

CHAPTER 10

Working Safely in the Laboratory: General Considerations and Physical Hazards

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I. RISK REDUCTION IN THE LABORATORY

There are four general approaches to risk reduction in the laboratory that apply to all categories of hazards:

- Reduce the presence of hazards
- Reduce the risk of inevitable hazards with good laboratory design
- Establish good laboratory practices for handling hazards
- Use personal protective equipment

The best strategy is to start at the top of this list and consider these approaches in sequence. First, the presence of hazards should be reduced as much as possible. For example, amounts of radioactive substances and flammable solvents on the premises should be limited. It may be possible to eliminate hazardous substances or replace them with safer substitutes. Next, the risk of those hazards that cannot be eliminated should be reduced by good laboratory engineering. This means, for example, the installation of properly functioning fume hoods, protective shielding, and fire-resistant chemical

storage facilities. Appropriate lab facilities should provide safe separation between personnel and hazards whenever possible. The third approach is to establish good laboratory practices in ways that reduce risk. All personnel must take advantage of the engineered solutions such as fume hoods, be aware of proper procedures for performing hazardous operations, and exercise caution in their work behavior. Adequate personnel training and maintenance of good housekeeping practices are essential. Finally, the provision of personal protective equipment (commonly abbreviated PPE), such as safety goggles, is essential to create a barrier between the worker and hazards, to reduce residual hazards and to guard against unexpected events. Personal protective equipment should be the final consideration after hazards have been minimized as much as possible.

II. PERSONAL PROTECTION IN THE LABORATORY

A. Clothing

i. GENERAL DRESS

Proper clothing is required whenever entering a laboratory. Even though a lab coat will protect you and your clothing from some hazards, what you wear under a lab coat can be just as important, see Figure 10.1. It is impor-

tant that clothes cover all parts of the body, including legs. For this reason, pants or long skirts are appropriate. Avoid dangling jewelry or ties and long loose hair that can fall into your experiment or get caught in moving equipment. It is also a good idea to refrain from wearing rings, bracelets, or watches in the laboratory. It is easy for chemicals to seep under these items. Any clothing worn in the laboratory should be fire-resistant and easily removable in case of chemical or biological contamination. It should also be appropriate for protection against the types of chemicals that are used in the laboratory (Table 10.1 offers some guidelines). Many experienced laboratory workers keep a spare change of clothing handy in case of spills, or for wearing after work.

ii. LAB COATS

Lab coats should be worn at all times in the laboratory. Even when you are not using hazardous materials yourself, other people's activities in the laboratory might present unexpected hazards. Lab coats provide a barrier against harmful agents and prevent contamination of street clothes. By soaking up spills, they allow more time to recognize contamination problems and protect yourself. They also protect experiments from contaminants outside the laboratory that might be carried in on clothing.

