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SAFETY PROCEDURES IN SCIENCE LABORATORY

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ABSTRACT:

This paper presents the basics of laboratory safety and point out the most common types of safety hazards in the science laboratory. This paper is not a complete listing of the safety hazards in the laboratory but rather it plays the role of alerting students/ scholars to the possible safety hazards in the laboratory.

Keywords: laboratory accidents, safety measures, hazardous waste, housekeeping

I INTRODUCTION

Experiments plays an important role in the progress of science as a large number of inventions and path breaking discoveries have been possible through investigations that are usually carried out in laboratories. A science laboratory is a place where basic experimental skills are learnt only by performing a set of prescribed experiments.Safety procedure usually involves chemical hygiene plan and waste disposal procedures and significant physical and health hazards associated with the specific type of research and instruction in specific procedures that researchers should use in order to prevent and limit exposure to the health hazards in that workplace. Safety is a learned behavior that must incorporate into our instructional plans. There are several safety aids available which include posters, safety contracts, safety tests, safety citations, texts, and handbooks on secondary science safety and a variety of safety equipment.

The two issues, the handling of hazardous materials, and laboratory safety are sometimes overlooked in research, but no researcher is immune from accidents. Therefore researchers should review information and procedures about safety issues which includes an appropriate usage of protective equipment and clothing, safe handling of materials in laboratories, safe

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operation of equipment, safe disposal of materials, safety management and accountability, hazard assessment processes, safe transportation of materials between laboratories, safe design of facilities, emergency responses etc.

II PERSONAL PROTECTIVE EQUIPMENT AND CLOTHING

Personal protective equipment is used in order to protect ourselves when working with chemical hazards. Common examples of personal protective equipment include: lab coats, footwear, gloves, safety goggles and glasses, face shields, hard hats and respirators.

Lab Coat

The primary purpose of a lab coat is to protect against splashes and spills. A lab coat should be nonflammable and should be easily removed. Lab coats should be buttoned when in use. Rubber coated aprons can be worn to protect against chemical splashes and may be worn over a lab coat for additional protection. We should not wear lab coats, gloves, or other personal protective clothing outside of lab areas. This clothing may become contaminated and could spread the contamination. We should avoid wearing loose-fitting clothing, tie back long hair, and remove loose jewelry to prevent their getting caught in moving or rotating parts or coming into contact with hazardous chemicals. Chemical fumes may react with some jewelry, such as pearls, and ruin them. Cotton clothing is preferable to wool, nylon, or polyester. Personal apparel should be appropriate for laboratory work. We should wear clothing to lab that we don't care if it gets dirty.

Footwear

Leather shoes which completely cover the toes, heel and top of foot provide the best general protection. The shoes must be made of water proof materials. The shoe must have a nonslip sole firmly attached to the foot. Sandals, sneakers, perforated shoes, open-toed shoes etc. do not provide adequate protection in case of spills, or when handling heavy objects that might fall onto the feet. If work is going to be performed with heavy machinery, steel-reinforced safety shoes may be required. Safety shoes specially designed to provide protection against extreme temperatures, caustic chemicals, or electrical hazards should be worn on requirement.

Gloves

When handling chemical, physical, or biological hazards that can enter the body through the skin, it is important to wear the proper protective gloves. Butyl, neoprene, and nitrile gloves are resistant to most chemicals, e.g., alcohols, aldehydes, ketones, most inorganic acids, and most caustics. Disposable latex and vinyl gloves protect against some chemicals, most aqueous solutions and reduce risk of product contamination. Leather and some knit gloves will protect against cuts, abrasions, and scratches, but not against chemicals. Temperature-resistant gloves protect against cryogenic liquids, flames, and high temperatures. Kevlar gloves will provide good protection from extreme temperatures. Cotton gloves provide a better grip when working with heavy machinery. Leather gloves provide good protection when working with flames or when sparks may be present. Metal mesh gloves are preferred when working with heavy machinery or cutting tools.

Eyewear

Safety goggles provide the best protection against chemical splashes, vapors, dusts, and mists. Eye wear is required to be worn any time projectile objects are being used in the laboratory. Contact lenses should not be worn during any investigations using chemicals (even if you are wearing goggles). In the event of an accident, chemicals can get behind contact lenses and cause serious damage before the lenses can be removed. If using contact lenses instead of glasses, then we should wear eye-cup safety goggles in the lab. We should wear ultraviolet absorbing protective safety glasses while working with ultraviolet light.

Face Shields

A face shield should be worn whenever there the entire face needs protection (e.g., high pressure work, welding, soldering, machining, fire, explosion, etc.). Face shields can protect against impact, dust, particulates, and splashes to the face, eyes, and throat. We should wear safety goggles underneath a face shield for maximal protection.

Respirators

Respirators filter contaminants, either small airborne particles or chemicals including gases. Respirators must be regularly cleaned, sanitized and maintained.

