ADVISORY NO. 4.1: PYROPHORICS

Purpose/Background

The purpose of this document is to provide information and procedures to assure that pyrophoric materials are used safely and to outline practices to be followed to prevent injury and damage associated with pyrophoric explosions.

Pyrophoric substances are liquids, solids, or gases that will ignite spontaneously in air or below 130 F (54.4 C). To receive the pyrophoric classification under GHS a chemical must ignite within 5 minutes in air. However, chemicals that ignite after 5 minutes also pose a significant risk to users and should be handled as pyrophoric. Many reducing agents are pyrophoric and water reactive due to their rapid oxidation by oxygen or moisture in the air. Serious burns could occur to personnel handling a pyrophoric if it were to spontaneously combust.

Water-reactive reagents are substances that react with water to release a gas that is either flammable or a health hazard. When water contacts a water-reactive substance, enough heat may be generated to cause spontaneous combustion or an explosion. Examples of water-reactive chemicals include alkali metals (sodium, potassium, and lithium), anhydrides, certain carbides, hydrides, sodium hydrosulfite, and similar chemicals.

Scope

This Standard Operating Procedure (SOP) is a generic guideline that can be used to aid UC laboratories, shops and studios that use pyrophoric substances to develop a material-specific and experiment-specific SOP for their work.

This SOP does NOT cover the use of pyrophoric gases.

Prerequisites

Laboratories working with pyrophoric substances must have a Chemical Hygiene Plan. Shops and Studios working with pyrophoric material are under UC Hazard Communication Program. Anyone working with a pyrophoric liquid or solid must have a specific written handling, transfer, and storage plan.

Procedures

General Use Procedures

Appendix A lists some pyrophoric substances. Some common pyrophoric chemicals include alkyl lithium(s), trialkyl aluminum reagents, and alkylboranes. The most pyrophoric of the lithium reagents is t-butyllithium, although concentrated n-butyllithium (approximately 10 M) is also pyrophoric.

Most incidents occur when pyrophoric materials are transferred to an appropriate reaction flask, for hydrolysis and/or neutralization with adequate cooling. Incidents in laboratories occur because this procedure has been done improperly. Root causes range from choosing the wrong solvent, to improper cooling, or even lack of an adequate quantity of solvent to provide enough of a heat sink (even though it has been cooled). Most incidents resulting from pyrophoric compounds have been a result of incorrect procedures during the quenching process versus actual experimentation with the material. Prior to performing this practice, consult with the principal investigator (PI) and/or laboratory director for guidance.

- **Information**: Acquire a Safety Data Sheet (SDS) and manufacturer technical bulletins for all pyrophoric substances being used. Due to the severe potential hazards of pyrophoric materials, carefully review the handling and storage procedures and become familiar with the chemical and physical properties of each substance before beginning work. Always review the incompatibility with other substances and the conditions to which the compounds are sensitive. Always read the manufacturers' recommendations contained in supplementary documents, such as technical bulletins. Contact the UC- EH&S Office to review new uses of pyrophoric substances.

- **Purchase**: In obtaining pyrophoric material, a careful analysis should be made of how much is needed for the time period of the research, factoring in allowable storage quantities noted in Appendix B. Experiments should be designed to keep the lowest possible amount on hand.

- **Training**: Anyone using pyrophoric substances must have thorough and adequate training and knowledge of the hazards and practices and procedure for working with them safely. If you are unsure of any of the procedures, get assistance. All users of pyrophoric materials must be fully qualified and experienced laboratory workers or working under direct supervision of experienced workers.

- **Storage Quantities:** According to the Ohio State Building Code 4101, Section 307, Table 307.1, pyrophoric substances are permitted only in buildings equipped throughout with an automatic sprinkler system in accordance with Section 903, and the quantities are limited by the control area space and the building height. Please contact UC-EHS at 513-556-4968 or ehssoncall@ucmail.uc.edu email for information about the maximum allowable quantity status and whether you are compliant.

- **SOP**: A laboratory specific SOP is required for the use of pyrophoric substances.

