Laboratory Safety and Fundamental Equipment

Student/Instructor Guide

February 13, 2017

Table of Contents

Instructional Preparation Guidelines

Items contained in blue text are instructor notes and can be “hidden” for a cleaner look for the students.

Recommended – Instructor should coordinate a tour at a local laboratory and obtain the local laboratory’s chemical hygiene plan for comparison to classroom knowledge requirements.

Access to laboratory equipment is required to complete the skills assessments contained in this lesson plan. Students should be given hands-on training of each piece of equipment and provided adequate practice time before completing the worksheet. Significant time should be allotted for this portion of the class.

Presentation Methods

Classroom

Laboratory hands-on

Evaluation Methods

Pre-Course Assessment

Post-Course Assessment

Research project – Students should be required to look up and present a laboratory accident.

Training Aids

Student handout – Sodium Hydroxide SDS
Student handout – Brauer Hall Incident
Student handout – Skills Worksheet

Associated Training Materials

Whiteboard

Notes to Instructor

Make copies of references and student handouts prior to class. Make them available to students to use as additional materials for study.

References

"Laboratory Safety Chemical Hygiene Plan (CHP)." United States Department of Labor, Aug. 2011. Web. 12 Feb. 2017. <https://www.osha.gov/Publications/laboratory/OSHAfactsheet-laboratory-safety-chemical-hygiene-plan.pdf>.

"Hazard Communication Standard: Labels and Pictograms." United States Department of Labor, Feb. 2013. Web. 12 Feb. 2017. <https://www.osha.gov/Publications/OSHA3636.pdf>.

"United States Department of Labor." OSHA QUICK CARD: Hazard Communication Safety Data Sheets | Occupational Safety and Health Administration. N.p., 2013. Web. 12 Feb. 2017. <https://www.osha.gov/Publications/HazComm_QuickCard_SafetyData.html>.

"Laboratory Safety Guidance." United States Department of Labor, 2011. Web. 12 Feb. 2017. <https://www.osha.gov/Publications/laboratory/OSHA3404laboratory-safety-guidance.pdf>.

Title - Slide 1

Introduction

1. **Introduce Self**

   Introduce self and break ice

2. **Learning Objectives**

   Hand out and review Learning Objectives

3. **Overview**

   Describe to the students how the course is to be taught and evaluated.

4. **Motivator** – What's In It for Me? Knowledgeable and properly trained laboratory technicians improve the safety of the laboratory and improve productivity. This course combined with other laboratory courses prepares the student to work safely and efficiently in the laboratory.

5. **Questions**

   Student Background

   Inquire to find out what kind of background the students may have to help tailor the discussions.

   Student Questions

   Convey to the students the ability to feel free to ask questions at any time.

Course Objectives

Objective Review – Slides 2 through 6
Discuss the course objectives

Knowledge Objectives

EO1 - State the government organization that regulates chemical hygiene.

EO2 - Given the elements in a chemical hygiene plan, describe the contents.

EO3 - Discuss the worker training requirements of a chemical hygiene plan.

EO4 - State the medical monitoring requirements of a chemical hygiene plan.

EO5 - State which federal standard sets the requirements for hazard communications in the workplace.

EO6 - Discuss the hierarchy of hazard controls.

EO7 - Explain the contents of a safety data sheet

EO8 - Discuss the contents and importance of labels on chemical containers in the laboratory.

EO9 - Describe acute and chronic chemical exposure affects.

EO10 - Discuss chemical exposure routes.

EO11 - Define and discuss the following chemical hazards:

- Corrosive
- Carcinogen
- Toxic
- Irritant
- Sensitizer

EO12 - Describe the following physical hazards in the laboratory:

- Ergonomic
- Slips, trips, and falls
- Noise
- Compresses gases
- Cryogens
- Fire
- Electrical

EO13 - For the following fundamental laboratory equipment, describe their function, common use, and any limitations or safety concerns:

- Fume hoods
- Pipets
- Hotplates and Stirrers
- Furnaces and Ovens
- Balances
- Volumetric Glassware
- Laboratory Centrifuges

Performance Objectives

PO1 - Skills Assessment: After completing hands-on training, complete the Laboratory Skills Worksheet.

Chemical Hygiene

Chemical Hygiene – Slide 7

Because a CHP is required for every laboratory, students should be provided a copy of one from a local laboratory for comparison of the elements.

Chemical hygiene is also known as chemical safety. Every chemical used in a laboratory has specific hazards and it is the responsibility of employer and employee to know and understand the hazards. The occupational safety and health administration (OSHA) requires that laboratories have a chemical hygiene plan (CHP). A CHP specifies the mandatory requirements to protect laboratory workers from harm due to hazardous chemicals. The CHP is a written program stating the policies, procedures and responsibilities that protect workers from the health hazards associated with the hazardous chemicals used in that workplace. The rules regarding chemical hygiene and laboratory safety are stated in OSHA's Occupational Exposure to Hazardous Chemicals in Laboratories standard (29 CFR 1910.1450), referred to as the Laboratory standard. A CHP provides for or states where the requirements can be found. The CHP covers specific elements as prescribed by OSHA, training of laboratory personnel, and medical exams.

Chemical Hygiene Plan Elements

OSHA provides a list of eight elements that a CHP must cover. These elements are designed to create a fully encompassing set of documents to ensure workers are protected from the hazards in the laboratory. The laboratory is responsible to show how these elements are met.

Required Elements in CHP – Slide 8

Remind the students that they will not be required to remember the list of CHP elements, only to discuss them when asked.

One element is standard operating procedures. A laboratory must have a suite of procedures, relevant to safety and health considerations, for each activity involving the use of hazardous chemicals. These procedures define how and where chemicals are used and in all circumstances, have been tested to ensure safety.

Another element of a CHP is hazard controls. The laboratory must establish the criteria that the employer will use to determine and implement control measures to reduce exposure to hazardous materials (i.e., engineering controls, administrative controls, the use of personal protective equipment (PPE), and hygiene practices) with attention given to selecting control measures for extremely hazardous materials. In many instances, the normal controls in the laboratory are not adequate for certain chemicals. One such example of this is the use of concentrated acids. Normal latex gloves are not suitable for contact with concentrated acids and additional personal protective equipment (PPE) is prescribed when handling the chemical.

The next element required by OSHA is that a laboratory CHP must ensure that fume hoods and other protective equipment are functioning properly and identify the specific measures the employer will take to ensure proper and adequate performance of such equipment. Items covering this element of a CHP include inspection criteria such as air flow rate, contamination limits, and chemical loading.

The fourth element requires information to be provided to laboratory personnel working with hazardous substances include:

- The contents of the laboratory standard and its appendices.
- The location and availability of the employer's CHP.
- The permissible exposure limits (PELs) for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard.
- The signs and symptoms associated with exposures to hazardous chemicals used in the laboratory.
- The location and availability of known reference materials on the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory including, but not limited to, the Safety Data Sheets received from the chemical supplier.

Required Elements in CHP, cont'd – Slide 8

The fifth element required is one in which the circumstances under which a laboratory operation, procedure or activity requires prior approval from the employer or the employer's designee before being implemented. These typically involve operations that are new or uncommon and may require additional controls such as additional monitoring.

The next element requires that the laboratory designates personnel responsible for implementing the CHP, including the assignment of a Chemical Hygiene Officer and, if appropriate, establishment of a Chemical Hygiene Committee. This person bears the ultimate responsibility of the implementation of the requirements and the safety of the laboratory personnel.

The seventh element for a CHP deals with provisions for additional worker protection for work with particularly hazardous substances. These include “select carcinogens,” reproductive toxins, and substances that have a high degree of acute toxicity. Specific consideration must be given to the following provisions and shall be included where appropriate:

- Establishment of a designated area.
- Use of containment devices such as fume hoods or glove boxes.
- Procedures for safe removal of contaminated waste.
- Decontamination procedures.

The final element required for a CHP is that it shall mandate that the employer reviews and evaluates the effectiveness of the CHP at least annually and update it as necessary. Typically, a laboratory will review all procedures annually and require management observations to the effectiveness of the procedures and safety requirements.

