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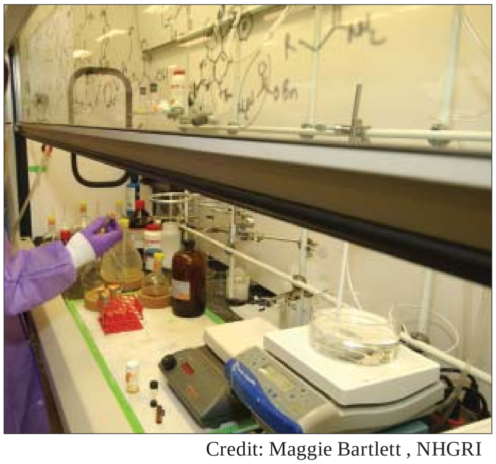
REPORT IN BRIEF

Prudent Practices in the Laboratory

Reflecting recent scientific developments and new regulations, this report updates National Research Council guidelines that have served as an authoritative reference for the safe use of hazardous chemicals for almost thirty years. The guidelines are used by laboratory workers, as well as regulatory agencies worldwide concerned with safety in the workplace and environmental protection. New topics covered in this update include: emergency planning, laboratory security, green chemistry, compatible chemical storage, and the handling of nanomaterials. Moreover, there is an expanded discussion of environmental health and safety systems.

Research in chemistry laboratories worldwide has increased understanding of the physical and biological world and abilities to manipulate it— but with this research comes the need to monitor the use of thousands of potentially dangerous chemicals to ensure the safety of laboratory workers and the protection of the environment.

First published in 1981, *Prudent Practices* is a reference on the safe handling and disposal of chemicals in the laboratory, providing guidance to laboratory personnel, and helping to inform regulatory policy on topics such as safety in the workplace and environmental preservation. The guidelines were last updated in 1995 in response to significant changes in laboratory culture and increased standards of safety, health, and environmental protection in laboratory operations.



Credit: Maggie Bartlett , NHGRI

This newest edition of *Prudent Practices* considers technical, regulatory, and societal developments that have occurred since the last publication, substantively expands some sections of the 1995 edition, and covers new topics such as emergency planning, laboratory security, the handling of nanomaterials, and an expanded discussion of environmental health and safety management systems. In the process of reviewing and modifying previous editions of the book, the report's authoring committee queried subject matter experts and industrial and academic researchers and teachers to determine the most prudent practices for laboratory operations.

Emergency Planning

Although most laboratory personnel are prepared to handle incidental spills or minor chemical exposures, many other types of emergencies ranging from power outages to floods or intentional malicious acts could have long-term consequences, and may severely impact the continuity of laboratory operations. The updated edition of *Prudent Practices* includes a new section on emergency planning to provide guidance on managing these emergencies. While emergency planning issues should be considered on an organizational level, laboratory personnel can also be trained to respond to large scale emergencies—*Prudent Practices* provides advice on preparations to ensure the laboratory is ready for an emergency event, as well as information on the response and recovery stages.

- **Mitigation**—efforts to minimize the likelihood that an incident will occur and to limit the effects of an incident that does occur, such as creating an organizational

Chemical Hygiene Plan that will ensure the safe storage of materials, or installing a sprinkler system.

- **Preparedness**—the process of developing plans for managing an emergency and taking action to ensure that the laboratory is ready to handle an emergency, such as ensuring that adequate supplies are available, providing appropriate training for laboratory personnel, and preparing a communications plan.
- **Response**—efforts to manage the emergency as it occurs, instituting a chain of command, possibly including outside responders as well as laboratory staff.
- **Recovery**—actions taken to restore the laboratory and affected areas to a point where the functions of the laboratory may be carried out safely.

The four phases are interconnected: effective mitigation efforts reduce the impact of the emergency and ease the response and recovery stages; good planning in the preparedness stage makes the response and recovery less complicated; and lessons learned during an emergency may lead to further mitigation and preparedness efforts during the recovery phase.

Laboratory Security

The updated *Prudent Practices* includes the first discussion of laboratory security. A laboratory security system helps to mitigate a number of risks including the theft of chemicals which could be sold, or used to manufacture weapons or illicit substances; threats from activist groups; or the accidental release of or exposure to hazardous materials. Furthermore, a good laboratory security system can increase overall safety for laboratory personnel and the public, improve emergency preparedness by assisting with preplanning, and ultimately lower the organization's liability and insurance premiums. The updated guidelines offer several security plans and advice for training laboratory members to ensure that all personnel understand the security measures in place and how to use them.

The Importance of Green Chemistry

Green chemistry is the philosophy of designing experiments, products, and processes to reduce or to eliminate the use and generation of hazardous substances, and to minimize accidents, injuries, and exposures to personnel. Principles of green chemistry are considered for the first time in the new edition of *Prudent Practices* as guidelines for the safe management of laboratory chemicals.