- **Personal Protective Equipment**: Flame resistant (FR) lab coats are required when handling pyrophoric substances, including chemicals that release flammable gases that may ignited spontaneously and self-heating chemicals that may catch on fire outside of a glove box. FR lab coats should also be worn when working with chemicals that react violently with water or release flammable gas, or when performing potentially vigorous reactions.
    - Protective eyewear is required and must be worn when handling pyrophoric and water-reactive materials. Fully enclosed safety goggles or a face shield are preferred, as they offer greater facial protection than safety glasses.
    - Gloves are required and must be worn when handling pyrophoric and water-reactive materials. It is recommended that Nomex gloves be worn between two pairs of nitrile gloves for fire protection purposes.
    - Clothing made from polyester and other synthetic fabrics and loose clothing should **NOT** be worn. Always wear long pants that cover the body to the ankles and closed-toe solid top shoes within the lab. Loose or long hair should be tied back to prevent ignition in the event of a flash fire. A chemical-resistant apron worn over the lab coat is required for working with large quantities.

- **Engineering Controls:**

- Pyrophoric chemicals should be used in **a chemical fume hood** (over a spill tray) using techniques that prevent the material from contacting air or in an inert-atmosphere **glove box** according to the manufacturer's recommendations. Anyone working in a glove box must be trained on the box and review the SOP with their Principal Investigator prior to beginning work. Aldrich Technical Bulletins AL-164 *Handling Pyrophoric Reagents* and AL-134 *Handling Air-sensitive Reagents* provide detailed instructions on using a standard syringe and double-tipped needle transfer techniques which prevents contact with air. Some pyrophoric substances must be handled in a gas-tight syringe to prevent exposure to air.
- Aldrich sells a portable controlled-atmosphere chamber known as an AtmosBag that can be sealed, purged, and inflated with an inert gas.
- If use of the pyrophoric substance in a chemical fume hood is appropriate according to the manufacturer's recommendations, then the sash should be as far down as feasible. If there is a potential explosion hazard, then isolate the process behind a blast shield, portable safety shield, or a barricade secured to an immovable object. Techniques must be used to prevent contact with air.
- It is recommended that tongs, stopcock turners, or mechanical arms be used for manipulating experiments at safer distance.

- **Work Practice Controls:**
  - Laboratories working with pyrophoric materials should develop material specific SOPs to assure safe handling.
  - Always follow the manufacturer's recommendations for use and storage. Aldrich Bulletins AL-164 *Handling Pyrophoric Reagents* and AL-134 *Handling Air-sensitive Reagents* provide detailed instructions for handling pyrophoric chemicals.
  - Only experienced laboratory workers should handle pyrophoric chemicals.
  - Use and purchase pyrophoric substances in the smallest quantities necessary and design experiments on as small scale as possible.
  - A small beaker of sand can be used to extinguish any fire that occurs at the syringe tip and to receive any last drops of reagent from the syringe.
  - Never return excess pyrophoric substances to the original container since small amounts of impurities introduced into the container may cause a fire or explosion.
  - Do not mix with other chemicals without prior knowledge of the hazards involved and take the appropriate precautions. Minimize quantities as much as possible for such reactions. Prior to introducing pyrophoric materials with other compounds, researchers should document the expected chemical reaction in a laboratory notebook.
  - Vacuum pumps should be rated for use with pyrophoric substances.
  - Do not allow pyrophoric materials to contact combustible material, such as paper or cardboard.
  - Transport and store the glass pyrophoric bottle in the original metal shipping container.
  - All of the pyrophoric substance should be used for the chemical reaction. Any residual or trace material must be transferred to an appropriate reaction flask for hydrolysis and/or neutralization with adequate cooling. Never open a container with residual or trace amounts of pyrophoric chemicals to the atmosphere.
  - Ensure that the heating methods used do not cause or increase the potential for ignition.
  - Never leave potentially hazardous experiments unattended.

General Storage and Disposal Procedures

Storing pyrophoric chemicals should be part of a comprehensive chemical storage plan that is outlined in the Chemical Storage SOP. The SDS for each material should be read to determine specific storage recommendations or special storage conditions.

