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Accredited ABET Engineering Accreditation Commission

MECHANICAL ENGINEERING LABORATORIES SAFETY MANUAL

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Abstract

The manual in hand is written to Revise and evaluate “Mechanical Engineering Department laboratories” to adapt the security & safety rules, concerning: “the *Determination of actual running devices used in practical experimentation, demonstration units & unexploited apparatuses, lab’s safe rearrangement, availability of catalogues, technicians & engineers’ assessments, and future needs”*.

Chapter-1

Introduction

Laboratory Safety is a very important aspect of scientific education. Without following its rules, experimentation could result in very serious injury, if not death, of course. In order to reduce the risks involved with experimentation, there are certain procedures that should be followed by individuals and by a member of a group. It is important that the correct procedures are used in various situations, when handling hazardous or biological materials, when preparing, executing or cleaning up an experiment. It is also essential to understand how to identify and use emergency equipment and protective gear.

This lab manual is provided to guide its reader through and develop an understanding of Laboratory Safety. It is very important to take time to understand the procedures, concepts and reasons to make laboratory as safe as possible.

1.1 Safety Definition

"Safety": the condition of being protected from risk, which means,"the likelihood of a specified undesired event which may occur due to the realisation of a hazard", and the "hazard can be defined as the potential to cause harm", which includes:

- ill health and injury,
- damage to property, plant, products or the environment,
- production losses or increased liabilities.

1.2 Hazard identification

is applied by using:

Comparative Methods e.g. checklists and audits.
Fundamental Methods e.g. Failure Modes & Effects Analysis.
Failure Logic e.g. Fault Trees, Event Trees & Cause-Consequence diagrams.

1.3 Types of Hazards

1.3.1 Mechanical Hazards:

- Blades
- Moving/rotating belts or chains
- Gears
- Shafts
- Pinch points
- Other

1.3.2 Physical Hazards:

- Noise
- Radiation
- Temperature
- Pressures
- Vibration

1.3.3 Biological Hazards:

- Bacteria
- Viruses
- Dust mites
- Pollens
- Molds and other fungus

1.3.4 Chemical Hazards:

- Gases
- Vapors
- Fumes
- Liquids
- Solids

1.3.5 Ergonomic Hazards:

- Unnatural posture
- Extreme force
- Repetition

1.4 Risk Assessments' Types:

- **Qualitative:** very straightforward process based on judgement requiring no specialist skills or complicated techniques, where we apply it in the present study.
- **Quantitative:** tends to deal with the avoidance of low probability events with serious consequences to the plant and the surrounding environment.

1.4.1 Qualitative risk assessment:

Qualitative risk assessment involves making a formal judgement on the consequence and probability using:

Risk = Severity x Likelihood

Table (1.1) Risk Level Assessment

Probability	Severity				
	Insignificant 1	Minor 2	Moderate 3	Major 4	Severe 5
A. Almost Certain	Moderate	Moderate	High	Extreme	Extreme
B. Likely	Low	Moderate	High	High	Extreme
C. Possible	Low	Moderate	High	High	High
D. Unlikely	Low	Low	Moderate	Moderate	High
E. Rare	Low	Low	Low	Low	Moderate

Table (1.2) Risk Severity

Severity	Description
1. Insignificant	No Treatment required
2. Minor	Minor injury requiring First Aid Treatment
3. Moderate	Injury requiring Medical Treatment or lost time
4. Major	Serious injury (injuries) requiring special Medical Treatment and/or Hospitalization
5. Severe	Loss of life, permanent disability or multiple serious injuries

Table (1.3) Risk Probability

Probability	Description
E. Rare	Will only occur in exceptional circumstances
D. Unlikely	Not likely to occur within the foreseeable future, or within the project lifecycle
C. Possible	May occur within the foreseeable future, or within the project lifecycle
B. Likely	Likely to occur within the foreseeable future, or within the project lifecycle
A. Almost Certain	Likely to occur within the foreseeable future, or within the project lifecycle

Table (1.4) Response to the levels of risk

Assessed Risk Level	Description	Actions
Low	If an incident were to occur, there would be little probability that an injury would result	- Undertake the activity with the existing controls in place - Monitor and Report from Management
Moderate	If an incident were to occur, there would be some chance that an injury requiring First Aid would result	- Additional controls may be needed - Investigate cause, mitigation measures and mixing zone considerations
High	If an incident were to occur, it would be likely that an injury requiring medical treatment would result	- Controls will need to be in place before the activity is undertaken - Senior Management attention needed
Extreme	If an incident were to occur, it would be likely that a permanent, debilitating injury or death would result	- Consider alternatives to doing the activity. - Significant control measures will need to be implemented to ensure safety - Immediate action required by Management

1.5 Risk Reduction

Risks are systematically reduced through control measures, according to the hierarchy of risk control shown in the table 1.6, as the Risk elements which include**:** "Source, Pathway and Receiver". The hierarchy control, is represented in figure (1.1)

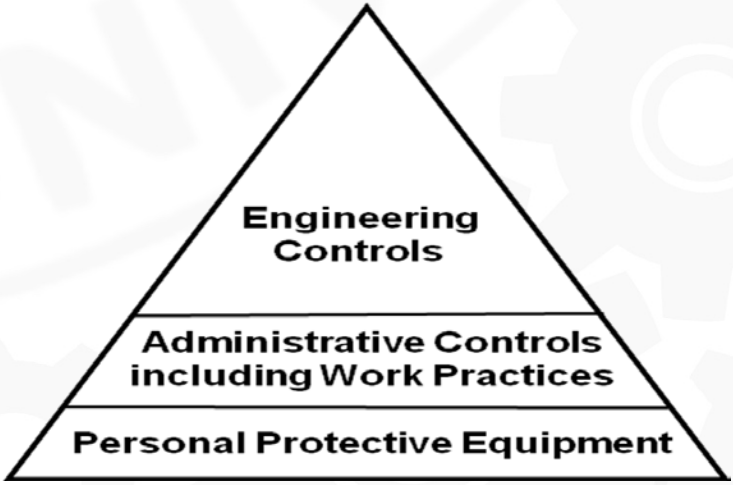


Figure (1.1) Hierarchy of Control

Table (1.6) Risk control Elements

Most effective (High level)	**Elimination:** remove the hazard completely from the workplace or activity
	Reduction: reduce a hazard with a less dangerous one by many means, as substitution (e.g. a less hazardous chemical)
	**Engineering Controls:** reduce the hazrd by many means, as *redesign:* making a machine or work process safer (e.g. raise a bench to reduce bending), or *Isolation:* separate people from the hazard (e.g. safety barrier)
	Administration Controls: putting rules, signage or training in place to make a workplace safer (e.g. induction training, highlighting trip hazards)
Least effective (Low level)	**Personal Protective Equipment (PPE):** Protective clothing and equipment (e.g. gloves, hats)

1.5.1 Risk Elimination

The best method of dealing with a hazard is to eliminate it. Once the hazard has been eliminated, the potential for harm has gone.

1.5.2 Risk Substitution

This involves substituting a dangerous process or substance with one that is not as dangerous. This may not be as satisfactory as elimination since there may still be a risk (even if it is reduced).

1.5.3 Risk Engineering Control

- Guarding
- Enclosures
- Substitution
- Process modification
- Equipment modification
- Ventilation
- Lighting Engineering controls eliminate the “human factor” in preventing injuries.

1.5.4 Administrative Elements

Administrative solutions usually involve modification.

This can be done by:

- Reducing the number of people exposed to the danger
- Reducing the amount of time exposed

- Providing training to those people who are exposed to the hazard.

1.5.5 Personal Protective Equipment (PPE)

Provision of PPE should only be considered when all other control methods are impractical.

- Eye (example: safety glasses)
- Face (example: face shield)
- Head (example: hard hat)
- Ear (example: ear plugs)
- Hand (example: rubber gloves)
- Foot (example: safety shoes)
- Body (example: rubber apron)
- Respiratory (example: respirator)

1.6 Laboratory Personnel Duties and Responsibilities In General

- Complete all required health, safety, and environmental training.
- Review and follow relevant laboratory authorizations and safety manual(s).
- Follow oral and written laboratory safety rules, regulations, and standard operating procedures (SOP) required for assigned tasks.
- Keep your work areas safe and uncluttered.
- Review and understand the hazards of materials and processes in your laboratory prior to conducting work.
- Take appropriate measures to control identified hazards, including consistent and proper use of engineering controls, personal protective equipment (PPE), and administrative controls.
- Understand the capabilities and limitations of PPE issued to you.
- Get prior approval from your PI/laboratory supervisor for the use of restricted chemicals and other materials.
- Consult with PI/laboratory supervisors before using highly hazardous materials or conducting certain higher risk experimental procedures.
- Report accidents and unsafe conditions immediately to the PI/laboratory supervisor.
- Participate in the medical surveillance program, when required.
- Inform the PI/laboratory supervisor of any work modifications ordered by a physician as a result of medical surveillance, occupational injury, or exposure.
- Follow basic laboratory security requirements for hazardous or controlled materials.
- If you discover a "Fire", you have to know the elements of : Fire Safety Resources, Procedures of Building Evacuation , Corridor Safety Requirements, Eye Wash and Emergency Shower Guidelines, How to Use a Fire Extinguisher, Flammable & Combustible Liquids Laboratory Fire Safety,

Special Laboratories Fire Safety, and Refrigeration Processes for Flammable Liquids Storage.

1.7 Safety Rules for Mechanical Engineering Laboratories

1.7.1 General Safety Rules

Please

- keep working area clean and tidy.
- wear safety goggles, ear protectors or gloves, if necessary.
- make sure that you are familiar with the fire escape route.
- ask lab technical staff's permission before using lab equipment or machine, if you are not an authorized user.
- use BS standard plugs and sockets as connecting to the main single-phase AC power supplies.
- check wiring connections before switching on the power.
  turn off heater or soldering iron after use.
- follow equipment or machine operating instructions.
  tie up long hair.
- In case of emergency, evacuate as soon as possible.

Must

- keep Compressed gas cylinders away from heat source.
- keep Electric extension boards away from water source.

Do not

- eat or drink.
- work alone at laboratory at any time.
- stay in non-opening hours unless you are authorized to do so.
- wear sandals or slippers.
- obstruct passageways.
- overload the AC power.
- Keep aisles clear.
- Maintain unobstructed access to all exits, fire extinguishers, electrical panels, emergency showers, and eyewashes.
- Do not use corridors for storage or work areas.

- If leaving a lab unattended, turn off all ignition sources and lock the doors.
- Do not store heavy items above table height. Any overhead storage of supplies on top of cabinets should be limited to lightweight items only. Also, remember that a 36" diameter area around all fire sprinkler heads must be kept clear at all times.
- Spills should be cleaned up immediately.
- Be careful when lifting heavy objects. Lift comfortably, avoid unnecessary bending, twisting, reaching out, and excessive weights, lift gradually and keep in good physical shape.

In all cases, there is a safe way to do all jobs

Ask yourself these questions:

1. What are the worst possible things that could go wrong?
2. How will I deal with them?

DO NOT perform the tasks or job until you have the answer to these questions.

The practices of safety in the laboratory requires:

1. The desire on the part of the individual to protect themselves and their associates, and
2. The need to follow the set guidelines as listed above.

The former can be termed safety moral and is an essential part of accident prevention.

1.8 Safety and Reliability

Safety engineering and reliability engineering have much in common, but safety is not reliability. If a medical device fails, it should fail safely; other alternatives will be available to the surgeon. If the engine on a single-engine aircraft fails, there is no backup. Electrical power grids are designed for both safety and reliability; telephone systems are designed for reliability, which becomes a safety issue when emergency calls are placed.

Probabilistic risk assessment has created a close relationship between safety and reliability. Component reliability, generally defined in terms of component *failure rate*, and external event probability are both used in quantitative safety assessment methods such as FTA. Related probabilistic methods are used to determine system *Mean Time Between Failure (MTBF)*, system availability, or probability of mission success or failure. Reliability analysis has a broader scope than safety analysis, in that non-critical failures are considered. On the other hand, higher failure rates are considered acceptable for non-critical systems.