Though not always directly applicable to laboratory safety, some of the principles of green chemistry encourage practices that can result in a safer laboratory environment. For example, one principle is waste prevention—planning experiments carefully to select procedures that minimize the quantities of hazardous chemicals used and the amount of hazardous chemicals that must be discarded at the end of the experiment. Green chemistry principles are consistent with ordering chemicals in small containers, even though it may be less expensive to buy in bulk quantities. Small containers are easier to handle than larger ones, reducing the risk of accidents and the exposure of laboratory personnel to hazardous materials. Because smaller containers take up less storage space it is easier to store them properly, for example in a well-ventilated area or in a locked cabinet. Furthermore, small quantities of chemicals are more likely to be used up quickly, reducing the likelihood of decomposition of reactive compounds over time and the subsequent costly disposal of the chemical.

Storage According to Compatibility

The storage requirements for stockrooms and laboratories vary widely depending on factors such as the level of expertise of the employees and the level of security of the facility. Furthermore, many local, state and federal regulations have specific requirements that affect the

Box 1. The Culture of Safety

A key focus of *Prudent Practices* is the importance of establishing and nurturing a "culture of safety"—an environment in which safe laboratory practice is standard. Since the last edition of the guidelines, significant progress toward this goal has been made.

Safety and training programs, often coordinated through an office of environmental health and safety, have been implemented to monitor the handling of chemicals from the time they are ordered until their disposal, and to train laboratory personnel in safe work practices. The careful consideration of habitual risk assessment, experiment planning, and preparing for worst-case scenarios is now as much a part of scientific education as learning the theoretical background of experiments or the step-by-step protocols for performing them in a professional manner.

storage and handling of chemicals. For example, radioactive materials, consumable alcohol, explosives, and hazardous wastes have requirements ranging from locked cabinets to specified waste containers and regulated areas.

Prudent Practices provides a list of general storage considerations, such as storing volatile toxic or odoriferous chemicals in ventilated cabinets and ensuring shelves have a lip to prevent containers from sliding off. In addition, the most recent update to *Prudent Practices* recommends storing containers of incompatible chemicals separately, to reduce the risk of mixing in case of accidental breakage, fire, earthquake, or response to a laboratory emergency. Even when containers are tightly closed, the mingling of vapors that may escape from containers of incompatible chemicals can cause reactions that degrade labels, shelves, cabinets, and containers themselves.

To make it easier to identify and separate incompatible chemicals, a detailed classification system for the storage of chemicals is provided in this report. The system classifies chemicals into 11 compatible storage groups, and recommends that each group should be separated by secondary containment, such as plastic trays, or stored in its own storage cabinet. According to this system, separate storage is most important for chemicals in storage group B, which include compatible pyrophoric chemicals (those that ignite on contact with air), and water-reactive chemicals (those that react on contact with water), and chemicals in storage group X, which are incompatible with all other storage groups. A compact disc accompanying the *Prudent Practices* book includes a spreadsheet of hundreds of chemicals that are listed according to these storage groups.

Working with Nanoparticles

For the first time *Prudent Practices* includes guidelines for working with nanoparticles, reflecting the growing use of these materials in chemical