- Some pyrophoric materials must be stored under an atmosphere of inert gas, under kerosene, or under another solvent, as indicated in the manufacturer's instructions and SDS.
- Once opened, containers should be dated, ensure that enough solvent remains to cover the material in the container during storage.
- Pyrophoric reagents from Aldrich are packaged in Sure/Seal bottles which can be handled and stored with exposure to atmospheric moisture or oxygen. The reagent can be dispensed using a syringe or double-tipped needle inserted through the hole in the metal cap. Check the crown cap and liner conditions regularly to make sure that they are in good condition to provide tight seals.
- Pyrophoric chemicals should be stored and transported in the original metal shipping container.
- The storage area should be conspicuously marked to indicate that pyrophoric materials are being stored.
- Pyrophorics are permitted only in buildings equipped throughout with an automatic sprinkler system and the quantities are limited to the allowable pounds per control area.

Disposal

- Excess pyrophoric chemicals should be treated as hazardous waste, special procedures may be required for waste collection.
- Disposal of empty pyrophoric containers: Under an inert atmosphere, add dry inert solvent (preferably the same solvent used for the original reagent) to empty the pyrophoric container and rinse three times. This solvent must also be neutralized or hydrolyzed. The rinse solvent must be added to and removed from the container under an inert atmosphere.
- After the container is triple-rinsed, it should be left open in the back of the fume hood for at least a week. After allowing the container to be exposed to the atmosphere for at least a week, the container must be triple-rinsed with water before disposal.
- The empty container, solvent rinses, and water rinse should be disposed of as hazardous waste and should not be mixed with incompatible waste streams.
- Certain metal powders, such as fine aluminum powder, should be submerged in oil prior to waste collection from the lab. Debris with aluminum powder may be collected with a thin coating of oil and kept separate from other debris waste streams.

- Reactive metals, such as lithium, potassium, and magnesium, should also be submerged under oil and handled as hazardous waste. Contact EH&S (513-556-4968) for additional guidance.

- All materials – disposable gloves, wipes, bench paper, etc. – that are contaminated with pyrophoric chemicals should be disposed of as hazardous waste.

- The contaminated waste should not be left out in the open lab but must be properly contained to prevent fires.

General Emergency Procedures

Plan ahead for possible emergencies involving pyrophoric materials. All personnel who work in areas where pyrophoric substances or explosives are used should be trained in how to respond to potential emergencies.

- Prior to using pyrophoric chemicals, consult the SDS for the appropriate clean-up supplies and ensure that they are readily available. Spill control materials are designed to be inert and unreactive with the reagent.

- Before using pyrophoric materials, ensure dry sand, powdered lime, Met-L-X or Lith-X suppression material or a Class D fire extinguisher is nearby as fire-extinguishing medium. For pyrophoric spills, do NOT use water or carbon dioxide-based extinguishers since they can enhance the combustion of the compounds. If you do NOT feel comfortable using a fire extinguisher, CALL 911. NOTE: Any use of a fire extinguisher must be reported to the UC Fire Safety Office.

- DO NOT USE a CO_2 extinguisher to attempt to quench the fire with pyrophoric reagents, this can enhance the problem.

- Notify people in the area that a spill has occurred. For a large spill, turn off sources of ignition and vacate the lab immediately. Dial 911 from a UC phone for emergency assistance.

- In case of fire or explosion, activate the fire alarms and dial 911 from a UC phone from a safe location, even if extinguished.

- In case of skin contact, wash the affected area thoroughly with water for at least 15 minutes and seek immediate medial attention by calling 911 from a UC phone. Always know the location of the nearest eyewash and shower and how to use the emergency equipment. Keep the area clear at all times. It is best to use the chemical fume hood closest to the safety shower to perform the work.

Roles & Responsibilities:

The UC-EH&S Office is responsible for:

- Providing General Chemical Hygiene Training (web-based or classroom) and UC Overview HAZCOM training.

- Maintaining up to date guidance pertaining to pyrophorics.

