
EAD-EQ-PCE-TG-16

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* Refer to SG Circular S.G/C-08/12 Concerning Appointment and Responsibilities of the Corporate Management Representative at the Environment Agency – Abu Dhabi.
Table of Contents

List of Abbreviations ....................................................................................................................................................................... 3
Definitions of Terms ........................................................................................................................................................................ 3
Purpose of This Guidance Document ............................................................................................................................................. 6
Introduction ..................................................................................................................................................................................... 6
A. Role of the Environment Agency–Abu Dhabi ........................................................................................................................................................................... 6
B. Risks Related to Hazardous Materials ..................................................................................................................................... 7
C. General Requirements for Storing Hazardous Materials ........................................................................................................ 8
   C.1 Requirements for Establishing Hazardous Materials Storage Areas ............................................................................. 8
   C.2 Requirements for Signage, Equipment, Training, and Related Items ............................................................................ 8
   C.3 Requirements for Proper Storage of Hazardous Materials ............................................................................................ 9
   C.4 Requirements for Labeling Hazardous Materials ........................................................................................................... 9
   C.5 Requirements for Storing, Opening, Inspecting, and Sealing Containers of Hazardous Materials .............................. 10
D. Special Requirements for Storing Hazardous Materials in Tanks .......................................................................................... 10
E. Special Requirements for Storing Compressed Gas Cylinders ............................................................................................. 10
F. Special Requirements Storing Flammable Materials ............................................................................................................. 11
G. Special Requirements for Storing Organic Peroxides ............................................................................................................ 12
H. Special Requirements for Storing Toxic Materials ................................................................................................................. 12
I. Special Requirements for Ensuring Safety of Employees at a Facility ................................................................................... 13
Bibliography .................................................................................................................................................................................. 13
Document Change History ............................................................................................................................................................ 15
Annex A: International Classification of Hazardous Materials and Separation Methods ............................................................... 16

List of Tables

1. Commonly Used Chemicals and Their Possible Harmful Effects from Exposure ................................................................. 7
2. Criteria for Inclusion in Class 6.1, Toxic Materials .................................................................................................................... 13

List of Abbreviations

°C  
degrees Celsius

EAD  
Environment Agency–Abu Dhabi

kPa  
kilopascal

LD₅₀  
Lethal Dose 50

m  
meter

MEKP  
methyl ethyl ketone peroxide

mg/kg  
milligrams per kilogram

mg/m³  
milligrams per cubic meter

PCB  
polychlorinated biphenyl

ppm  
parts per million

psi  
pounds per square inch

TDI  
toluene di-isocyanate

Definitions of Terms

**Boiling Point**—The temperature at which a material changes from a liquid to a gas or the temperature at which a substance’s vapor pressure is equal to atmospheric pressure.

**Chemical Abstracts Service Number**—The internationally recognized number used to identify and register pure chemical materials. This number is sometimes referred to as a registration number, which consists of nine digits. The Chemical Abstracts Service Number is considered to be an accurate method for identifying chemicals. This number differs from United Nations’ number because it is not related to the physical and chemicals specifications of the material.

**Competent Authority**—Refers to EAD, which is the authority responsible for supervising the implementation of the environmental laws in Abu Dhabi Emirate.

**Compressed Gases**—Pure or mixed components of gases in a cylinder or container, in which compression does not exceed 40 pounds per square inch (psi) under 21 degrees Celsius (°C) or exceeds 104 psi under 54°C. Compressed gases can also be flammable liquid materials with a vapor pressure exceeding 40 psi at 38°C or higher.

**Containers and Packages**—Any movable equipment used to store, transport, treat, or dispose of hazardous materials. Containers or packages include all types of mobile methods used for hazardous materials.

**Fire Point**—A temperature at which a particular substance emitting vapors can ignite, causing a sustained fire.

**Flammable Liquids**—A hazardous material with a flash point temperature lower than 60.5°C that can catch fire.

**Flammable Solids**—Solids or waste solids, other than those classified as explosives, that are readily combustible, or may cause or contribute to fire through friction, under conditions encountered in transport.

**Flash Point**—The minimum temperature at which a liquid gives off vapor in sufficient concentration to form an ignitable mixture with air near the surface of the liquid.
Handling Card—Information required either alone or along with the hazard warning labels. The handling card comes in different oblong shapes.

Handling Hazard Materials—Any handling of hazardous materials that occurs during production, manufacturing, importing, exporting, transit in customs, storing, transporting, and consumption.

Hazard—A source of danger (i.e., material, energy source, or operation) with the potential to cause illness, injury, or death to employees or damage to a facility or to the environment.

Hazard Class—A system used to classify groups of chemicals and hazardous materials with similar properties or by their potential to cause specific hazards (e.g., fire, explosions).

Hazard Division—A further classification of chemicals and hazardous materials assigned to a specific hazard class. For instance, depending on their hazardous nature, flammable solids or substances, which are assigned to Hazard Class 4, are then further categorized by placing them into another division. These divisions are Hazard Division 4.1, Flammable Solids; Hazard Division 4.2, Spontaneously Combustible; or Hazard Division 4.3, Dangerous When Wet. It is important to note that not all hazard classes have hazard divisions.

Hazard Warning Labels—Information required for most containers to identify the degree of hazard associated with hazardous materials. These labels appear as squares at 45-degree angles (see Annex A of this document).

Hazardous Materials—A substance that can be biological, chemical, or physical and has the potential to cause harm to humans, animals, plants, or the environment either by itself or by interacting with another material or factor (e.g., water, temperature change). “Hazardous material” may be defined and regulated differently in each country, but this term generally includes chemicals that are carcinogens, toxic agents, irritants, corrosives, combustible, explosive, flammable, oxidizers, and unstable-reactive or water-reactive. This term also applies to chemicals that, during the course of normal handling, use, or storage, may produce or release dusts, gases, fumes, vapors, mists, or smoke, which may have any of the previously mentioned characteristics.

Lethal Concentration 50 (LC_{50})—The amount of a concentration (measured in milligrams per cubic meter) capable of killing 50% of a group of test animals.

Lethal Dose 50 (LD_{50})—The dose (measured in milligrams per kilogram) capable of killing 50% of a group of test animals.

Material Safety Data Sheet—A document used for the manufacturing and importing of hazardous material. Material Safety Data Sheets specify the type of material and the properties associated with health and safety hazards.

Organic Peroxides—Any organic waste or compound containing two oxygen atoms that are joined together in a bivalent structure. Organic peroxides may also be considered a derivative of hydrogen peroxide, in which one or more of the hydrogen atoms have been replaced by organic radicals.