Worker Training

Worker Training – Slide 10

Worker training regarding chemical hygiene is usually part of the overall safety training a laboratory worker will receive.

Chemical hygiene training is required for all workers in the laboratory. The training is designed to ensure the safety of the personnel working with chemicals and must include the following:

- Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.).
- The physical and health hazards of chemicals in the work area.
- The measures workers can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect workers from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective equipment to be used.
- The applicable details of the employer’s written CHP.

Medical Exams

Medical Exams – Slide 11

The employer must provide all personnel who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances:

- Whenever a worker develops signs or symptoms associated with a hazardous chemical to which the worker may have been exposed in the laboratory, the worker must be provided an opportunity to receive an appropriate medical examination.
- Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the PEL) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements, medical surveillance must be established for the affected worker(s) as prescribed by the standard.
- Whenever an event takes place in the work area such as a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure, the affected worker(s) must be provided an opportunity for a medical consultation to determine the need for a medical examination.
- All medical examinations and consultations must be performed by or under the direct supervision of a licensed physician and be provided without cost to the worker, without loss of pay and at a reasonable time and place.

Laboratory Safety

Laboratory Safety – Slide 12

Safety in the laboratory is everyone's responsibility. PPE requirements, use of special precautions, and handling and storage of laboratory chemicals and equipment are part of the overall program. Employers have specific requirements that must be met, but if everyone involved is part of the program and its implementation, the lab is less likely to have a safety incident.

Lesson Learned – What Happened? – Slide 13

After allowing the students to review the event, create a discussion regarding the cause. Stress that it is likely more than one cause, even if the worker is at fault.

Lesson Learned – Why? – Slide 14

Lesson Learned – Now What? – Slide 15

Hazardous Communication Standard

HazCom Standard – Slide 16

The Hazard Communication Standard (29 CFR 1910.1200), sometimes called the HazCom Standard, is a set of requirements first issued in 1983 by OSHA. The standard requires evaluating the potential hazards of chemicals, and communicating information concerning those hazards and appropriate protective measures to employees. The standard includes provisions for developing and maintaining a written hazard communication program for the workplace, including lists of hazardous chemicals present; labeling of containers of chemicals in the workplace, as well as of containers of chemicals being shipped to other workplaces; preparation and distribution of safety data sheets (SDSs) to workers and downstream employers; and development and implementation of worker training programs regarding hazards of chemicals and protective measures.

This OSHA standard requires manufacturers and importers of hazardous chemicals to provide SDSs to users of the chemicals describing potential hazards and other information. Manufacturers must also attach hazard warning labels to containers of the chemicals.

Employers must make SDSs available to workers and must train their workers in the hazards caused by the chemicals workers are exposed. Employers must also dictate the appropriate protective measures that must be used when handling the chemicals.

Hierarchy of Controls

Hierarchy of Controls – Slide 17

Ask the students to provide examples of the hierarchy of controls they have seen in other industries or from their own experiences, even at home.

Promote this discussion for each type of control presented.

Occupational safety and health professionals use a framework called the “hierarchy of controls” to select ways of dealing with workplace hazards. The hierarchy of controls prioritizes intervention strategies based on the premise that the best way to control a hazard is to systematically remove it from the workplace, rather than relying on workers to reduce their exposure. The types of measures that may be used to protect laboratory workers, prioritized from the most effective to least effective, are:

- elimination of hazard or substitution
- engineering controls
- administrative controls and work practices
- personal protective equipment

Most employers use a combination of control methods. Employers must evaluate their workplace to develop a plan for protecting their workers that may combine both immediate actions as well as longer term solutions. A description of each type of control follows.

Engineering Controls

Chemical Fume Hood – Slide 18

Engineering controls are those that involve making changes to the work environment to reduce work related hazards. These types of controls are preferred over all others because they make permanent changes that reduce exposure to hazards and do not rely on worker behavior. By reducing a hazard in the workplace, engineering controls can be the most cost-effective solutions for employers to implement.

Examples include:

- Chemical Fume Hoods
- Biological Safety Cabinets (BSCs).

Administrative Controls and Work Practices

Administrative Controls – Slide 19

Administrative controls are those that modify workers' work schedules and tasks in ways that minimize their exposure to workplace hazards.

Examples include:

- Developing a Chemical Hygiene Plan
- Developing Standard Operating Procedures for chemical handling.
- Signs and postings to remind personnel hazards or PPE requirements

Work practices are procedures for safe and proper work that are used to reduce the duration, frequency or intensity of exposure to a hazard. When defining safe work practice controls, it is a good idea for the employer to ask workers for their suggestions, since they have firsthand experience with the tasks as actually performed. These controls need to be understood and followed by managers, supervisors and workers.

Examples include:

- No mouth pipetting or other strict laboratory protocols
- Chemical substitution where feasible (e.g., selecting a less hazardous chemical for a specific procedure).
- Warning statements in procedures telling workers the hazards and its effects.

Personnel Protective Equipment

PPE – Slide 20

PPE is protective gear needed to keep workers safe while performing their jobs. Examples of PPE include respirators (for example, N95), face shields, goggles and disposable gloves. While engineering and administrative controls and proper work practices are more effective in minimizing exposure to many workplace hazards, the use of PPE is also very important in laboratory settings. It is important that PPE be:

- Selected based upon the hazard to the worker;
- Properly fitted and in some cases periodically refitted (e.g., respirators);
- Conscientiously and properly worn;
- Regularly maintained and replaced in accord with the manufacturer's specifications;
- Properly removed and disposed of to avoid contamination of self, others, or the environment
- If reusable, properly removed, cleaned, disinfected, and stored

Chemical Hazard Identification

Chemical Hazard ID – Slide 21

Hazardous chemicals present physical and/or health threats to workers in laboratories. Laboratory chemicals include cancer-causing agents (carcinogens), toxins (e.g., those affecting the liver, kidney, and nervous system), irritants, corrosives, sensitizers, as well as agents that act on the blood system or damage the lungs, skin, eyes, or mucous membranes. To keep employees informed, the use of safety data sheets and chemical labeling is necessary to allow for proper identification. A new Global Harmonization Standard (GHS) for chemicals has recently been put in place.

Safety Data Sheets

Safety Data Sheet (SDS) – Slide 22

Safety Data Sheets (SDSs) for chemicals received by the laboratory must be supplied by the manufacturer, distributor, or importer and must be maintained and readily accessible to laboratory workers. SDSs are written or printed materials concerning a hazardous chemical. Employers must have an SDS in the workplace for each hazardous chemical in use.

SDSs provide chemical hygiene officers, industrial hygienists, and authors of procedures with adequate information regarding a chemical, but SDSs should not take the place of local policies and procedures referring to chemical safety.

SDS Content – Slide 23

For each element, discuss the details of student guide content

Use an SDS as a handout and have student explain the section and create a discussion in the classroom

Under the new regulation, SDSs are required to contain the following 16 sections:

1. Identification that includes product identifier; manufacturer or distributor name, address, phone number; emergency phone number; recommended use; restrictions on use.
2. Hazard(s) identification that includes all hazards regarding the chemical; required label elements.
3. Composition/information on ingredients including information on chemical ingredients; trade secret claims.
4. First-aid measures that include important symptoms/effects (e.g. acute, delayed); required treatment.
5. Fire-fighting measures listing suitable extinguishing techniques, equipment; chemical hazards from fire.
6. Accidental release measures listing emergency procedures; protective equipment; proper methods of containment and cleanup.

7. Handling and storage that list precautions for safe handling and storage, including incompatibilities.
8. Exposure controls/personal protection listing OSHA's Permissible Exposure Limits (PELs); ACGIH Threshold Limit Values (TLVs); and any other exposure limit used or recommended by the chemical manufacturer, importer, or employer preparing the SDS where available as well as appropriate engineering controls; PPE.
9. Physical and chemical properties listing the chemical's characteristics.
10. Stability and reactivity that lists chemical stability and possibility of hazardous reactions.
11. Toxicological information including routes of exposure; related symptoms, acute and chronic effects; numerical measures of toxicity.
12. Ecological information*
13. Disposal considerations*
14. Transport information*
15. Regulatory information*
16. Other information, which includes the date of preparation or last revision.

