

Fundamentals of productive laboratory inspections in academia

By Barbara L. Foster

INTRODUCTION

In academia, Safety Directors and Chemical Hygiene Officers oversee the health and safety of students and personnel who work and learn in two unique laboratory environments; the research laboratory and the academic laboratory. Why should we inspect these laboratories on a regular basis? Quite simply, inspections protect the health and safety of laboratory workers and students by identifying unsafe work practices and hazardous work conditions. Appendix A of the OSHA Laboratory Standard, 29 CFR 1910.1450, *Occupational Exposure to Hazardous Chemicals in Laboratories*, contains a section entitled “Non-Mandatory National Research Council Recommendations Concerning Chemical Hygiene in Laboratories”. Section D.4.b. of Appendix A suggests that “Formal housekeeping and chemical hygiene inspections should be held at least quarterly for units which have frequent personnel changes and semi-annually for others; informal inspections should be continual.”¹

When performing laboratory inspections in academia, the inspector should:

- Ensure that the facilities provide a healthy, safe, and code-compliant

Barbara L. Foster has served as the West Virginia University Department of Chemistry Safety Director for the academic and research programs since 1991 and the Eberly College of Arts and Sciences Safety Coordinator since 1999. Foster is a Certified Chemical Hygiene Officer and a Committee Associate on the American Chemical Society Joint Board-Council Committee on Chemical Safety.

environment in which to teach and learn.

- Ensure that the employees and students follow departmental and institutional chemical hygiene plans.
- Ensure that all laboratory activities are conducted in a prudent manner to avoid employee and student exposure to hazardous chemicals.

To protect laboratory employees and students from exposure to hazardous materials and unsafe work practices, the laboratory inspection checklist should include the following topics: Laboratory housekeeping, personal protective equipment, chemical storage and chemical waste, signs and labels, safety documents, laboratory chemical hoods, gas cylinder storage, emergency safety equipment, and physical plant concerns and security issues.

To facilitate your inspection efforts, an example of a laboratory inspection checklist is included in Figure 1. Note that the checklist is designed to incorporate “yes” or “no” answers and inspector’s comments. When preparing the inspection checklist, you should expand the comment section to allow ample room for the inspector’s written comments. All too often we forget important points after we exit the room. By taking careful notes, one will be able to create a more detailed and relevant inspection report.

THE INSPECTION CHECKLIST

Laboratory Housekeeping

Prudent Practices in the Laboratory: Handling and Disposal of Chemicals states, “There is a definite correlation between orderliness and level of safety in the laboratory.”² Furthermore, the *Handbook of Chemical Health and Safety* states, “Most safety experts will

agree that the principal cause of laboratory accidents is poor housekeeping.”³

Inspection items include:

- Access to aisles, emergency equipment, utilities, and exits should be kept clear (Figure 2). Hallways and stairways should not be used for storage areas.
- Coats, bags, and other personal items should be stored in the appropriate areas, not on the bench tops or on the floor.
- Bench tops and sinks should be clean and free of clutter, broken glass, spilled chemicals, and paper litter. Chemical hazards should be maintained at least two inches from the edge of the bench top.
- There should be no evidence of food or drink in the laboratory or equipment to prepare food or drink (i.e., microwave ovens and coffee makers).
- Drawers and cabinets should be kept closed when not in use.
- Equipment and apparatus should be properly stored when not in use.
- Hoods should be clean and contain only the chemicals that are being used for the work-in-progress.
- Floors should be clean and dry. Do not store chemicals or other materials on the floor.
- Glass disposal boxes must be replaced when full and all sharps should be disposed in proper containers.
- To avoid costly floods, check to ensure that all hose connections are properly clamped.
- Check for defective or frayed electrical cords on equipment.