Oxidizers—Chemical compounds that readily transfer oxygen atoms or substances that gain electrons during a redox chemical reaction. Oxidizers are substances that are not necessarily combustible, but they may (by yielding oxygen) cause or contribute to the combustion of other materials nearby.

Packaging—The container in which materials or goods are received or held for transport, including anything that enables the container to receive or hold the material or goods.

Packing—Containers or other items used to contain hazardous materials as per the appropriate packaging requirements.

Parts per Million—The unit used to denote relative proportions in measure quantities. The equation for determining parts per million is as follows:

\[
Parts \, per \, million = \left( \frac{mass \, component}{mass \, solution} \right) \times 1,000,000
\]

Permit—A written permit issued by the Competent Authorities to define limited activities and practices with conditions and general requirements.

Permit Owner—The party permitted to conduct specific work. A permit owner is responsible for all commitments and obligations outlined in the permit.

Personal Protective Equipment—Any device or appliance designed to be worn or held by an individual for protection against one or more health and safety hazards. This equipment includes respirators and masks, gloves and coveralls, safety glasses, steel-toed shoes, and hardhats.

Proper Shipping Name—The name used for shipped materials as per the recommendations of the United Nations, the International Maritime Dangerous Goods, and the International Civil Aviation Organization, or according to the regulations from the World Customs Organization.

Toxic Materials—Substances or other materials that cause severe, dangerous, or chronic health effects and could lead to death if swallowed, inhaled, or absorbed through the skin.

Risk—The product of the measure of the likelihood of occurrence of an undesired event and the potential adverse consequences which this event may have upon people (injury or harm to physical or psychological health) and the environment (water, air, soil, animals, plants, social). Risk is calculated by frequency multiplied by consequences.

Safety—Often referred as the opposite of risk. Safety is the practical certainty that adverse effects will not result when a substance is used in the quantity and in the manner proposed for its use, and it is properly handled.

Safety Officer—A qualified person who is responsible for the monitoring and assessment of safety hazards or unsafe situations and ensures the safety of employees at a facility by enforcing all safety measures. The Safety Officer is assigned by the permit owner.

Segregation—The separation of containers and packages containing incompatible hazardous materials. Segregating the containers and packages helps to reduce the chances of fires and explosions from occurring in a storage area and during transport.

Solvent—A liquid substance capable of dissolving other substances.

Tank—Fixed equipment designed to contain hazardous materials in its different forms and conditions.

Training—Encompasses the steps necessary to ensure that employees and contractors have the job competencies (i.e., knowledge, skills, and values) necessary to fulfill their job responsibilities.

United Nations Number—The identification serial number assigned to any chemical or hazardous material by the United Nations Committee of Experts on the transportation of these materials and as published in the United Nations’ recommendations on the transport of dangerous goods.
Purpose of This Guidance Document

The purpose of this document is to

- Address the need for proper planning to protect humans and the environment from the risks that could result from improper storage of hazardous materials
- Assist industrial facilities to implement safe storage policies that comply with local and international standards and specifications, while sustaining work efficiency and production capabilities at the facilities
- Guide facilities to establish storage areas based on proper implementation of the standards and specifications and on scientific methods
- Ensure the provision of equipment and qualified employees to supervise the storage operations
- Provide assistance to industrial facilities in minimizing the hazards of fires, spillages, occupational diseases, and injuries resulting from the improper storage and handling of hazardous materials
- Ensure that the health and safety procedures adopted by a facility are based on international best practices that help to guarantee safe work environment for all employees
- Promote and increase awareness among employees in industrial fields on the proper hazardous materials management practices to minimize adverse health impacts and increase safety measures to reduce the risks to the employees and the environment.

It is important to note that explosives (Class 1), radioactive materials (Class 7), infectious materials (Class 6.2), and hazardous waste are subject to their own specific guidance; therefore, they are excluded from this guideline.

Introduction

Chemicals play an important role in the industrial activities and economic development in Abu Dhabi Emirate. In Abu Dhabi Emirate, chemicals are used in a wide range of industrial activities (e.g., oil and gas extraction, galvanizing and electroplating, iron and steel production, aluminum smelting and production, power generation) and commercial activities (e.g., selling paints, pesticides, exports). However, hazardous chemicals must be properly handled to ensure the health and safety of employees and the public and to protect the environment from accidental exposure. Every effort should be made to ensure that the benefits of hazardous materials supersede their adverse effects. Improper handling and misuse of chemicals could lead to detrimental, adverse impacts on human health and the environment. Therefore, a challenging task in the industrial and commercial industries is how to properly handle and store chemicals, especially those classified as hazardous materials.

A. Role of the Environment Agency–Abu Dhabi

Law No. (16) of 2005, pertaining to the Reorganization of the Environment Agency–Abu Dhabi (EAD), established the Agency as the Competent Authority in Abu Dhabi Emirate for environmental protection. In this capacity, EAD has the authority to implement Federal Law No. (24) of 1999 for the Protection and Development of the Environment in the United Arab Emirates. EAD also performs the following tasks in Abu Dhabi Emirate:

- Assesses the impacts of chemicals, hazardous materials, pesticides, chemical fertilizers, and non-organic fertilizers on the environment; classifies these materials according to their level of impact; and proposes projects and regulations to regulate their utilization and monitoring
- Monitors the environment and conducts research and environmental assessments
- Develops and implements effective Environmental Management Systems
- Enforces appropriate environmental laws and legislation through the adoption of appropriate measures and regulations in issuing environmental permits and monitors the environment for environmental problems

- Ensures that the public and private sectors comply with the relevant practices for proper storage and handling of hazardous materials
- Performs routine inspections of storage facilities containing hazardous materials to ensure their compliance with the local and international standards and specifications for storing such materials
- Conducts public awareness campaigns to inform the industrial facilities about the proper methods for storing hazardous materials and the hazards that could result from improper handling and improper storage of the chemicals and other materials.

B. Risks Related to Hazardous Materials

Potential exposure to hazardous materials can cause harm to human health and the environment; therefore, it is important that employees and others know the risks that could result from exposure and how to minimize the risks. The following list provides more information about hazardous materials and their risks:

- Hazardous materials exist in different forms (i.e., solid, liquid, and gas); therefore, facility management and employees are constantly challenged with controlling its risks and reactions.
- Hazardous materials can enter the human body in a variety of ways (i.e., swallowing, inhaling, and direct contact with the skin). After a hazardous material enters the body, it can immediately harm a person’s health, or the material can stay in the body and appear after a long time.
- Some forms of hazardous materials are colorless, tasteless, and odorless; therefore, it can sometimes be difficult for employees to discover that a spillage has occurred.
- Some hazardous materials can affect equipment or tools by causing rust, corrosion, cracking and bulges, and explosion. Fire can also break out from within the equipment or tools. If one or more of these problems occurs at a facility, this can be an imminent threat to the health and safety of employees (even resulting in death), cause a loss of materials, and negatively impact operations at a facility.
- The speed at which a hazardous material diffuses from its place at the facility and the multitude of risk levels for that substance can worsen the impact and damage resulting from an accidental spillage, fire, or explosion.