- Reviewing SOPs and new uses of pyrophorics
- Addressing questions or concerns pertaining to pyrophorics.
- Assisting with inspections/audits of the use and storage areas for pyrophorics.

PI/Supervisors are responsible for:

- Addressing questions or concerns pertaining to pyrophorics.
- Assisting with inspections/audits of use and storage areas for pyrophorics.
- Ensuring SOPs for pyrophoric materials specific to the laboratory are developed.
- Ensuring that supervised individuals receive adequate pyrophorics training.
- Ensuring that pyrophorics are used and stored in the smallest quantities necessary in the work areas that they supervise.
- Ensuring appropriate PPE is available for work with pyrophorics.

The Lab Manager/coordinator or Chemical Hygiene Officer:

- Addressing questions or concerns regarding the use or storage of pyrophorics and consulting with the EH&S Office if necessary.
- Inspecting chemical storage areas, including the storage areas of pyrophorics, twice a year; notifying the laboratory personnel and the PI/Supervisor of problems found so that they can be corrected or prevented, and updating the PI if pyrophorics are routinely used or stored in the lab.

EH&S Representatives are responsible for:

- Conducting audits and assisting the PI/supervisor with the safe use and storage of pyrophorics in the work area. Specific duties may include periodically inspecting use and storage areas and keeping an inventory of pyrophorics.
- Knowing and following the pyrophorics SOPs established in their laboratory/work area.
- Assuring that they have adequate training.
- Using materials in accordance with training guidance provided, such as SOPs.
- Reporting any incidents, near misses, and problems or concerns with handling materials to PI/supervisor.

- Wearing the PPE that is specified.

Training:

All laboratory personnel working with pyrophorics must have completed General Chemical Hygiene Training (web-based) and Lab-Specific Chemical Hygiene Training.

The Lab-Specific Chemical Hygiene Training performed by the laboratory PI should include the following information if pyrophorics are used in the laboratory/work area:

- The hazards and safe use of pyrophorics.
- The location and function of specialized equipment needed for the safe use and storage of pyrophorics.
- Procedures to be used in case of an emergency with pyrophorics.
- The location of SDSs and SOPs for pyrophorics.
- Knowledge of appropriate PPE.

Awareness level training should be given to others who work in areas where pyrophorics are present. Laboratories or Lab Managers desiring additional training for special or unusual applications of pyrophorics may contact the UC-EH&S Office for help in developing and implementing training specific to their needs.

References:

The following references are available through the EH&S Office:

Standards

- OHSA 1910.1450 Occupational Exposure to Hazardous Chemicals in Laboratories
- OSHA 1910.106 Flammable and Combustible Liquids
- State of Ohio Building Code Section 307, Table 307.1

Supplementary Documents

- UC Environment, Health, and Safety Policy
- Aldrich Technical Bulletin AL-134, Handling Air-Sensitive Reagents
- Aldrich Technical Bulletin AL-164, Handling Pyrophoric Reagents
- "Prudent Practices for the Disposal of Chemicals from Laboratories" published by the National Academy Press

Helpful Websites

- OSHA Regulations and Technical Manuals: https://www.osha.gov

Definitions:

Safety Data Sheet (SDS)

A written document that outlines health and safety information for a hazardous chemical. A SDS is prepared in accordance with requirements of OSHA 29 CFR 1910.1200 Hazard Communication.

Mixture

Any combination of two or more chemicals provided that the combination is not, in whole or in part, the result of a chemical reaction.

Pyrophoric Substances

Liquids or solids that will ignite spontaneously in air at or below 130 F (54.4 C)

Unstable (reactive)

A chemical which, in the pure state, or as produced or transported will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shock, pressure, or temperature.

Use

Packaging, handling, reacting, emitting, generating as a byproduct, or transferring.

Water-reactive Substances

Substances that react with water to release a gas that is either flammable or a health hazard. When water contacts a water-reactive substance enough heat may be generated to cause spontaneous combustion or an explosion.