Safety generally cannot be achieved through component reliability alone. Catastrophic failure probabilities of 10^{-9} per hour correspond to the failure rates of very simple components such as *resistors* or *capacitors*. A complex system containing hundreds or thousands of components might be able to achieve a MTBF of 10,000 to 100,000 hours, meaning it would fail at 10^{-4} or 10^{-5} per hour. If a system failure is catastrophic, usually the only practical way to achieve 10^{-9} per hour failure rate is through redundancy.

When adding equipment is impractical (usually because of expense), then the least expensive form of design is often "inherently fail-safe". That is, change the system design so its failure modes are not catastrophic. Inherent fail-safes are common in medical equipment, traffic and railway signals, communications equipment, and safety equipment.

The typical approach is to arrange the system so that ordinary single failures cause the mechanism to shut down in a safe way (for nuclear power plants, this is termed a *passively safe* design, although more than ordinary failures are covered). Alternately, if the system contains a hazard source such as a battery or rotor, then it may be possible to remove the hazard from the system so that its failure modes cannot be catastrophic. The U.S. Department of Defense Standard Practice for System Safety places the highest priority on elimination of hazards through design selection.

One of the most common fail-safe systems is the overflow tube in baths and kitchen sinks. If the valve sticks open, rather than causing an overflow and damage, the tank spills into an overflow. Another common example is that in an elevator the cable supporting the car keeps spring-loaded brakes open. If the cable breaks, the brakes grab rails, and the elevator cabin does not fall.

Some systems can never be made fail safe, as continuous availability is needed. For example, loss of engine thrust in flight is dangerous. Redundancy, fault tolerance, or recovery procedures are used for these situations (e.g. multiple independent controlled

and fuel fed engines). This also makes the system less sensitive for the reliability prediction errors or quality induced uncertainty for the separate items. On the other hand, failure detection & correction and avoidance of common cause failures become here increasingly important to ensure system level reliability.

Chapter-2

Safety Management in Machine Shop

2.1 Information About Machine Shop

The machine shop is available to all college of engineering students, staff and faculty working on University projects. Everyone must read this safety handout and pass a safety test before using the tools in the shop.

The goal of this handout is to summarize the risks that are inherent in metal working and to provide some guidelines for working safely. It is not the first step in preventing personal injury or machine damage is to make sure that you know how to operate the equipment you will be using correctly. If you are unsure – ask!

Because it is a communal area, used by so many people, it is important to keep the shop clean and orderly. This means that every user must clean the machines and work areas they use, and put away all tools and material before leaving the shop.

Inattention, hurried work, horseplay, bad judgment, fatigue, improper clothing, defective tools, and poorly secured work pieces cause most accidents. Avoid accidents by following all of, the rules in this handout and asking for help if you are unsure about the safest approach.

Disregarding shop rules, working unsafely or leaving a mess will result in suspension of shop privileges.

Normal Hours from (8 am) to (4 pm), entering engineering workshop may be limited during the courses registered in the semester.

By special permission from the head of the Department of Mechanical Engineering and during periods of congestion in the classroom can open the workshop in the evening or in the weekend, please contact the administrator of the workshop for additional information.

Mechanical Engineering workshop is composed of four sections which are as follows:

1st section: Casting Equipment.

2nd section: Sheet Metal Working machines.

3rd section: Machining Processes Machines.

4th section: CNC Machines.

2.2 First Section: Sand Casting Equipment

Two **ELECTRICAL FURNACES** form AMACO with maximum temperatures up to 1066 C

Machine code

CA-1A

CA-1B

Two **ELECTRICAL FURNACE** form **SHIMADZU** maximum temperatures up to 1000 C

Machine code

CA-2A

CA-2B

Six box sand casting training equipment

2.3 Second Section: Sheet Metal work

- Punching Machines

Machine code

PU-3A

Machine code

PU-3B

- Notch Machines

Machine code

NO-4A

Machine code

NO-4B

- Shear Machines

Machine code

CU-5

Machine code

CU-6

Machine code

CU-7

- Bending Machines

Machine code

BN-8

Machine code

BN-9

- Rolling Machine

Machine code

RO-10

Machine code

BN-11

- Rod Parter

Machine code

CU-12

2.4 Third Section: Machining Process

- Hack Sew Machines

Machine code

CU-13A

CU-13B

- Horizontal Bend Machines

Machine code

CU-14

- Vertical Bend Machine

Machine code

CU-15

- Lathe Machines

Machine code

LA-16A

LA-16B

Machine code

LA-16C

LA-16D

- Shaper Machine

Machine code

SH-17

- Horizontal Milling Machine

Machine code

MI-18A

MI-18B

- Vertical Milling Machines

Machine code
MI-19A
MI-19B
MI-19C

- Drill Press Machines

Machine code
DR-20A
DR-20B
DR-20C

- Surface Grinding Machine

Machine code
GR-23

- Bench gridding

Machine code

GR-24A

GR-24B

GR-24C

2.5 Fourth Section: CNC Milling Machine

- CNC Milling Machine

Machine code

CN-21

- CNC Turning Machine

Machine code

CN-22

2.6 Operation Responsibilities

Principal investigators/supervisors and all others in authority shall:

- Provide students and all other designated people with adequate training on the operation of the machines and power tools;
- Ensure that all persons working with the machines and power tools have received the required training;
- Schedule the use of machines and power tools;
- Ensure that only qualified persons who are authorized to access the workshop operate the machines and the power tools;
- Ensure that the machines and power tools are maintained and are in good condition;
- Ensure that all persons operating the equipment wear appropriate protective equipment;
- Ensure that all persons working with machines and power tools follow the safety procedures outlined in this manual;

2.7 The users of machines and power tools shall

- Operate the machines and power tools according to the safety procedure outlined in this manual;
- Follow the instruction of the supervisor/principal investigator;
- Inspect any equipment for defects prior to its use;
- Report any defects in any part of the equipment;
- Wear appropriate protective equipment;
- Report all injuries to the supervisor/principal investigator;
- Keep the work area clean.

2.8 General Safety Guidelines

All mechanical motion is potentially hazardous. Motion hazards, such as rotating devices, cutting or shearing blades, in-running nip points, reciprocating parts, linear moving belts and pulleys, meshing gears, and uncontrolled movement of failing parts, are examples of motion and peculiar to any one machine operation. Personnel working within machine shops or areas where they are exposed to machinery or equipment hazards must be aware of the potential for accidents. The following guidelines must be followed when working with machines and power tools:

- Eye protection must be worn at all times while using a machine or while in the vicinity of the machine.
- Foot protection must be worn while in the machine shop or when using any machines. Open toed footwear must never be worn around the machines.
- Loose clothing (Saudi uniform), long hair, scarves, watches and other accessories, that could catch in the moving machine, must not be worn while working with the machines unless they are so tied, covered or otherwise secured as to prevent the hazard.
- Gloves should not be worn around machine unless sharp or rough materials are being handled. If gloves are being worn, care should be exercised not to get them caught in any machinery.
- A minimum of two persons shall be in the shop at any time the facility is in use.
- Tools shall only be used for their designated purpose. A tool or an attachment shall not be used for something it was not designed to do.
- The tools should be always operated at the correct speed for the job at hand.
- All guards must be kept in place. Under no circumstance should the guards be removed from a machine.
- Machines and tools shall be cleaned after each use.
- The machines shall be cleaned using a brush. Hands or compressed air shall not be used to clean machine. Compressed air must not be used for cleaning one's clothes.
- Machines designed for a fixed location shall be securely anchored to prevent movement.
- Tools must be returned to proper storage area after use.
- Damaged tools and machines shall be reported to the person in charge of the machine shop or the person responsible for the equipment. Defective tools or machines must not be used.
- Person shall not engage in horseplay while operating a machine.
- The operator should watch the work while operating a machine. The operator must be free of distractions during the machine operation. If a distraction is present the work shall be stopped.
- No person must ever reach over the equipment while it is running.
- No person shall disable or tamper with safety releases or other automatic switches.

- Power tools shall be disconnected before performing maintenance, changing components or clearing jams. Machines shall be locked out/tagged out before repair.
- Chuck keys or adjusting tools must be removed prior to operation.
- No person that is sick, fatigued or is taking medications should operate any machines.
- Bystanders shall be kept away from moving machinery.
- Users of machine shops shall be aware of the location of first aid kits, fire exits, fire extinguishers, fire alarms, eye washes, deluge showers, emergency telephones and other safety related facilities.
- Accidents must be reported to the person in charge of the machine shop and the supervisor.
- Smoking is prohibited in the workshop, as all university facilities.
- Do not use of mobile phone in workshop.
- No eating or drinking in the workshop.

2.9 Drill Press Safety Guidelines

- Work must be securely clamped to the table to prevent it from spinning.
- The speed setting of the drill shall be appropriate to the work being done.
- The bit shall be mounted securely to the full depth of the chuck and in the center.
- The chuck key must be removed before starting the drill.
- The feed stroke shall be adjusted so that there is no possibility of the bit striking the table.
- Machine guards must not be tampered with or removed.
- The drill spindle shall be allowed to stop of its own accord.
- The machine shall be cleaned of chips and cutting fluid after use.
- The drillings shall be removed using a brush, never by hand.

2.10 Grinder Safety Guidelines

- Grinding wheels shall be examined for cracks before turning the machine on. Wheels that are badly worn or cracked shall be replaced.
- No flammable or combustible materials that could be ignited by the sparks from the grinder wheel shall be present nearby.
- When starting and stopping the grinder the operator shall stand to one side of the grinding wheel.

- Before using a new wheel, the wheel shall be left running for few seconds to ensure it is balanced.
- If excessive imbalance or wobbling is noted the grinder must be shut off.
- A grinding wheel that has been dropped or received a heavy blow shall not be used, even if there is no apparent damage.
- A wheel proper to the work being done must be used.
- The side of the straight wheel must never be used for grinding.
- Work shall not be forced against the wheel.
- Under no circumstances must the maximum operating speed of the wheels be exceeded.
- The gap between the face of the wheel and tool support must be kept to a minimum.
- The guard must be as close as possible to work being ground. The guard must never be removed or tampered with.
- The cutting surfaces shall be kept sharp by properly dressing the wheel.
- Water container shall be kept handy for cooling off the work piece.
- The wheel shall be stopped before adjusting, the machine shall be stopped when not in use.
- Users shall keep hands clear of the rotating grinding wheel

2.11 Lathe Safety Guidelines

- All stop controls shall be checked before starting work.
- All belt and gear guards must be in place before starting the machine.
- The lathe must be stopped to perform any adjusting, measuring, cleaning or lubricating.
- The spindle shall be stopped by shutting the lathe off and letting it coast to a stop. If the lathe is equipped with break treadle, the break treadle shall be depressed to stop the spindle.
- The users must never attempt to stop the spindle with hands or fingers.
- The lathe shall not be stopped by reversing its direction of rotation.
- The chuck key must be removed before starting the machine.
- The users shall keep hands clear of the chuck rim when the lathe is in motion.
- All tools, measuring instruments and other objects must be removed from the saddle or lathe bed before starting the machine.
- All work shall be solidly clamped with an appropriate size work-holding device.

- All work shall be solidly supported.
- Chucks must be mounted and removed by hand.
- Files used shall have sound handles.
- The chips shall be removed using a brush or pliers, never by hands. Air hoses shall not be used to clean the machine.
- No sand paper or polishing cloth shall be wrapped around any revolving part of the lathe.
- If vibration or odd noise develops, the machine shall be stopped immediately.