Different hazardous materials can cause a variety of health effects on the human body. Table 1 lists some chemicals that are commonly used in industries and their possible harmful effects on the human body. It is important to note that all of these chemicals serve important purposes at facilities, but these materials still present possible health risks from exposure.

<table>
<thead>
<tr>
<th>Chemicals</th>
<th>Possible Harmful Effects</th>
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<tbody>
<tr>
<td>Acetic acid</td>
<td>Tissue damage</td>
</tr>
<tr>
<td>Calcium oxide</td>
<td>Skin infections and eye burns</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>Tissue concretion</td>
</tr>
<tr>
<td>Liquid bromide</td>
<td>Tissue damage and erosive effects on the respiratory system</td>
</tr>
<tr>
<td>Methyl bromide</td>
<td>Lungs may be most severely injured by the acute inhalation exposure of methyl bromide</td>
</tr>
<tr>
<td>Mixture of sulfuric and nitric acid</td>
<td>Tissue damage and severe burns</td>
</tr>
<tr>
<td>Oxalic acid</td>
<td>Tissue damage and ulceration</td>
</tr>
<tr>
<td>White phosphorus</td>
<td>Heat burns</td>
</tr>
<tr>
<td>Silver nitrate</td>
<td>Severe heat on the skin and erosive effects</td>
</tr>
<tr>
<td>Sodium (mineral)</td>
<td>Heat burns</td>
</tr>
<tr>
<td>Trichloride acetic acid</td>
<td>Tissue damage</td>
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</table>
C. General Requirements for Storing Hazardous Materials

The following sections present the basic rules governing the proper management of hazardous materials. All employees within the premises of the facility must abide with these requirements.

C.1 Requirements for Establishing Hazardous Materials Storage Areas

- Before starting a project involving the construction of hazardous material storage areas, approval must be obtained from the Abu Dhabi General Directorate of Civil Defense. Construction activities must be based on the specifications, requirements, and standards set forth by the Directorate.

- The location of the storage area must be selected based on the necessary conditions and standards and on the type and quantity of materials to be stored.

- Storage areas must be designed so employees and others can easily enter and exit the area without any difficulties, especially during emergency situations or other occupational safety incidents.

- The capacity of a storage area must be able to accommodate the different hazardous materials stored there.

- Storage areas must be properly ventilated, dry, and temperature controlled and must not be exposed to direct sunlight. These areas must be located far away from direct flames or other heat sources (e.g., boilers, ovens) that may exist at a facility.

- There must be enough light in the storage area so employees and others can see the hazardous materials, detect any issues, and read the hazard warning labels.

- To reduce the chances of exposure and possibly fire spreading to other buildings and facilities at the site, a storage area must be isolated from these structures.

- The floor of the storage area must be made of non-absorbent and impermeable materials. The floor must be free of cracks and not be slippery.

- Once a storage area has been designated for a particular hazardous material or hazardous class, only that substance may be stored in the designated store.

- Storage areas must be fenced to help prevent any unauthorized access. Only approved personnel must have access to the storage area. Hazardous materials must be properly stored away from the fence.

C.2 Requirements for Signage, Equipment, Training, and Related Items

- Warning signs must be posted outside the hazardous materials storage area indicating that the stored contents inside are potentially dangerous. The warning sign should include the “skull with crossed bones” and the hazard placards of the stored materials.

- A map must be provided that indicates the location and the types of hazardous materials in the area and where emergency kits and firefighting equipment are located. The layout should be posted outside the storage area so it is accessible to employees and others.

- Material Safety Data Sheets (MSDSs) must be available for all stored materials and must be accessible to all employees and others. All employees must be fully trained on how to interpret the important information contained in MSDSs.

- Storage areas must be equipped with spill-control kits and emergency tools.

- Mechanical equipment used to lift and handle storage containers and packages must be spark proof to reduce the risk of fire. Only authorized employees who have completed training may use the mechanical equipment. These employees must be constantly monitored to help ensure that incidents do not occur.
Employees responsible for handling hazardous materials must be provided with specialized training courses on these substances. These courses, provided by the permit owner, must be completed prior to conducting any activities involving hazardous materials.

An inventory of hazardous materials stored at the facility must be maintained and periodically updated with records of quantities and their locations. The inventory should highlight the hazard class of each material.

**C.3 Requirements for Proper Storage of Hazardous Materials**

- In a storage area, hazardous materials having the most risk for causing serious harm must be segregated (or separated) from the others. The segregation of substances, which is ensured by storekeepers and the Health, Safety, and Environment Officer, must be performed based on the hazardous materials compatibility charts (see Annex A of this document).

- The hazardous materials storage area must only be dedicated to storing hazardous substances. Stored materials must be properly stacked to minimize the risk of being easily knocked down.

- Storage of hazardous materials in open storage area can be accepted for some materials under the condition that such storage conditions does not contradict with the storage conditions specified in the MSDS. Open storage areas must be secured, and all stored materials must be covered with flame-retardant covers.

- Stored materials that can be damaged by exposure to water must be kept a minimum of 3 inches above the floor (such as on pallets).

- When storing hazardous materials, the hazard class for the material must be used. Determination of whether a material must be segregated from other substances in the storage area or if it is compatible with others is the responsibility of the storekeepers and Health, Safety, and Environment Officer (see Annex A of this document).

- Hazardous materials must not be stored in alphabetical order because this could result in the storage of incompatible materials near each other.

- If a hazardous material has more than one hazard class, then priority must be given to the highest hazard class (primary hazard).

- Hazardous materials must be stored in stacks for easy access.

- Stack locations must be clearly identified with signs.

- The height of the stacks must not be from the floor up to the ceiling. Instead, there should be a minimum of 3 feet between the top of the stacks and the ceiling.

- Stacks must be arranged so they do not obstruct the movement of forklifts and other equipment.

- Empty containers and expired materials must be stored in a separate, designated area, and the area must be labeled as "Quarantine Area" or "Expired Chemicals."

- Special outlets must be located in the storage area that is connected to sumps, which collect the leaked or spilled hazardous material.