Appendix A: Examples of Pyrophoric Substances

1. Alkyls and aryls (metal and nonmetal):
    a. Butyllithium, $CH_3(CH_2)_3Li$
    b. Diethylzinc, $(C_2H_5)_2$ Zn
    c. Ethyl lithium, CH_3CH_2Li
    d. Ethyl sodium, CH_3CH_2Na (and other sodium alkyls)
    e. Tributyl aluminum, $(CH_3CH_2CH_2CH_2)_3Al$
    f. Triethyl aluminum, $(C_2H_5)_3Al$
    g. Triethyl arsine, $(C_2H_5)_3As$
    h. Triethyl borane, $(C_2H_5)_3B$
    i. Triethyl phosphine $(C_2H_5)_3P$
2. Carbonyls (metal):
    a. Cobalt carbonyl, $Co_2(CO)_6$
    b. Nickel carbonyl, $Ni(CO)_4$
    c. Iron carbonyl, $Fe(CO)_5$
3. Gases:
    a. Dibrobane (borane), B_2H_6
    b. Dichloroborane, BCl_2H
    c. Dichlorosilane, SiH_2CL
    d. Disilane, Si_2H_6
    e. Silane, SiH_4
    f. Phosphine, PH_3
4. Grignard Reagents (organomagnesium halides, RMgX):
    a. Methyl magnesium bromide, CH_3MgBr
5. Hydrides (metal and nonmetal):
    a. Arsine hydride, AsH_3
    b. Aluminum borohydride, Al(BH)
    c. Boron hydrides, BH_3, B_2H_6, B_{20} H_{26}, and other boranes (borane-phosphorus trifluoride BH_3-PF_3)
    d. Lithium aluminum hydride, $LiAlH_4$
    e. Lithium hydride, LiH
    f. Phosphine hydride, PH_3
    g. Sodium borohydride, $NaBH_4$
    h. Sodium hydride, NaH
6. Metal powders:

a. Aluminum, Al	g. Platinum, Pt
b. Cobalt, Co	h. Sodium, Na
c. Iron, Fe	i. Titanium, Ti, including titanium (II) chloride $TiCl_2$
d. Lead, Pb	j. Tin, Sn
e. Magnesium, Mg	k. Zinc, Zn
f. Manganese, Mn	l. Zirconium, Zr

7. Phosphorous (white), P_4 (synonym: phosphorus (yellow))

Appendix B: Storage Quantities

Exempt amounts of Hazardous Materials, Liquids and Chemicals Presenting a Physical Hazard
Maximum Quantities Per Control Area

The Ohio State Building Code, Table 307.1 (Reproduced in Part)

APPENDIX B: MAXIMUM ALLOWABLE STORAGE QUANTITIES

MATERIAL	CLASS	USE GROUPS	STORAGE[b]			USE-CLOSED SYSTEMS[b]			USE-OPEN SYSTEMS[b]	
			Solid pounds (cubic feet)	Liquid gallons (pounds)	Gas (cubic feet at NTP)	Solid pounds (cubic feet)	Liquid gallons (pounds)	Gas (cubic feet at NTP)	Solid pounds (cubic feet)	Liquid gallons (pounds)
Pyrophoric	NA	H-2	4[e, g]	(4)[e, g]	50[e, g]	1[g]	(1)[g]	10[e, g]	0	0
Water reactive	3	H-2	5[d, e]	(5)[d, e]	NA	5[d]	(5)[d]	NA	1[d]	(1)[d]
	2	H-3	50[d, e]	(50)[d, e]		50[d]	(50)[d]		10[d]	(10)[d]

For SI: 1 cubic foot = 0.028 m3, 1 pound = 0.454 kg, 1 gallon = 3.785 L.
NL = Not Limited; NA = Not Applicable; UD = Unclassified Detonable.