Personal Protective Equipment (PPE)

PPE must be available to students and employees and must be compatible to the degree of potential chemical hazard. Laboratory workers should

Name of Institution
Department Name
Name of Inspector
Date of Inspection
Building _____ **Room Number** _____
Laboratory Supervisor _____

LABORATORY HOUSEKEEPING

Aisles and exits are clear and unobstructed Y N
 Floors are clean and dry Y N
 Benchtops and sinks are clean Y N
 Evidence of food or drink in the laboratory Y N
 Evidence of food or drink in the refrigerator/freezer Y N
 Refrigerator/freezer defrosted and clean Y N
 Hose connections on faucets are secure Y N
Comments:

PERSONAL PROTECTIVE EQUIPMENT

Employees are wearing proper eye protection Y N
 Employees are wearing proper clothing protection Y N
 Gloves are available, if needed Y N
 Personal apparel is appropriate for laboratory work Y N
 Shoes are appropriate and protect the feet Y N
Comments:

CHEMICAL STORAGE AND CHEMICAL WASTE

Chemicals are stored according to compatibility and hazard class Y N
 Chemicals in secondary containers are properly labeled Y N
 Chemical containers are properly capped Y N
 Chemical containers are dated upon receipt Y N
 Chemicals are stored in excess of five feet in height Y N
 Proper secondary containment devices are used, where necessary Y N
 Chemical waste processed according to institutional policy Y N
Comments:

SIGNS AND LABELS

NFPA 704 Posting Blue ___ Red ___ Yellow ___ Other ___
 Contact sheet is posted on the door and is up-to-date Y N
 Emergency equipment marked with highly visible signs Y N
 Proper labeling of lasers Y N
 Proper labeling of high voltage equipment Y N
Comments:

SAFETY DOCUMENTS

CHP is available to workers Y N
 Emergency Action Plan is available to workers Y N
 Chemical inventory is up-to-date and available Y N
 MSDS are readily accessible Y N
Comments:

LABORATORY CHEMICAL HOODS

Chemicals are stored in the hood Y N
 Workers are properly using the hood Y N
 Chemicals and equipment are six inches from the sash Y N
 Hood glass is clean with no decals or posters Y N
 Secondary containment devices are present Y N
 Date of last hood inspection Y N
 Hood inspection results in fpm
Comments:

GAS CYLINDER STORAGE

Stored upright and properly restrained Y N
 Caps in place on unused cylinders Y N
 Cylinders block egress or access to work areas Y N
 Old cylinders are present that should be sent to supplier Y N
Comments:

EMERGENCY SAFETY EQUIPMENT

Emergency eyewash inspection date
 Emergency shower inspection date
 Eyewash and shower located within 10 seconds of hazard Y N
 Fire extinguisher inspection date
 Fire blanket present in laboratory Y N
Comments:

PHYSICAL PLANT CONCERNS AND SECURITY ISSUES

Leaky faucets Y N
 Unexplained odors Y N
 Dirty floors Y N
 Damaged ceiling tiles Y N
 Light fixture requires new bulb Y N
 Malfunctioning door closers Y N
 Need to replace floor mats Y N
Comments:

IS A FOLLOW-UP INSPECTION REQUIRED? Y N

Figure 1. Laboratory inspection checklist.

consult the label and the Material Safety Data Sheet (MSDS) for the hazardous material with which they are working to obtain information about proper PPE.

Inspection items include:

- Safety goggles that conform to ANSI Z87.1-1989, *Practice for Occupational and Educational Eye and Face Protection*, must be worn at

all times when working with corrosive chemicals and when a splash hazard exists.⁴ A face shield (in addition to safety goggles) should be used when there exists a possibility of explosion or implosion. Protective safety glasses must be worn when working with lasers.

- Visitors and laboratory inspectors should wear appropriate PPE when they enter the laboratories.

- Gloves that are appropriate to the degree of hazard must be worn at all times when handling hazardous materials.
- Lab coats or aprons made of chemically inert materials should be worn in the laboratory.
- Personal apparel, commonly the first line of defense in the event of a chemical exposure, should be protective and appropriate to the degree

