Architecture & Construction, Transportation, Distribution & Logistics Clusters

Facility Design

When designing, equipping, or remodeling a skilled and technical education lab, there are a great many situations and details that must be anticipated as planning proceeds. Consider the moral, financial, and legal aspects of a sound safety program. It is prudent to give safety a dominant and controlling role in the planning process.

The placement of machines and equipment in a given work area is critical and must allow for the normal flow of machines through the operational process. There must be a minimum of cross traffic of both material and/or students.

The planner or the specification writer normally considers the following factors:

- Flow of materials and foot traffic
- Tool and equipment storage, specifications, and arrangement
- Electrical and other utilities
- Ventilation and dust collection
- Color and lighting
- Costs
- Noise

Aisle and Machine Placement

All machines and equipment must comply with existing state and federal regulations. Although OSHA does not have direct authority over schools, it is strongly recommended that schools consider adopting these requirements. Where hazards exist around a machine, the machine must be placed so students in the area are not in the line of danger.

Machines such as table saws, jointers, and planers are capable of violent kickback of the stock. They must be arranged so that the stock will not be accidentally thrown into areas where students will be working. Painted lines on the floor must also designate the hazard areas. The aisles must provide adequate travel space between benches and machines; they must also provide adequate space in front of tool panels and storage lockers and other areas where students may either congregate or work. Give special consideration to those areas that present potentially dangerous operations.

Noise

Physical technology laboratories produce a higher level of noise than other types of laboratories. The level of noise exposure, in conjunction with the duration of exposure, must be kept below permissible exposure levels. This may be accomplished through the use of sharp tooling, proper maintenance and correct alignment of machinery, the use of energy- and noise-absorbing materials, or the substitution of quieter procedures and equipment.

Personal Protective Equipment for ear protection is necessary when noise levels and the time of exposure exceed OSHA standards. If a normal speaking voice cannot be understood from two feet away, the noise level is probably excessive.

Dust Collection

The control or collection of dust is necessary, particularly in the materials areas. This may be accomplished through the installation of a dust-collection system or by individual (localized) dust collectors attached to specific machines or incorporated into the design of portable power tools. General cleanliness in the lab may contribute greatly to dirt and dust control. If the lab is air conditioned, a central dust collection system is imperative. Additional protection could be offered by supplying every student with a disposable dust mask.

Ventilation

Mechanical exhaust ventilation is, in most cases, the first choice for control of air contaminants, which are potential health and/or fire hazards. A properly designed and maintained localized exhaust or general-dilution ventilation system will remove air contaminants which may be present or lower the concentration of fumes, vapors, dusts, mists, or other contaminants generated in the working environment.

Local exhaust ventilation removes the hazardous materials at or near their point of origin and prohibits them from being drawn through the breathing zone of the student. Local exhaust ventilation is the preferred type, because it usually performs most efficiently and prevents air contaminants from circulating through the entire lab area or school building. There are three basic types of localized exhaust systems: down draft, lateral flow, and suspended canopy. The suspended canopy is the least-desirable type of localized ventilation because the hazardous material contaminants are drawn through the person's breathing zone.

Local-exhaust ventilation systems must be installed whenever a large volume of air contaminant is generated or where a particularly hazardous substance is used. Some operations requiring the use of local-exhaust ventilation are welding, spray painting, woodworking, and processes involving the use of resins, solvents, and flammable liquids. Processes involving the use of asbestos, lead, mercury, chromium, and zinc must not be performed in skilled and technical education labs.

General-dilution ventilation depends upon a sufficient volume of air passing through the lab area to dilute the contamination to a recommended nonhazardous level. Dilution ventilation works best with low-toxicity contaminants and requires a greater volume of air movement for efficient operation. General-dilution ventilation may be an effective control for areas generating low concentrations of relatively nonhazardous substances.