1. a. For use of control areas, see Section 414.2 of the International Building Code.
2. b. The aggregate quantity in use and storage shall not exceed the quantity specified for storage.
3. c. The quantities of alcoholic beverages in retail and wholesale sales occupancies shall not be limited provided the liquids are packaged in individual containers not exceeding 1.3 gallons. In retail and wholesale sales occupancies, the quantities of medicines, foodstuffs or consumer products, and cosmetics containing not more than 50 percent by volume of water-miscible liquids with the remainder of the solutions not being flammable, shall not be limited, provided that such materials are packaged in individual containers not exceeding 1.3 gallons.
4. d. Maximum allowable quantities shall be increased 100 percent in buildings equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1. Where Note (e) also applies, the increase for both notes shall be applied accumulatively.
5. e. Maximum allowable quantities shall be increased 100 percent when stored in approved storage cabinets, day boxes, gas cabinets, gas rooms or exhausted enclosures or in listed safety cans in accordance with Section 5003.9.10 of the International Fire Code. Where Note (d) also applies, the increase for both notes shall be applied accumulatively.
6. f. Quantities shall not be limited in a building equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1.
7. g. Allowed only in buildings equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1.
8. h. Containing not more than the maximum allowable quantity per control area of Class IA, IB or IC flammable liquids.
9. i. The maximum allowable quantity shall not apply to fuel oil storage complying with Section 605.4.2 of the International Fire Code.
10. j. Quantities in parentheses indicate quantity units in parentheses at the head of each column.
11. k. A maximum quantity of 220 pounds of solid or 22 gallons of liquid Class 3 oxidizers is allowed when such materials are necessary for maintenance purposes, operation or sanitation of equipment when the storage containers and the manner of storage are approved.
12. l. Net weight of the pyrotechnic composition of the fireworks. Where the net weight of the pyrotechnic composition of the fireworks is not known, 25 percent of the gross weight of the fireworks, including packaging, shall be used.
13. m. For gallons of liquids, divide the amount in pounds by 10 in accordance with Section 5003.1.2 of the International Fire Code.
14. n. For storage and display quantities in Group M and storage quantities in Group S occupancies complying with Section 414.2.5, see Tables 414.2.5(1) and 414.2.5(2).
15. o. Densely packed baled cotton that complies with the packing requirements of ISO 8115 shall not be included in this material class.
16. p. The following shall not be included in determining the maximum allowable quantities:
1. 1. Liquid or gaseous fuel in fuel tanks on vehicles.
2. 2. Liquid or gaseous fuel in fuel tanks on motorized equipment operated in accordance with the International Fire Code.
3. 3. Gaseous fuels in piping systems and fixed appliances regulated by the International Fuel Gas Code.
4. 4. Liquid fuels in piping systems and fixed appliances regulated by the International Mechanical Code.
5. 5. Alcohol-based hand rubs classified as Class I or II liquids in dispensers that are installed in accordance with Sections 5705.5 and 5705.5.1 of the International Fire Code. The location of the alcohol-based hand rub (ABHR) dispensers shall be provided in the construction documents.
17. q. Where manufactured, generated or used in such a manner that the concentration and conditions create a fire or explosion hazard based on information prepared in accordance with Section 414.1.3.

Appendix C: Common Pyrophoric and Water-Reactive Chemicals

Classification: Pyrophoric substances are liquids, solids, or gases that will ignite spontaneously in air at or below 130 °F (54.4 °C). Water-reactive substances are substances that react with water or moisture to release a gas that is either flammable or a health hazard. When water contacts a water-reactive substance, enough heat may be generated to cause spontaneous combustion or an explosion. Flame resistant (FR) lab coats are required when handling pyrophoric substances, including chemicals that release flammable gases that may ignite spontaneously and self-heating chemicals that may catch fire *(highlighted blue below)*. FR lab coats should also be worn when working with chemicals that react violently with water or release flammable gas *(highlighted yellow)*, or when performing potentially vigorous reactions.

Key Phrases: SDSs do not always accurately classify chemicals as pyrophoric. Look both for pyrophoric classifications as well as other key phrases indicative of spontaneously combustible or violent reactions. Examples include "extremely flammable", "catches fire spontaneously", and "reacts violently with air or water". These phrases should trigger a closer look at other safety data sources or outreach to the EHS Office for assistance.

GHS Hazard Statements: The following hazard statements, found in section 2 of the SDS, indicate that the chemical exhibits pyrophoric or water-reactive characteristics that may warrant FR lab coat use.