* Since other agencies regulate this information, OSHA will not be enforcing Sections 12 through 15.

The GHS process is designed to improve comprehensibility, and thus the effectiveness of the Hazard Communication Standard (HCS), and help to further reduce illnesses and injuries. GHS is a system that defines and classifies the hazards of chemical products, and communicates health and safety information on labels and SDSs, in the GHS.

The most significant changes to the Hazard Communication standard will include changing terminology: "hazard determination" to "hazard classification" (along with related terms) and "material safety data sheet" to "safety data sheet." The goal is that the same set of rules for classifying hazards, and the same format and content for labels and safety data sheets (SDS) will be adopted and used around the world. An international team of hazard communication experts developed GHS. The biggest visible impact of the GHS is the appearance of and information required for labels and SDSs. Labels will require signal words, pictograms, precautionary statements and appropriate hazard statements. The GHS system covers all hazardous chemicals and may be adopted to cover chemicals in the workplace, transport, consumer products, and pesticides. Information on GHS classification, labels, and SDSs is available at: http://www.unece.org/trans/danger/publi/ghs/ghs_welcome_e.html.

Labeling in the Laboratory

Chemical Labeling – Slide 24

While much standardization has occurred, each laboratory may still have their own labeling program, but the information is common

Labels are an appropriate group of written, printed or graphic informational elements concerning a hazardous chemical that are affixed to, printed on, or attached to the immediate container of a hazardous chemical container.

Labels provide a worker with immediate identification of hazards and special controls necessary for safe handling. Labels for laboratory chemicals should contain the following information:

- Chemical name
- Hazard(s)
- Precautionary Statement
- Pictogram (optional)
- Expiration Date

Product identifier is how the hazardous chemical is identified. This can be (but is not limited to) the chemical name, code number or batch number. The manufacturer, importer, distributor, or laboratory in the case of chemical produced in the lab can decide the appropriate product identifier.

Hazard(s) is the necessary word(s) to identify what dangers exist with the chemical. Common hazard words include: corrosive, caustic, flammable, reactive, etc. More than one hazard is allowed on a workplace label.

Precautionary statements describe recommended measures that should be taken to minimize or prevent adverse effects resulting from exposure to the hazardous chemical or improper storage or handling. For example, a chemical presenting a specific target organ toxicity (repeated exposure) hazard would include the following on the label: “Do not breathe dust/fume/gas/mist/vapors/spray. Get medical advice/attention if you feel unwell. Dispose of contents/container in accordance with local/regional/national and international regulations.”

Pictograms are used to show a hazard in picture format. Laboratories should identify a common set of pictograms for use. These are usually in the form of stickers attached to the container.

Expiration dates are important to ensure a chemical remains stable and safe for use. Chemicals beyond their expiration date should be disposed of properly per local policies and procedures.

Chemical Hazards

Chemical Exposure – Slide 25

A chemical hazard is a type of occupational hazard caused by exposure to chemicals in the workplace. Exposure to chemicals in the workplace can cause short-term or long-term detrimental health effects. There are many types of hazardous chemicals, including corrosives, carcinogens, toxins, irritants, and sensitizers. These hazards can cause physical and/or health risks. Depending on chemical, the hazards involved may be varied, thus it is important to know and apply the appropriate hazard controls.

Exposure Effects

Workplace chemical exposures can have serious effects on the body, both immediate and long-term, referred to as acute and chronic.

Have students describe other acute exposure signs.

Acute effects appear immediately after exposure to high levels of a toxic substance and may be treatable. The sudden collapse of a worker after being exposed to carbon monoxide, for example, is an acute effect.

Have students describe other chronic exposure signs.

Chronic effects become apparent only after many years and by and large, are not treatable. They can occur when the body attempts to repair itself or compensate for acute effects of a substance. For example, cancer is a chronic effect, as is the lung scarring caused by silica dust or the hearing damage caused by excessive noise. Chronic disease becomes evident only after severe damage has occurred.

Exposure limits have been developed for various hazardous materials to protect workers, but they should not be treated as a fine line between safe and unsafe workplaces. Not all individuals react in the same manner to the same amount of a harmful material. The levels of workers' exposures should be reduced to the lowest practical level achievable. Efforts to reduce workers' exposures should start at half the exposure limit.

Routes of Entry

Routes of Entry – Slide 26

Using the slide, have students discuss each type and provide examples. Also, have students create scenarios on how it may happen for each route of entry different than the student guide.

Working with chemicals can involve the risk of exposure, becoming hazardous to a person's health. Those health risks are dependent upon the toxicity of the chemical, the types of effects, and how the chemicals enter the body.

There are four major routes of entry chemicals can follow:

- Inhalation (breathing)
- Absorption (skin contact)
- Ingestion (eating)
- Injection

The most common way workplace chemicals enter the body is by breathing. Other chemicals can be absorbed through the skin into the bloodstream. They can also be accidentally swallowed if hands or cigarettes are contaminated. Contaminated cigarettes also pose an inhalation risk, which can be elevated since the cigarette is heating and/or vaporizing the chemical contaminant. Of course, workers should never eat, drink, or smoke in areas where they may be exposed to toxic chemicals.

Injection is another way that chemicals enter the body. Though less common in most workplaces, it can occur when a sharp object (e.g., a needle) punctures the skin and injects a chemical (or virus) into the bloodstream. This can also occur when a chemical is sprayed at the body at high pressure.

Particles are inhaled to the lungs. Eyes are also another route of entry, although usually only very small amounts of chemicals in the workplace enter through the eyes or mouth.

However, when a chemical enters the body, it is distributed throughout the body via the bloodstream, where they can attack and harm organs which are far away from the original point of entry as well as where they entered the body.

To prevent harmful health effects, take steps to eliminate or reduce the hazard. Control at the source, such as substitution with a less hazardous material or industrial process, is the best method. Bear in mind the specific hazards of the material and the extent and pattern of exposure.

Common Hazard Definitions

Corrosive

Hazard Definitions – Slide 27

Corrosives are materials that can attack and chemically destroy exposed body tissues. Corrosives can also damage or even destroy metal. They begin to cause damage as soon as they touch the skin, eyes, respiratory tract, digestive tract, or the metal. They might be hazardous in other ways too, depending on the corrosive material.

Most corrosives are either acids or bases. Common acids include hydrochloric acid, sulfuric acid, nitric acid, chromic acid, acetic acid and hydrofluoric acid. Common bases are ammonium hydroxide, potassium hydroxide (caustic potash) and sodium hydroxide (caustic soda).

Carcinogen

Hazard Definitions – Slide 28

A carcinogen is any substance that has the potential to cause cancer in living tissues. Carcinogen exposure can occur from the inhalation, ingestion, or absorption of many different types of substances into our bodies. Carcinogens act on our DNA, causing dangerous changes at the cellular level. These include a change in the rate of cell division, which increases the probability of abnormal DNA synthesis. This can lead to cancer, a group of diseases involving abnormal cell growth with the potential to metastasize or spread to other parts of the body.

There are many examples of carcinogens in our environment. Most people are aware of the common carcinogens. These include tobacco and tobacco smoke, pesticides used to control bugs, asbestos, radon, and arsenic. However, many of the substances used in the laboratory may also be carcinogenic, such as cadmium, chromium, and nickel compounds.

Toxic

Based on the definition, have the student list a few “toxic” chemicals.

Toxic is also referred to as poisonous. It is typically referred to as toxicity and refers to the amount that is dangerous to a living organism. OSHA further uses the term acute toxicity when referring to chemicals as being that amount that can kill or harmfully affect a living organism, or the lethal dose.

