to be developed if those by-products are of concern in a specific situation. This decontamination section refers to solid phosphides and phosphine gas only.
Decontamination/Cleanup Planning: Once site controls are in place, develop a site-specific decontamination/cleanup plan. Decontamination may require a “tiered approach” using a variety of techniques and products. Call the EPA/HQ-EOC at 202-564-3850 for more information.
General Considerations: A cost vs. benefit evaluation should be undertaken for each decontamination strategy and approach that considers: public safety, total cost, impact on the facility, wastes generated, as well as the time the facility or item will be out of service and any socio-economic, psychological, and/or security impacts that may result. Large volumes of decontamination wastes may be generated that will need to be collected, treated and disposed of properly. Waste handling and disposal must be addressed as early in the decontamination and cleanup process as possible (see Waste Management section below).
Disposal Option: The urgency to restore a facility as quickly as possible may result in the outright and timely removal and disposal of contaminated materials. Certain materials may be resistant to decontamination formulations, or may be cheaper to discard and replace than to decontaminate and restore.
Monitored Natural Attenuation Phosphine: Phosphine gas dissipates rapidly (hours) via natural processes. Environmental monitoring must be maintained during decontamination and recovery phases. Monitored natural attenuation may require institutional controls (e.g., access restriction and contaminant containment measures). The time to achieve clearance must be considered in the overall cost/benefit evaluation. This option is more passive than other options but is non-destructive to materials.
Monitored Natural Attenuation Solid Phosphides: Not recommended. Solid phosphides do not evaporate appreciably over months to years, but may instead hydrolyze in presence of moisture to create highly toxic and explosive phosphine gas.
Fix-in-Place Option: Phosphine dissipates rapidly via natural processes, as such a “Fix-in-Place Option” will not be required or feasible. In the presence of solid phosphides, physical barriers can be used to separate and immobilize the agent contamination from encountering the environment or the public. This can be a temporary or permanent solution.
Decontamination Strategy: A decontamination strategy can be developed by designating contaminated areas based on presence of: 1) liquid phosphine, 2) gaseous phosphine, 3) solid phosphides, and 4) aqueous solutions containing phosphine and/or solid phosphides. EPA-approved labels for registered pesticides are intended to provide information for small spills/leaks and are not intended to provide guidance on decontamination/cleanup for emergency responses.
Strategy for Liquid Phosphine: Actions that promote safe volatilization of liquid phosphine may be useful since phosphine in gaseous form can be allowed to dissipate; volatilization may be a slow process depending on site conditions.
Strategy for Gaseous Phosphine: Phosphine gas is extremely flammable and may react explosively with air, so Hot Air ventilation is NOT recommended. Forced Air ventilation methods are suggested for low concentration of phosphine gas in volumetric spaces or open areas.
Strategy for Solid Phosphides: Intact tablets, pellets, or other forms containing solid phosphides may be transferred into air-tight containers with care being taken that dust is not dispersed into the air. All necessary precautions should be taken to prevent large quantities of solid phosphides from encountering liquid or airborne acids, water, or humid atmospheres. The residue after shoveling, or small spills, may be removed by dry HEPA vacuuming. Phosphide-containing pesticide label instructions may identify use of a wet deactivation strategy by placing residue in water with detergent. This strategy requires respiratory protection and controlled air ventilation due to formation of phosphine gas; see strategy for aqueous solution of phosphine or solid phosphides section.
Strategy for Aqueous Solutions of Phosphine or Solid Phosphides: Warning: Highly toxic and explosive phosphine may be present near aqueous solutions. If phosphine or phosphides are present in solution, contain liquid or transfer liquid to appropriate containers. Phosphine degrades or dissipates slowly (days) from an open water system. Unreacted phosphine gas requires subsequent management; see above strategy for gaseous phosphine. The dissipation time will depend on amount initially present and environmental conditions, and can be decreased by agitation. Oxidation with excess sodium hypochlorite (bleach) can convert dissolved phosphine and residual phosphides to less toxic compounds, but insufficient reaction conditions (e.g., when large quantities of phosphides are present) may lead to additional toxic by-products.

Decontamination/Cleanup (continued)

Sensitive Equipment and Items: For difficult-to-clean equipment thought to be contaminated with small amounts of solid phosphides, additional options for consideration include flushing with detergent and water, although the residual aqueous solution may contain phosphine gas that requires controlled air ventilation methods.

CAUTION: Decontamination/neutralization products may have unique safety/PPE requirements due to their own toxicity or that of breakdown products during use.

Verification of Decontamination: Site and situation specific. Please contact EPA/HQ-EOC at 202-564-3850 for further assistance.

Waste Management

Transportation: Federal requirements for transporting hazardous materials and procedures for exemptions are specified at www.fmcsa.dot.gov/safety-security/hazmat/complyhmregs.htm#hmp. Phosphine is considered Hazard Class 2.3, subsidiary Class 2.1 for transportation purposes, and aluminum phosphide, magnesium phosphide, and zinc phosphide are considered Hazard Class 4.3, subsidiary Class 6.1 for transportation purposes. Current resources on packaging, labeling and shipping are available at www.phmsa.dot.gov/hazmat. Detailed state regulations can be found at www.envcap.org/.

Waste Management: Under the Resource Conservation and Recovery Act (RCRA), solid waste can be classified as hazardous waste (subtitle C) or solid waste (subtitle D). The RCRA regulations generally define a waste to be hazardous if it is: (1) a listed waste (40 CFR §261.31-261.32), (2) exhibits specific characteristics (40 CFR §261.21-261.24) or (3) is a discarded commercial chemical product, off-specification species, container residue, or spill residue listed in 40 CFR §261.33. Phosphine is listed under RCRA chemical code P096 for discarded commercial chemical products (40 CFR §261.33), aluminum phosphide is listed under RCRA chemical code P006, zinc phosphide greater than 10% in concentration is listed under RCRA chemical code P122, and zinc phosphide less than or equal to 10% in concentration is listed under RCRA chemical code U249. Phosphine, aluminum phosphide, magnesium phosphide, and zinc phosphide waste can also be ignitable hazardous waste, chemical code D001, if it is in compressed gas form or if it is capable of causing fire through friction, absorption of moisture, or spontaneous chemical changes (40 CFR §261.21). Listed or characteristic waste may be land disposed only if the waste meets the applicable treatment standards (40 CFR §268.40). Phosphine, aluminum phosphide, and zinc phosphide are also regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) with reportable quantity thresholds of 100 pounds (40 CFR §302.4). The States (except for Alaska and Iowa) have the primary responsibility to implement the hazardous waste regulations and can impose more stringent requirements than the Federal program, so it is critical to open a dialogue with regulators as early as possible. Management of toxic decomposition products, associated residual decontamination solutions, local waste acceptance criteria, and transportation and handling requirements should be considered. The EPA has developed I-WASTE, a web-based tool that contains links to waste transportation guidance, treatment and disposal facilities, state regulatory offices, packaging guidance, and guidance to minimize the potential for contaminating the treatment or disposal facility. Access to this decision support tool requires pre-registration (www2.ergweb.com/bdrtool/login.asp).