**Department of ……………………………...……… Engineering**

**Hijjawi Faculty for Engineering Technology**

**Yarmouk University**

# Risk Management Policy

## Health, Safety & Security Management Policy


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# I. Health, Safety & Security Management Policy

## 1. Intent:

The Hijjawi Faculty Departments are committed to provide safe and secure environment to all staff, faculty, and students at the premises of the departments which enhances the experience for all involved in academic and service areas to work actively and creatively without risk of injury, illness and equipment malfunction.

## 2. Objectives:

- Prevent Injury or illness in all departments' labs.
- Provide friendly and safe environment for students, staff and visitors in the departments.
- Continually improve the standards of health, safety and personal security to promote an overall safety culture in the College.
- Do every measure that is reasonably practicable to protect the physical property of the departments, staff, students and visitors from theft or sabotage.
- Integrate health, safety and security into the University's structures and systems.
- Ensure compliance with national and international regulatory requirements.

## 3. Scope:

This policy applies solely to the staff, students and visitors in the Departments of Engineering at the Hijjawi Faculty for Engineering Technology-Yarmouk University, such as the Departments of Communication, Power, Electronics, Computer, Biomedical and Industrial Engineering. The other Departments, such as Civil Engineering may customize it for their own specific risks not mentioned herewith.

# 4. Policy Provisions

**4.1** The Hijjawi Faculty Departments are committed to provide and maintain *safe environment* to all involved in the departments' activities.

### (a) Definition

***Safe environment*** comprises all building structures and installations used by staff, faculty, students and visitors such as offices, labs and classrooms and equipment, whose improper function or misuse could cause injuries or hazardous effects on health and any financial hardship.

### (b) Guiding Principles

- The Hijjawi Faculty Departments maintain all installations in labs under strict supervision of well-trained engineers and technicians.
- Safety guidelines and warnings are provided in each lab.
- Students are not allowed to use lab equipment prior strict instructions by the responsible engineer.
- Equipment in classrooms are protected by a password for the sole use by trained faculties or maintenance engineers.
- The departments guarantee that all kinds of sensitive equipment are properly installed, maintained, and operated to prevent any hazardous effects.

### (c) Rules

- The Hijjawi Faculty Departments should make sure that all appointed lab engineers and technicians are well-trained and experienced before assigning them any lab responsibility.
- Equipment with possible dangerous effects such as diagnostic x-ray devices used in Medical imaging lab (Radiography and CT), malfunctioned safeguards, should be accompanied with appropriate warnings and instructions of proper operation.
- Equipment with possible dangerous effects such as high voltage, microwave, laser systems, hazardous nip points, malfunctioned safeguards, hazardous chemicals which should be accompanied with appropriate warnings and instructions of proper operation.

- Any doubt of malfunction of any of the dangerous equipment in any relevant lab should encourage the supervisor to stop using them until replacement or secure maintenance.
- Machines should only be operated by authorized personnel under the proper protocol of lockout/tagout (section b, appendix 3).
- Proper use of Personal Protective Equipment (PPE) when needed is mandatory (section c, appendix 3).
- Proper training should be provided to corresponding personnel for actions taken in cases of emergency (Hazcom considerations) (section e, appendix 3).
- The relevant departments ensure that all safety measures have been taken regarding machine operation, PPE use, chemical hazards, energy discharge, Hazcom and others (Appendix 3).
- All machines/equipment should be maintained in a good sanitary working condition. All places of work should be clean, decluttered and clear from objects blocking the passageways in cases of emergency.
- The relevant Hijjawi Faculty Departments ensure that the environmental conditions are well maintained in labs/workshops such as: temperature, noise, illumination, ventilation, and humidity (section g, appendix 3).
- The relevant Hijjawi Faculty Departments ensure that the lab fume hoods are fully functional during the tests. Also, periodical maintenance is ~~are~~ enforced to follow up the status of each fume hood to ensure that timely mannered remedial actions are taken.
- The relevant departments ensure that each student wears his/her gloves ~~cloves~~ and lab coats in addition to all necessary safety gears to avoid any direct contact with chemicals.
- The relevant departments ensure that each student wears his/her noise canceling hearing protection gears to eliminate the effect of high noise levels.
- The relevant departments ensure that each student wears his/her sun protection gears to reduce the effect of sun exposure for long periods.
- Students should not be allowed to power any lab kit/equipment/machine until the supervisor checks that it is properly connected, and the students are aware of the relevant warnings.
- The relevant departments should make sure that vendor companies are not paid until a full and proper installation of purchased equipment and that a proper training to local staff is provided.

## (d) Guidelines to Meet Rules and Exceptions

- In case of urgent need, appointment of a fresh untrained lab engineer can only be allowed on the authority of the relevant department chair or an authorized committee.
- Exceptions of the above rules cannot be tolerated except those with strong reasoning of no risk consequences and approval of the relevant department chair or an authorized by him person or committee.

**4.2** The The Hijjawi Faculty Departments are committed to ensure and safeguard the security of ***personal and department properties***.

## (a) Definition

***Personal properties*** comprise possessions of staff, faculty, students and visitors such as computers, books and relevant confidential information.

***Department properties*** comprise all kinds of equipment in labs, classrooms and research centers with all kinds of relevant confidential information.

## (b) Guiding Principles

- The departments guarantee to provide all involved staff with secure offices and unique keys to prevent theft or sabotage.
- The departments guarantee special cupboards with unique keys to be used by students to store their belongings.
- The departments ensure that labs and classrooms containing important equipment are locked properly when they are not in use by the authorized persons.
- The departments ensure that machine operation is performed under the principles of lockout/ttagout to maintain the security and safety measures.
- The departments guarantee integrity between their security measures with those of the university's corresponding security body, safeguarding against theft or sabotage.