Irritant

Irritants are substances which, while not corrosive, causes a temporary or reversible inflammation of living tissue (such as eyes, skin, or respiratory organs) by a chemical action at the point of contact. The effects of an irritant may be acute (due to a single high level exposure) or chronic (due to repeated low level exposures). Common irritants include bleach, ammonia, and hydrogen peroxide.

Sensitizer

Have the student provide examples from everyday life of sensitizers.

A sensitizer is defined by OSHA as a chemical that causes a substantial proportion of exposed people or animals to develop an allergic reaction in normal tissue after repeated exposure to the chemical. The condition of being sensitized to a chemical is also called chemical hypersensitivity. Certain chemicals have no immediate health effects. But by being exposed to them several times can make a human allergic or sensitive to other chemicals, often quite suddenly. A classic example is formaldehyde. Typical reactions to sensitizers can include skin disorders such as eczema and respiratory disorders such as asthma.

Sensitization is an immune response. Therefore, some people may be easily sensitized while others may never be affected. Like any allergic response, a reaction to a sensitizer can be fatal in rare circumstances. Treat all sensitizers with great respect and follow proper chemical safety and hygiene procedures.

Physical Hazards

Physical Hazards – Slide 29

Besides exposure to chemicals and biological agents, laboratory workers can also be exposed to physical hazards. Some of the common physical hazards that they may encounter include the following ergonomic, slips, noise, compressed gases, cryogens, fire, and electrical hazards. Exposure to physical hazards are typically those that can cause injury due to trauma. These hazards are described below.

Ergonomic

Ergonomics – Slide 30

Explain to the student s that the cost of treating ergonomic injuries far outweighs the cost of implementing programs and procedures to minimize ergonomic hazards.

Laboratory workers are at risk for repetitive motion injuries during routine laboratory procedures such as pipetting, working at microscopes, operating microtomes, using cell counters and keyboarding at computer workstations. Repetitive motion injuries develop over time and occur when muscles and joints are stressed, tendons are inflamed, nerves are pinched and the flow of blood is restricted. Standing and working in awkward positions in front of laboratory hoods/biological safety cabinets can also present ergonomic problems. By becoming familiar with how to control laboratory ergonomics-related risk factors, employers can reduce chances for occupational injuries while improving worker comfort, productivity, and job satisfaction. In addition to the general ergonomic guidance, laboratory employers are reminded of some simple adjustments that can be made at the workplace.

Slips, Trips, and Falls

Slips, Trips, and Falls – Slide 31

Slips, trips, and falls are still, by far, the most common cause of workplace injury.

Worker exposure to wet floors, spills, and clutter can lead to slips/trips/falls and possible injuries. To keep workers safe, the following practices can prevent these types of events:

- Keep floors clean and dry, provide warning (caution) signs for wet floor areas
- Keep all places of employment clean and orderly and in a sanitary condition,
- Keep aisles and passageways clear and in good repair, with no obstruction across or in aisles that could create a hazard
- Provide floor plugs for equipment, so that power cords need not run across pathways.
- Ensure that spills are reported and cleaned up immediately.
- Eliminate cluttered or obstructed work areas.
- Eliminate uneven floor surfaces.
- Promote safe work practices, even in cramped working spaces.

Noise

Noise – Slide 32

Laboratory workers are exposed to noise from a variety of sources. Operation of large analyzers (e.g., chemistry analyzer), fume hoods, biological safety cabinets, incubators, centrifuges (especially ultracentrifuges), cell washers, sonicators, and stirrer motors, all contribute to the noise level in laboratories. Further sources of noise in laboratories

include fans and compressors for cryostats, refrigerators, refrigerated centrifuges, and freezers. As an example, a high-speed refrigerated centrifuge alone can generate noise levels as high as 65 dBA. To provide some further context, a whisper registers approximately 30 dBA; normal conversation about 50 to 60 dBA; a ringing phone 80 dBA and a power mower 90 dBA. If noise levels exceed 80 dBA, people must speak very loudly to be heard, while at noise levels of 85 to 90 dBA, people must shout.

Facility safety professionals can provide testing and monitoring of high-noise areas to ensure compliance with standards and provide recommendations for lowering noise levels.

Compressed Gases

Compressed Gas Hazards – Slide 33

An uncontrolled compressed gas bottle that is damaged can become a missile, easily going through concrete walls and traveling several hundred yards.

Within laboratories, compressed gases are usually supplied either through fixed piped gas systems or individual cylinders of gases. Compressed gases can be toxic, flammable, oxidizing, corrosive, or inert. Leakage of any of these gases can be hazardous. Leaking inert gases (e.g., nitrogen) can quickly displace air in a large area creating an oxygen-deficient atmosphere and toxic gases can create poison atmospheres. Flammable (oxygen) or reactive gases can result in fire and exploding cylinders.

In addition, there are hazards from the pressure of the gas and the physical weight of the cylinder. A gas cylinder falling over can break containers and crush feet. The gas cylinder can itself become a missile if the cylinder valve is broken off. Laboratories must include compressed gases in their inventory of chemicals in their Chemical Hygiene Plan. Compressed gases contained in cylinders vary in chemical properties, ranging from inert and harmless to toxic and explosive. The high pressure of the gases constitutes a serious hazard if gas cylinders sustain physical damage and/or are exposed to high temperatures.

Strict procedures direct the handling and care of compressed gas cylinders in the laboratory.

Cryogens

Cryogenics – Slide 34

Radiochemistry laboratories often use small transfer dewars of liquid nitrogen that are filled manually, exposing workers to the hazard on several occasions. In cases like this, complacency is an issue.

Cryogens, substances used to produce very low temperatures [below -153°C (-243°F)], such as liquid nitrogen (LN2) which has a boiling point of -196°C (-321°F), are commonly used in laboratories. Although not a cryogen, solid carbon dioxide or dry ice which converts directly to carbon dioxide gas at -78°C (-109°F) is also often used in laboratories. Shipments packed with dry ice, samples preserved with liquid nitrogen, and in some cases, techniques that use cryogenic liquids, such as cryogenic grinding of samples, present potential hazards in the laboratory. Several safety hazards are associated with the use of cryogenic liquids.

Cold contact burns from contact from any cryogenic substance will produce effects on the skin like a burn from a heat source.

Asphyxiation will occur when the oxygen content of the working environment is less than 20.9% by volume. This decrease in oxygen content can be caused by a failure/leak of a cryogenic vessel or transfer line and subsequent vaporization of the cryogen. Effects from oxygen deficiency become noticeable at levels below approximately 18% and sudden death may occur at approximately 6% oxygen content by volume.

Pressure explosions are a hazard if containers become heated. The cryogen vaporizes in the presence of heat the potential exists for pressure buildup cryogenic containment vessels and transfer lines. Adequate pressure relief should be provided to all parts of a system to permit this routine outgassing and prevent explosion.

Whenever handling or transfer of cryogenic fluids might result in exposure to the cold liquid, boil-off gas, or surface, protective clothing must be worn. This includes:

- face shield or safety goggles;
- safety gloves; and
- long-sleeved shirts, lab coats, aprons.

Eye protection is required when working with cryogenic fluids. When pouring a cryogen, working with a wide-mouth Dewar flask or around the exhaust of cold boil-off gas, use of a full-face shield is recommended. Hand protection is required to guard against the hazard of touching cold surfaces. It is recommended that cryogen safety gloves be used by the worker.

Fire

Fire and Electrical Hazards– Slide 35

Fire and electrical hazards are typically “unseen” and incidents are sudden.

Fire is the most common serious hazard that one faces in a typical laboratory. While proper procedures and training can minimize the chances of an accidental fire, laboratory workers should still be prepared to deal with a fire emergency should it occur. In dealing with a laboratory fire, all containers should be properly stores to minimize damage and exposure.

Small bench-top fires in laboratory spaces are not uncommon. Large laboratory fires are rare. However, the risk of severe injury or death is significant because fuel load and hazard levels in labs are typically very high. Laboratories, especially those using solvents in any quantity, have the potential for flash fires, explosion, rapid spread of fire, and high toxicity of products of combustion (heat, smoke, and flame).