III EMERGENCY EQUIPMENT

Research laboratory is equipped with a wide range of emergency equipment that can be invaluable in case of an accidental exposure to or a fire or explosion involving a hazardous reagent. The equipment that should be available in the laboratory in case of emergency includes:

Fire Extinguisher

There are four main types of fire extinguishers: A, B, C, and D. Class A fire extinguishers use water to put out paper and wood based fires. Class B fire extinguishers use compressed non-flammable gases such as carbon dioxide to put out fires involving flammable materials. The gas extinguishes the fire by starving it of oxygen. Class C fire extinguishers shoot a very fine non-flammable, non-conductive powder in order to extinguish electrical fires and Class D fire extinguishers are for use in combating fires involving flammable metals such as magnesium and sodium. Fire blankets are used to extinguish clothing fire. The fire extinguishers in the laboratory should be inspected on a regular basis. Periodically check the date on the fire extinguisher to make sure that the extinguisher is full and the extinguisher is in good working order.

Eye Wash Stations

Eye wash stations consist of a mirror and a set of bottles containing saline solution that can be used to flood the injured eye with water. The eye wash station is intended to allow us to flood the eye with a continuous stream of water.

Safety Showers

Emergency shower are intended to provide on-the-spot cleansing when a chemical or solvent has been spilled. If anyone appears to have been splashed with a chemical or solvent, assist them to the nearest emergency shower. If anyone’s clothing catches on fire, do not run, walk to the emergency lab shower and use the shower to put out the fire.

First- Aid Kit

A first aid must be readily available in science laboratory for use during accidents and emergencies. It is equipped with tincture of iodine, ferric chloride (alcoholic), burnol, savlon, cotton, sodium bicarbonate solution, adhesive plaster, bandages and scissors. It is important to

periodically inspect and restock the first aid kit so that it will be useful in an emergency. In general these kits are most useful for small injuries such as a cut finger.

Fume hood

A fume hood is a type of local ventilation device that is designed to limit exposure to hazardous or noxious fumes, vapors or dusts. It provides personal protection against toxic fumes, vapor and dust. Fume hoods should not be used for storage.

Exhaust fans

The laboratory should be well ventilated and for this, exhaust fans must be fitted near the ceiling of laboratory for speedy removal of waste gases to keep the laboratory free from polluted air.

IV HOUSEKEEPING

Good housekeeping practices can significantly reduce the risk of accidents and exposure to hazardous materials. Good housekeeping means that the area is kept clean and items are stored in appropriate areas to ensure the safety of students. If everything is organized then labs will be more productive and cost effective.

Work area

Work areas should be kept clean and free from unnecessary chemicals and obstructions. Floors should be free of hazards. Laboratory equipments or glassware should not be removed from cabinets without permission. Reagents and chemicals to be used frequently are kept on reagent shelves. Reagent bottles are arranged in a definite order on these selves. All sensitive electronic equipment should be placed safely on table or within bag under table so that expensive damage can be avoided. We should not block access to emergency equipment (i.e. fire extinguishers, eyewashes, etc.), emergency shut-offs, and utility controls (i.e. electrical panels). When the fire alarm sounds we must evacuate the building via the nearest exit. Extinguish all flames and turn off all equipment before leaving.

Labeling samples and materials

All containers containing chemicals or solutions of any kind that are retained between laboratory sessions must be labeled with full chemical name and hazard classification. The label must also contain the date and the name of the responsible person. Hazards symbols should be used as guide for handling of chemical reagents. Chemicals should be labeled as explosives, flammable, oxidizers, toxic and infectious substances, radioactive materials, corrosives etc. Each laboratory must maintain chemical inventory that should be updated at least once in a year.

Chemical Handling and storage

We should work with materials only after learned about their flammability, reactivity, corrosiveness and toxicity. When dispensing chemicals, we should read the label carefully before starting the experiment. To avoid contamination and possible violent reaction we should never return unwanted chemicals to their container. We should not put dropper into a supply bottle. To avoid overheating and spurting never add water to concentric acid instead always add acid to water slowly with stirring. No pipetting should be done by mouth; we should use a pipette bulb or other pipetting device. Pipette must be used in a vertical position. Always dispense and dilute concentrated acid into a fume hood. Spilled chemicals should be cleaned up immediately and disposed of properly. Spill control chemicals should be used for major spills. Acids and corrosive chemicals should be neutralized with soda ash (sodium carbonate) or sodium bicarbonate and spillage of alkali be neutralized by covering with dry sand. Chemicals should be stored in their original containers. Cabinets should be suitably ventilated. We should not store chemical containers on the floor. Sharp and pointed tools should be properly stored.