**C.4 Requirements for Labeling Hazardous Materials**

- All stored materials must have hazard warning labels on the storage container. These labels must comply with the following requirements:
  - Each storage container must have sufficient space available for a hazard warning label. The information on the hazard warning label must reflect the information noted in the MSDS.
  - Labels must be pasted onto each container using a substance durable enough to withstand normal transportation conditions. The text in the hazard warning labels should be clear and concise and appear in non-erasable Arabic and English.

– Hazard warning labels must also contain the following information:
  • The manufacturer’s name and registration number and the country of origin of the hazardous material
  • The proper shipping name and the commercial name of the hazardous material, its active ingredient, its purity percentage, and other impurities, if any
  • The United Nations number (i.e., the number assigned by the United Nations’ Expert Committee to any hazardous materials in the process of transporting it)
  • The hazard class and the hazard placard of the material and its health and environmental effects
  • The weight of the hazardous material
  • The dates when the material was produced and when it will expire.

C.5 Requirements for Storing, Opening, Inspecting, and Sealing Containers of Hazardous Materials

• The integrity of the packages and containers (e.g., free of dents, bulges, cracks) must be ensured before hazardous materials are stored.
• Any damaged or improperly sealed packages and containers must be kept to the side and repackaged in safe packaging. Care and caution must be used during the repackaging process to minimize the chances of health and environmental risks from occurring.
• Packages and containers must be opened in a separate room away from the storage area. Care and caution must be used when opening packages and containers of stored hazardous materials.
• The date when the package or container was opened must be recorded.
• Stored packages and containers of hazardous materials must be handled according to the manufacturer’s instructions to avoid any cracking of the containers or spillage of the stored material.
• After use, opened containers and packages must not be kept at the production line; instead, these items must be immediately returned to the storage area.

D. Special Requirements for Storing Hazardous Materials in Tanks

The following list presents some of the special requirements for storing hazardous materials in tanks:

• When choosing the tanks, it is important to consider the characteristics of the hazardous materials to be handled. In addition, precautionary measures must be taken to prevent corrosion.
• Secondary containment must be provided to prevent spillage of hazardous materials into the environment. The containment must be sufficiently inclined to enable easy removal of spillage.
• Tanks must be covered from the exterior with a material that is strong enough and compatible with the stored hazardous substances to prevent the tanks from collapsing and cracking.

E. Special Requirements for Storing Compressed Gas Cylinders

The following list presents some basic requirements for storing compressed gas cylinders:

• All gas cylinders must be protected against undue absorption of heat from sunlight or other heat sources. Gas cylinders must also be kept in cool, dry places, away from the vapors of corrosive and flammable materials.
• Flammable and toxic gas cylinders must be stored above the ground. The cylinders must not be stored in vaults.
• When storing of compressed gas cylinders of different hazard classes, proper segregation procedures must be adopted based on the compatibility charts. For instance, chlorine cylinders must be separated from acetylene cylinders to avoid potential incidents involving fire (Table A-1 in Annex A).

- Cylinder valves must always be properly covered with protective caps.
- **At gas manufacturers' and distributors' facilities:** The accepted safe methods for securing capped compressed gas cylinders in storage are to nest cylinders by positioning them in a tight mass using a contiguous three-point contact system with other cylinders or using a solid support structure such as a wall or railing.
- **At user's sites:** All compressed gas cylinders in service or storage must be secured to prevent them from falling. An appropriate method for securing cylinders is to provide a substantial chain, rope, or strap positioned in front of or around the cylinders and secured to a solid structure or rigid support.
- Proper tools must be used while handling and transporting cylinders (e.g., carts used to transport cylinders must have straps for securing the cylinder to the cart). Refrain from sliding, dragging, or rolling cylinders on edge.
- Empty cylinders must be separated from the filled ones in a designated area.
- All cylinders must be labeled and must have internationally recognized color codes on them. (for labeling requirements refer to Section E.4 of this document).
- A best management practice is to store compressed cylinders near the loading and off-loading area to avoid transport-related accidents.

**F. Special Requirements Storing Flammable Materials**

The following list presents some of the special requirements for storing flammable materials:

- A warning sign indicating the presence of flammable materials must be posted outside the storage of flammable materials.
- Labels must be properly affixed on the flammable containers using a substance durable enough to withstand normal transportation conditions.
- To help minimize the risk of fire, explosion, or another type of incident, proper segregation procedures should be practiced when storing flammable materials. Materials that are incompatible with flammable substances must be separated as per the compatibility charts. For instance, flammable materials must not be stored near oxidizing materials to avoid reactions that might cause fire (see Table A-3 in Annex A).
- A stock inventory list containing each flammable material stored must be maintained and regularly updated. The inventory list must include the types and quantities of flammable materials stored.
- When designing the storage area, the building must be constructed of a fire-resistant material to ensure the containment of fire in case an incident should occur.
- Flammable materials must be stored in a shaded and well-ventilated place that is away from any source of ignition.
- Highly flammable materials must be stored in a cold store.
- A fire extinguishing system that is adequate enough to extinguish small fires should be installed.
- Fire exit doors must be rated as fire resistant. Fire exit doors must be identified as such in case of emergencies.
- Smoking or using any open flame or another source of heat is strictly prohibited inside the storage area and within 6 meters (m) of the outside of the storage area. Warning signs must be posted at the storage area to inform employees and others about these restrictions.
- Any small containers of highly flammable materials must be kept in appropriate safety cabinets. It is important to note that storing more than 60 gallons of materials in Hazard Divisions 3.1 and 3.2 and 120 gallons of Hazard Division 3.3 in each container is strictly prohibited. Appropriate warning signs must be affixed on the safety cabinet (Figure 1) to inform employees and others about the highly flammable contents inside.

G. Special Requirements for Storing Organic Peroxides

The following list presents some of the special requirements for storing organic peroxides:

- As a best management practice, it is advised to store organic peroxides in a location that is separated from other hazardous materials.
- Organic peroxides must be stored under a low and suitable temperature (below 38°C). It is important to note that some organic peroxides must be stored in special and safe (spark-proof) coolers to prevent the risk of ignition in case of gas leaks.
- Organic peroxides must be stored at a low height, preferably below eye level, and in such a manner that the containers and packages will not fall while handling or storing the material.
- All containers and packages of organic peroxides must be stored away from entrances, exits, and emergency pathways.
- Filling, taking samples, and packaging of organic peroxide should be performed in a room that is separate from the storage area and away from any heat source.
- Bunds must be constructed around organic peroxides containers and packages and at the entrances and exits of the storage area to prevent any leakages from the low-viscosity nature of the material.
- Details about the type of material, production date, the suitable temperature for storing, and the dates when the package was received and opened must appear on all packages and containers of organic peroxides.
- All packages and containers of organic peroxides must be constantly monitored to ensure that they are intact and tightly sealed to reduce the risk of container bleeding. Improperly sealed containers could allow solvents to evaporate, become extremely dry, and then become very hazardous.
- Some organic peroxides, such as methyl ethyl ketone peroxide (MEKP), produce hazardous gases after decomposition. Containers and packages of such materials must be fitted with release valves.
- Compressed air and even inert gases must not be used to increase the pressure inside containers and packages because the pressure of decomposed gases from the peroxides can cause an explosion.