2.12 Band Saw Safety Guidelines

- Gloves should be worn when handling saw band.
- Adjustable guards shall be kept as close over the point of operation as the work permits.
- Band wheel covers must be closed before tensioning band or starting machine.
- The saw shall be at full speed before starting to feed in work. Stock shall be fed into the saw only as fast as the teeth will easily remove material.
- Stock shall be held flat on the table.
- The machine shall be stopped before adjusting or measurements.
- The machine shall be stopped only on low speed.
- The electrical supply must be disconnected before removing panels or drive covers.
- Users must never reach over the saw line to position or guide materials.
- Proper speeds and blades shall be used for the material being cut.
- Dust collector shall be used when dust is generated.
- The operator shall not leave the table until the blade has come to a complete stop.

2.13 Milling Machine Safety Guidelines

- Users of milling machine must fully understand all the machine controls before starting the work.
- The clutch and feed controls must be in neutral before the machine is started.
- The machine must not be started until the guards are in position.
- The work table must be kept free from tools and loose material.

- Proper feed rate and spindle speed must be used.
- The holding device shall be solidly mounted to the table and the work firmly held before commencing work.
- Heavy attachments such as the vise, dividing head, or rotary table shall not be moved without help.
- Adjustments must not be made near a moving cutter.
- The cutter must be stopped to check the work and clear away metal waste.
- Chips shall be removed with a brush, not the hand. Air hoses shall not be used to clean the machine.
- Before any cleaning work is carried out, the machine must be isolated from the power supply.
- Before changing a work piece, the milling fixture, the vise or the clamp must be withdrawn well clear of the cutting area.
- Sharp edges shall be removed from completed work.

2.14 Horizontal Cut-off Saw Safety Guidelines

- Correct speed must be used.
- The blade must be eased into the work piece.
- Care must be taken not the drop the saw frame.
- The cut-off piece must be handled carefully, due to the sharp edges and corners present.

2.15 Shaper Safety Guidelines

- The guards must not be adjusted during machine operation.
- Deep cuts should be avoided.
- The spindle shall be brought up to operating speed slowly, by applying power in a series of short starts and stops.
- Knives and grooves in the collars must fit perfectly and be free of dust.
- Knife must not be used once it’s so short that its butt end does not extend beyond the middle point of the collar.
- The two knives must balance perfectly.
- Direction of the cut must be made in the opposite direction of the rotation of the cutting head.
- Hold down-push blocks or jigs shall be used when shaping narrow stock.

- Long handled brush shall be used to remove chips and scraps from the worktable.

2.16 Shears Safety Guidelines

- Before the machine is used, all cuttings and scrap from the shear table and the surrounding area shall be removed.
- Users shall avoid touching knife edges when taking measurements.
- The shear table shall be kept free of loose tools and materials.
- Safety guards shall not be removed or tampered with.
- When clamping, the user shall keep the other hand away from hold down.
- Only the persons operating the machinery shall be in close proximity of the shears.
- Leather gloves should be worn when handling sheet metal.
- Scraps shall be removed promptly and deposited in the appropriate scrap bin.
- Shears must only be used to cut materials specified in the manufacturer's instructions.

2.17 Bending Brake Safety Guidelines

- Machine capacity must not be exceeded.
- Leather gloves should be worn when handling sheet metal.
- Operator’s hands must be located at a safe distance from the point of operation.
- Only the persons operating the machinery shall be in close proximity.

2.18 Casting Safety Guidelines

- Wear leather shoes preferably
- Always stand when casting. Wear long a long sleeve shirt, long pants, and a shop apron. Wear safety glasses or goggles, and work gloves.
- Cast in a well-ventilated area, with fan forced air flow if necessary, separated from normal household confusion and distractions
- Place the furnace on a solid bench, away from any combust able items where you have adequate room for a bullet drop cloth and casting accessories without having to turn your back or step away.

- Drinks and liquids of any kind should be at least 10 feet away, never close to the molten lead.
- Never leave the work shop or area with the melting furnace on.

2.19 Electrical Safety in the Workshop

- Know the location of electrical panels and disconnect switches in or near your laboratory so that power can be quickly shut down in the event of a fire or electrical accident. to enhance safety, post the location of the electrical panel on the equipment it services.
- Never obstruct electrical panels and disconnect switches. these should be clearly labeled to indicate what equipment or power source they control. a minimum 3-foot clearance must be maintained around electrical panels at all times to permit ready and safe operation and maintenance of such equipment.
- Do not overload circuits or wiring. overloading can lead to overheated wires and arcing, which can cause fires and electrical shock injuries.
- Inspect all electrical equipment (hot plates, stirrers, ovens, extension cords, etc.) before use to ensure that cords and plugs are in good condition—not worn, twisted, frayed, abraded, corroded, or with exposed wires or missing ground pins. live parts must be effectively insulated or physically guarded. equipment with damaged or defective cords or plugs should be taken out of service immediately and repaired by qualified personnel.
- Ensure that all electrical outlets have a grounding connection requiring a three-pronged plug. all electrical equipment should have three-pronged, grounded plugs or be double-insulated.
- Electrical outlets, wiring, and other electrical equipment integral to the building may only be serviced and repaired by facilities operations qualified trades personnel or other qualified electricians.
- Work on electrical equipment must be done only after the power has been disconnected. on cord and plug connected equipment, the power cord must be unplugged and under the exclusive control of the person performing the work so that the equipment cannot be accidentally turned on by someone else. on hard-wired equipment, the main disconnect device or circuit breaker must be shut off and locked and tagged with a special padlock and tag. service and/or repair work on hard-wired equipment may

only be carried out by authorized individuals who have received lockout/tag out training.

- Limit the use of extension cords—they are for temporary, short-term use only. In all other cases, request the installation of a new electrical outlet.
- Do not use extension cords as substitution for fixed receptacle outlets. The long-term use of multi-outlet power strips is also illegal, except for use with computer equipment.
- Ensure that all extension cords used are carefully placed, visible, and not subject to damage. Cords must not run across aisles or corridors where they might be damaged or create a tripping hazard. Cords must not run through doors, walls or partitions, under rugs, or above dropped ceilings. They must not be tied in knots, draped overhead, or attached to walls.
- Keep corrosive chemicals and organic solvents away from electrical cord these can easily erode the insulation on wires.
- Keep flammable materials away from electrical equipment.
- Keep electrical equipment away from wet or damp locations or potential water spillage, unless specifically rated for use under such conditions.
- Never handle electrical equipment when hands, feet, or body are wet or perspiring or when standing on a wet floor.
- In the event of an electrical fire, leave the area, **call 998**, and pull the nearest fire alarm. Do not use water on an electrical fire. The appropriate fire extinguisher is labeled **"C"** or **"ABC".** If safe and possible, shut down the main power source.
- In an electrical emergency, if a person received an electrical shock, do not touch the equipment, cord or person. **Call 998** so that the Fire Department can treat the injured person and evaluate the situation. If safe and possible, shut down the main power source.

2.20 Guidelines for Cleaning

- Turn off power to the machine before cleaning. This will avoid accidentally starting the machine and injuring yourself.
- Remove cutting tools. Take out drill bits, mills and remove lathe tools to reduce the chances of getting cut. On the table saw lower the blade completely.
- Put away all hand tools and other items around the tool so that you don't make them dirtier.

- Clean chips from the tool, the chip pans. Recycle clean chips where possible.
- Put a light coat of way oil on the machine ways. Ask staff to show you where this oil is kept.
- Sweep the floor in the area where you have been working.
- Do not over use compressed air. Do not blow air into the bearing surfaces, and do not scatter chips all over the shop. Sometimes a shop vacuum works better than the air gun.
- Report missing, broken or damaged tools to shop staff.
- Spend five minutes on general cleaning around the shop. We're all in this together.

Chapter-3

Safety Management in Welding Lab

3.1 Information About Welding Laboratory

The welding lab contains different welding equipment for training the students with welding technologies including: gas welding and cutting, electric arc welding (SMAW), Tungsten Inert Gas (TIG), Metal Inert Gas (MIG), Plasma welding, and Spot welding. The lab is also used in the graduation projects related to certain welding operations or studying an advanced welding process, and also in research work in the field of welding.

3.2 Welding Laboratory Machines

- Electric Arc Welding machine

Figure 3.1

- Tungsten Metal Arc Welding (TIG) machine

Figure 3.2

- Gas Metal Arc Welding (MIG) machine:

Figure 3.3

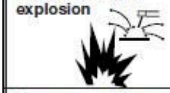
- Spot Welding machine

Figure 3.4

- Gas Welding with Oxy-Acetylene Equipment

Figure 3.5

3.3 Welding Safety Checklist

WELDING SAFETY CHECKLIST		
HAZARD	**FACTORS TO CONSIDER**	**PRECAUTION SUMMARY**
Electric shock can kill 	• **Wetness** • **Welder in or on workpiece** • **Confined space** • **Electrode holder and cable insulation**	• Insulate welder from workpiece and ground using *dry* insulation. Rubber mat or dry wood. • Wear *dry, hole-free* gloves. (Change as necessary to keep dry.) • Do not touch electrically "hot" parts or electrode with bare skin or wet clothing. • If wet area and welder cannot be insulated from workpiece with dry insulation, use a semiautomatic, constant-voltage welder or stick welder with voltage reducing device. • Keep electrode holder and cable insulation in good condition. Do not use if insulation damaged or missing.
Fumes and gases can be dangerous 	• **Confined area** • **Positioning of welder's head** • **Lack of general ventilation** • **Electrode types, i.e., manganese, chromium, etc. See MSDS** • **Base metal coatings, galvanize, paint**	• Use ventilation or exhaust to keep air breathing zone clear, comfortable. • Use helmet and positioning of head to minimize fume in breathing zone. • Read warnings on electrode container and material safety data sheet (MSDS) for electrode. • Provide additional ventilation/exhaust where special ventilation requirements exist. • Use special care when welding in a confined area. • Do not weld unless ventilation is adequate.
Welding sparks can cause fire or explosion 	• **Containers which have held combustibles** • **Flammable materials**	• Do not weld on containers which have held combustible materials (unless strict AWS F4.1 procedures are followed). Check before welding. • Remove flammable materials from welding area or shield from sparks, heat. • Keep a fire watch in area during and after welding. • Keep a fire extinguisher in the welding area. • Wear fire retardant clothing and hat. Use earplugs when welding overhead.
Arc rays can burn eyes and skin 	• **Process: gas-shielded arc most severe**	• Select a filter lens which is comfortable for you while welding. • Always use helmet when welding. • Provide non-flammable shielding to protect others. • Wear clothing which protects skin while welding.
Confined space 	• **Metal enclosure** • **Wetness** • **Restricted entry** • **Heavier than air gas** • **Welder inside or on workpiece**	• Carefully evaluate adequacy of ventilation especially where electrode requires special ventilation or where gas may displace breathing air. • If basic electric shock precautions cannot be followed to insulate welder from work and electrode, use semiautomatic, constant-voltage equipment with cold electrode or stick welder with voltage reducing device. • Provide welder helper and method of welder retrieval from outside enclosure.
General work area hazards 	• **Cluttered area**	• Keep cables, materials, tools neatly organized.
	• **Indirect work (welding ground) connection**	• Connect work cable as close as possible to area where welding is being performed. Do *not* allow alternate circuits through scaffold cables, hoist chains, ground leads.
	• **Electrical equipment**	• Use only double insulated or properly grounded equipment. • Always disconnect power to equipment before servicing.
	• **Engine-driven equipment**	• Use in only open, well ventilated areas. • Keep enclosure complete and guards in place. • See Lincoln service shop if guards are missing. • Refuel with engine off. • If using auxiliary power, OSHA may require GFI protection or assured grounding program (or isolated windings if less than 5KW).
	• **Gas cylinders**	• Never touch cylinder with the electrode. • Never lift a machine with cylinder attached. • Keep cylinder upright and chained to support.