Hot equipment and glassware handling

All glassware should be inspected before use and any broken, cracked, or chipped glassware should be disposed of in an appropriate container. All hot equipment should be allowed to cool before storing it. All glassware must be handled carefully and stored in its appropriate place after use. All glass chemical containers should be transported in rubber or polyethylene bottle carriers when leaving one lab area to enter another. We should use a cart if transporting more than two bottles. Only borosilicate (Pyrax, Kimax etc) containers should be used for heating solutions. We should never heat a closed system such as a sealed test-tube or closed bottle. When a burner or

hot plates are used we should always wear goggles and an apron to protect our eyes and clothing. We should never leave a hot plate unattended while it is turned on. Many metal, ceramic, and glass items do not always look hot when they are hot. Handle hot equipment with safety gloves and other appropriate aids but never with bare hands. We should keep our head, hands, hair, and clothing away from the flame or heating area, and turn heating devices off when they are not in use. Gas burners should be lit only with a spark lighter. Make sure all heating devices and gas valves are turned off before leaving the laboratory.

V. UNAUTHORIZED ACTIVITY

Horse Play

The performance of unauthorized experiments and the use of any equipment in an unauthorized or unsafe manner are strictly forbidden in the laboratory. Horseplay in the lab is very dangerous. Laboratory equipment and apparatus are not toys. We should never play in the lab. Unauthorized person should not allow entering in the laboratory.

Food, drink and Smoking

No food or drinks of any kind are allowed in the laboratory. Any food or drink brought to the lab must remain in the carrying bag until they leave. We should not store food and drinks in laboratory refrigerators. We should not drink from lab equipment. Wash hands frequently throughout the day and before leaving the lab to avoid carrying toxic materials. Smoking is banned throughout the college and it is never allowed in any laboratories. In addition, do not apply cosmetics the laboratory. Never smell or taste chemicals or touch them with bare hands.

VI WASTE DISPOSAL

Sinks with water taps for washing purposes and liquid waste disposal are usually provided on the working table. Use water taps only when required and should not waste any water. It is essential to clean the sink regularly. We should never put broken glass or ceramics in a regular waste container. Use a dustpan, a brush, and heavy gloves to carefully pick up broken pieces, and dispose of them in a container specifically provided for this purpose. Hazardous chemical waste including solvents, acids, and reagents should never be disposed of down sewer drains. Waste must be separated based on chemical compatibility in order to avoid violent reactions and

disposed of in the proper waste containers. All chemical waste must be identified properly before it can be disposed. Bottles containing chemical waste must be properly labeled. Labeling should include the words "hazardous waste." Chemical waste should be disposed of in glass or polyethylene bottles. Plastic coated glass bottles are best for this purpose. Aluminum cans which are easily corroded should not be used for waste disposal and storage.

VII SAFETY CONSIDERATIONS FOR SPECIAL HAZARDS

Due to the increasingly instrumental nature of laboratory research today, many devices and instruments are electrically powered. Some devices such as lasers, power supplies, and vacuum pumps can pose serious safety hazards. Consequently, it is critical to know the proper use of these devices and instruments before begin to use them in research.

Electricity

Electricity is not dangerous if it is properly used and if electrical equipment is properly installed, operated and maintained. Fire and explosions can be caused by heat generated due to the passage of excessive electric current in the circuit due to overloading, breakdown of insulation, or by inadequate ventilation or cooling. Before connecting or disconnecting any high voltage cable we should make sure that the high voltage power supply is in the off mode. Before supplying current to any electrical equipment, we should check the equipment is properly earthed and the insulation provided in the cable is sufficiently strong. Rubber or insulated mat must be laid on the floor of the electrical laboratory. We must wear shoes in electrical lab. In case of an electrical shock, the first attempt of the attendant should be to switch off the connection immediately. If not possible, the shocked person be either pulled touching his or her cloth or pushed with a piece of dry wood or with thick dry paper. In no case one should touch the body of the shocked person. In case of fire, it is dangerous to throw water on a live conductor and equipment. An appropriate fire extinguisher (Class C), dry chemical - carbon dioxide should be used. We must know where the master switch is for electricity in the laboratory. The electrical cord must be visible at all times to ensure it is in good condition. Extension cord should not go under doors, across aisles, be hung from ceiling, or plugged into other extension cords.We should use low voltage DC for studying simple circuits. When using batteries, always inspect them first for cracks, leaking, etc. In spite of its low voltage, a high current can be drawn from it on a short circuit. Voltages above

50Vrms ac and 50V dc are always dangerous, extra precaution should be considered as voltage levels are increased.