H. Special Requirements for Storing Toxic Materials

A material is presumed to be toxic to humans if it falls into one of the categories in Table 2 when tested on laboratory animals (in the absence of adequate data on human toxicity). Determining the toxicity of solid and liquid materials depends upon their
lethal dose or lethal concentration and the route of intake (i.e., oral, dermal, or by inhalation). Table 2 shows the upper limits for solid and liquid materials.

Table 2. Criteria for Inclusion in Class 6.1, Toxic Materials

<table>
<thead>
<tr>
<th>Physical Condition of Material</th>
<th>LD$_{50}$ Oral Toxicity (mg/kg)</th>
<th>LD$_{50}$ Dermal Toxicity (mg/kg)</th>
<th>LD$_{50}$ Inhalation Toxicity (mg/m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid</td>
<td>≤200</td>
<td>≤1,000</td>
<td>≤10</td>
</tr>
<tr>
<td>Liquid</td>
<td>≤500</td>
<td>≤1,000</td>
<td>≤10</td>
</tr>
</tbody>
</table>

LD$_{50}$ = Lethal Dose 50; mg/kg = milligrams per kilogram; mg/m$^3$ = milligrams per cubic meter.

The following list presents some of the special requirements for storing toxic materials:

- Toxic materials must be stored in a separate storage area away from other hazardous substances and chemicals.
- Toxic materials must be stored according to compatibility and segregation chart requirements (Tables A-1 and A-2 in Annex A).
- A warning sign indicating the presence of toxic materials must be posted outside the storage of toxic materials.
- Storage areas for toxic materials must be fitted with ventilation and air-conditioning systems.
- Toxic materials that are susceptible to humidity must be stored in dry boxes.
- Handling of toxic materials must be performed under the supervision of an authorized officer at the facility.
- Regular inventory of toxic materials must be maintained.
- A tracking record for the movement of toxic materials must be maintained. The record should specify the type, amount, and recipient of the toxic material.

I. Special Requirements for Ensuring Safety of Employees at a Facility

The following list presents some of the basic requirements that employees must abide by to ensure their safety onsite:

- Touching, smelling, or tasting must not be used to identify any hazardous materials stored at the facility.
- All employees at the site must be trained on how to properly handle hazardous materials to ensure their safety.
- Personal protective equipment (e.g., safety shoes, masks, gloves, goggles, earmuffs) must be provided to employees.
- Facility management must ensure that all employees undergo periodic medical evaluations to assess and monitor their health.
- First aid kits must be available onsite for all employees. Facility management must inform all employees where the first aid kits are located.
- The kitchen and employee dressing rooms must be separated from the storage area by at least 10 m.
- Battery charging, heat packaging, and welding are strictly prohibited inside the storage area.

Bibliography


EPA (Environment Protection Authority), EPA Chemical Compatibility Chart. Available at http://web.princeton.edu/sites/ehs/chemwaste/EPAChemicalCompatibilityChart.pdf


Document Change History

<table>
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<tr>
<th>Doc. No.</th>
<th>Rev. No.</th>
<th>Rev. Date</th>
<th>Revision Description</th>
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<td>00</td>
<td>14 April 2014</td>
<td>First Issue</td>
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Remarks:
Annex A

International Classification of Hazardous Materials and Separation Methods
Hazard Warning Labels

The purpose of hazard warning labels is to immediately alert employees and others at a facility that hazardous materials in storage areas have the potential to cause harm to human health and the environment. The appropriate hazard warning label must be securely affixed to each stored container or package containing hazardous materials. The hazard warning labels for the hazard classes, which are discussed further in Section A of this annex, are presented in Figure A-1.

Figure A-1. The main hazard warning labels used to identify hazardous materials.

A. Hazard Classes

A.1 Hazard Class 2, Gases Compressed, Liquefied, or Dissolved Under Pressure

Chemicals are classified as gases when the vapor pressure of a material at 50 degrees Celsius (°C) is greater than 300 kilopascals (kPa) or when the chemical material in the gaseous phase at 20°C is equivalent to a normal atmospheric pressure of 101.3 kPa. More information about the different types of gases is presented as follows:

- Compressed gas is a mixture or material that does not condense into a liquid during the complete gaseous phase while packaging under pressure and at 20°C.
- Liquefied gas is a mixture or material that condenses into a liquid under pressure and at 20°C.
- Refrigerated liquefied gas is a mixture or material that, when refrigerated, partially or completely condenses into a liquid.
- A gas dissolved under pressure is a mixture or material that dissolves in solvents under high pressure while packaging.

The properties of gases are used to identify the type of substance that it is (i.e., whether they are compressed or liquefied and whether they can dissolve under pressure). These types of gases are assigned to Hazard Class 2. The hazard warning labels used to identify each type of these gases is presented as Figure A-2.

![Figure A-2. Hazard warning labels for different types of gases assigned to Hazard Class 2.](image)

Depending on their hazardous nature, these gases are then further categorized by placing them into one of the following three hazard divisions of Hazard Class 2:

- Hazard Division 2.1, Flammable Gas: This type of gases becomes flammable when they are mixed with air in a volumetric ratio of 13% or less. Some examples include liquefied petroleum gas (LPG), liquefied natural gas (LNG), hydrogen, and acetylene.
- Hazard Division 2.2, Non-flammable Non-toxic Compressed Gas: These gases are compressed at 280 kPa or higher and at 20°C. They include materials that reduce or replace oxygen in the air in the closed space and causes suffocation. They also include materials that cause or contribute to the combustion of other substances. Some examples include nitrogen, carbon dioxide, compressed air, and helium.
- Hazard Division 2.2, Oxidizing Gas: These gases are non-flammable, non-toxic gases with a sub-risk of Class 5.1. These gases, although not flammable, can accelerate combustion and increase the risk of fire in the presence of combustible or flammable materials. Some examples include nitrous oxide, entonox, and nitrous oxide.
- Hazard Division 2.3, Toxic Gas: On inhalation, these toxic gases may cause death or injury. Many of these gases may have other properties (e.g., flammable, oxidizing, or corrosive). Some examples include: anhydrous ammonia, methyl bromide, sulfur dioxide, and carbon monoxide.