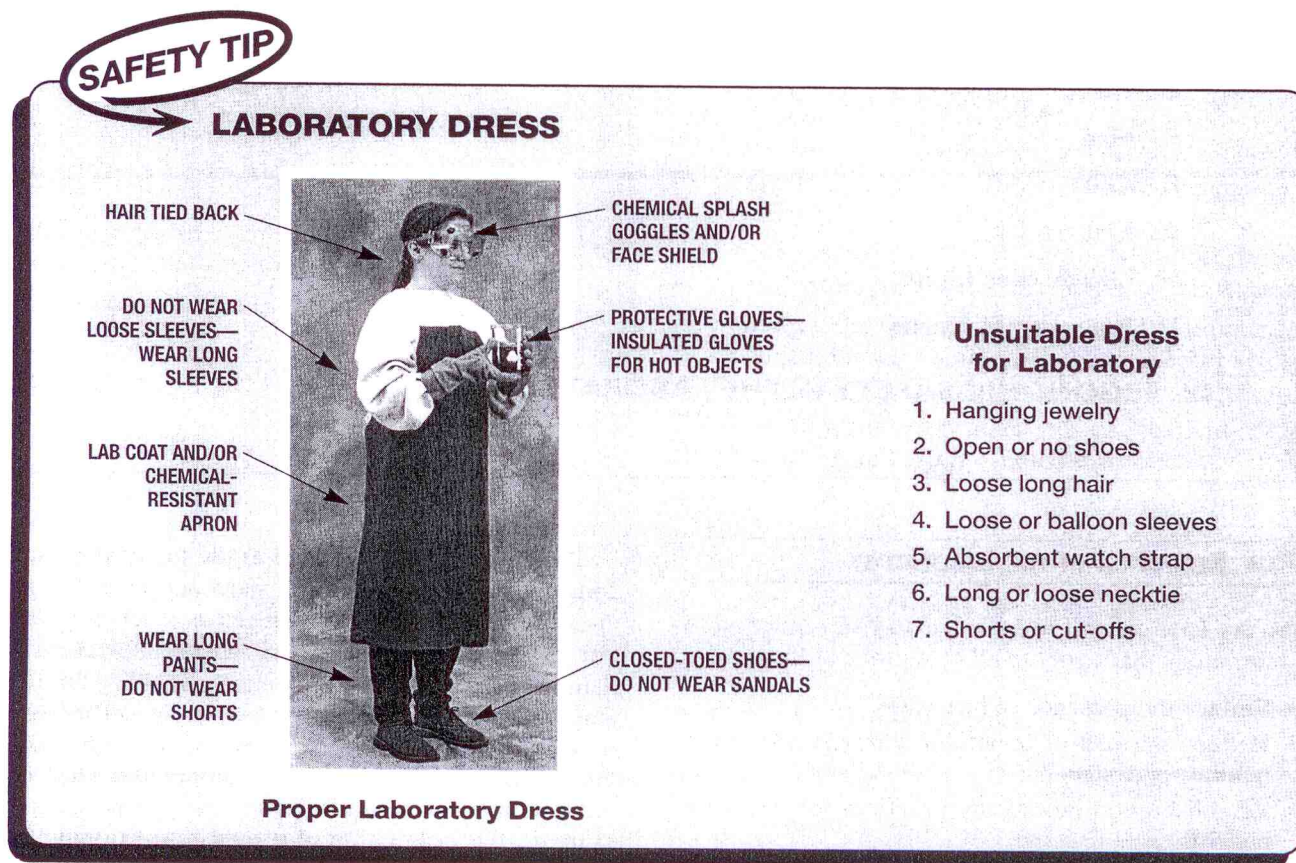


Figure 10.1. Proper Laboratory Dress. (©1998 Flinn Scientific Inc. All Rights Reserved. Reproduced with permission from Flinn Scientific Inc., Batavia, IL, USA.)

Many types of lab coats are available and selection should be based on the hazards that are of most concern. For example, front-buttoning coats are more desirable for protection against chemical spills than for biological hazards because they can be removed quickly. All lab coats should be flame-resistant, with cotton frequently providing the best resistance to both chemicals and heat in a comfortable garment, see Table 10.1. For specialized work, such as pouring large quantities of corrosive chemicals, an impermeable apron may be most appropriate.

To be effective, lab coats must fit properly and remain buttoned at all times in the laboratory. Sleeves must be long enough to provide arm protection and should fit the arm fairly snugly to avoid flapping. Rolling up the sleeves provides a holding area for chemical and biological contaminants and is not recommended. This practice also leaves the wrists and lower arms without protection.

Lab coats should be laundered regularly at your institution, even in the absence of any known contamination. Never take laboratory clothing home for washing. In case of known contamination, the coat can be decontaminated in the laboratory before washing, or be discarded. Do not wear lab coats used in the laboratory into common areas such as lunch rooms or lavatories.

iii. SHOES

Proper footwear for the laboratory includes shoes with covered toes and nonslip soles, which will protect the feet from broken glass and hazardous spills. Sandals, sneakers, or woven shoes provide little protection. Low heels are generally the most comfortable while standing at the lab bench and also protect against falls.

Laboratory workers may want to consider keeping a special pair of shoes to wear only in the lab. Changing

to and from street shoes prevents the tracking of hazardous materials from the lab into the outside environment, and also prevents the introduction of potential contaminants into a cleanroom. (A **cleanroom** is a special laboratory facility where all contaminating materials and any particulate matter in the air must be limited.) Numerous studies have shown that shoes worn in a bacterially contaminated environment may carry higher concentrations of bacteria on their soles than the floor itself. One method to prevent contamination of shoes is the use of disposable shoe covers, which are routinely used for animal surgery and cleanroom operations, and which are removed before exiting the laboratory. Shoe covers will also prevent your shoes from carrying bacterial contamination into public areas and your home.

B. Gloves

i. CHOICE OF GLOVES

The proper use of gloves in the laboratory provides a significant measure of protection against many types of hazards. One of the most obvious benefits is the creation of a barrier between your skin and chemical or biological contamination.