The design of ventilation systems is somewhat detailed, involving determination of the volume of air that needs to be moved, the type of fan that will adequately exhaust the air volume, the placement of the exhausts, make-up air, and the positioning of the system. Consult a mechanical engineer or industrial hygienist who can assist in providing an effective environmental control through the use of a ventilation system.

In addition, filters must be cleaned and changed regularly, and qualified personnel must check all ventilation systems at the beginning of each school year to confirm continued effectiveness. As a word of caution, it is recommended that teachers do not modify existing systems because this may create an environment with negative health results.

Lighting

The lab planner must consider the quantity and quality of illumination required for various tasks, the problem of glare, and the replacement of specialized lighting equipment in hazardous areas. The current minimum levels of illumination for industrial areas as recommended by the Illuminating Engineer Society (IES) are given in ANSI/ES RP-7-1979.

Electrical Requirements

Fuses

Before removing any fuse from a circuit, be sure the switch for the circuit is open or disconnected. When removing fuses, use an approved fuse puller and break contact on the hot side of the circuit first. When replacing fuses, install the fuse first into the load side of the fuse clip, then into the line side.

GFCIs

A ground fault circuit interrupter (GFCI) is an electrical device which protects personnel by detecting potentially hazardous ground faults and quickly disconnecting power from the circuit. A potentially dangerous ground fault is any amount of current above the level that may deliver a dangerous shock. Any current over 8 mA is considered potentially dangerous, depending on the path the current takes, the amount of time exposed to the shock, and the physical condition of the person receiving the shock.

Therefore, GFCIs are required in such places as dwellings, hotels, motels, construction sites, marinas, receptacles near swimming pools and hot tubs, underwater lighting, fountains, and other areas in which a person may experience a ground fault.

Lockout/Tagout

Electrical power must be removed when electrical equipment is inspected, serviced, or repaired. To ensure the safety of personnel working with the equipment, power is removed and the equipment must be locked out and tagged out before any preventive maintenance or servicing is performed. Lockout is the process of removing the source of electrical power and installing a lock, which prevents the power from being turned on. Tagout is the process of placing a danger tag on the source of electrical power, which indicates that the equipment may not be operated until the danger tag is removed.

A danger tag has the same importance and purpose as a lock and is used alone only when a lock does not fit the disconnect device. The danger tag must be attached at the disconnect device with a tag tie or equivalent and must have space for the worker's name, craft, and other required information. A danger tag must withstand the elements and expected atmosphere for as long as the tag remains in place. A lockout/tagout is used when:

- servicing electrical equipment that does not require power to be on to perform the service;
- removing or bypassing a machine guard or other safety device;
- the possibility exists of being injured or caught in moving machinery;
- clearing jammed equipment; and
- the danger exists of being injured if equipment power is turned on.

Lockouts and tagouts do not by themselves remove power from a circuit. An approved procedure must be followed when applying a lockout/tagout. Lockouts and tagouts are attached only after the equipment is turned off and tested to ensure that power is off. The lockout/tagout procedure is required for the safety of all persons due to modern equipment hazards. OSHA provides a standard procedure for equipment lockout/tagout. OSHA's procedure is:

1. Prepare for machinery shutdown.
2. Machinery or equipment shutdown.
3. Machinery or equipment isolation.
4. Lockout or tagout application.
5. Release of stored energy.
6. Verification of isolation.

Warning: Personnel must consult OSHA Standard 29 CFR 910.147 for industry standards on lockout/tagout.

Storage of Materials

- Place/locate the material storage area so that it is convenient for unloading of delivery trucks and adjacent to production/fabrication areas, with easy access for the teacher using cutting tools and machines for cutting materials into smaller sizes for student use.
- Place machines and equipment in each work area so that it allows for the normal flow of materials through the operational process. There must be minimal cross traffic of both material and/or students. Lay out project-