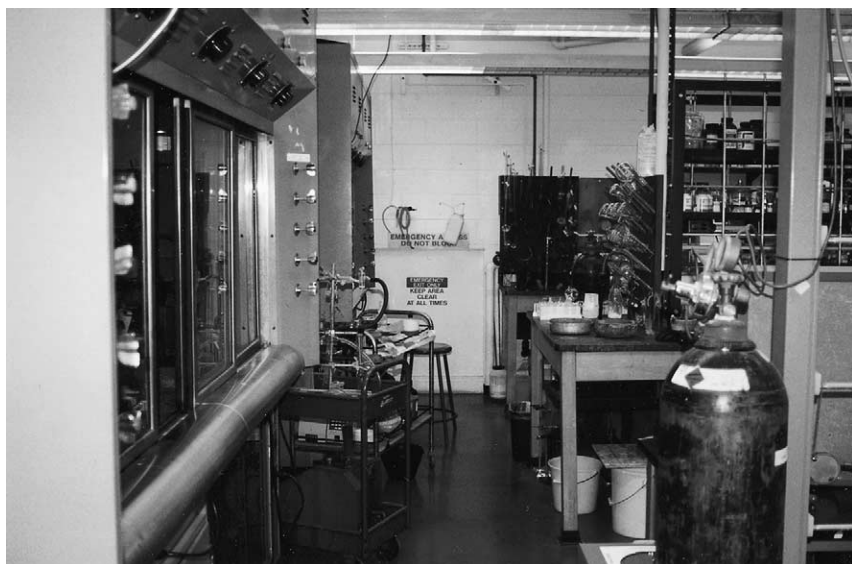


Figure 2. To protect laboratory workers in the event of a chemical spill or fire, access to aisle ways and emergency exits must never be blocked. Note the numerous aisle way and exit obstructions that are evident in the above laboratory photograph.

of hazard. Laboratory workers should wear clothing that sufficiently covers the upper and lower body. Open-backed shirts should not be worn in the laboratory. Shorts or short skirts are inappropriate apparel in the chemical laboratory.⁵ Long hair and loose clothing must be confined. Jewelry should not be worn in the laboratory. Chemicals can seep under jewelry and cause injuries to the skin. Jewelry can become caught in machinery and can conduct electricity.

- Shoes that completely cover the feet should be worn at all times. Open-toed shoes, open-backed shoes, high-heeled shoes, perforated shoes, sandals, or shoes made of cloth material should not be worn in the laboratory.

Chemical Storage and Chemical Waste

Inspecting tip: The four-point stance is very effective when conducting a laboratory inspection. On your hands and knees, you can peer into under-the-cabinet storage and under-the-hood storage to check for chemical compatibility and proper labeling (Figure 3). In-your-face odors in these storage areas may indicate a problem with the storage ventilation or choice of storage venue. Be especially curious

about any cabinet or storage area that is blocked by carts, boxes, etc. These areas can frequently hide spectacular surprises for the inspector (i.e., a splendid mix of incompatible materials). Move any items that block your access and be sure to inspect all storage areas in the laboratory. The area that you did

not inspect will inevitably contain the 10-year-old peroxide-forming chemical that can and will explode (usually at midnight) before the next scheduled inspection.

Inspection items include:

- Chemicals should be dated upon receipt and must be separated according to category and compatibility.
- Secondary containers must be properly labeled with the name of the chemical, known hazards, and name of manufacturer (Figure 4).
- To protect laboratory workers, chemicals should not be stored above five feet in height (Figure 5). Shelving should have lips to prevent accidents.
- Chemicals should not be stored in the fume hood.
- Do not store food or drink in the laboratory refrigerator or freezer.
- Secondary containment devices, such as trays, should be used where appropriate to avoid costly clean-ups and potentially hazardous conditions in the event of a spill.
- The chemical inventory should be up-to-date.
- Chemical waste must be processed according to institutional policies.



Figure 3. Incompatible chemical storage was discovered in this acid cabinet. Additionally, the integrity of the shelving has been seriously compromised by rust and corrosion. New shelves should be purchased, the cabinet should be thoroughly cleaned, and the laboratory supervisor must store these chemicals according to hazard category.



Figure 4. Unlabeled beakers and flasks and spilled chemicals on the bench top can compromise the health and safety of laboratory workers and can precipitate substantial fines from federal inspectors.

- Refrigerators and freezers should be cleaned and defrosted on a regular basis. Cleaning the refrigerator can provide a wonderful opportunity to update the laboratory chemical inventory and to make critical deci-

sions about the worth of an item. Containers which have lost their labels or have cracked caps should be removed from the refrigerator. Missing labels and cracked caps must be replaced immediately (Figure 6).