3.4 Welding and Cutting Safety

- Proper eye protection must be worn while using the torch.
- Leather gloves, full length work pants, and a shirt with sleeves shall be worn while welding.
- Welding and cutting operations shall be conducted in a designated area free from flammable materials.
- Welding and cutting areas shall be periodically checked for combustible atmospheres.
- Gas cylinders shall never by stricken, rolled or exposed to extreme heat.
- The cylinders shall be stored and secured upright at all times.
- The unused gas cylinders from the welding and cutting area.
- The cylinders shall be isolated from other flammable materials.
- Hoses shall be kept out of doorways and away from other people. If a hose has a break or a puncture, it must not be used.
- The torch tips shall be kept clean of grease, oil and slag.
- Proper fitting wrenches shall be used when making connections. Vise grips or pipe wrenches shall not be used.
- Reverse flow check valve shall be installed.
- All portable welding equipment must be properly grounded.
- All equipment shall be checked prior to use.
- Proper regulator for the gas being used must be used.
- When opening the cylinder valve, the operator shall stand to the side of the regulator.
- The oxygen hose shall not be used to blow off clothing.
- The burning shall not be done directly on a concrete floor.
- The torch has to be pointed away from the operator and other people at all times.
- Workers doing oxyacetylene work shall not carry butane lighters.
- When welding in confined space, adequate ventilation must be present.
- When electric arc welding, the ground shall be dry and the cables shall be in good conditions and properly connected.
- When electric arc welding, screens and shielding shall be erected to protect nearby people.
- Electrodes shall be removed from electrode holder when not in use.
- Adequate ventilation shall be provided during electric arc welding.

Chapter-4

Safety Management in Mechanical Vibrations Lab

4.1 Information About Mechanical Vibrations Laboratory

Vibrations occur in a variety of ways in engineering. While they are desirable in vibrating screens or vibrating conveyors, they are often unwanted in engines or other rotating machines. This Lab is equipped with TM 155 experimental unit from GUNT. It clearly demonstrates the fundamentals needed to deal with free and forced vibrations. The differences between the two main types of excitation for forced vibrations can be shown on a simple vibration model.

The Lab is also equipped with PT 500 unit from GUNT for Machine Fault diagnosis. It permits vibration measuring exercises (measurement of vibration displacement, velocity and acceleration in the time/frequency range). Field balancing of rigid rotors and alignment of shafts can also be practiced.

4.2 Mechanical Vibrations Laboratory Machines

- Universal Vibration System (TM 150)

Figure 4.1

- Machinery Diagnostic System, Base Unit (PT 500)

Figure 4.2

4.3 Mechanical Vibration Laboratory Safety

4.3.1 Housekeeping

- Stay in your assigned section during the laboratory period. Do not sit in the aisles or on the benches.
- Do not perform any lab work until you have been briefed.
  All unauthorized experiments are expressly forbidden.
- Do not enter instructor stations or the Stockroom unless asked to do so by the staff.
- Do not move or try to repair instruments. Report malfunctioning equipment to your instructor at once.

4.3.2 Instrument Room

The instrument room is a community area, its housekeeping is as important as at individual bench top areas.

4.3.3 Drawers and Bench Tops

Maintain general order and cleanliness in all parts of these areas, equipment must be kept clean, and intact.

4.3.4 Fire Extinguishers

For a small fire incident, a portable fire extinguisher is a very valuable piece of equipment. Tags on the extinguishers must be checked to verify that they have been inspected within the past twelve months. If they are overdue for inspection, notify your instructor at once.

Chapter-5

Safety Management in Automatic Control Lab

5.1 Information About Automatic Control Laboratory

Automatic control has played a vital role in the advancement of engineering and science. It is an important and integral part of manufacturing and industrial processes. For instance, automatic control is essential in such industrial operations as controlling pressure, temperature, humidity, viscosity, and flow in the process industries. The automatic control course at Um Al-Qura University introduces the students to the theory of automatic control providing means for attaining optimal performance of dynamic systems and improving productivity.

Gaining the practical experience of automatic control comes from direct applications of the automatic control theory. This can be achieved from different practical training modules in the Control lab. Automatic control lab offers every opportunity to learn the fundamentals of control engineering through experimentation on a flow control **RT020**, level control **RT010**, pressure control **RT030**, speed control **RT050** and position control **RT060** systems from **GUNT**.

5.2 Automatic Control Laboratory Machines

- Level Control Hood Inflation System (GUNT RT 010)

Figure 5.1

- Flow Control HIS (GUNT RT 020)

Figure 5.2

- Pressure Control HIS (GUNT RT 030)

Figure 5.3

- Speed Control HIS (GUNT RT 050)

Figure 5.4

- Position Control HIS (GUNT RT 060)

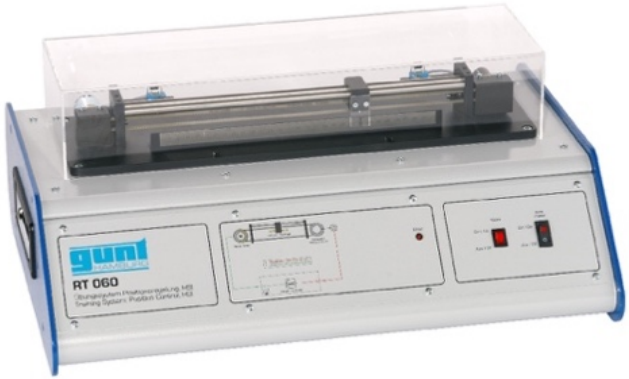


Figure 5.5

5.3 Automatic Control Laboratory Safety

5.3.1 Equipment Safety

- Before using an instrument or machine, be sure to know how to turn it off in case of emergency.
- Check all electrical connections and mounting bolts before each use.
- Check that all parts of the machine are free to turn, and that there is no mechanical obstruction before operating.
- Maintain a work space clear of extraneous material such as books, papers and clothes.

5.3.2 Electrical Safety

- Never change wiring with circuit plugged into power source.
- Avoid contacting circuits with wet hands or wet materials.
- Check circuits for proper grounding with respect to the power source.
- Keep the use of extension cords to minimum and cords as short as possible.
- Make sure to turn off the power source before unplugging.
- Beware of faulty electrical equipment/instrumentation or wiring.

5.3.3 General Safety and Cleanliness

- Keep bench tops and labs clean and organized.
- Keep drawers and cabinets closed.
- Return tools, glassware, and other general use items to proper storage areas when you’re done with them.

Chapter-6

Safety Management in CAD-CAM Lab

6.1 Information About CAD-CAM Laboratory

The lab is designed and equipped to be employed in introducing different courses such as CNC – CAM – FMS – Robot – Handling – Automation. The lab contains the following facilities:
Bench CAD CAM lathe machine (Emco compact 5) – VMC (Denford TRIAC) – Computer local network consists of master computer and 10 slaves – FMS cell consists of one VMC, one CNC lathe, 5 axis Mitsubishi robot, and 5 stations for inspection sorting and inventory connected together with a conveyor. The lab also equipped with CAM software MASTERCAM V3.

6.2 CAD-CAM Laboratory Machines

- Flexible Manufacturing system (FMS50)

Figure 6.1

- CNC Milling machine (TRIAC VMC)

Figure 6.2

- 3D Printer (Ultimaker 2)

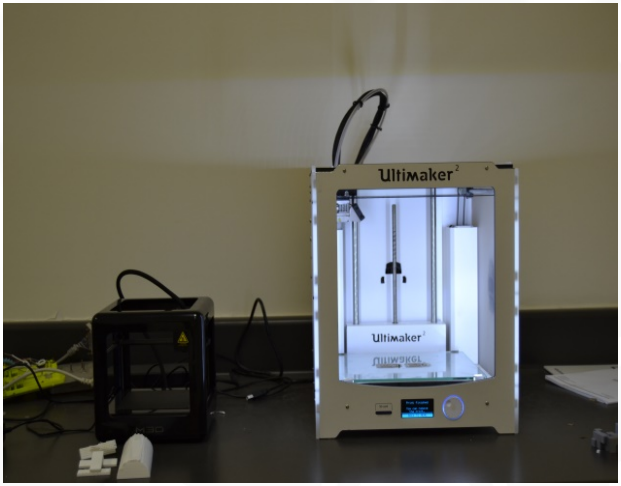


Figure 6.3

6.3 CNC Laboratory Safety

6.3.1 General Safety Rules

- Never operate a CNC machine without proper training or consulting the specific operator's manual for that particular machine and control type.
- Never attempt to program a CNC machine without proper training or consulting the specific programmer's manual for that particular machine and control type.

6.3.2 CNC Machine Safety System:

The built-in safety system on a CNC machine includes guards and protective devices which should be securely fitted and always kept in position while the machine is being used. It may include:

- Emergency stop button.
- Curtain guards.
- Guard fence.
- Contact mats.

6.3.3 Machine Safety Rules

- Always keep the area around the machine clear of obstacles.
- Always stack material where you can reach it but where it is clear of the moving parts of the machine.
- Always check that tools are set correctly.
- Always make sure that all guards are in position while the machine is in operation.
- Always make sure that all work and fixtures are clamped securely before starting machine.
- Do not use the machine table as a workbench.
- Do not use the compressed air to blow chips from the parts of the machine, machine surfaces, cabinets, controls or floor around the machine.

6.3.4 Personal Safety Rules

- Always wear safety glasses and hearing protection when operating CNC machines.
- Always wear safety glasses when closely observing cutting tools.
- Always keep long hair covered when operating CNC machines.
- Always keep hands clear of moving parts during machining operations.
- Always turn the CNC machine off completely and clean it up when you have finished using it.
- Never wear loose clothing or jewelry.
- Never reach into a CNC machine while it is running.

Chapter-7

Safety Management in Measurements Lab

7.1 Information About Measurements Laboratory

This lab has the ability for the dimensional measurements with accuracy up to 1-micron, angular measurements with accuracy up to 5 minutes and form measurements such as roundness straightness and flatness. Roughness measurements are also conducted.

The lab has the following facilities:

Block gauges – angle block gauge – limit gauges – calipers – micrometers – dial indicators – protractors – sensitive levels – bore gauges – clinometers – sine bar – talysurf – talyrond – surtronic+4 – minidekker – surface roughness in 2D and 3D.

7.2 Measurements Laboratory Machines and Equipment

- Vernier Caliper

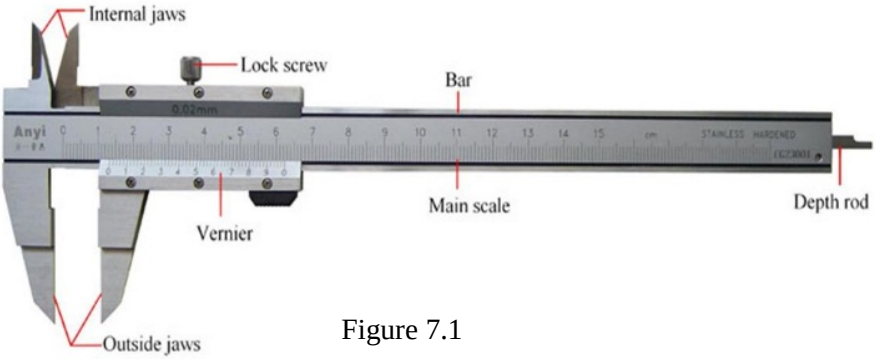


Figure 7.1

7.2.1 Vernier Caliper Safety Instructions

- Make sure the instrument is clean and make sure it works.
- Check for Zero error and Parallax error.
- The work piece should not be clamped in the caliper jaws and waved in air.

- Micrometer

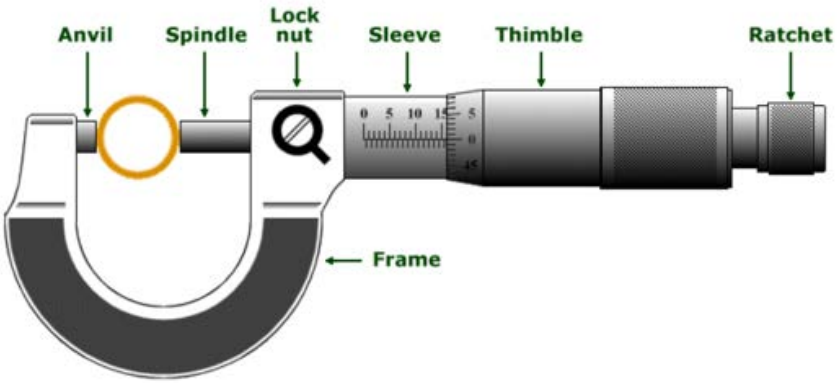


Figure 7.2

7.2.2 Micrometer Safety Instructions

- Maintain micrometer in good and clean condition for best and safest performance.
- Maintain correct balance and footing. Ensure the floor is not slippery and wear non-slip shoes.
- Do not use the micrometer for any purpose other than for which it is designed.
- The micrometer is a precision instrument, treat with care, avoid using force and do not subject to knocks or shocks.