storage areas to minimize congestion at the start and end of class and provide lockers, open cubicles, shelves, bins, or racks to accommodate a variety of project types and sizes.
- Store inflexible three-dimensional materials (e.g., angle iron, square tubing, bar stock, lumber, conduit, and plastic bar stocks) vertically or horizontally. In the horizontal position, store the heavier materials on lower levels and the lighter materials at higher levels. Vertical storage of materials must lean toward the wall, with the height limited to eight to 10 feet, allowing a person to grasp the material above its midpoint.
- Store materials which need to remain flat (such as sheet metal) horizontally on wide shelving or vertically between full-width dividers.
- Store oxygen cylinders and fuel gas cylinders so that they are protected by a ½ hour fire-rated barrier or are stored at least 20 feet apart. All compressed gas cylinders must be stored secured and upright.
- Store finishes in a flammable-materials cabinet.

Hazardous Material Storage

Storage of Petroleum Products

Follow appropriate guidelines when setting up fuel-storage facilities to ensure that environmental and fire safety requirements are met. Labeling regulations vary and depend on the size and placement of fuel tanks. Disposal of used oil products and the recycling of used petroleum is subject to regulation.

Hazardous Waste

Hazardous waste includes such materials as batteries, paint, and unused chemicals. Many regulations exist and cover the handling of hazardous waste. Consult with local authorities to determine how to properly dispose of hazardous waste. Use recycling programs whenever possible.

Cabinet Requirements

Cabinets must meet the following requirements:
- Each cabinet must be labeled with the contents of the cabinet.
- Each cabinet must be clearly labeled as to the hazard class of the materials stored within the cabinet (e.g., acids, flammables, etc.).
- Each cabinet must be rated for use with the hazard class of the most hazardous material stored within.
- No paper products, office equipment, food, or any other nonhazardous material should be stored in any hazardous material storage cabinet.
- The cabinet must be listed with an approved testing laboratory (e.g., UL, FM) for the intended use.

Welding Gasses

Compressed gasses such as oxygen, carbon dioxide, argon, and acetylene are commonly found in labs. Cylinders in use must be restrained by nonflammable restraints (e.g., chain) at the base and upper third of the cylinder. Gas must be stored in ventilated areas. Please also refer to *Compressed Gas Safety*, the fact sheet created by Oregon OSHA (https://osha.oregon.gov/OSHAPubs/factsheets/fs09.pdf).

Lab Maintenance

Studies by safety engineers have pointed out a definite relationship between the number of accidents in any particular lab and the housekeeping conditions of the lab. It is important to establish and maintain cleanliness and orderliness,

eliminate hazards, and develop proper attitudes and orderly work habits in students. The following are recommended housekeeping practices considered essential for the lab:

- Arrange all equipment to permit safe and efficient work practices.
- Store materials and supplies safely and prohibit the storage of materials and debris on benches in the work areas.
- Provide the appropriate type and quantity of waste containers and dispose of combustible waste materials using proper methods.
- Ensure floors are cleaned regularly.
- Conduct regular inspections to maintain clean and orderly conditions.
- Clean splash guards and collecting pans of all machines that use oil and coolants.
- Maintain a supply of brooms, bench brushes, towels, and other cleaning equipment and use housekeeping tools, equipment, and supplies properly.
- Remind students of their responsibility to keep the lab clean and orderly and organize a housekeeping routine which involves all students.

Personal Protective Equipment

For details on eye, face, head, foot, leg, hand, arm, body, and hearing protection, please refer to the publication *Personal Protective Equipment* from OSHA (https://www.osha.gov/Publications/osha3151.pdf).

PPE Guidelines

- Eye protection (safety glasses) must be worn at all times in the lab. Eye protection must meet a minimum standard of ANSI Z87.1. Eye protection must provide front and side protection.
- Face shields, welding helmets, and handheld shields must be worn over primary eye protection (safety glasses).
- A lab coat or coveralls are recommended to be worn at all times in the lab. Never wear loose-fitting clothing or frayed or rolled edges of garments, which could be caught in machinery or catch sparks. Ensure that no flannel or oily garments are worn in the lab.
- Complete coverage of the foot with nonflammable footwear (no nylon) is required in the lab setting.
- Wear leather gloves and coveralls for protection against burns.