Signs and Labels

The National Fire Protection Association (NFPA) 704 diamond label postings and emergency contact sheet information on the laboratory doors should be kept up-to-date. Record the 704 data for each room on the inspection sheet for your reference. Emergency contact sheets should contain the names, office phone numbers, and home phone numbers of the laboratory supervisor, the departmental safety director, and the director of the Department of Environmental Health and Safety. Lasers, high-voltage equipment, fire alarms, emergency telephones, safety showers, fire blankets, fire extinguishers, and safety eyewashes should be clearly marked with highly visible signs. Warning signs should be posted for areas of special or unusual hazards.

Safety Documents

Laboratory workers should have round-the-clock access to MSDS, emergency action plans, and the departmental and institutional Chemical Hygiene Plans. The emergency action plan should include procedures for fires, chemical spills, evacuation, ventilation failure, medical emergencies, and incident reporting. The chemical inventory should be updated on an annual basis and a copy should be available on-site for the laboratory inspector.

Laboratory Chemical Hoods

Laboratory chemical hoods should be used when working with toxic chemical vapors, dusts, gases, and volatile substances. Workers should keep their heads and bodies outside of the hood and listen for changes in the airflow. Except for the chemicals that are needed for the work-in-progress, chemicals should never be stored in the hood. Secondary containment devices should be present in all hoods. All chemicals and equipment should be positioned so that they do not block the back baffles and should be placed at least six inches from the hood face to ensure proper airflow. Large pieces of equipment should be raised on racks to facilitate the airflow in the hood. The workspace and the sash glass must be kept clean. The view should not be obstructed with posters, decals, or other items. Hood performance should



Figure 5. These chemicals are stored on shelving that exceeds five feet in height, creating a health risk and potential disaster for the laboratory worker. The person in the photograph is standing on a stool, reaching up to grasp a bottle containing a liquid material. If she loses her grasp on the bottle, or suddenly loses her balance and tries to grab the shelves to avoid falling, any number of bottles of chemicals could be broken. The laboratory worker could sustain chemical burns, cuts, and exposure to hazardous materials and fumes when incompatible chemicals are mixed during a catastrophic incident.



Figure 6. Refrigerators and freezers should be cleaned and defrosted on a regular basis. Missing labels should be replaced immediately and unneeded chemicals should be removed from the laboratory. The haphazardly stored and improperly labeled round bottom flasks in the photograph present an obvious safety risk to the laboratory workers (and the intrepid inspector) when the freezer door is opened.

be tested on a regular basis and a tag or label should be attached to the hood to indicate the date of the testing and the test results in feet per minute (fpm).

Gas Cylinder Storage

Gas cylinders must be stored upright and properly restrained. Caps should be placed on unused cylinders. Cylinders must not block access to work areas or points of egress. Make note of gas cylinders with old dates and include this information in your report. Gas cylinders must be returned to the supplier on a regular basis to be properly inspected and tested. Gas cylinders are usually rented on a monthly basis from the supplier. The department can save substantial amounts of money in terms of demurrage charges if personnel expeditiously return their empty or unneeded gas cylinders to the supplier.

Emergency Safety Equipment

Eyewash stations, showers, and fire extinguishers must be inspected on a regular basis and the inspection dates and initials of the inspector should be written on the attached tags. Eyewashes

Name of Institution
Department Name
Name of Inspector
Date of Inspection

PART I INSPECTION RESULTS

Room Number	Principal Investigator	NPFA 704 Posting	Comments
120	Dr. Ethylene Ligand	4, 4, 4, W, OX	Nitric acid should be stored separately from the other acids. This laboratory should be cleaned and the aisles and emergency exits should be cleared. To avoid accidents, do not store chemicals over five feet in height. Send unused gas cylinder (nitrogen cylinder dated 1998) back to the supplier to save money in demurrage costs. Thoroughly clean and defrost the refrigerator.
246	Dr. Bunsen Burner	3, 4, 3, W, OX	Do not cover the 704 posting and the room number on the door with papers or decals. Write out all chemical names on the labels, do not use abbreviations. Contact Physical Plant Fire Control to arrange for the installation of a fire extinguisher in this laboratory. Incompatible chemicals are stored together under the hood. Return the compressed air cylinder dated 04-16-96 if not needed to save money on demurrage charges.
423	Dr. Jane Smith Dr. John Jones	3, 3, 3, OX	The researchers who share this laboratory are to be commended for the excellent level of housekeeping in this laboratory. No violations were noted during the inspection process.