Emergency procedures should be trained frequently so employees have the confidence to respond properly and contain or extinguish small fires. The use of water, fire extinguishers, and fire suppression systems is necessary to ensure personnel are adequately prepared.

Electrical

In the laboratory, there is the potential for workers to be exposed to electrical hazards including electric shock, electrocutions, fires and explosions. Damaged electrical cords can lead to possible shocks or electrocutions. A flexible electrical cord may be damaged by door or window edges, by staples and fastenings, by equipment rolling over it, or simply by aging.

The potential for possible electrocution or electric shock or contact with electrical hazards can result from several factors, including the following:

- Faulty electrical equipment/instrumentation or wiring
- Damaged receptacles and connectors
- Unsafe work practices

Case Study: Lab Accident – Slide 36

Distribute handout for Brauer Hall Incident. After reading, promote discussion on laboratory safety.

Watch CSB Video and discuss the incidents from the video.

Fundamental Laboratory Equipment

Basic Lab Equipment – Slide 37

Following classroom presentation, students will be required to demonstrate proper and safe techniques in using the equipment presented in this lecture.

From the picture, most of the equipment in the lecture is used on a day-to-day basis. Having these as a skill-of-the-craft is essential.

The list of equipment available to laboratory personnel is very long and can vary significantly from lab to lab. This course will focus on the most fundamental equipment including common terminology, uses, techniques, and safety (where applicable) for each one.

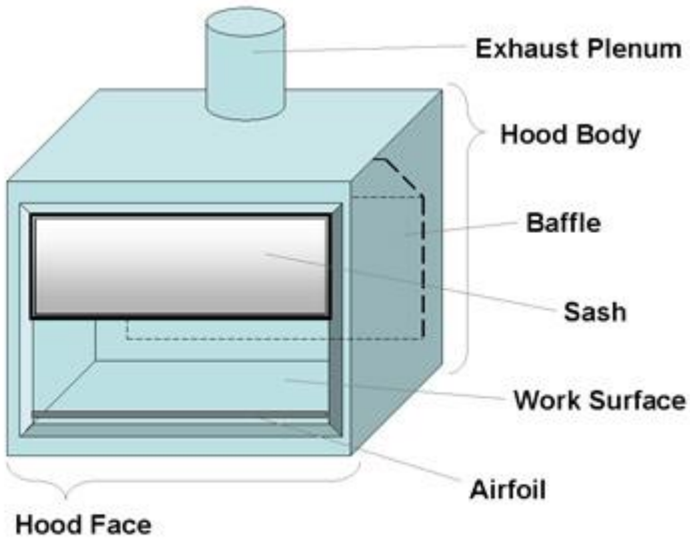
Fume Hoods

Laboratory Fume Hoods - Slide 38

Laboratory chemical fume hoods are considered the primary means of protection against inhalation of hazardous vapors and gases and yet there are many limitations to their effectiveness. Many of these limitations are created unknowingly by the user. Understanding this information will allow you to maintain optimal performance of your chemical fume hood to keep you as safe as possible.

A laboratory chemical fume hood is a partially enclosed workspace that is exhausted to the facility ventilation system. When used properly, hazardous gases and vapors generated inside the hood are captured and removed before they can enter the technician's breathing zone.

Basic Components of Laboratory Chemical Fume Hoods



Fume Hood Components – Slide 38

Hood Body - The visible part of the chemical hood that serves to contain hazardous gases and vapors.

Sash - The sliding "door" to the hood. By using the sash to adjust the front opening, airflow across the hood can be adjusted to the point where capture of contaminants is maximized. Each hood is marked with the optimum sash configuration. The sash should be held in this position when working in the hood and closed completely when the hood is not in use. The sash may be temporarily raised above this position to set up equipment, but must be returned to the optimum sash height setting prior to generating contaminants inside the hood.

Airfoil - Located along the bottom and side edges the airfoil streamlines airflow into the hood, preventing the creation of turbulent eddies that can carry vapors out of the hood. The space below the bottom airfoil provides a source of room air for the hood to exhaust when the sash is fully closed. Removing the airfoil can cause turbulence and loss of containment.

Work surface - The floor of the hood, this is the area under the hood where apparatus is placed for use.

Baffles - Moveable partitions used to create slotted openings along the back of the hood body. Baffles keep the airflow uniform across the hood opening, thus eliminating dead spots and optimizing capture efficiency.

Exhaust plenum - An important engineering feature, the exhaust plenum helps to distribute airflow evenly across the hood face. Materials such as paper towels drawn into the plenum can create turbulence in this part of the hood, resulting in areas of poor airflow and uneven performance.

Face - The imaginary plane running between the bottom of the sash to the work surface. Hood face velocity is measured across this plane.

Fume Hood Work Practices

Work Practices – Slide 39

The protection afforded by a fume hood is only as good as the work practices of the hood user. The following are general guidelines to be followed when working in the hood:

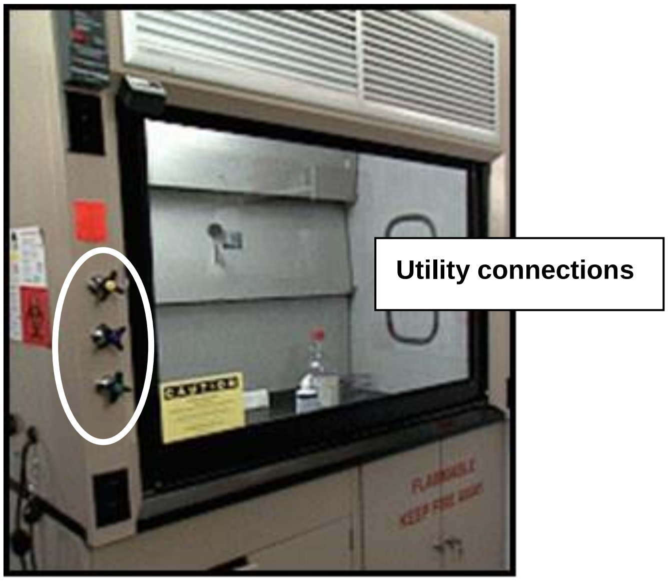
- Know the toxic properties of the chemicals with which you work and can identify signs and symptoms of overexposure.
- Mark a line with tape 6 inches behind the sash and keep all chemicals and equipment behind that line during procedure. This will help to keep vapors from escaping the hood when air currents from people walking past the hood, etc. interfere with air flow at the face of the hood.
- Keep the sash completely lowered anytime "hands-on" experiments are not in progress or whenever the hood is on and unattended.

- Keep the sash positioned as low as possible when performing work.
- Never utilize the hood unless there is some indication that the hood is operating. A tissue taped to the sash or inside the hood provides a good indicator of air flow.
- Check the magnehelic gauge reading and compare it with the reading documented on the hood inspection sticker. If the reading differs significantly from that on the sticker, the hood may not be operating sufficiently.
- The hood is not a substitute for personal protective equipment. Wear gloves, safety glasses, etc., as appropriate.
- Visually inspect the baffles (openings at the top and rear of the hood) to be sure the slots are open and unobstructed.
- Do not block baffles. If large equipment is in the hood, put it on blocks to raise it approximately two inches so that air may pass beneath it.
- Do not use the hood as a storage cabinet. Keep only the materials necessary for the procedure inside the hood. If chemicals need to be stored in the hood for a period, install shelves on the sides of the hood, away from the baffles.
- Keep the sash clean and clear.
- Clean all chemical residues from the hood chamber after each use.
- All electrical devices should be connected outside the hood to avoid sparks which may ignite a flammable or explosive chemical.
- DO NOT USE A HOOD FOR ANY FUNCTION FOR WHICH IT WAS NOT INTENDED. Certain chemicals or reactions require specially constructed hoods. Examples are perchloric acid or high pressure reactions. Most special use hoods are labeled as to the uses for which they are designed.