- Snap Gauges

Figure 7.3

- Plug Gauges

Figure 7.4

- Block Gauges

Figure 7.5

7.2.3 Gauges Safety Instructions

- Do not use gauges for any other purpose than inspection.
- As a gauge has a sharp portion to satisfy requirements for its function, concern avoiding injury.
- Do not bring it close to fire.

- Coordinate Measuring Machine (Ely Millennium CMM)

Figure 7.6

- Surface Finish and Contour Measurement machine (Form Talysurf i60)

Figure 7.7

- Roundness Measuring machine (Talyrond 31)

Figure 7.8

- Micro Hardness Tester machine (ZHV30)

Figure 7.9

7.3 Measurement Laboratory Safety

7.3.1 General Safety Rules

- Never do unauthorized experiments.
- Do not leave an on-going experiment unattended.
- Always inform your instructor if there's failure in an experiment, or if the machine isn't acting properly.
- Keep your space clean and organized.
- Do not touch or use anything you are not familiar with.
- Read and understand all aspects of safety before using any equipment.
- Use the required personnel protective equipment (PPE) in laboratory work.

7.3.2 Equipment Safety

- Before using an instrument or machine, be sure to know how to turn it off in case of emergency.
- Check all electrical connections and mounting bolts before each use.
- Check that all parts of the machine are free to turn, and that there is no mechanical obstruction before operating.
- Maintain a work space clear of extraneous material such as books, papers and clothes.

Chapter-8

Safety Management in Materials Science Lab

8.1 Information About Materials Science Laboratory

This lab is used in the experiments of the materials science course to introduce the materials characteristics and its elements. The lab contains microscopic examinations and specimens' preparations (polishing and etching operations). The lab is used in the graduation projects related to material science.

8.2 Materials Science Machines

- Grinding/Polishing machine (UNIPOL-1210)

Figure 8.1

8.3 Materials Science Laboratory Safety

8.3.1 General Safety Rules

- In order to ensure your safety in research labs, wear proper protective equipment at all times.
- Safety glasses are required for eye protection inside the laboratory.
- Wearing proper protective clothing protects you from splashes and spills in the lab. Proper attire includes a lab coat, gloves, closed-toed shoes and long pants.

8.3.2 Housekeeping

- Work areas need to be kept clean and free from obstructions.
- Keep laboratory benches clear of bottles, because of their propensity to be knocked over.
- Chemicals stored in the laboratory should be inventoried periodically, and unneeded items should be disposed of.

8.3.3 General Safety and Cleanliness

- Keep bench tops and labs clean and organized.
- Keep drawers and cabinets closed.
- Return tools, glassware, and other general use items to proper storage areas when you're done with them.

Chapter-9

Safety Management in Material Testing Lab

9.1 Information About Material Testing Laboratory

This lab is used in the determining the mechanical properties of the materials. In this lab mechanical tests are conducted such as tension, compression, hardness, bending, and impact. Materials testing is a well-established technique used to determine the physical and mechanical properties of raw materials and components from a human hair to steel, composite materials and ceramics.

9.2 Material Testing Machines

- Universal Hardness Tester

Figure 9.1

- Charpy Impact Tester

Figure 9.2

- Fatigue Tester

Figure 9.3

- (Zwick Roell) Compression/Tensile Tester

Figure 9.4

9.4 Material Testing Laboratory Safety

9.4.1 General Safety Rules

- In order to ensure your safety in research labs, wear proper protective equipment at all times.
- Safety glasses are required for eye protection inside the laboratory.
- Wearing proper protective clothing protects you from splashes and spills in the lab.
- Proper attire includes a lab coat, gloves, closed-toed shoes and long pants.
- Never eat, drink, or smoke while working in the laboratory.
- Wash hands before leaving the lab and before eating.

9.4.2 Housekeeping

- Work areas need to be kept clean and free from obstructions.
- Keep laboratory benches clear of bottles, because of their propensity to be knocked over.
- Chemicals stored in the laboratory should be inventoried periodically, and unneeded items should be disposed of.

9.4.3 Laboratory Equipment Safety

- Follow all safety instructions given in the class and in the laboratories.
- Charpy machine can be lethal. Never leave the hammer in the up position until ready to break a specimen.
- Tensile Testing. During the tensile test pieces can fly out during fracture. Use safety eye shield when grinding specimens.
- Do not remove specimens from abrasive cut-off machine until the wheel has stopped.
- Hand protection should be utilized when inserting glass tubing into stoppers or when placing rubber tubing on glass hose connections.
- The ordinary household refrigerator is not equipped with explosion-safe controls or door switches and should not be used.

Chapter-10

Safety Management in Refrigeration &Air-Conditioning Lab

10.1 Information About Refrigeration &Air-Conditioning Laboratory

The Main goal aspect of this Lab. is to give the students an overall background on the components of 6 running experiments on "Refrigeration and Air-Conditioning" systems, including: Determination of the coefficient of performance, cooling and heating loads, rates of humidification and dehumidification of Refrigeration and Air-Conditioning systems.

Figure 10.1 General view of the Lab.

Figure 10.2 Different refrigeration component cross-sections demo units.

Figure 10.3 Experimental refrigeration multi-pressure vapor compression system.

Figure 10.4 Industrial training recirculating air-Conditioning unit.

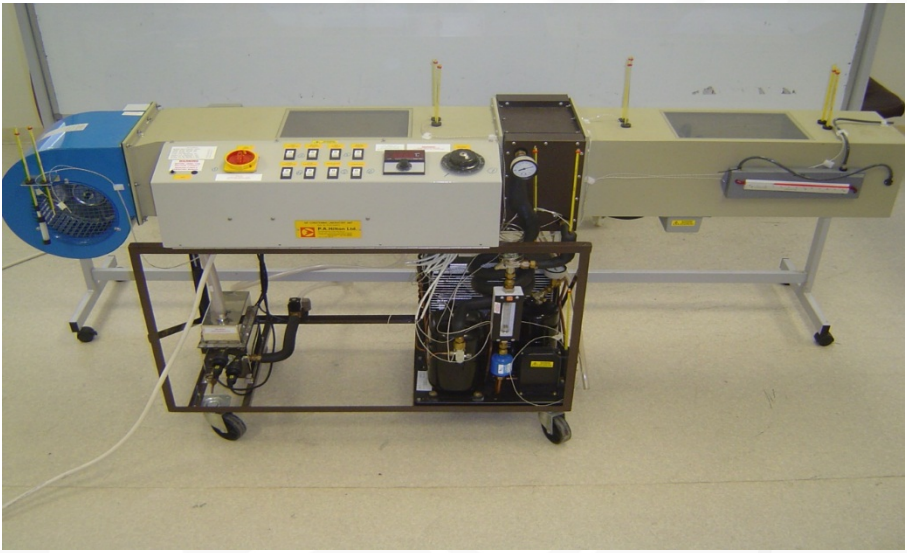


Figure 10.5 Experimental one-through air-Conditioning unit.

Figure 10.6 Experimental wet air-cooling tower for AC simulation.

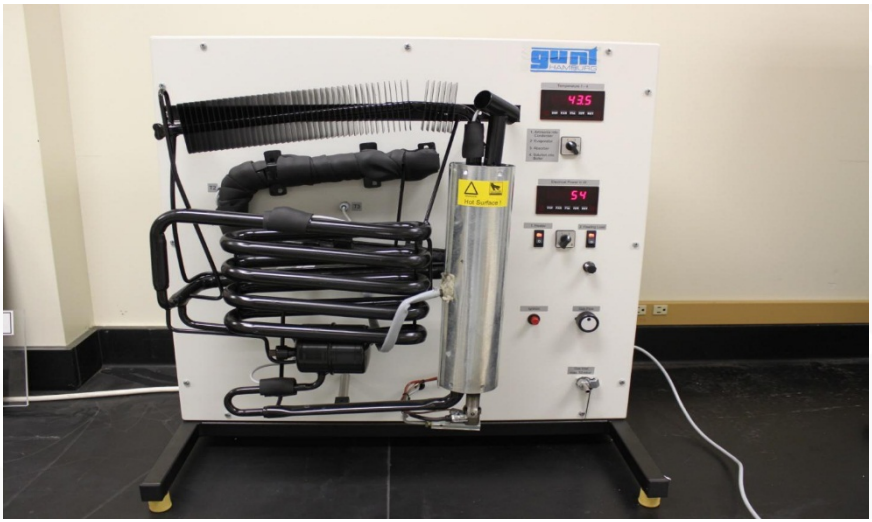


Figure 10.7 Experimental absorption system, using a mixture of ammonia/water/hydrogen solution, with natural circulation.

Figure 10.8 Experimental steam-jet refrigeration system.

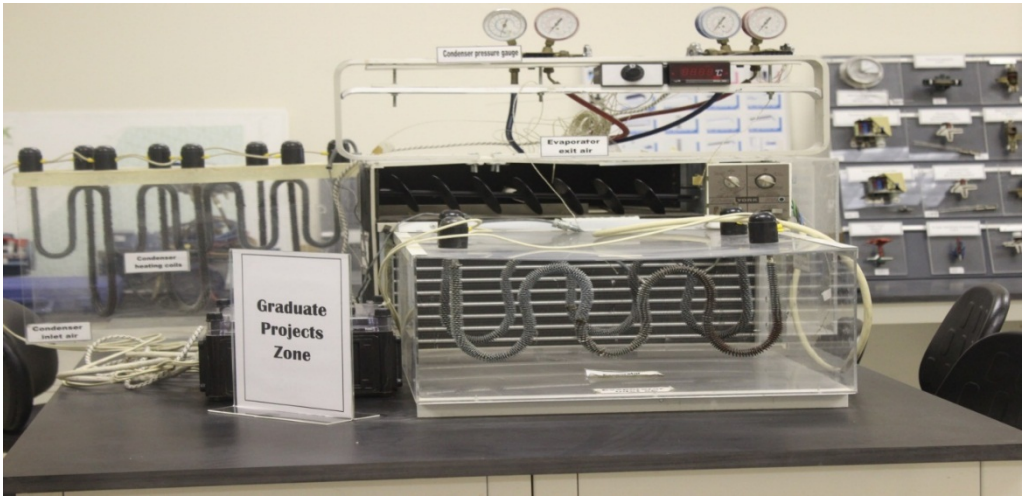


Figure 10.9 Sample of "Graduate Projects" installed in the Lab (Limited zone).

10.2 Safety Regulations

Fire alarm &Firefighting system

- Automatic-sensed &well installed and tested, beside 2 handy activated powder fire-extinguishers.

Means of Evacuation

- 2 emergency doors available (1 and 2meters width).

Hygiene, Housekeeping &Storage

- No chemicals are used, daily disposal of wastes, with available hands washing facility.

First-aid Boxes

- Available, but have to be monitored regularly for health validity.

Ventilation

- No needs of ventilation, as air-conditioning is sufficient.

Electrical Connections& Circuit Breakers Boards

- Different transformers (110/220Volt) are used with care to disassemble the cables after finishing such experiment, while protected breakers are used.

Lighting System

- Regular replacement of unlighted lamps is a must.

Safety Working Signs &Labelling

- All apparatus is labelled during the present study, with reference safety signs.