Category/Type			Example Chemicals	CASNO	H250	H251	H260	H261	HNOC	H220
Hydrides	Metal Hydrides		ALUMINUM BOROHYDRIDE	16962-07-5			X			
			CALCIUM HYDRIDE	7789-78-8			X			
			DIISOBUTYLALUMINUM HYDRIDE	1191-15-7	X		X	X		
			LITHIUM ALUMINUM HYDRIDE	16853-85-3			X			
			LITHIUM BOROHYDRIDE	16949-15-8			X			
			LITHIUM HYDRIDE	7580-67-8			X			
			POTASSIUM HYDRIDE	7693-26-7			X			
			SODIUM BOROHYDRIDE	16940-66-2			X			
			SODIUM HYDRIDE	7646-69-7			X			
			SUPER-HYDRIDE (LITHIUM TRIETHYLBOROHYDRIDE)	22560-16-3			X			
			SODIUM TRIACETOXYBOROHYDRIDE	56553-60-7				X		
			SODIUM TRIETHYLBOROHYDRIDE	17979-81-6				X		
	Non-Metal Hydrides	Arsenic Compounds	ARSINE	7784-42-1						X
		Boron Compounds	9-BORABICYCLO [3.3.1]NONANE	280-64-8	X		X			
			BORANE TETRAHYDROFURAN COMPLEX	14044-65-6			X			
			BORANE TRIFLUORIDE	7637-07-2			X			
			DIBORANE	19287-45-7	X					X
			DICHLOROBORANE	13701-67-2	X					
			POLYBORANES		X					
			TRIBUTYLBORANE	122-56-5	X					
			TRIETHYLBORANE	97-94-9	X					
			TETRABUTYLAMMONIUM BOROHYDRIDE	33725-74-5				X		
			TETRAFLUOROBORIC ACID-DIETHYL ETHER COMPLEX	67969-82-8				X	X	
			TETRAMETHYLAMMONIUM TRIACETOXYBOROHYDRIDE	109704-53-2				X		
		Phosphorus Compounds	DI-T-BUTYLMETHYLPHOSPHINE	6002-40-0	X					
			DI-TERT-BUTYLPHOSPHINE	819-19-2	X					
			DICHLOROISOPROPYLPHOSPHINE, 97%	25235-15-8			X		X	
			DIPHENYLPHOSPHINE	829-85-6	X					
			PHOSPHINE	7803-51-2						X
			TRI-N-BUTYLPHOSPHINE	998-40-3	X					
			TRI-TERT-BUTYLPHOSPHINE	13716-12-6	X					
			TRIETHYL PHOSPHONE	554-70-1	X					
			TRIBUTYLPHOSPHINE	998-40-3	X					
		Silicon Compounds	DICHLOROSILANE	4109-96-0				X		X
			DISILANE	1590-87-0						X
			METHYL SILANE	992-94-9					X	X
			SILANE	7803-62-5	X					
			TRICHLOROSILANE	10025-78-2	X				X	

Category/Type	Example Chemicals	CASNO	H250	H251	H260	H261	HNOC	H220
Metal Powders (Excluding Oxides) *NOTE: Many metal powders present special storage and handling concerns when finely divided, including hazards such as air- or water-reactivity or explosive dust generation. Whether a given metal powder exhibits these properties depends on multiple factors, including but not limited to particle size, surface area, moisture level, purity, etc.* *Please contact your EHS Coordinator or the EHS Office for assistance when working with small-particle-size metal powders.*	ALUMINUM	7429-90-5	X			X	X	
	BARIUM	7440-39-3			X	X		
	CADMIUM	7440-43-9	X					
	CALCIUM	7440-70-2	X			X		
	CERIUM	7440-45-1	X					
	CESIUM	7440-46-2			X			
	CHROMIUM	7440-47-3	X					
	COBALT	7440-48-4	X					
	EUROPIUM	7440-53-1	X		X			
	HAFNIUM	7440-58-6	X					
	IRIDIUM	7439-88-5	X					
	IRON H251	7439-89-6		X				
	LEAD	7439-92-1	X					
	MAGNESIUM	7439-95-4	X		X		X	
	MANGANESE	7439-96-5			X			
	NICKEL	7440-02-0	X					
	PALLADIUM	7440-05-3	X					
	PLATINUM	7440-06-4	X					
	PLUTONIUM	7440-07-5	X					
	RHODIUM	7440-16-6	X					
	RUBIDIUM	7440-17-7			X			
	STRONTIUM	7440-24-6			X			
	TANTALUM	7440-25-7	X					
	TECHNETIUM	7440-26-8	X					
	THORIUM	7440-29-1	X					
	TITANIUM	7440-32-6	X		X			
	URANIUM	7440-61-1	X					
	VANADIUM	7440-62-2	X					
	ZINC	7440-66-6	X		X		X	
	ZIRCONIUM	7440-67-7	X		X			