Utility Connections

Fume Hood Utilities – Slide 40

Laboratory fume hoods are normally provided with facility vacuum, deionized water, and instrument quality air to assist with procedural requirements, decontamination, waste handling, etc. Fume hoods will natural gas connections create a unique flammable gas hazard that must be addressed. Tygon tubing can be connected to the utilities as needed and provided to equipment inside hood. The controls for these utilities are provided on the outside of the hood as displayed below:



Decontamination

On occasion, the fume hood may need to be cleaned or decontaminated to acceptable levels dependent on the projected use of the hood. The insides of the fume hood are normally a polished stainless steel to aid in the ease of cleaning and for corrosion protection as well. Cleaning may include the use of a soapy water and wiping or the use of commercial cleaners such as Windex or 409, etc. if the cleaner is compatible with the material inside the hood. When decontaminating the inside of the fume hood, the recommended technique is to clean from top to bottom and from front to rear to control the spread of contamination. Dependent of conditions, personnel protective clothing/equipment and specified cleaning agents may be required before attempting cleaning activities per facility chemical/radiological requirements.

Pipets

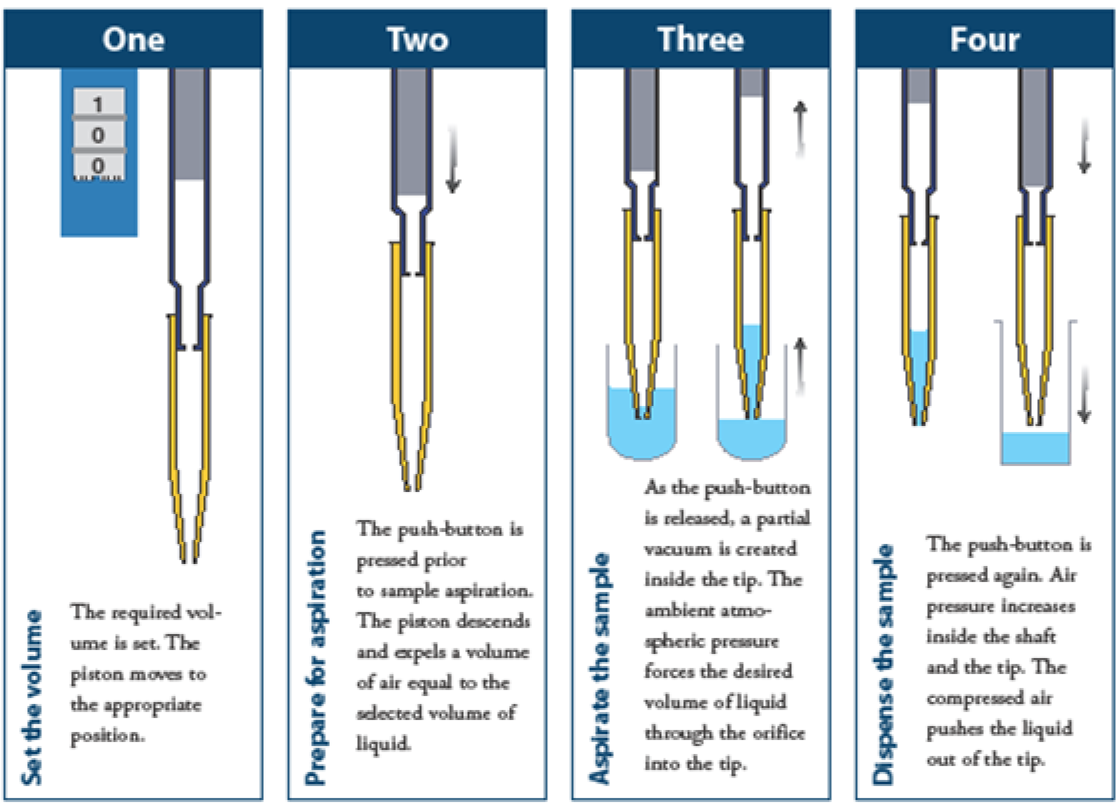
Laboratory Pipets – Slide 41

Laboratory pipets are one of the most accurate and efficient ways to measure small volumes in the laboratory. Pipets some in various sizes from 10 microliters up to 100 mL. In many cases, they are calibrated and certified, which means delivery is consistent and within tolerable ranges for most applications.

How do air-displacement pipettes work?

Air-displacement Pipets – Slide 42

When the push-button or plunger is pressed on an air-displacement pipette, the piston inside the instrument moves down to let air out. Air is displaced by the piston. The volume of air displaced is equivalent to the volume of liquid aspirated. The schematic drawings (below) show how the piston determines the volume of air displaced and subsequently the volume of sample aspirated.



Volumetric Pipets – Slide 43

Volumetric (Class ‘A’) pipets are very common and meant to deliver a specific, calibrated amount of liquid. Like all manual pipets, they require a vacuum source to draw liquid into the pipet. The vacuum source can be integral to the unit, a small pump or a bulb. Under no circumstances should mouth-pipetting be allowed or considered. These also require the pipet to be clean and free of residual liquid.

Pipet Considerations – Slide 44

Because of the small volumes transferred with these types of pipets, there are several factors that may affect the accuracy. Pipet tip, temperature, humidity, and pipet angle are the primary factors.

Pipets are calibrated based on a specific type of tip. The technician must understand which tip to use to ensure the most accurate measurements are taken. Typically, the tips are specific to the manufacturer of the pipet and the size of the aliquot.

If the liquid being transferred is subject to a temperature change during the transfer, the amount aspirated from a container may be different than the amount dispensed to the new container. Liquids should be room temperature when pipetting.

Evaporation, especially in the tip, is a major concern when pipetting. Extremely dry atmospheres can cause significant loses of liquid due to evaporation in the tip. Care must be taken to immediately dispense liquids from the tip after extracting the liquid.

The angle of the pipet during aspiration and dispensing can change the amount of liquid dispensed due to air escaping during the process. Keeping the pipet perpendicular to the liquid is required.

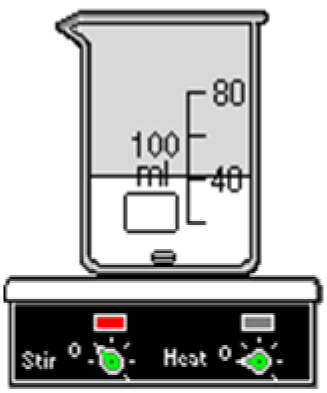
Hotplates and Stirrers

Hotplates and Stirrers – Slide 45

Stirring and heating are two of the most frequently used techniques in chemistry. In homogeneous systems, they are used to facilitate mixing and heat transfer, and for agitation. In heterogeneous systems for renewing liquid-liquid and liquid-solid interfaces. The most versatile system and the simplest to use is the magnetic stirrer, which commonly includes a hotplate for combined heating and stirring.

Stirring rates are controlled by a variable speed motor driving a rotating bar magnet inside the apparatus. This in turn drives a magnetic stirrer bar placed in the container. There are many types of stirrer bars, different sizes and shapes designed to suit a range of different containers. Care should be taken in choosing the right size stirrer bar for the container and the degree of vigor needed for stirring.

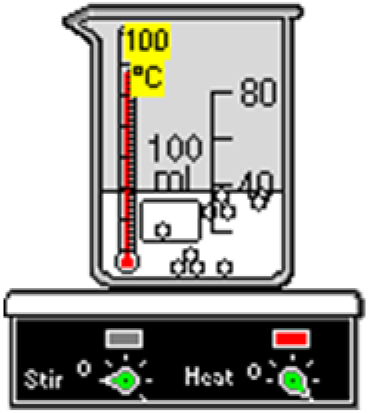
The stirring bar is placed into a flask or beaker by gently sliding it along the wall of the container. To prevent breakage, do NOT drop the bar onto the bottom of the container. The bars are most easily and safely removed by a magnetic "wand".



Always place the container (vessel) on the stirrer base with the speed control knob turned to its lowest setting. Use just enough speed to start the bar turning in the container and then adjust upward as necessary. If too high a speed is initially selected, the stir bar may just "violently vibrate" in place which may lead to splashing the solution out of the vessel.