Chapter-11

Safety Management in Heat Transfer Lab

11.1 Information about Heat Transfer Laboratory

To develop experiments in the field of heat transfer and measurements the heat transfer laboratory was established. The lab contains experiments about the heat conduction, convection and radiation measurements, as well as about the heat transfer applications such as heat exchangers and furnaces. Moreover, there are measurements of the material thermal properties. The temperature measurements by different methods are also considered in the lab. The facilities in the lab are qualified for 5 experiments, while 4 are missing their software and must be replaced by new recent units (marked under the concerning figures).

Figure 11.1 General view of the Heat Transfer Lab.

Figure 11.2 Experimental thermal radiation measurement unit.

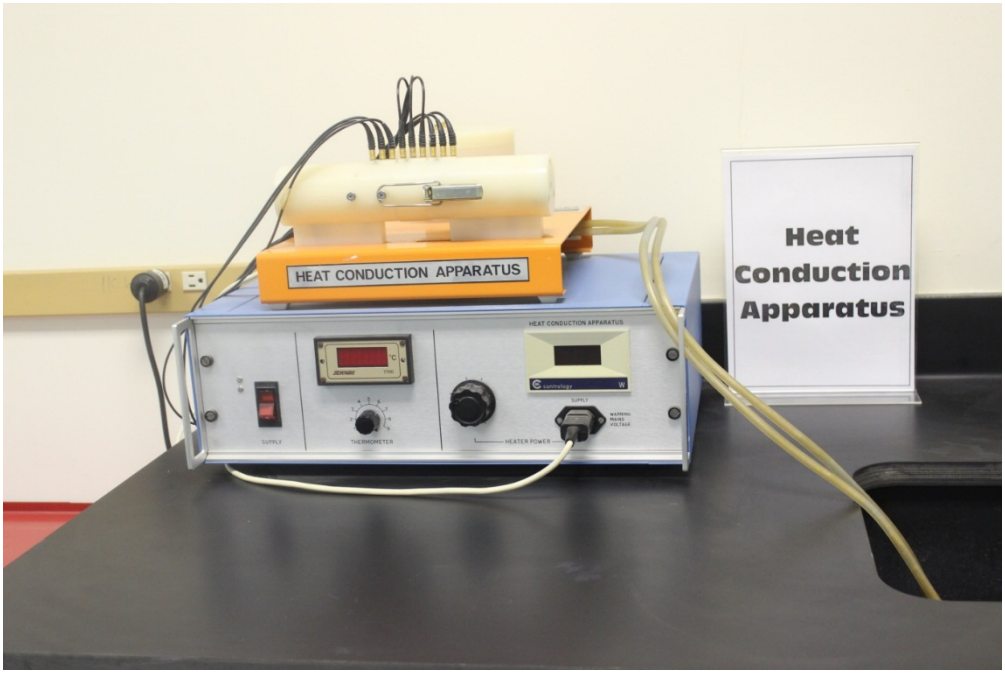


Figure 11.3 Experimental heat conduction measurement unit.

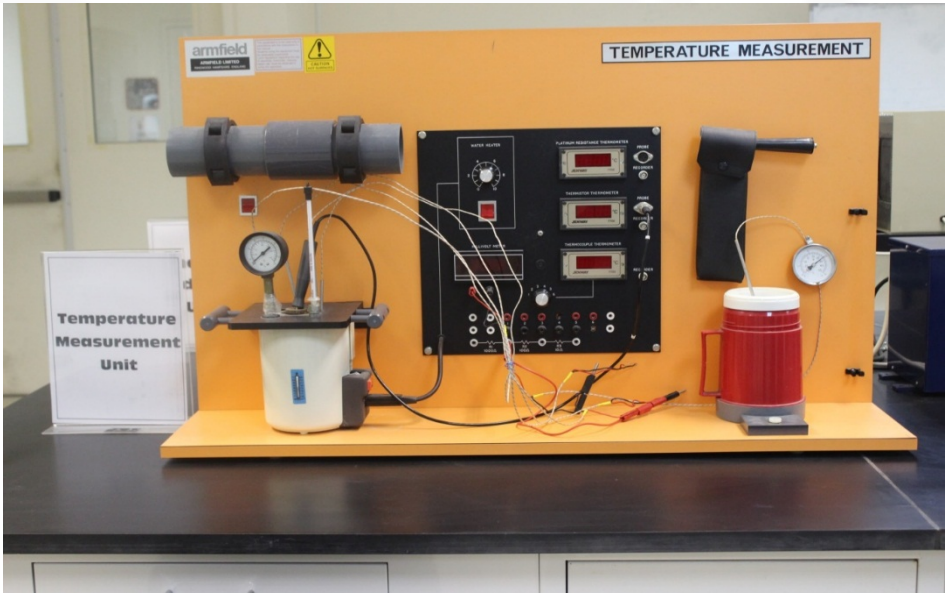


Figure 11.4 Experimental temperature measurement using different methods.

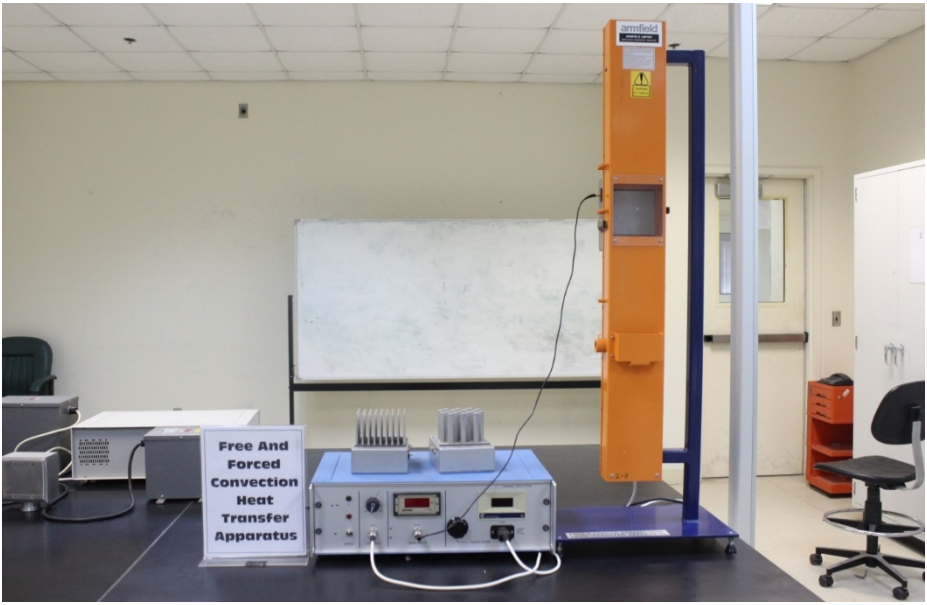


Figure 11.5 Free& forced convective heat transfer unit at different geometries (flat plate, cylinder, tube bundle).

Figure 11.6 Experimental "water heat-exchanger" effectiveness study unit, including "refrigeration unit" for controlled cooling-water system.

Figure 11.7 (a) Film &drops condensation heat transfer unit (forced water circulation is missed, stopped running) (b) Boiling heat transfer unit

Figure 11.8 Measurement of building materials thermal conductivity unit

Figure 11.9 Cross flow heat exchanger study unit

11.2 Safety Regulations

Fire alarm &Firefighting system

- Automatic-sensed &well installed and tested, beside 2 handy activated powder fire-extinguishers.

Means of Evacuation

- 2 emergency doors available (1 and 2meters width).

Hygiene, Housekeeping &Storage

- No chemicals are used, daily disposal of wastes, with available hands washing facility.

First-aid Boxes

- Available, but have to be monitored regularly for health validity.

Ventilation

- No needs of ventilation, as air-conditioning is sufficient.

Electrical Connections& Circuit Breakers Boards

- Different transformers (110/220Volt) are used with care to disassemble the cables after finishing such experiment, while protected breakers are used.

Lighting System

- Regular replacement of unlighted lamps is a must.

Safety Working Signs &Labelling

- All apparatus is labelled during the present study, with reference safety signs.

Chapter-12

Safety Management in Fluid Mechanics Lab

12.1 Information about Fluid Mechanics Laboratory

The lab is used to introduce the principles and types of incompressible fluids flow, and the measurements of pressure, velocity, and flow rate, also, the friction in pipes and its advantages to flow and the forces resulting in the static fluids. The lab can participate in the post graduate researches after developing it with specialized equipment.

Figure 12.1 General view of the "fluid mechanics lab", as the biggest one.

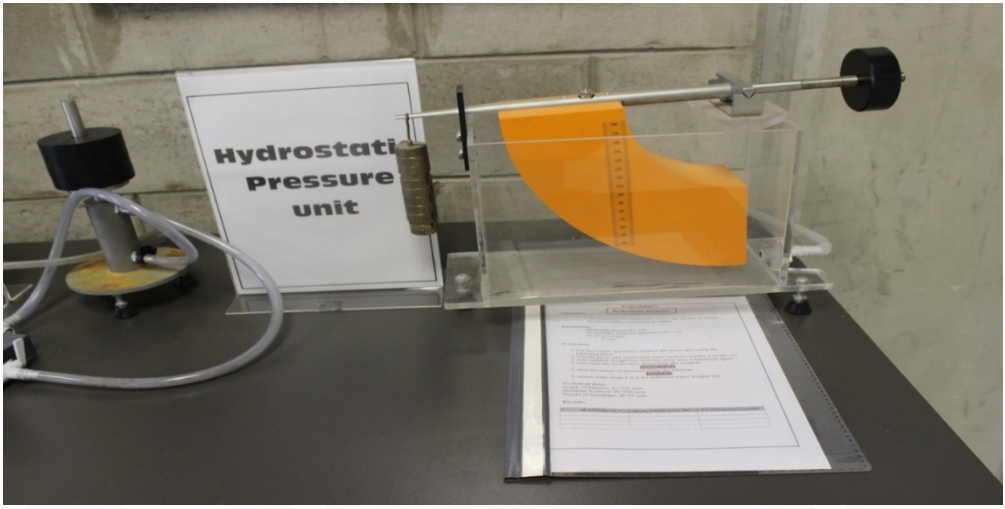


Figure 12.2 Hydrostatic pressure apparatus (floating phenomena).

Figure 12.3 Dead weight apparatus (used for manometers calibration).

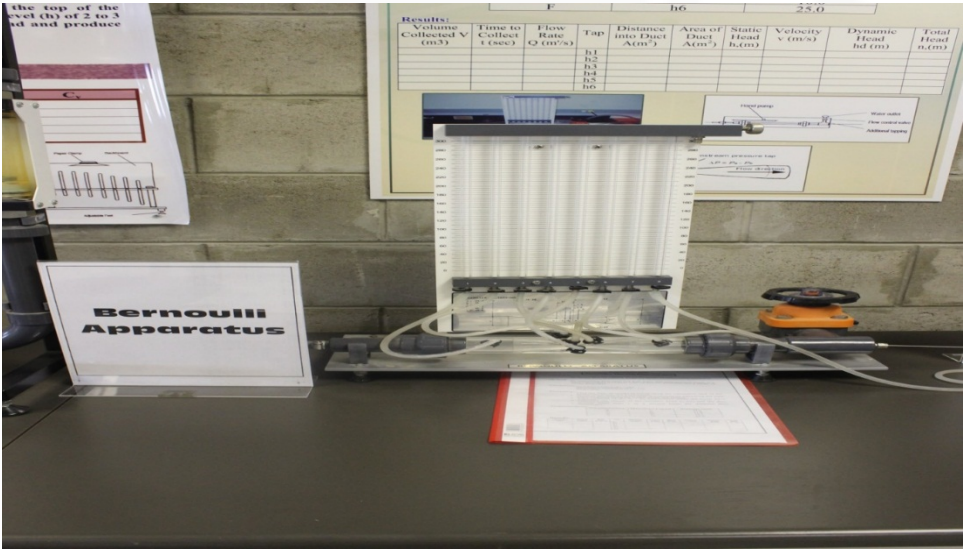


Figure 12.4 Bernoulli apparatus (controlled open flow system calibration).