A.2 Hazard Class 3, Flammable and Combustible Liquids

A substance is referred to as a flammable or combustible liquid if it can easily ignite and burn rapidly. Flammable and combustible liquids are assigned to Hazard Class 3. The hazard warning label used to identify flammable and combustible liquids is presented as Figure A-3.
A flammable liquid (Class 3) is defined as a liquid having a flash point of not more than 60.5°C. It is important to note that a flash point is different from a fire point. The fire point of a substance is a temperature at which a particular substance emitting vapors can ignite, causing a sustained fire. Combustible liquid is defined as any liquid that does not meet the definition of any other hazard class and has a flash point above 60.5°C and below 93°C. An example of a combustible liquid is diesel fuel.

Hazard Class 3 also consists of substances that, when they are transferred or shipped at high temperature during the liquid phase, can yield gases and vapors that can ignite. Some examples include unleaded petrol, xylene, kerosene, and acetone.

The following liquid chemicals are excluded from Hazard Class 3:

- Liquid substances that were classified under other hazard classes because of their characteristics are more dangerous to human health than just igniting a fire
- Aqueous solutions of flammable liquids, specifically solutions in which the weight ratio of water in them exceeds more than 90%
- Liquid substances with a flash point not lower than 23°C and not higher than 60.5°C, but their fire point is higher than 100°C or liquid substances that boil before fire point.

### A.3 Hazard Class 4, Flammable Solids

A material is referred to as a flammable solid or substance if it can easily ignite while still in a solid form. Flammable solids or substances are assigned to Hazard Class 4. The hazard warning labels used to identify flammable solids or substances are presented as Figure A-4.
Figure A-4. The hazard warning labels for flammable solids or substances assigned to Hazard Class 4.

Depending on their hazardous nature, flammable solids or substances are then further categorized by placing them into one of the following three hazard divisions of Hazard Class 4:

- Hazard Division 4.1, Flammable Solid: These materials include flammable and combustible solids that can cause fire through friction. Flammable solids can also spark a fire from the exothermic reactions that occur during decomposition in high and moderate temperatures. Some examples include red phosphorous, hexamine, naphthalene, and camphor.
- Hazard Division 4.2, Spontaneously Combustible Material: These substances can spontaneously heat or can heat up in contact with air and liable to catch fire. Some examples include white phosphorous and cotton waste.
- Hazard Division 4.3, Dangerous When Wet: These types of materials can become spontaneously flammable or emit flammable vapors when they come into contact with water. Some examples include aluminum phosphide (liberates phosphine gas), calcium carbide, (liberates acetylene on contact with water), and sodium.

**Hazard Class 5, Oxidizers and Organic Peroxides**

A material is referred to as an oxidizer or organic peroxide if it can cause other substances to combust by emitting oxygen. Oxidizers and organic peroxides are assigned to Hazard Class 5. The hazard warning labels used to identify oxidizers and organic peroxides are presented as Figure A-5.

Figure A-5. The hazard warning labels for oxidizers and organic peroxides assigned to Hazard Class 5.

Depending on their hazardous nature, oxidizers (e.g., ammonium nitrate, hydrogen peroxide) and organic peroxides (e.g., benzoyl peroxide, methyl ethyl ketone peroxide [MEKP]) are then further categorized by placing them into one of the following two hazard divisions of Hazard Class 5:

- Hazard Division 5.1, Oxidizer: This division includes materials that emit oxygen through oxidation processes, although they are not flammable. The oxidation processes can cause other substances nearby to combust.
- Hazard Division 5.2, Organic Peroxide: These materials are considered to be a derivative of hydrogen peroxides. These chemicals may
  - Be liable to explosive decomposition
  - Burn rapidly
  - Be sensitive to heat, shock, or friction
  - React violently with other materials.
**Hazard Class 6, Hazard Division 6.1, Toxic Materials**

A liquid or solid substance is referred to as “toxic material” if it can cause severe damage, and even death, to humans if it is swallowed, inhaled, or absorbed through the skin. Toxic materials are assigned to Division 6.1 of Hazard Class 6. The hazard warning label used to identify toxic materials is presented as Figure A-6.

![Figure A-6. The hazard warning label for toxic materials assigned to Hazard Class 6.](image)

Toxic solids are substances resulting in the death of 50% of the animals that swallowed 200 milligrams per kilogram (mg/kg) of the substance, inhaled 10 milligrams per cubic meters (mg/m³) of the material, and came into contact with 1,000 mg/kg of the substance through the skin. For toxic liquids, the amounts are 500 mg/kg if swallowed, 10 mg/m³ if inhaled, and 1,000 mg/kg if contacted with the skin. Some examples of toxic solids include paraquat, endosulfan, arsenic compounds, cyanide, toluene diisocyanate (TDI).

Division 6.1 also includes toxic substances derived from plants, animals, or bacteria, unless they contain infectious materials (Note: Infectious substances [etiologic agents] are assigned to Hazard Division 6.2; these types of substances are not covered in this guideline).

**Hazard Class 8, Corrosive Material**

Corrosive materials are substances capable of causing the degradation and destruction of living tissue, steel, and other materials on contact. Some corrosive materials may emit irritating vapors affecting the eyes, airways, and skin. Some examples include nitric acid, sulfuric acid, hydrochloric acid, and lead acid batteries. During storage or transportation, if containers storing corrosive materials leak, then the substance could ignite and cause an explosion when the gases are emitted into the air and mix with atmospheric gases. Corrosive materials can also destroy metallic materials and fabrics. When corrosive materials are mixed with water, they emit gases and vapors, which can cause heat fusion and can irritate the mucous membranes and cause redness of the eyes. Corrosive materials are assigned to Hazard Class 8. The hazard warning label used to identify corrosive materials is presented as Figure A-7.
Hazard Class 9, Miscellaneous Hazardous Material

A substance is referred to as a miscellaneous hazardous material if it does not meet the hazard definitions for Hazard Classes 1 through 8, but it still poses a hazard to human health and the environment during transport. Miscellaneous dangerous materials include substances that are transported at 100°C or higher in the liquid phase or solid materials transported at 240°C or higher. Miscellaneous hazardous materials are assigned to Hazard Class 9. Some examples of miscellaneous hazardous materials include dry ice, asbestos, molten bitumen, polychlorinated biphenyls (PCBs), and wheelchair and other electric vehicles. The hazard warning label used to identify such materials is presented as Figure A-8.