On many brands of combined stirrer/hotplates, the controls for the stirrer and temperature control look alike. Care must be taken to distinguish their functions. A fire or explosion may occur if the temperature rather than the stirrer speed is increased inadvertently. There are two control knobs; one controls the heating rate and the other controls the stirring rate. Always start with the controls at the low end of their range.

If the liquid is to be heated to a temperature less than its boiling point, then a thermometer can be clamped to and/or suspended in the beaker, being careful to keep the thermometer bulb away from (above) the stirrer bar. The red lamp on the left indicates that the unit is stirring at the rate indicated on the left-hand dial.



The red lamp on the right indicates that the unit is heating at the rate indicated on the right-hand dial.

Hotplate and Stirrer Safety – Slide 46

When finished, turn down the heating control but don't try to remove the vessel without proper protective gear or until it has cooled sufficiently to handle. Never leave a hot plate to cool down without communicating some indication that it is still hot. Always keep flammable materials away from a hot plate when in use.

Furnaces and Ovens

Muffle Furnaces

Muffle Furnace – Slide 47

Muffle furnaces are so named because the furnace area is encased in a ceramic material. These furnaces are capable of heating to temperatures more than 1000 degrees Celsius. In most cases, there are no interlock devices to prevent the furnaces from being opened when they are hot and quite often it is necessary to do so.

The following procedure should be carried out with great care:

- Stand to one side of the furnace as the door is opened.
- Wear protective gloves provided, as well as lab coat (with sleeves rolled down) and safety glasses.
- Use long-reach tongs for loading/unloading the furnace.
- Practice using the tongs before attempting to pick up a precious or extremely hot sample.
- Make sure a protective surface is available nearby to set removed material.

Always check the temperature at which the furnaces are set. They are used at various settings and may not be set at the temperature you require.

An important point to remember: HOT glass and porcelain look exactly like COLD glass and porcelain. Do not test them with your fingers. Always wear the appropriate gloves when removing things from the ovens.

The additional tools and PPE will limit dexterity when working around a muffle furnace.

Ovens

Laboratory Ovens – Slide 48

Electrically heated ovens are commonly used in the laboratory to evaporate water or other solvents from chemical samples and filter papers and to dry laboratory glassware.

Laboratory ovens are generally constructed such that their heating elements and temperature controls are physically separated from their interior atmospheres.

Laboratory ovens don't always have a provision for preventing the discharge of the substances volatilized in them. However, connecting the oven vent directly to an exhaust system or using in a fume hood will reduce the possibility of substances escaping into the lab or an explosive concentration developing within the oven.

Ovens should not be used to dry any chemical sample that might pose a hazard because of acute or chronic toxicity unless special precautions have been taken to ensure continuous venting of the atmosphere inside the oven.

Bimetallic strip thermometers are preferred for monitoring oven temperatures. Mercury thermometers should not be mounted through holes in the top of ovens so that the bulb hangs into the oven where it can be broken.

Microwave Ovens

Microwaves – Slide 49

Household appliances are not designed to withstand the hazardous materials utilized in a laboratory nor the processes in which they are utilized. Household microwaves should not be used in a laboratory.

Microwave ovens are used for heating and defrosting in laboratories and for dissolving otherwise difficult materials in acid or other reagents. However, improper use of a microwave can pose several hazards including:

- Ignition of flammable vapors
- Electrical shock from ungrounded or faulty units
- Ignition of materials being heated
- Pressure build-up in sealed containers
- Integrity of containers holding materials
- Sudden boiling of liquid in an open container following removal

Microwave Safety

Never attempt to heat flammable liquids or solids, hazardous substances, or radioactive materials in any type of microwave oven unless specially designed for such use. Design would include special pressure vessels to ensure the safety of the materials.

Do not place metal items inside the microwave, including aluminum foil and plastic coated magnetic stirrer bars and do not modify the microwave in any way, including the removal of the grounding pin or change of the plug. Laboratory microwaves are never used for food preparation.

Do not heat sealed containers in a microwave. Even a loosened cap or lid poses a significant risk since microwaves can heat material so quickly that the container explodes either in the oven or shortly after removal. Microwave-safe vessels with pressure relief devices should be used.

Take care to avoid overheating liquids. It is possible to raise water to a temperature greater than normal boiling point; when this occurs, any disturbance to the liquid can trigger violent boiling that could result in severe burns.

Balances

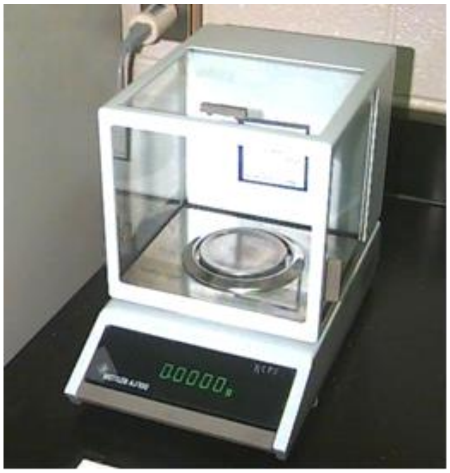
A laboratory balance is used to measure the mass of reagents or laboratory equipment. These electronic balances have a wide range of accuracy depending on the intended use. Most balances encountered in the laboratory can be classified as either TOP-LOADING or ANALYTICAL. Top-loading balances usually provide less sensitive measurement of mass than do analytical balances. Analytical balances are used when a high degree of accuracy is needed for the measurement or when interferences can affect the results.

Top-loading Balance

Top-loading Balance – Slide 50

A typical top-loading balance will weigh items to three decimal places. That is, it will weigh to the nearest thousandth of a gram. These types of balances should be left on always. If the components of an electronic balance are cold when taking a measurement, the registered mass will drift while it is warming up, causing changes in the measurements.

Analytical Balance



Analytical Balance – Slide 51

An analytical balance is an instrument that's used to measure mass to a very high degree of precision. The weighing pan(s) of a high-precision (.01 mg or better) analytical balance are inside a transparent enclosure with doors so dust does not collect and so any air currents in the room do not affect the measurement. The sample must be at room temperature to prevent natural convection from forming air currents inside the enclosure, affecting the weighing.

Due to the instrument's sensitivity, several precautions are recommended when using the analytical balance:

- Do not bump or place objects on the bench after zeroing the balance
- Weigh powders on paper or dishes
- Handle objects with tongs, tweezers, gloves, or paper to prevent fingerprints
- Let hot objects cool to room temperature before weighing
- Weigh hygroscopic materials rapidly since they will absorb water during weighing
- DO NOT leave spilled chemicals on or around the balance!
- Be aware that static electricity can have a substantial impact on both accuracy and precision while using electronic balances

Both top-loading and analytical balances use the same basic procedure for operation. The balance is zeroed (also called a tare weight) by pressing a button. When the balance reads all zeroes, it is ready to have an item weighed. Variations of this process have material added to an existing weight and the difference calculated to determine the amount of material added.

Common sources of errors, especially regarding analytical balances include evaporation, vibration, and static electricity. Laboratory personnel must control these factors for the most accurate measurement.

Volumetric Glassware

Volumetric Measurements – Slide 52

Accurate volumetric measurements are critical to obtaining quality data. Although different measuring devices are used in the laboratory, depending on the volumes and accuracy needed, the vessels listed in this chapter are the more common in use. These vessels are designed to contain or deliver known volumes within certain limits of accuracy:

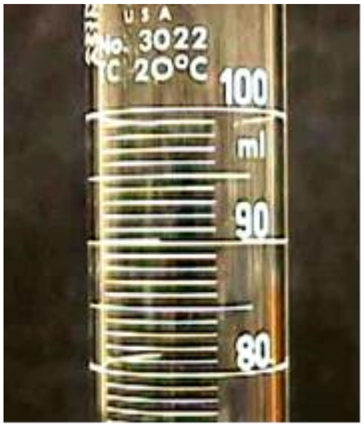
Types	Accuracy (@ 20°C)
Graduated Cylinder	1-5%
Buret	0.1%
Erlenmeyer Flasks and Beakers	5%
Volumetric Flasks	0.02 – 0.05%

Graduated Cylinders

Graduated Cylinders – Slide 53

Graduated cylinders are either glass or plastic and are used to measure and deliver volumes of liquids where less accuracy is acceptable.