Posting of Eye Hazardous Areas

The entrance to all labs or other areas that require industrial-quality eye protection must be posted with a sign indicating these requirements. In addition, machines, equipment, or process areas and laboratories requiring operators to wear specific eye and face protection must be posted with warning signs. Visitors must also wear any protective devices required in the area they are visiting. Extra devices must be available at all times to lend to visitors.

Clothing

Follow these guidelines with regard to clothing in the lab:

- Do not wear clothing or jewelry that can get caught in any machinery or otherwise cause an accident.
- Do not wear loose clothing, baggy shirts, shorts, dragging pants, or any clothing that has cuffs or frayed edges; do not wear flannel clothing.
- Some tasks, such as welding, require long sleeves along with coveralls or a leather jacket.
- Do not weld if clothing or shoes have oil on them.
- Wear closed-toed shoes (boots or heavy leather shoes are best); do not wear flip-flops or other sandals.

Respiratory Protection

If there is ever a danger of an inhalation hazard, wear a respirator. The four general types are as follows:

- Self-contained breathing apparatus (SCBA)—carries its own air supply in a compressed air tank; is used where there is not enough oxygen or where there are dangerous fumes in the air.

- Supplied air mask—uses a remote compressor or air tank to provide oxygen and is used under the same conditions as the SCBAs.
- Full-facepiece mask with a chemical canister (gas mask)—used to protect against brief exposure to a dangerous gas or fume.
- Half mask or mouthpiece with a mechanical filter—used where dust or other solid particles can be inhaled.

Automotive and Collision Repair and Refinishing

Safety is a critical aspect of the automotive-repair industry. Listed below are some potential exposures and safety precautions.

Lab and Personal Safety

- Identify general lab safety rules and procedures.
- Use safe procedures for the handling of tools and equipment; locate and demonstrate knowledge of the SDS.
- Identify and use proper placement of floor jacks and jack stands.
- Identify and use proper procedures for safe lift operation.
- Use proper ventilation procedures for working within the lab area.
- Identify the location and the types of fire extinguishers and other fire safety equipment; demonstrate knowledge of the procedures for using fire extinguishers and other fire safety equipment.
- Identify marked safety areas; identify the location and use of eye wash stations; identify the location of the posted evacuation routes.
- Comply with the required use of safety glasses, ear protection, gloves, and shoes during lab activities; identify and wear appropriate clothing for lab activities; and secure hair and jewelry for lab activities.
- Demonstrate awareness of the safety aspects of supplemental restraint systems (SRS), electronic brake control systems, and hybrid vehicle high-voltage circuits.
- Demonstrate awareness of the safety aspects of high-voltage circuits (such as high intensity discharge [HID] lamps, ignition systems, injection systems, etc.).

Suggested safety guidelines can be found at Microsoft Word - AUTOMOTIVE REPAIR SHOPS-safety rules.doc (amtrustfinancial.com).

Jacking and Hoisting

- Do not jack up the vehicle if anyone is under it.
- Use jack stands when working under vehicles. When using a hoist, it must have air/hydraulic backup controls and/or locks.
- Avoid excessive shaking of the vehicle when it is on jack stands.
- The teacher must inspect the jack stand supports before students work under any vehicle.
- Long jack handles are a tripping hazard; ensure that they are barricaded or raised out of position.
- Do not use bumper jacks.
- Do not run an engine when the car is on the hoist or on jack stands.
- Use caution when lowering a vehicle.

Painting and Refinishing

Finishing Room Safety

- Do all finishing in a separate, well-ventilated area specifically designed for finishing.
- Make sure the proper types of fire extinguishers are available in the room.
- For spraying, use a properly installed spray booth. Keep the spray booth clean and well-maintained.
- Keep the entire area clean and free from spills.

- Never leave opened finishing materials unattended.
- Never use tools or machines that can cause sparks or start a fire in the finishing area.