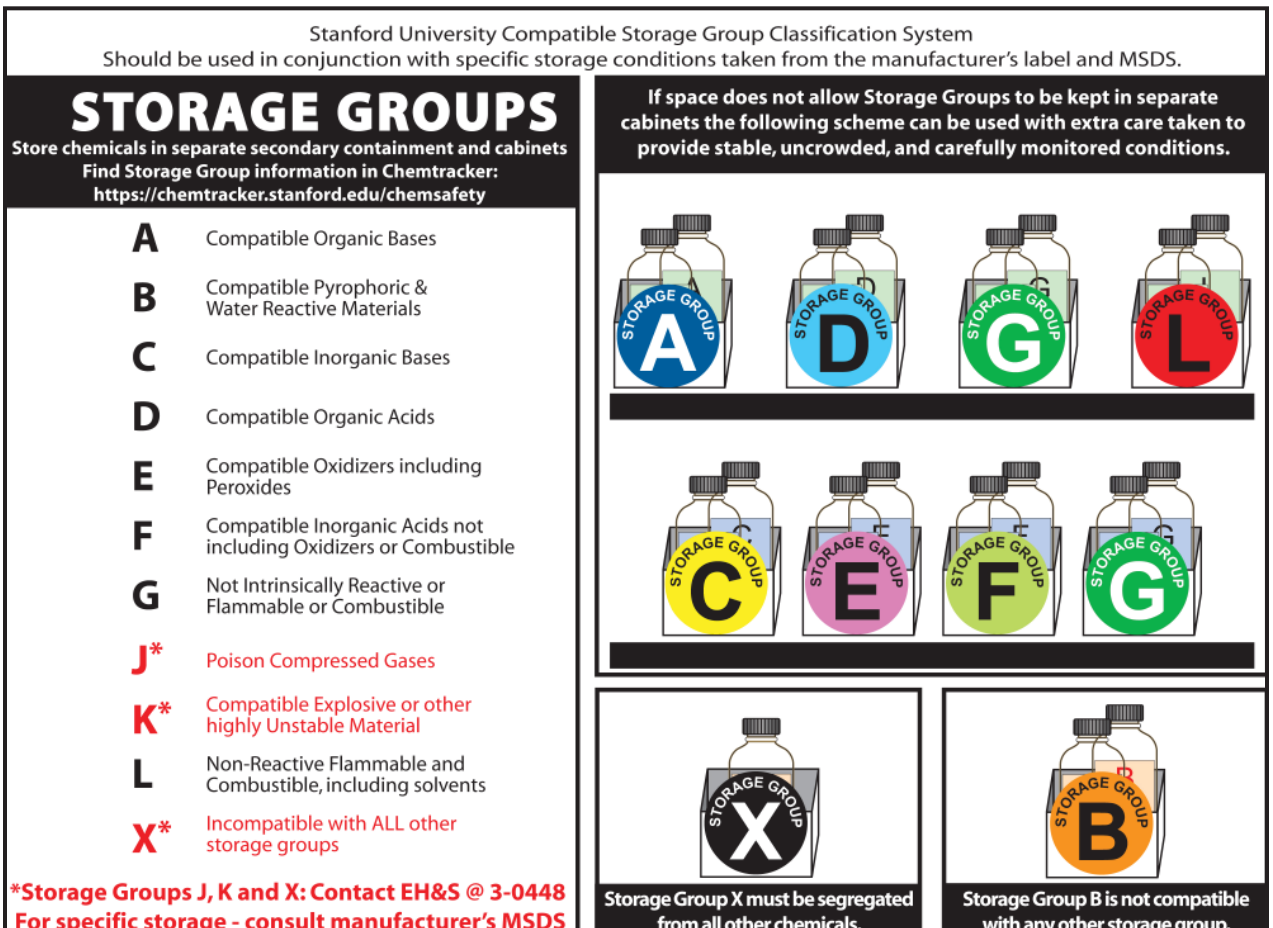


Figure 1. Compatible storage group classification system.

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research. Tiny particles measuring between 1 and 100 nanometers, nanoparticles may be more reactive than normal-sized particles. Understanding and exploiting the properties of these particles is now an active area of research. However, because this is a relatively new field of study, the risks and hazards associated with exposure to nanoparticles are not well known, and specific guidelines for handling the chemicals have not yet been developed.

This update sets out general guidelines for the management of nanomaterials, which were developed from accepted chemical hygiene protocols for handling compounds of unknown toxicity. Among the topics covered by these guidelines are planning and assessing the hazards of nanomaterial work, information on grading the risk of working with different types of nanomaterial, and suggestions on ways to make sure the working environment is designed to protect laboratory personnel from exposure to nanoparticles.

Environmental Health and Safety

A comprehensive legal framework already exists for laboratory environmental health and safety management, requiring organizations to manage activities in order to anticipate and prevent circumstances that might result in occupational injury, ill health, or adverse environmental impact. The latest edition of *Prudent Practices* includes an expanded section on improving environmental health and safety performance by providing guidance on how to integrate environmental health and safety management within an overall laboratory management system to control health and safety risks in a systematic, proactive manner.

Within many organizations, some elements of environmental health and safety management are already in place, but other aspects still need to be developed. To provide information on the scope, adequacy, and implementation of the current system, the guidelines suggest that an initial status review of the environmental health and safety management system should be carried out. A formal environmental health and safety policy can then be defined and developed in collaboration with laboratory personnel to ensure that concerns are addressed. After the development stage, a successful environmental health and safety management system will include planning and implementing the policy, measuring performance, and conducting a management review. The manner and extent to which these elements are applied depends on factors such as the size of the organization, the nature of its activities, and the hazards and conditions in which it operates.

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The National Academies appointed the above committee of experts to address the specific task sponsored by the Department of Energy, the National Science Foundation, and the National Institutes of Health, with additional support from the American Chemical Society, Eastman Kodak Company, DuPont, Howard Hughes Medical Institute, Air Products and Chemicals, Inc., and PPG Industries. The members volunteered their time for this activity; their report is peer-reviewed and the final product signed off by both the committee members and the National Academies. This report brief was prepared by the National Research Council based on the committee's report.

EXPERT CONSENSUS REPORT

For more information, contact the Board on Chemical Sciences and Technology at (202) 334-2156 or visit http://dels.nas.edu/bcst. Copies of *Prudent Practices in the Laboratory* are available from the National Academies Press, 500 Fifth Street, NW, Washington, D.C. 20001; (800) 624-6242; www.nap.edu.