Radioactivity

. To prevent accidental entry of radioactive materials into the body, high standards of cleanliness and good housekeeping must be maintained in all laboratories where radioactive materials are used. The low activity radioactive sources used in the laboratory should be stored in the lead brick structure. After using radioactive source, it should be put back in the lead brick structure again. All radioactive sources must be securely stored when not in use. If cut by glassware, injured by hypodermic needle, splinters etc, containing radioactive materials, we should immediately wash the wound under a strong stream of water. Any spills of radioactive materials should immediately be covered with absorbent materials. All radioactive materials must always be handled with gloves. One should not be permitted to work with the radioactive isotopes for an extended period of time. We should not work with radioactive materials if there is a break in the skin below the wrist. Laboratories should be provided with special radioactive waste containers with printed lebeling “Caution, Radioactive Waste”. We should not allow radioactive materials to come into contact with skin, hair, clothing, or personal belongings.

Lasers

Unprotected laser exposure can cause serious and permanent damage to the skin and the delicate tissue of eyes. So, users should wear laser safety goggles when working with lasers. We should use shields to prevent strong reflections and the direct beam from going beyond the area needed for the demonstration or experiments. Whenever a laser is operated outside the visible range (such as a CO_2 laser), a warning device must be installed in order to indicate its operation. We should view holograms only with a diverged laser beam. We should never permit eye exposure to either direct or reflected laser light. Students should not move about the room during the activity. We should operate the laser at the lowest possible power and maintain the room's illumination bright enough so that the pupils of the eye remain small. Prisms should be set up before experiment to avoid unexpected reflections. Appropriate beam stops should be used to terminate the laser beam where needed. We should never lower our head to the level of the laser beam. The laser beam should always be at or below chest level.

Mechanics

While using compressed air, use only approved nozzles and never directs the air towards any person. Sudden or unexpected motion near hydraulically or pneumatically driven equipment can inflict serious injury. One can be injured if hit by rapidly moving objects or projectiles. Always use caution when dealing with projectiles, falling objects, moving equipment, exposed belts, powerful permanent magnets, sharps knives and razor blades, and springs. When using any apparatus that rotates, be sure the safety nut is secured. Securely anchor tabletop centrifuges and place in a location where the vibration will not cause lab equipment to fall off the bench top. If the centrifuge starts vibrating, stop and check the load balances. We should use sealed safety cups while centrifuging hazardous materials. Additional space may be needed to assure the spinning mass does not hit anything. We should never walk in the path of the spinning masses.

Pressurized and Vacuum Systems

Compressed (pressurized) gases are gases stored under pressure in a metal cylinder. Some compressed gases such as hydrogen chloride or ammonia are highly corrosive. Others such as hydrogen or acetylene are highly reactive and flammable. Even inert gases such as nitrogen can be dangerous because in confined areas their rapid release may displace enough oxygen causing loss of consciousness and asphyxiation. Gas cylinders are color coded to facilitate ready identification of gas contents. Be sure to use the proper regulator for the gas tank. Cylinders containing flammable or reactive gases should be stored and used in well-ventilated areas and should never be operated in the vicinity of open flames or electrical devices capable of sparking. The regulators on these cylinders should be regularly inspected for leaks using gas leak detectors. Gas cylinders should always be transported using an appropriate wheeled gas transport cart. Gas cylinders should never be rolled, spun, twirled, or dragged.

Working with vacuums has the potential of an implosion and the possible hazards of flying glass, splattering chemicals and fire. Placement of transparent plastic around the apparatus helps prevent injury from flying glass in case of an explosion. We should protect vacuum pumps with cold traps and vent the exhaust into an exhaust hood. The pumps should have belt guards to prevent hands or loose clothing from getting caught in the belt pulley. We should not operate pumps near containers of flammable chemicals, flammable chemical wastes, or combustible

materials. Old vacuum tubing must be replaced as crumbly tubing can degrade performance. The shortest length of tubing should be used. We should close the valve between the vacuum vessel and the pump before shutting off the pump to avoid sucking vacuum oil into the system. The oil levels should be checked regularly and should be changed when necessary.

VIII CONCLUSION

Everyone in the lab is responsible for their own safety and the safety of others. One should be cognizant of potential hazards by conducting all experiments and demonstrations prior to their implementation. Advance planning coupled with knowledge is the best offence in case of emergency. The introductory laboratory should engage each student in significant experiences with experimental processes, including some experience designing investigations. We should develop a broad array of basic skills and tools of experiment and data analysis and help the students to master basic concepts. We should understand the role of direct observation and to distinguish between inferences based on theory and the outcomes of experiments and help students to develop collaborative learning skills that are vital to success in many lifelong endeavors. The laboratory accidents are caused by unsafe conditions such as improperly guarded or unguarded equipments; defective equipments; slippery, weak or uneven floor surfaces, hazardous arrangement, improper ventilation and illumination. Laboratory accidents are also caused by unsafe acts such as making safety devices inoperative, using unsafe equipment, unsafe position, horseplay, failure of safe clothing, using unsafe dress or apparel etc. Unsafe acts are due to the human elements which includes; physical and mental characteristics, knowledge, skill and attitudes of the individuals.

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