Category/Type	Example Chemicals	CASNO	H250	H251	H260	H261	HNOC	H220
Non-Metals	WHITE PHOSPHORUS (PHOSPHORUS TETRAMER)	12185-10-3	X					

Metal Halide	TITANIUM (III) CHLORIDE	10049-06-6	X					

Alkali Metals (Group 1)	LITHIUM	7439-93-2			X		X	
	POTASSIUM	7440-09-7			X		X	
	SODIUM	7440-23-5			X		X	

Metal Carbonyls	COBALT CARBONYL	10210-68-1		X				
	CYCLOPENTADIENYL IRON DICARBONYL DIMER	12154-95-9		X				
	DISODIUM TETRACARBONYL FERRATE DIOXANE COMPLEX	58733-73-2	X					
	IRON CARBONYL	13463-40-6	X					
	NICKEL CARBONYL	13463-39-3	X					

Category/Type		Example Chemicals	CASNO	H250	H251	H260	H261	HNOC	H220
Metal-Organic Compounds	**Grignard Reagents (R-Mg-X)**	ALLYLMAGNESIUM BROMIDE	1730-25-2	X		X		X	
		ALLYLMAGNESIUM CHLORIDE	2622-05-1	X		X		X	
		BUTYLMAGNESIUM CHLORIDE	693-04-9	X		X		X	
		CYCLOHEPTYLMAGNESIUM BROMIDE	78378-12-8			X			
		ETHYLMAGNESIUM BROMIDE	925-90-6			X		X	
		ISOBUTYLMAGNESIUM BROMIDE	926-62-5			X			
		ISOBUTYLMAGNESIUM CHLORIDE	5674-02-2			X			
		ISOPROPYLMAGNESIUM CHLORIDE	1068-55-9			X	X		
		METHYLMAGNESIUM BROMIDE	75-16-1			X		X	
		METHYLMAGNESIUM IODIDE	917-64-6			X		X	
		SEC-BUTYLMAGNESIUM CHLORIDE	15366-08-2	X		X	X	X	
		VINYLMAGNESIUM BROMIDE	1826-67-1			X		X	
		2,2-DIMETHYLPROPYLMAGNESIUM CHLORIDE	13132-23-5				X	X	
		2,2,6,6-TETRAMETHYLPIPERIDINYLMAGNESIUM CHLORIDE LITHIUM CHLORIDE COMPLEX	898838-07-8					X	
		PROPYLMAGNESIUM CHLORIDE	2234-82-4				X		
		SEC-BUTYLMAGNESIUM CHLORIDE LITHIUM CHLORIDE COMPLEX	1027768-06-1				X	X	
		(TRIMETHYLSILYLMETHYL)MAGNESIUM CHLORIDE	13170-43-9					X	
		BIS(CYCLOPENTADIENYL)MAGNESIUM	1284-72-6	X			X	X	
		ETHYLLITHIUM	811-49-4	X			X		
		HEXYLLITHIUM	21369-64-2	X		X			
		LITHIUM DIISOPROPYLAMIDE	4111-54-0	X				X	
		LITHIUM DIMETHYLAMIDE	3585-33-9	X			X		