B. Segregation and Separation (Compatibility) Methods of Hazardous Materials

The basic principle of proper storage is to keep hazardous materials away from others to avoid any reactions that could cause serious impacts on human health or the environment (Table A-1). Based on international standards for storing hazardous materials, the most important procedure to follow when segregating substances is to adhere to the Material Safety Data Sheets for the materials (Table A-2).

Table A-1. Examples of Some Incompatible Chemicals and the Hazards That Could Occur

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid + caustic</td>
<td>Heat or spattering</td>
</tr>
<tr>
<td>Acid + oil from grease</td>
<td>Fire</td>
</tr>
<tr>
<td>Aluminum powder + ammonium nitrate</td>
<td>Explosion</td>
</tr>
<tr>
<td>Chlorine gas + acetylene</td>
<td>Explosion</td>
</tr>
<tr>
<td>Ammonia + bleach (or another chlorine source)</td>
<td>Toxic chloramine</td>
</tr>
<tr>
<td>Sodium cyanide + sulfuric acid</td>
<td>Lethal hydrogen cyanide</td>
</tr>
</tbody>
</table>

Table A-2. Segregation and Separation Requirements for Hazardous Materials

<table>
<thead>
<tr>
<th>Class</th>
<th>1.1</th>
<th>2.1</th>
<th>2.2</th>
<th>2.3</th>
<th>3.1</th>
<th>4.1</th>
<th>4.2</th>
<th>4.3</th>
<th>5.1</th>
<th>5.2</th>
<th>6.1</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td></td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
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<td>C</td>
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<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>2.1</td>
<td>C</td>
<td></td>
<td>C</td>
<td>B</td>
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<td>C</td>
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<td>C</td>
<td>C</td>
<td>B</td>
<td>B</td>
<td></td>
</tr>
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<td>2.2</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>2.3</td>
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<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
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<td>C</td>
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<td>B</td>
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<td>C</td>
<td>B</td>
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<td>B</td>
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</tr>
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<td>C</td>
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<td>C</td>
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<td>B</td>
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</tr>
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<td>A</td>
<td>C</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td></td>
<td>A</td>
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</tr>
<tr>
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<td>A</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>

Source: GCC, 2002

Note: Peach-colored cells denote items from the same class, which do not need to be segregated from each other.

The separation between two different categories of hazardous chemicals is determined by using a symbol at the intersection of the vertical line, which represents the first category, and the horizontal line, which represents the other category. When storing and separating hazardous chemicals, employees should adhere to the following points:

- Separation should be at a distance of at least 3 meters (m).
- Separation should be at a distance of at least 5 m.
- Storage is prohibited in the same room or the same space because the minimum separation distance between the storage areas should be 10 m.

Table A-3 indicates some of hazards that could result from reactions with incompatible chemicals. It is important to note that not all hazards are mentioned in Table A-3, and empty cells do not necessarily mean that any hazards are eliminated from mixing the materials. Table A-4 presents examples of different chemical groups and the materials with which they are incompatible.
### Table A-3. Hazards That Could Result from Reactions with Incompatible Chemicals

<table>
<thead>
<tr>
<th>Reactivity Group No.</th>
<th>Reactivity Group Name</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Acids, Mineral, Non-Neutralizing</td>
<td><strong>Fire</strong></td>
</tr>
<tr>
<td>2</td>
<td>Acids, Mineral, Neutralizing</td>
<td><strong>Flammable Gas Generation</strong></td>
</tr>
<tr>
<td>3</td>
<td>Alkalis and Alkaline Earth Metals</td>
<td><strong>Flammable Gas Generation</strong></td>
</tr>
<tr>
<td>4</td>
<td>Oxidizing Agents</td>
<td><strong>Explosions</strong></td>
</tr>
<tr>
<td>5</td>
<td>Reducing Agents, Strong</td>
<td><strong>Explosions</strong></td>
</tr>
<tr>
<td>6</td>
<td>Water, Water-Based Solutions</td>
<td><strong>Explosions</strong></td>
</tr>
<tr>
<td>7</td>
<td>Organic Peroxides</td>
<td><strong>Explosions</strong></td>
</tr>
<tr>
<td>8</td>
<td>Oxidizing Agents, Weak</td>
<td><strong>Explosions</strong></td>
</tr>
<tr>
<td>9</td>
<td>Peroxides</td>
<td><strong>Explosions</strong></td>
</tr>
<tr>
<td>10</td>
<td>Flammable Liquids</td>
<td><strong>Explosions</strong></td>
</tr>
<tr>
<td>11</td>
<td>Flammable Solids</td>
<td><strong>Explosions</strong></td>
</tr>
<tr>
<td>12</td>
<td>Flammable Gases</td>
<td><strong>Explosions</strong></td>
</tr>
</tbody>
</table>

**EPA’s Chemical Compatibility Chart**

<table>
<thead>
<tr>
<th>Reactivity code</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td><strong>Fire</strong></td>
</tr>
<tr>
<td>H</td>
<td><strong>Explosions</strong></td>
</tr>
<tr>
<td>G</td>
<td><strong>Flammable Gas Generation</strong></td>
</tr>
<tr>
<td>T</td>
<td><strong>Toxic Gas Generation</strong></td>
</tr>
<tr>
<td>E</td>
<td><strong>Violent Polymerization</strong></td>
</tr>
<tr>
<td>R</td>
<td><strong>Oxidation of Toxic Substance</strong></td>
</tr>
<tr>
<td>U</td>
<td><strong>May be Hazardous But Unknown</strong></td>
</tr>
</tbody>
</table>

**Example**

<table>
<thead>
<tr>
<th>Reactivity code</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>H, F, G</td>
<td><strong>Heat Generation, Fire, and Toxic Gas Generation</strong></td>
</tr>
</tbody>
</table>

**Extremely Reactive! (Do not mix with any chemical or waste material!)**

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Table A-4 indicates the minimum separation requirements between each hazard class division in the storage area and the distance between chemical storage and working areas.

### Table A-4. The Category and Minimum Space Required (in m) Between Each Hazard Class Division

<table>
<thead>
<tr>
<th>Minimum Space (in Meters)</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>2.1</td>
</tr>
<tr>
<td>5</td>
<td>2.2</td>
</tr>
<tr>
<td>15</td>
<td>2.3</td>
</tr>
<tr>
<td>10</td>
<td>3.1</td>
</tr>
<tr>
<td>5</td>
<td>4.1 and 4.2</td>
</tr>
<tr>
<td>5</td>
<td>5.1 and 5.2</td>
</tr>
<tr>
<td>5</td>
<td>6.1 and 6.2</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
</tr>
</tbody>
</table>

Source: GCC, 2002

Some examples of incompatible chemicals are presented in Table A-5.