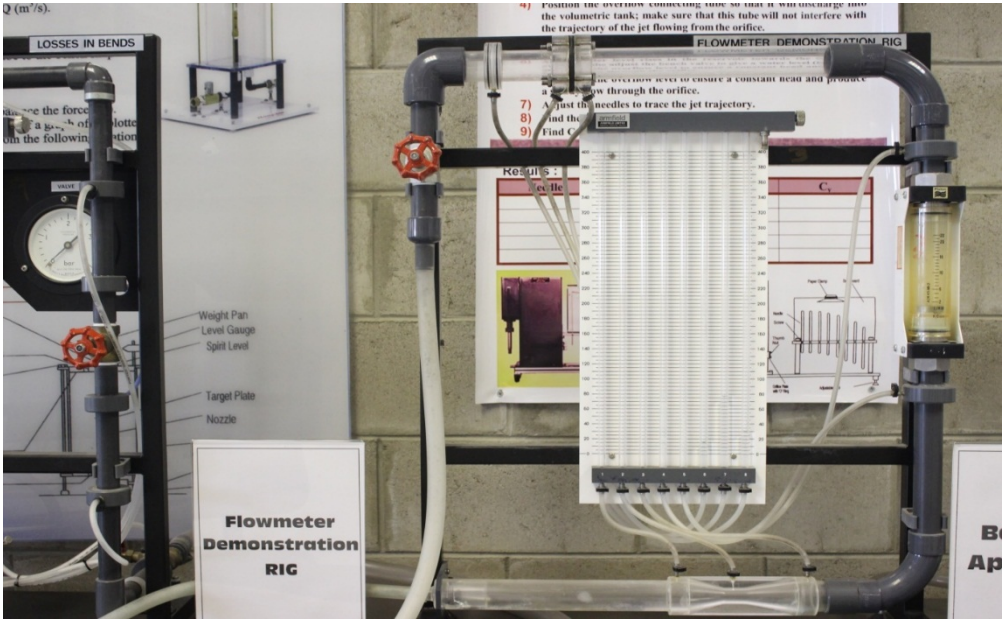


Figure 12.5 Different water flow-meters calibration test-rig.

Figure 12.6 Test-rig of measuring the pressure loss in bends &valves.

Figure 12.7 Friction loss measurement through pipes, using main circulation water tanks.

Figure 12.8 (a) Series& parallel water pups test-rig (right-hand), (b) Pelton water turbine characteristics test-rig (middle), and (c) Hydrostatic bench (left-hand).

Figure 12.9 Computerized controlled aerodynamics wind tunnel study unit.

Figure 12.10 Reverse-Osmosis water desalination unit (local department consumption), which can be used as test-rig.

Figure 12.11 Graduate projects zone (@half of the fluid mechanics lab)

12.2 Safety Regulations

Fire alarm &Firefighting system

- Automatic-sensed &well installed and tested, beside 2 handy activated powder fire-extinguishers.

Means of Evacuation

- 2 emergency doors available (1 and 2meters width).

Hygiene, Housekeeping &Storage

- No chemicals are used, daily disposal of wastes, with available hands washing facility.

First-aid Boxes

- Available, but have to be monitored regularly for health validity.

Ventilation

- No needs of ventilation, as air-conditioning is sufficient.

Electrical Connections& Circuit Breakers Boards

- Different transformers (110/220Volt) are used with care to disassemble the cables after finishing such experiment, while protected breakers are used.

Lighting System

- Regular replacement of unlighted lamps is a must.

Safety Working Signs &Labelling

- All apparatus is labelled during the present study, with reference safety signs.

Chapter-13

Safety Management in Combustion Labs

13.1 Information about Combustion Laboratory Sec-1

Set of 3 internal combustion reciprocating engines under various operating conditions. All of the engines in are in un-running conditions.

Figure 13.1 General view of the combustion lab Sec-1(left-side)

Figure 13.2 General view of the combustion lab Sec-1(right-side)

Figure 13.3 Single cylinder petrol engine

Figure 13.4 Four-cylinders petrol engine (left-side) and "6-V" petrol engine (demo)

Figure 13.5 Room for demonstration of Petrol & Diesel cross-section engines parts, and wall panels (right-side).

Figure 13.6 Room for demonstration of Petrol & Diesel cross-section engines parts, and wall panels (left-side).

13.2 Information about Combustion Laboratory Sec-2

This laboratory is focusing on performance evaluation of power generation units (as gas turbine units, including burners &combustion chambers), and steam equipment (as steam boilers &turbines and its accessories which used in power plants).

Figure 13.7 General view of the combustion Lab Sec-2 (right side), showing main experiments zone.

Figure 13.8 Motor side of a wind tunnel occupying about half of the graduate project zone (left- side).

Figure 13.9 Three stopped running equipment need maintenance & resetting: liquid fuel industrial steam boiler (right side), small water heating unit (middle), and burner flame study-unit (left side).

Figure 13.10. Single cylinder variable compression-ratio petrol engine (full computerized and monitored), with extended exhaust gases flexible tubular manifold through the main out-door exit.

13.3 Safety Regulations

Fire alarm &Firefighting system

- Automatic-sensed &well installed and tested, beside 2 handy activated powder fire-extinguishers.

Means of Evacuation

- 2 emergency doors available (1 and 2meters width).

Hygiene, Housekeeping &Storage

- No chemicals are used, daily disposal of wastes, with available hands washing facility.

First-aid Boxes

- Available, but have to be monitored regularly for health validity.

Ventilation

- No needs of ventilation, as air-conditioning is sufficient.

Electrical Connections& Circuit Breakers Boards

- Different transformers (110/220Volt) are used with care to disassemble the cables after finishing such experiment, while protected breakers are used.

Lighting System

- Regular replacement of unlighted lamps is a must.

Safety Working Signs &Labelling

- All apparatus is labelled during the present study, with reference safety signs.

Chapter-14

Safety Management in Solar Energy Lab

14.1 Information about Combustion Laboratory

The main objective of the lab is to give the students an overall background on the thermal and electrical applications of solar energy for domestic and industrial uses. This includes the determination of the feasibility and efficiency of solar engineering systems, like water and air heating, food and wood drying, water desalination, solar ovens, solar concentrators for industrial processes heat and power generation and solar energy storage systems. Construction and systems evaluation of graduate projects are considered in the laboratory.

Figure 14.1 General outside view of the solar energy laboratory (2014).

Figure 14.2 General outside view of the solar energy laboratory in 2017

Figure 14.3 General upside view of the platform of solar energy graduate project zone.

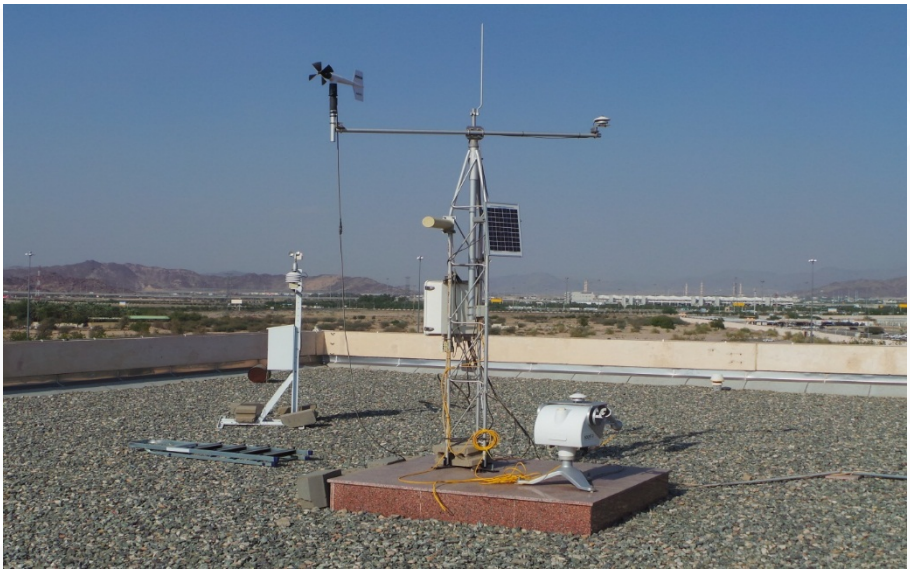


Figure 14.4 Meteorological station, installed on the roof of the solar energy main monitoring room.

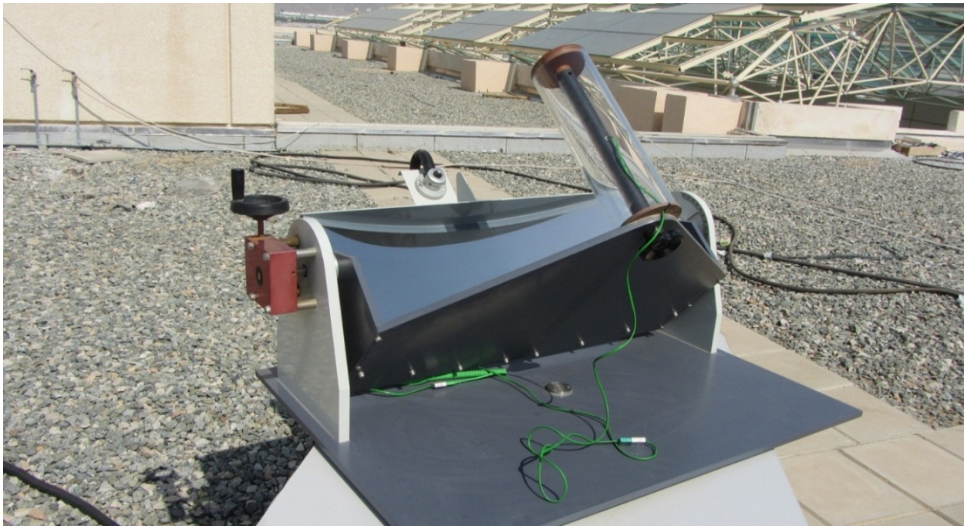


Figure 14.5 Experimental parabolic trough solar concentrator test-rig

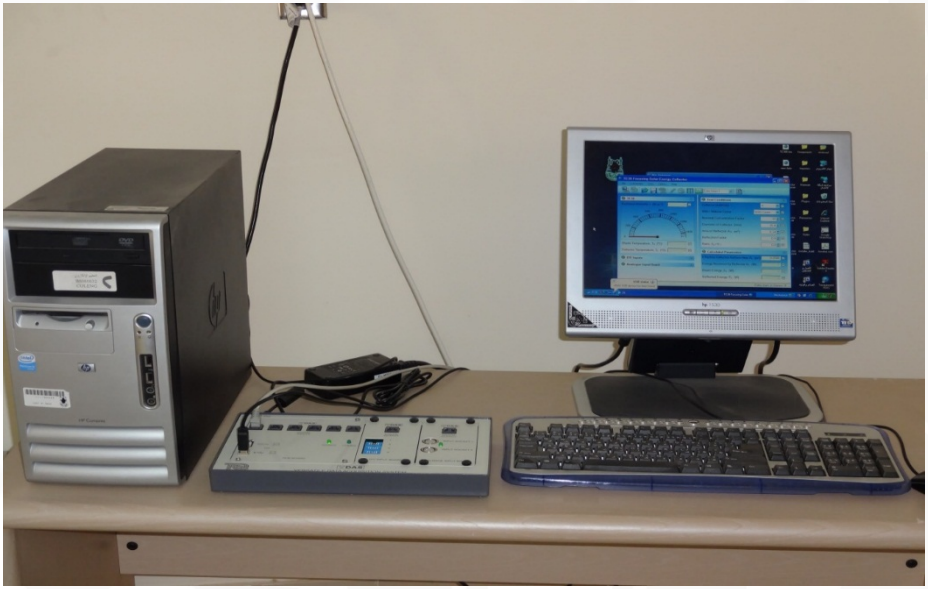


Figure 14.6 Monitoring station of the experimental parabolic trough solar concentrator test-rig, with full tracking for performance study.