Figure 7. Laboratory inspection report.

and showers must be located within 10 seconds of the hazard.⁶ Workers should have access to telephones and fire alarms on a round-the-clock basis. Fire blankets and first-aid kits should be available for use by laboratory workers.

Physical Plant Concerns and Security Issues

Make a list of all physical plant concerns, such as leaky faucets, unexplained odors, dirty floors, damaged ceiling tiles, temperature extremes, or light fixtures that require new light bulbs. To avoid theft of equipment and chemicals, check the door closers on all laboratory doors to ensure that they are closing promptly when personnel leave the lab. Frequently, personnel lock the door prior to exiting the laboratory and don't check to see if the door has closed behind them. If the door closer is malfunctioning, they are unaware that there is a potential security problem. If there was no one in the laboratory during your inspection,

PART II INSPECTION SUMMARY HOUSEKEEPING

"There is a definite correlation between orderliness and level of safety in the laboratory."¹ I urge the chair to meet with faculty to discuss the results of the laboratory inspections and to plan a course of action to correct the safety violations that were cited. Researchers must adhere to the guidelines that are outlined in the departmental Chemical Hygiene Plan.²

CHEMICAL STORAGE

"Strong oxidizers, such as nitric acid, perchloric acid, and sulfuric acid must be segregated from flammable chemicals. Such acids must be stored in separate rooms, separate cabinets, and in break-resistant containers if large glass bottles must be stored in proximity of flammable chemicals."³ There are currently no hoods in this facility that were manufactured for use with perchloric acid.

"All chemicals should be stored only to eye level."⁴ Personnel are storing their chemicals on the top shelves. Chemicals should be stored according to the MSDS and compatibility tables. For the researcher's convenience, I have attached chemical compatibility tables to this report. Acetic acid should not be stored with other acids or bases. Nitric acid should not be stored with acetic acid or sulfuric acid.⁵ Concentrated strong acids (especially nitric, chromic, sulfuric, hydrofluoric) can cause severe and painful burns. Leakage from containers can cause corrosion of shelving and if the acids are stored with materials with which they may react, accidents can occur from resulting reactions.⁶ "In general, chemicals should never be stored in a fume hood, since this may interfere with the proper operation of the hood and may increase the danger or damage in case of fire or explosion."⁷

SECONDARY CONTAINER LABELING

Properly label all secondary containers to avoid accidents. Federal officials have been known to impose substantial fines for each improperly labeled chemical container. The Department of Chemistry must be prepared to pay these fines if the researchers do not choose to follow university, departmental, and federal regulations regarding container labeling in laboratories.

GAS CYLINDERS

Researchers should promptly return all unused/empty gas cylinders to the vendor to reduce the monthly departmental demurrage costs. The monthly demurrage bill could be significantly reduced if researchers returned their cylinders in a timely manner.

EXPLOSION-PROOF REFRIGERATORS

The refrigerators should be defrosted and cleaned in most of the research laboratories. A system is in place for the researcher to borrow a refrigerator on wheels from the Stockroom, place his/her chemicals in the borrowed refrigerator, and clean his/her refrigerator. These appliances are expensive to replace and will last longer if they are properly maintained.

REFERENCES

1. *Prudent Practices in the Laboratory, Handling and Disposal of Chemicals*; National Research Council; National Academy Press: Washington, D.C., 1995; p. 84.
2. *Chemical Hygiene Plan*, State University Department of Chemistry; 2000; p. 7.
3. Hall, Stephen K., *Chemical Safety in the Laboratory*; CRC Press: 1994; p. 87.
4. Hall, Stephen K., *Chemical Safety in the Laboratory*, CRC Press: 1994; p. 85.
5. Mahn, William J., *Academic Laboratory Chemical Hazards Guidebook*, Van Nostrand Reinhold: New York, NY, 1991; p. 82, p. 215.
6. *Chemical Hygiene Plan*, State University Department of Chemistry; 2000; p. 54.
7. Dux, James P. and Stalzer, Robert F., *Managing Safety in the Chemical Laboratory*; Van Nostrand Reinhold: New York, NY, 1998; p. 56.