Using and Storing Paint and Solvents

- Solvents emit dangerous fumes. Use only in a well-ventilated area.
- Many solvents are extremely flammable. Keep all solvents away from sources of heat, sparks, and fires.
- Store paint and solvents in their original containers. If this is not possible, clearly label the new container.
- Read and obey the labels on each type of solvent (refer to SDS for a complete list of hazards and precautions).

Health and Safety Guidelines for Painting

In industry, the most popular method of applying paint is to spray it on, using compressed air, a high-velocity airless sprayer, or an electrostatic applicator. The material itself is the primary hazard when painting. Painting may cause exposure to potentially dangerous chemicals that may damage health. Choose paint materials with safety in mind. Never use materials that are unlabeled or if the contents cannot be determined. Always follow the safety recommendations for the material being used.

Health Hazards

Overexposure to a substance means too much has been breathed in, swallowed, or absorbed through the skin. The possible effects of overexposure to paint and the chemicals it contains vary according to the type of paint. Some health problems caused by overexposure to paint material are:

- drowsiness;
- dizziness/light headedness;
- disorientation;
- nausea/vomiting;
- irritation of the eyes and throat;
- dermatitis;
- general allergic response, such as hives;
- asthma like wheezing with tightness in the chest;
- heavy-metal poisoning (from lead, chromium, nickel and cadmium); or
- nerve, kidney or liver damage.

How to Control Health Hazards

Whenever possible, painting or priming operations must be done in a spray booth. These areas are designed to reduce exposure to paint vapors and additives—use them correctly. Ensure that the ventilation in the spray booth is adequately maintained and working properly.

Before using the spray booth:

- Check the spray-booth filters and change if necessary.
- Turn on the make-up air unit.

When painting:

- Follow the equipment manufacturer's instructions.
- Avoid using plastic drop cloths on the floor (slip hazard).
- Never point a spray gun in the direction of any person.
- Ensure that the piece being sprayed is positioned between the worker and the exhaust fan.
- Do not over spray.
- Use PPE.

Electricity

The following guidelines relate to hazards presented by electricity:

- Follow the manufacturer's instructions for the installation and use of all electrical equipment. Never disconnect or damage any safety device that is provided by the manufacturer or specified by electrical codes. Install all electrical wiring according to NEC specifications.
- Make sure all receptacles, switches and fixtures are secured to a box and that the box is properly grounded. Do not use any switches, outlets, fixtures or extension cords that are cracked or damaged in any way.
- Do not touch electrical appliances, boxes or wiring with wet hands or wet feet.
- Do not remove the long grounding prong from three-prong, 120-volt plugs.
- Use GFCIs wherever moisture may increase shock hazard; keep appliances dry to reduce shock hazard and prevent rust.
- Do not place extension cords under carpeting; do not use any extension cord that feels warm or smells hot. This means that too much amperage is trying to flow through the wire.
- Use only double-insulated portable tools or tools with three-wire grounded cords..
- Do not leave heat-producing appliances unattended (e.g., soldering irons).
- Place all heaters and lamps away from combustible materials.
- Keep the metal cases or cabinets of electrical appliances grounded at all times.
- Keep electrical motors lubricated and free of dirt. Dirty motors can accumulate flammable materials and overheat.

Plumbing

Materials

The materials used in plumbing may expose the plumber to health hazards. Follow these guidelines:

- Glues and solvents used with plastic pipe are of special concern. Use these materials in well-ventilated areas and avoid ignition sources. See the material's SDS for more information.
- Pipe-sealing compounds may also pose some hazards. See the material's SDS for more information.

Scaffolding

Scaffolds are a safe way to gain access to high places inside and outside buildings but that is when they are properly erected and worked from. They must have complete guardrail systems and toeboards. People working underneath should be discouraged. With proper scaffolding is a safer work platform than a ladder and doesn't have the added hazards of scissor lifts or articulated boom lifts.