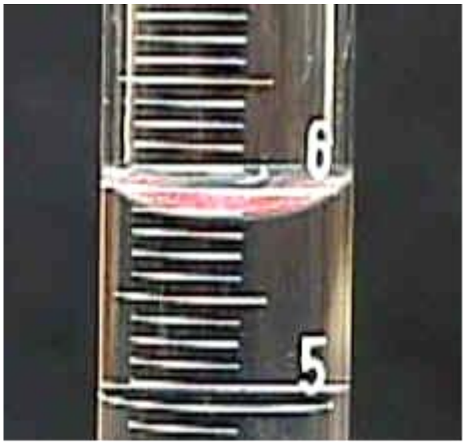
It is important to notice what each line or interval on the graduated cylinder represents. Different kinds of graduated cylinders are set up differently. A 100 mL cylinder, for example, usually has one milliliter for each graduation, but some have two milliliters for each graduation. The way to check this is to count the divisions between consecutive numbers. Here we have the usual 10 divisions from one number to the next; therefore, the volume increment for each of those lines is one milliliter. Estimating the measurements by reading between the lines allows measurements in the cylinder to one-half of one milliliter.



Meniscus

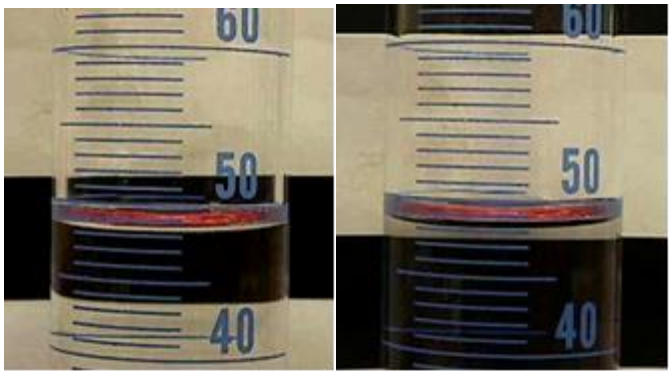
Proper Meniscus Reading – Slide 54

A characteristic of liquids in glass containers is that they curve at the edges. This curvature is called the meniscus. You measure the level at the horizontal center or bottom part of the meniscus. With water in glass, the meniscus will curve up at the edges and down in the center.

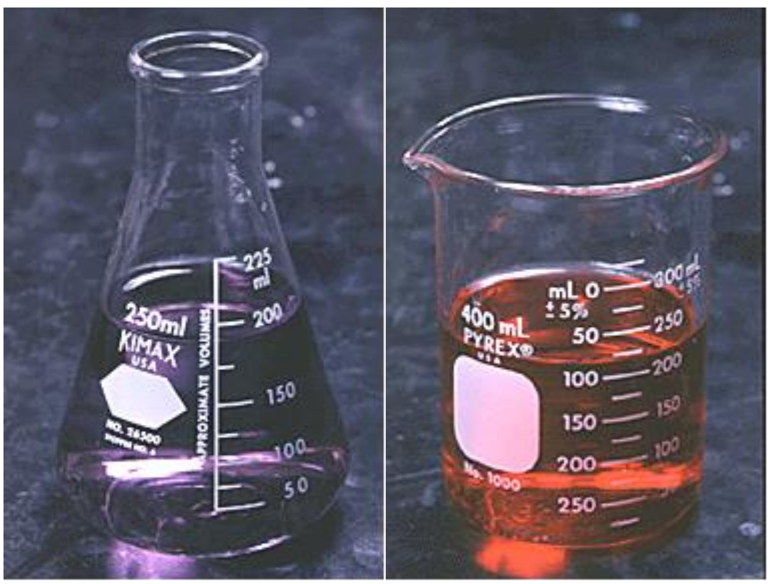


In some plastic cylinders, water has a flat surface. In that case, top or bottom doesn't matter, but we can still say use the center rather than the edges.

The visibility of the meniscus can be enhanced by using a card with a dark stripe on it, placed behind the cylinder. Adjusting the placement of the card can give you either a white meniscus against a black background or a black meniscus against a white background.



Erlenmeyer Flasks and Beakers



Erlenmeyer Flasks and Beakers – Slide 55

Erlenmeyer flasks and beakers are used for heating, mixing, transporting, or reacting, but not for accurate measurements. The volumes stamped on the sides are approximate and accurate only to within about 5%.

Volumetric Flasks

Volumetric Flasks – Slide 56

A volumetric flask is used to make up a solution very accurately. This pictured volumetric flask measures 500 mL ± 0.2 mL. To make up a solution, first dissolve the solid material completely in less water than required to fill the flask to the mark. After the solid is completely dissolved, very carefully fill the flask to near the 500 mL mark. Add demineralized water a drop at a time until the bottom of the meniscus lines up exactly with the mark on the neck of the flask. Take care that no drops of liquid are in the neck of the flask above the mark.

Laboratory Centrifuge

Centrifuge and Tubes – Slide 57

A laboratory centrifuge is a piece of laboratory equipment, driven by a motor, which spins liquid samples at high speed. There are various types of centrifuges, depending on the size and the sample capacity.

Like all other centrifuges, laboratory centrifuges work by the sedimentation principle, where the centripetal acceleration is used to separate substances of greater and lesser density. The higher density materials will be driven to the bottom of the centrifuge tube.

Centrifuge tubes are precision-made, high-strength tubes of glass or plastic made to fit exactly in rotor cavities. They may vary in capacity from 50 mL down to much smaller capacities.

The load in a laboratory centrifuge must be carefully balanced. This is achieved by using a combination of samples and balance tubes which all have the same weight or by using various balancing patterns. Small differences in mass of the load can result in a large force imbalance when the rotor is at high speed. This force imbalance strains the spindle and may result in damage to the centrifuge or personal injury. Some centrifuges have an automatic rotor imbalance detection feature that immediately discontinues the run when an imbalance is detected.

Before starting a centrifuge, an accurate check of the rotor and lid locking mechanisms is mandatory. Centrifuge rotors should never be touched while moving, because a spinning rotor can cause serious injury. Modern centrifuges generally have features that prevent accidental contact with a moving rotor as the main lid is locked during the run.

Centrifuge rotors have tremendous kinetic energy during high speed rotation. Rotor failure, caused by mechanical stress from the high forces imparted by the motor, can occur due to manufacturing defects, routine wear and tear, or improper use and maintenance. Such a failure can be catastrophic failure, especially with larger centrifuges, and generally results in destruction of the centrifuge. While centrifuges generally have safety shielding to contain these failures, such shielding may be inadequate, especially in older models, or the entire centrifuge unit may be propelled from its position, resulting in damage to nearby personnel and equipment. Uncontained rotor failures have shattered laboratory windows and destroyed refrigerators and cabinetry. To reduce the risk of rotor failures, centrifuge manufactures specify operating and maintenance procedures to ensure that rotors are regularly inspected and removed from service or de-rated (only operated at lower speeds) when they are past their expected lifetime.

Skills Assessment

Laboratory Skills – Slide 58

Students are given hands-on training of the equipment, followed by adequate practice time.

Students will complete the laboratory skills worksheet (see handout), which demonstrates proper application, use, and accuracy (where applicable) of common equipment in a laboratory setting.

Course Review

Questions?? – Slide 59

Review - Slide 60

The summary should provide a recap of what was covered.

A. Restate the Motivator
B. Restate the Terminal Objective
C. Review Enabling Objectives
D. Add Other Summary Items as Necessary

Include these elements in the order that best promotes learning:

Review Objectives and Major Learning Points - Tell them what you told them. Don't re-teach the lesson.

Elicit Questions - Ask for all unanswered questions related to the topic.

Connect to the Job - Explain how the transfer of the knowledge and skills back to the job supports performance.

Answer All Questions - Always.

Punctuate the Finish! – Revisit the motivator, "What's In It For Me?"