Inspector's Name / Date

Figure 7. (Continued).

was the door locked when you arrived? Personnel in academia sometimes have to be reminded of the importance of taking appropriate security measures at all times in the chemical work place. Check the condition of the floor mats. Upturned ends can present a dangerous trip-and-fall hazard. Include the physical plant concerns and security issues in your official report and encourage the laboratory supervisor to call the appropriate officials to initiate the work

orders for repairs. The appropriate departmental personnel should address all security issues in a timely manner.

THE INSPECTION REPORT

After the laboratory inspection, the inspector should prepare a detailed report and submit it to the laboratory supervisor, chair, and dean. Arrange a sit-down meeting in a comfortable setting with the laboratory supervisor and

go over the report with him or her. Be inclusive and allow time for questions and answers. The report should indicate all infractions of the rules that were discovered during your inspection. Be sure to include photographs of problem areas in your report. Additionally, the report should include all positive findings (i.e., "the housekeeping is much improved since the last inspection").

Use tact and diplomacy to obtain your desired results. Simply telling a professor that she has to reduce the quantity of solvents in her lab is not good enough. Be supportive and help her to share her solvents with others

After the laboratory inspection, the inspector should prepare a detailed report and submit it to the laboratory supervisor, chair, and dean.

who have storage space or help her to find alternative storage sites within the facility. The report should include a date on which the inspector intends to return to perform a follow-up inspection. Be fair. Allow them enough time to rectify the situation. If the follow-up inspection reveals that violations continue to exist in the laboratory, disciplinary action may be taken against the laboratory supervisor by the dean or other university officials. A colleague once asked if disciplinary action was possible in an academic setting. My answer was a resounding "YES". If the administration (i.e., university president, dean, or chair) is supportive of the departmental safety program, disciplinary action can be taken against personnel who knowingly and willfully violate the departmental or university CHP or city, state, or federal codes. The key is to provide employees with copies of all requisite regulations and policies, appropriate training, and a friendly and helpful safety director who can and will answer their questions and help them with their safety-related problems.

Figure 7 is a two-part example inspection report. Part I consists of comments that are derived directly from the Inspection Checklist. Part II is a summary that contains overall suggestions and comments that are designed to help the laboratory supervisor to attain compliance with codes and regulations.

SUMMARY

Laboratory inspections are a key element of any successful laboratory safety program. A thorough inspection will reveal existing and potential problems that might pose a health threat to the employees and students who work in the laboratory. Before leaving your office to begin the inspection, **grab your camera**. When inspecting laboratories, a picture can truly be worth a thousand words. It is very difficult to deny a violation when photographic evidence is inserted into an official report.

During the inspection process, always remember that your main objective is to protect the workers from exposure to hazardous chemicals and

A thorough inspection will reveal existing and potential problems that might pose a health threat to the employees and students who work in the laboratory.

unsafe work practices. File a detailed inspection report with the laboratory supervisor, the department chair, and the dean. Conduct follow-up inspections, as needed. Inspect to protect

your employees and students. Work Safely and Teach Safety!

References

1. Occupational Safety and Health Administration, *Occupational Exposure to Hazardous Chemicals in Laboratories*; 29 CFR, Part 1910.1450, 1990.
2. *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals*; National Research Council, National Academy Press: Washington, D.C., 1995.
3. *Handbook of Chemical Health and Safety*, Alaimo, R. J. (Ed.), American Chemical Society, Oxford University Press: Washington, D.C., 2001.
4. ANSI Z87.1-1989. *Practice for Occupational and Educational Eye and Face Protection*, American National Standards Institute: New York, NY, 1989.
5. *Safety in Academic Chemistry Laboratories*, American Chemical Society: Washington, D.C., 1995.
6. ANSI Z358.1-1998. *Emergency Eye-wash and Shower Equipment*, American National Standards Institute: New York, NY, 1998.