### Table A-5. Some Incompatible Chemicals

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Is Incompatible with</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetic acid</td>
<td>Chromic acid, ethylene glycol, hydroxy compounds, nitric acid, perchloric acid, peroxides, and permanganates</td>
</tr>
<tr>
<td>Acetone</td>
<td>Mixtures of concentrated nitric and sulfuric acids</td>
</tr>
<tr>
<td>Acetylene</td>
<td>Bromine, chlorine, copper, fluorine, mercury, and silver</td>
</tr>
<tr>
<td>Alkali and alkaline earth metals (e.g., powdered aluminum or magnesium, calcium, lithium, sodium, potassium)</td>
<td>Carbon dioxide, carbon tetrachloride or other chlorinated hydrocarbons, halogens, and water</td>
</tr>
<tr>
<td>Ammonia (anhydrous)</td>
<td>Bromine, calcium hypochlorite, chlorine, hydrofluoric acid (anhydrous), iodine, and mercury (e.g., in manometers)</td>
</tr>
<tr>
<td>Ammonium nitrate</td>
<td>Acids, chlorates, finely divided organic and combustible materials, flammable liquids, nitrites, powdered metals, and sulfur</td>
</tr>
<tr>
<td>Aniline</td>
<td>Hydrogen peroxide and nitric acid</td>
</tr>
<tr>
<td>Arsenical materials</td>
<td>Any reducing agent</td>
</tr>
<tr>
<td>Azides</td>
<td>Acids</td>
</tr>
<tr>
<td>Bromine</td>
<td>See entry for chlorine</td>
</tr>
<tr>
<td>Calcium oxide</td>
<td>Water</td>
</tr>
<tr>
<td>Carbon (activated)</td>
<td>Calcium hypochlorite and all oxidizing agents</td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>Sodium</td>
</tr>
<tr>
<td>Chlorates</td>
<td>Ammonium salts, acids, finely divided organic and combustible materials, powdered metals, and sulfur</td>
</tr>
<tr>
<td>Chromic acid and chromium</td>
<td>Acetic acid, alcohol, camphor, flammable liquids in general, glycerol, and naphthalene</td>
</tr>
<tr>
<td>Chemical</td>
<td>Is Incompatible with</td>
</tr>
<tr>
<td>------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Chlorine</td>
<td>Acetylene, ammonium, benzene, butadiene, butane, finely divided metals, hydrogen, methane, propane (or other petroleum gases), sodium carbide, and turpentine</td>
</tr>
<tr>
<td>Chlorine dioxide</td>
<td>Ammonia, hydrogen sulfide, methane, and phosphine</td>
</tr>
<tr>
<td>Copper</td>
<td>Acetylene and hydrogen peroxide</td>
</tr>
<tr>
<td>Cumenehydroperoxide</td>
<td>Acids (organic and inorganic)</td>
</tr>
<tr>
<td>Cyanides</td>
<td>Acids</td>
</tr>
<tr>
<td>Flammable liquids</td>
<td>Ammonium nitrate, chromic acid, halogens, hydrogen peroxide, nitric acid, and sodium peroxide</td>
</tr>
<tr>
<td>Fluorine</td>
<td>All other chemicals</td>
</tr>
<tr>
<td>Hydrocarbons (e.g., butane, propane, benzene)</td>
<td>Bromine, chlorine, chromic acid, fluorine, and sodium peroxide</td>
</tr>
<tr>
<td>Hydrocyanic acid</td>
<td>Alkali and nitric acid</td>
</tr>
<tr>
<td>Hydrocyanic acid (anhydrous)</td>
<td>Ammonia (aqueous and anhydrous), chromium, combustible materials, copper, iron, most metals or their salts, and nitromethane</td>
</tr>
<tr>
<td>Hydrogen sulfide</td>
<td>Fuming nitric acid and oxidizing gases</td>
</tr>
<tr>
<td>Hypochlorites</td>
<td>Acids and activated carbon</td>
</tr>
<tr>
<td>Iodine</td>
<td>Acetylene, ammonia (aqueous or anhydrous), fulminic acid, and hydrogen</td>
</tr>
<tr>
<td>Mercury</td>
<td>Sulfuric acid</td>
</tr>
<tr>
<td>Nitrates</td>
<td>Acetic acid, anhydride acid, aniline, brass, copper, chromic acid, gases, and any heavy metals</td>
</tr>
<tr>
<td>Nitroparaffins</td>
<td>Acids</td>
</tr>
<tr>
<td>Oxalic acid</td>
<td>Amines, inorganic bases, mercury, and silver</td>
</tr>
<tr>
<td>Oxygen</td>
<td>Flammable liquids, grease, hydrogen, oils, and solids or gases</td>
</tr>
<tr>
<td>Perchloric acid</td>
<td>Acetic anhydride, alcohol paper, bismuth and alloys, grease, oils, and wood</td>
</tr>
<tr>
<td>Peroxides, organic</td>
<td>Acids (organic or minerals); avoid friction and store cold</td>
</tr>
<tr>
<td>Phosphorus (white)</td>
<td>Air, alkalies, oxygen, and reducing agents</td>
</tr>
<tr>
<td>Potassium</td>
<td>Carbon dioxide, carbon tetrachloride, and water</td>
</tr>
<tr>
<td>Potassium chlorate</td>
<td>Sulfuric and other acids</td>
</tr>
<tr>
<td>Potassium perchlorate (see also chlorates)</td>
<td>Sulfuric and other acids</td>
</tr>
<tr>
<td>Selenides</td>
<td>Reducing agents</td>
</tr>
<tr>
<td>Silver</td>
<td>Acetylene, ammonium compounds, fulminic acid, oxalic acid, and tartaric acid</td>
</tr>
<tr>
<td>Sodium</td>
<td>Carbon dioxide, carbon tetrachloride, and water</td>
</tr>
<tr>
<td>Sodium nitrate</td>
<td>Ammonium nitrate and other ammonium salts</td>
</tr>
<tr>
<td>Sodium peroxide</td>
<td>Acetic anhydride, benzaldehyde, carbon disulfide, ethyl acetate, ethyl or methyl alcohol, ethylene glycol, methyl acetate, furfural, glacial acetic acid, and glycerin</td>
</tr>
<tr>
<td>Sulfides</td>
<td>Acids</td>
</tr>
<tr>
<td>Sulfuric acid</td>
<td>Potassium chlorate, potassium perchlorate, and potassium permanganate (similar compound of light metals such as sodium and lithium)</td>
</tr>
<tr>
<td>Telluride</td>
<td>Reducing agents</td>
</tr>
</tbody>
</table>

Source: ACS, 2003