Figure 14.7 KACARE meteorological wireless station

Figure 14.8 Main solar tracking & fixed sensors of KACARE meteorological station for measuring global, direct, diffuse, and normal incidence solar radiation intensity.

14.3 Safety Regulations

Fire alarm &Firefighting system

- Automatic-sensed &well installed and tested, beside 2 handy activated powder fire-extinguishers.

Means of Evacuation

- 2 emergency doors available (1 and 2meters width).

Hygiene, Housekeeping &Storage

- No chemicals are used, daily disposal of wastes, with available hands washing facility.

First-aid Boxes

- Available, but have to be monitored regularly for health validity.

Ventilation

- No needs of ventilation, as air-conditioning is sufficient.

Electrical Connections& Circuit Breakers Boards

- Different transformers (110/220Volt) are used with care to disassemble the cables after finishing such experiment, while protected breakers are used.

Lighting System

- Regular replacement of unlighted lamps is a must.

Safety Working Signs &Labelling

- All apparatus is labelled during the present study, with reference safety signs.

Appendix-A

Emergency Evacuation

A.1 Emergency Evacuation

A.1.1 Building

- On hearing the evacuation alarm, immediately prepare to leave the building – secure confidential materials and valuables, collect personal belongings, shut down experiments, switch off computers, electrical appliances, equipment and machinery.
- If the evacuation alarm sounds, or if instructed to do so by university security and safe, leave the building by the nearest and safest exit route. All doors should be closed (but not locked) on leaving.
- If possible, take hand held personal belongings (such as handbags and briefcases) with you when you leave. Do not return to collect belongings.
- Assist any person with a disability to leave the building, or to the nearest fire isolated or fire safe haven for multi-story buildings. Do not attempt to carry people down stairs. See the People with Specific Needs section.
- Walk quickly and calmly to the designated assembly area for your building or as advised by supervisor
- Remain at the assembly area (in groups) until instructed to leave
- Do not re-enter the building until informed that it is safe to do so by supervisor. Do not enter a building in alarm.

A.1.2 Lecture Theatres / Laboratories

It is the responsibility of the lecturer/tutor to ensure that their class is evacuated and to maintain control of the students during an emergency until released by University of Umm AL-Qura.

A.1.3 Cafes / Public Theatres / Public Venues

University staff will arrange for and provide information to patrons during emergency situations and evacuations.

Appendix-B

Fire Hazard

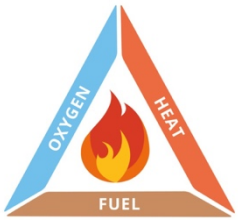
B.1 How Fires Start

Fire is a **chemical reaction** involving rapid oxidation or burning of a fuel. It needs three elements to occur:

FUEL - Fuel can be any combustible material - solid, liquid or gas. Most solids and liquids become a vapor or gas before they will burn.

OXYGEN - The air we breathe is about 21 percent oxygen. fire only needs an atmosphere with at least 16 percent oxygen.

HEAT - Heat is the energy necessary to increase the temperature of the fuel to a point where sufficient vapors are given off for ignition to occur.



B.1.1 Chemical Reaction: A chain reaction can occur when the three elements of fire are present in the proper conditions and proportions. Fire occurs when this rapid oxidation, or burning takes place.

Take any one of these factors away, and the fire cannot occur or will be extinguished if it was already burning.

B.2 Fire Classifications

CLASS A

Ordinary combustibles or fibrous material, such as wood, paper, cloth, rubber and some plastics.

CLASS B

Flammable or combustible liquids such as gasoline, kerosene, paint, paint thinners and propane.

CLASS C

Energized electrical equipment, such as appliances, switches, panel boxes and power tools.

CLASS D

Certain combustible metals, such as magnesium, titanium, potassium and sodium. These metals burn at high temperatures and give off sufficient oxygen to support combustion. They may react violently with water or other chemicals, and must be handled with care.

B.3 How to Prevent Fires

B.3.1 Class A — Ordinary combustibles

Keep storage and working areas free of trash Place oily rags in covered containers.

B.3.2  Class B — Flammable liquids or gases

- Don't refuel gasoline-powered equipment in a confined space, especially in the presence of an open flame such as a furnace or water heater.
- Don't refuel gasoline-powered equipment while it's hot.
- Keep flammable liquids stored in tightly closed, self-closing, spill-proof containers.
- Pour from storage drums only what you'll need.
- Store flammable liquids away from spark-producing sources.
- Use flammable liquids only in well-ventilated areas.

B.3.3  Class C — Electrical equipment

- Look for old wiring, worn insulation and broken electrical fittings. Report any hazardous condition to your supervisor.
- Prevent motors from overheating by keeping them clean and in good working order. A spark from a rough-running motor can ignite the oil and dust in it.
- Utility lights should always have some type of wire guard over them. Heat from an uncovered light bulb can easily ignite ordinary combustibles.
- Don't misuse fuses. Never install a fuse rated higher than specified for the circuit.
- Investigate any appliance or electrical equipment that smells strange. Unusual odors can be the first sign of fire.
- Don't overload wall outlets. Two outlets should have no more than two plugs.

B.4 Fire hazard in the workshop

The next primary danger to an area where dust is not collected and disposed of. Install a smoke alarm and fire extinguisher. Anywhere dust has settled, a fire path is presented from the spark or flame source to anything combustible within the shop. Uncontrolled and uncollected, airborne dust particles settle and build up on any exposed area or item in the work area. In a studio workshop, where all aspects of carving are dealt with many situations are presented wherein a spark is generated.

A few worthy of consideration are:

- electrical motors and any heat or spark generating electrical appliances.
- switches, outlets, and light bulbs.
- sparks generated from grinding metal when sharpening tools.
- assembling metal armatures, bird legs and supports with soldering iron or torch.
- heating elements.
- torches used for soldering and bit cleaning.
- improperly stored finishes.
- spontaneous combustion from improperly discarded or un-cared for finish rags, brushes, wipes.
- tobacco smoker.

B.4.1 Evacuation procedure when there is fire hazard

- If safe to do so, ensure the immediate safety of anyone within the vicinity of the fire.
- Raise the alarm if not already sounding, using a break glass alarm panel or by shouting ‘Fire, Fire, Fire’ if a panel is not available. The alarm system automatically notifies the Fire and Rescue Services and Security (who then notifies other emergency personnel).
- Phone Security (**call 998**). Give your name, building, level, room number, type and extent of the fire / smoke and inform your supervisor or Building Warden if safe to do so.
- Evacuate the immediate area.
- If safe to do so and if trained in the use of fire equipment – attempt to extinguish the fire.
- Choose the correct fire extinguisher. Do not use water or foam on an electrical fire.

- **If your clothing catches fire,** drop to the floor and roll to smother the fire. If a co-worker's clothing catches fire, get the person to the floor and roll him or her to smother the flames. Use a safety shower immediately thereafter.

B.5 Fire Fighting

Remember the acronym, "P.A. S.S."—

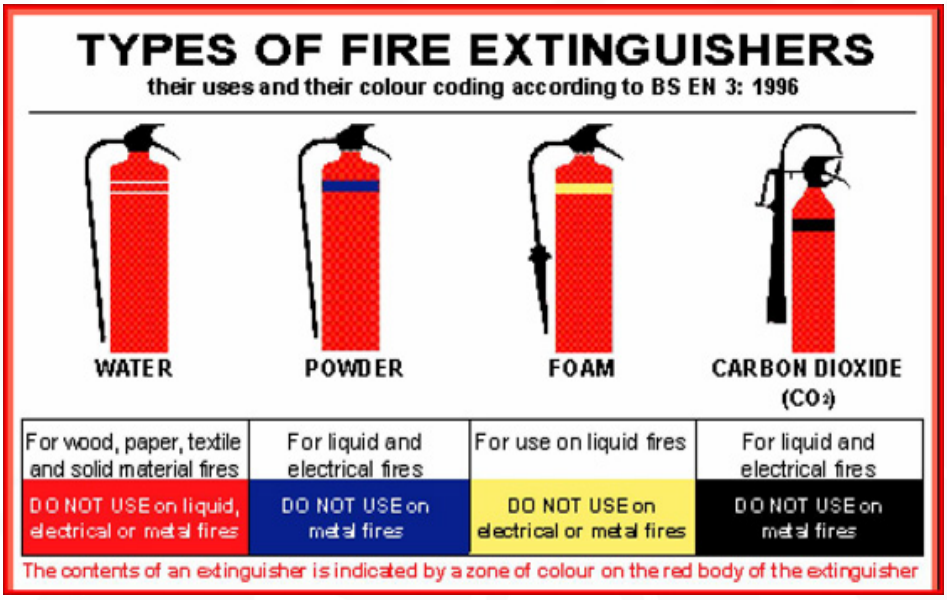
How to use a fire extinguisher

(P) Pull the Pin.

(A) Aim the extinguisher nozzle at the base of the flames.

(S) Squeeze trigger while holding the extinguisher upright.

(S) Sweep the extinguisher from side to side, covering the area of the fire with the extinguishing agent.



Types of fire extinguishers

Appendix-C
First Aid

C.1 First-Aid Kit

Keep a well-stocked basic First-Aid Kit in your shop where it can be reached easily. Always replace what you use as soon as possible. Carvers should always be up to date on their tetanus shots.

Equip your kit with:

- A variety of bandages
- Needles and tweezers
- Antiseptic ointment
- Cotton swabs
- Cotton balls
- Eye drops or eye bath & wash
- A first-aid handbook
- A chemical cold pack
- Elastic bandages
- First-Aid tape
- Sterile gauze
- Scissors

C.2 Personal Injury

Personal injury – minor

- Contact the nearest First Aid Officer within the building.
- Send the injured person to Campus Medical Centre if necessary (business hours only).
- Inform supervisor.
- Complete a confidential incident / injury report form.

Or you can help the injured person by following these steps in case minor Injuries:

C.2.1 Cut or stab to the hand or finger

- Cover the entire wound with a thick sterile or clean cloth pad.
- Press firmly on the entire wound for 10 minutes without releasing pressure.
- If possible, raise the injury above the level of your heart.
- When bleeding stops, wash the wound with warm water and soap.
- Apply antibiotic ointment and cover wound with an adhesive bandage or clean gauze.

C.2.2 Cut off finger or thumb:

- Cover the entire wound with a thick sterile or clean cloth pad.
- Apply direct pressure to the wound.
- If possible, raise the injury above the level of your heart.
- Seek medical attention immediately!
- If bleeding doesn't stop, apply a tourniquet.
- Wrap the amputated part in a cold, damp cloth, but do not place in water.
- Place the wrapped part in a plastic bag, and put the closed bag inside a second container full of ice.
- Avoid direct contact between the part and the ice.

C.2.3 Tore off thumb/finger nail:

- If the nail is not detached – put it down and place a Band-Aid on.
- If the nail is detached – use antibiotic ointment and Band-Aid to let the nail grow in under it.

C.2.4 Tore off piece of skin:

- If there is a flap left – place the flap back and apply direct pressure.
- Use ice in a paper towel or cloth to help stop the bleeding.
- If needed, go to emergency to get stitches. If not, place a Band-Aid on wound.

C.2.5 Inhaling paint fumes

- Get fresh air immediately.
- If continue to wheeze, go to emergency.
- If loose conscientiousness, go to emergency.

C.2.6 Burns

- Immerse in cool water until pain lessens.
- Gently pat dry with a sterile or clean cloth.
- Cover the burned area loosely with a sterile or clean dry cloth.
- If skin is tingling or has no feeling go to emergency.

C.3 Personal injury – major

- Care for injured person(s) – call for assistance.
- Send someone to phone Security (**call 997**).

C.3.1 Provide all information

Name;

- Location (building, level, room number);
- Nature and type of injury;
- State of consciousness of the injured person(s);
- Age and gender of the injured person(s);
- If possible, the names of the injured person(s);

Any relevant information – breathing/not breathing, chest pains, bleeding.