If you look in a laboratory supply catalog, you will find a bewildering variety of gloves available, in many materials and styles. It is important to remember that although every type of glove provides a barrier, none can protect against all types of hazards. Each glove type will provide at least some protection against one or more of the following:

- corrosive or toxic chemicals
- biological contaminants
- sharps
- extreme temperatures

Table 10.1. PROTECTIVE CLOTHING MATERIALS

| Material | Use | Properties |
|-----------------------------------|---|--|
| Cotton | Lab coats | Lightweight, degraded by acids |
| Cotton/polyester blend | Lab coats | Lightweight, neat appearance |
| Modacrylic | Lab coats | Nonflammable, resistant to most chemicals, easy to clean, low static |
| Nylon | Lab coats, hair nets | Lightweight, strong, water-resistant, very flammable unless treated |
| Neoprene | Aprons | Excellent chemical resistance, inflexible |
| Rubber | Aprons, long gloves | Very good chemical resistance |
| Vinyl | Aprons, sleeves, shoe covers | Lightweight, high static |
| Polypropylene | Aprons, full body suits, caps, shoe covers | Chemical resistant, strong, lightweight, water-repellent |
| Tyvek (high density polyethylene) | Full-body suits, shoe covers, disposable lab coats, aprons, caps, sleeves | Strong, lightweight, excellent barrier protection for user, protects lab materials from human contamination, recyclable material |

Table 10.2. PROTECTIVE GLOVE MATERIALS

| Type | Advantages | Disadvantages | Recommended for Protection from |
|-------------------------|---|--|---|
| Latex | Low cost, good flexibility, comfortable | Poor protection from oils, grease, organic solvents. May trigger allergic reactions. | Bases, alcohols, bloodborne pathogens |
| Vinyl | Low cost, medium chemical resistance | Protection against some chemicals lower than latex | Strong acids and bases, salts, other aqueous solutions, alcohols |
| Neoprene | Medium cost, medium chemical resistance, abrasion-resistant | Not as flexible as rubber, can give poor grip | Oxidizing acids, phenol, glycol ethers |
| Nitrile | Puncture and abrasion-resistant, dexterity, comfortable for longer wear, hypoallergenic, good chemical resistance | Poor protection from benzene, methylene chloride, trichloroethylene, many ketones | Oils, aliphatic chemicals, xylene, bloodborne pathogens |
| Butyl | Specialty glove, resistant to polar organics | Expensive, poor protection from hydrocarbons, chlorinated solvents | Gases, aldehydes, glycol ethers, ketones, esters |
| Polyvinyl alcohol (PVA) | Specialty glove, resists a very broad range of organic solvents | Very expensive, water-sensitive, poor protection from light alcohols | Aliphatics, aromatics, chlorinated solvents, ketones (except acetone), esters, ethers |
| Fluoroelastomer (Viton) | Specialty glove, resistant to organic solvents | Extremely expensive, poor physical properties, poor protection from some ketones, esters, amines | Carcinogens, aromatic and chlorinated solvents |
| Norfoil (silver shield) | Specialty glove, excellent chemical resistance, lightweight, flexible | Poor fit, easily punctured, poor grip | Use as glove liner, good for emergency use in chemical spills |

Because no glove can provide all the necessary protective features, most laboratories have several glove types available, including:

- thin-walled gloves for dexterity
- heavy rubber gloves for dishwashing
- insulated gloves for handling hot and cold materials
- puncture-resistant gloves for handling animals

The first step in choosing the right glove for a job is deciding what protection is required. Are you trying to protect yourself or your work materials from contamination? Do you need maximum protection from a highly toxic chemical? Table 10.2 provides an overview of the most common glove materials and their advantages and disadvantages.

When choosing gloves for protection against chemicals, always consult the specific glove manufacturer's chemical resistance chart, which is usually supplied with the gloves or found in the supplier's catalog. This will provide information about the properties of specific glove materials. The information provided generally includes:

- **degradation rate**, which indicates the tendency of a chemical to physically change the properties of a glove on contact

- **permeation rate**, which measures the tendency of a chemical to penetrate the glove material
- **breakthrough rate**, which indicates the time required for a chemical that is spilled on the outside of a glove to be detected on the inside of the glove.

The following example indicates how to use this information.

EXAMPLE: CHOOSING A GLOVE FOR CHEMICAL RESISTANCE

For this example, assume that you are performing an experiment and are concerned about the possibility of acetone spills. After taking precautions to minimize the risk of skin exposure to acetone, you will still want to wear gloves. The two types of gloves you have available are made of either PVC or butyl. You then check the chemical resistance guide from the glove manufacturer and find the following information for acetone:

- PVC gloves: Degradation rate > 25% in 30 minutes
Permeation and breakthrough rate < 1 minute
- Butyl gloves: Degradation rate—no effect
Permeation and breakthrough rate > 17 hours