- For all rules and regulations pertaining to scaffolds, refer to 29 CFR 1926 Subpart L
- Follow the manufacturer's instructions when erecting the scaffold.
- Only people trained in inspecting and the proper use of scaffolds should be allowed to work from a scaffold.
- Do not work on scaffolds outside during stormy or windy weather.
- Do not climb on scaffolds that wobble or lean to one side.
- Inspect the scaffold before mounting it. Do not use a scaffold if any pulley, block, hook, or fitting is visibly worn, cracked, rusted, or otherwise damaged.
- Do not use any scaffold tagged "Out of Service."
- Do not use unstable objects such as barrels, boxes, loose brick, or concrete blocks to support scaffolds or planks.
- Do not use unstable objects such as barrels, boxes, loose brick, or concrete blocks under legs for leveling. Barrels, boxes, Ladders, Etc, should not be used to raise the level of the planks or used on the working surface (planks) to add height.
- Do not work on platforms or scaffolds unless they are fully planked.
- Do not use cross braces or end frames for access to and egress from the scaffold. Ladders should be properly installed and used.

- Do not use a scaffold unless guardrails and all flooring are in place.
- Level the scaffold after each move. Do not extend adjusting leg screws more than 12 inches.
- Do not jump from, to, or between scaffolding.
- Keep both feet on the decking. Do not sit or climb on the guardrails.
- Keep the scaffold free of scraps, loose tools, and other obstructions.
- Do not throw anything to or from an elevated position, use debris chutes or hoist/lower by hand.
- Do not move a mobile scaffold if anyone is on the scaffold.
- Chock the wheels of the rolling scaffold, using the wheel blocks, and also lock the wheels by using your foot to depress the wheel-lock, before using the scaffold.
- See *Fall Protection in Construction* (OSHA) (https://www.osha.gov/Publications/OSHA3146.pdf).
- See *Safety Rules: Plumbing, Heating and Air Conditioning* (The State Auto Insurance Companies) (https://www.stateauto.com/uploadedfiles/Content/Insurance/Products/Businesses/Risk_Control_Services/Risk_Control_Services_PDFs/Plumbing%20HVAC%20Rules.pdf).

Drone Safety Blueprint

Drone Safety Categories and Best Practices were compiled through research of procedures used in industry and education through published works and interviews with pilots and instructors.

Preflight Checklist (14%)

  - Check propellers for damage
  - Check airframe for damage
  - Check UAS battery level
  - Check remote battery level
  - Turn on the remote prior to turning on the drone
- Location (14%)
  - Do not operate unguarded propellers indoors
  - Safety cones at all pedestrian egress/ingress points
  - Do not fly over people
  - Do not fly near people below 10’ AGL
  - Designated takeoff/landing zones clearly marked
- Operation (23%)
  - Always maintain VLOS
  - Always have hands on controls while drone is powered on
  - Never operate more than one vehicle (drone, car, or otherwise) at a time per pilot
  - Never handle a drone while propellers are spinning
  - Do not fly near other vehicles (land or air)
  - Do not fly over 400’ AGL
  - Do not take footage of people/places without express permission
  - Do not attempt any maintenance while powered on
  - Ensure proper control function prior to beginning mission

- Battery safety (35%)
  - Signs a battery is internally damaged
    - Excessively hot
    - Swelling
    - Unbalanced cell voltage
  - Never use a Physically Damaged battery
  - Charging

        - Fire safe container
        - Never unsupervised
        - Never trickle charge
        - Do not overcharge
    - Storage
        - Fire safe container
        - Not fully charged for extended periods of time
        - Not fully discharged for extended periods of time
        - At room temperature
    - Proper Disposal for LiPo batteries
    - Fire (Class D Extinguisher) nearby storage and charging stations
- Operator (14%)
    - Should always wear safety goggles
    - Wear reflective vest
    - Have flight credentials/ID
    - Use a Visual Observer
    - Similar conditions for flying as for driving (drowsy, medicated, etc)