## (c) Rules

- The staff in each department should make sure that their offices are properly locked when they leave them.

- Safeguarding personal properties and relevant confidential information are the sole responsibility of the individuals involved in each department.
- Lab supervisors in each department should make sure that their labs are locked when left or not in use.
- Security guards should make sure that all offices, labs and classrooms in each department are properly secured beyond the working time weekends or vacations.

### (d) Guidelines to Meet Rules and Exceptions

- In the event of an accident or emergency, offices and labs can be accessed on the authority of department chairman or authorized body to prevent further consequences such as fire.
- Exceptions of the above rules can only be allowed to meet legal obligations to legal bodies.

# II. Risk Management Plan

## 1. Identification of Risks:

Table 1 shows the major possible risks and their time indicators in all relevant departments.

**Table 1:** The major risks and possible time indicators for all relevant departments

| Risk Area | Risks | Indicators: Daily/Weekly/Monthly |
|---|---|---|
| **Health and Safety**<br><br>**Cont.** | - Risks of electrical shocks<br>- Risk of x-ray radiation leakage from the diagnostic x-ray devices used in Medical imaging lab (Radiography and CT) due to equipment damage, improper maintenance or abuse.<br>- Risk of misusing laser sources<br>- Risk of misusing microwave sources.<br>- Risks of high electric and magnetic fields.<br>- Risks of chemical materials handling and storing.<br>- Risks of misusing electrical machines.<br>- Risks of nuclear radiation.<br>- Risks related to machine safeguards. | - Number of accidents related to electrical shocks.<br>- x-ray dermatitis or radiation burns.<br>- Complaining from continuous headache.<br>- Complaining from eye's troubles.<br>- Injuries due to chemical materials or electrical machines.<br>- Injuries related to safeguards such as: Bruises, cuts, lacerations, contusions, loss of body parts, changes in skin color.<br>- Difficulties in breathing.<br>- Numbness in extremities.<br>- Unbearable Hands pain, heavy sweating, high body temperature.<br>- Injuries related to either the lack of use or the misuse of PPE. |

| | | |
|---|---|---|
| | - Risks of creating new hazards, such as actions leading to create new pinch points or objects falling into moving parts.<br>- Risks related to PPE in the laboratory/workshop.<br>- Risks related to the control of hazardous energy (lockout/tagout).<br>- Risks related to Hazcom.<br>- Risks related to fume hoods.<br>- Risks related to the environmental conditions, such as: temperature, humidity, illumination, noise,…etc.<br>- Risks related to vapors resulting from incineration of testing materials.<br>- Risk related to danger of direct contact with chemicals.<br>- Risk related to exposure to a high level of acoustic noise from the testing machines.<br>- Risks related to heatstroke~~heat stocks~~ after resulting from direct exposure to the sun for long periods.<br>- Risk related to danger of direct contact with chemicals such as conductive gel used in electrode-skin connection in some biosignal recording experiments. | - Slips, trips and falls.<br>- Loss of dexterity, unconsciousness, temporary loss of control, temporary poor vision.<br>- Number of accidents related to choking gases.<br>- Number of accidents related to direct contact with chemicals.<br>- Number of accidents related to hear damage due to exposure to a high level of acoustic noise.<br>- Number of heatstroke~~heat stocks~~ accidents.<br>- Possible allergic accidents related to direct contact with biosignal acquisition chemicals. |
| **Security of Personal Properties & Educational Resources** | - Computers and smart board theft or sabotage.<br>- Electrical power failure.<br>- Internet failure.<br>- Failure in the equipment of the labs. | - Reports of property and equipment thefts<br>- Complaining from malfunction of computers and boards in class rooms.<br>- Complaining from repeated electrical power failure.<br>- Complaining from repeated internet failure.<br>- Complaining from the performances of the laboratory equipment. |

# 2. Risk Analysis

Table 2 shows the various possible risks in all relevant departments and their category levels (Red, Amber and Green)

**Table 2:** Possible risks and their category levels for all relevant departments

| Description of Risks (Health, Safety & Security) | High Risk | Moderate Risk | Minor Risk |
|---|---|---|---|
| Risks of electrical shocks. | **Red** | | |
| Risk x-ray radiation leakage (see Appendix **1, b**). | **Red** | | |
| Risk of misusing laser sources (see Appendix **2**). | **Red** | | |
| Risk of misusing microwave sources (see Appendix **1**). | | **Amber** | |
| Risks of chemical materials handling and storing. | **Red** | | |
| Risks of high electric and magnetic field radiations (see Appendix **1** & **2**) | | **Amber** | |
| Risks of misusing electrical machines. | **Red** | | |
| Risks of nuclear radiation | | **Amber** | |
| Risks related to machine safeguards. | **Red** | | |
| Risks of creating new hazards, such as actions leading to create new pinch points or objects falling into moving parts. | **Red** | | |
| Risks related to PPE in the laboratory/workshop. | **Red** | | |
| Risks related to the control of hazardous energy (lockout/tagout). | **Red** | | |
| Risks related to Hazcom. | **Red** | | |
| Risks related to fume hoods. | | **Amber** | |
| Risks related to the environmental conditions, such as: temperature, humidity, illumination, noise,…etc. | **Red** | | |
| Risks related to vapors resulting from incineration of testing materials. | **Red** | | |
| Risk related to danger of direct contact with chemicals. | **Red** | | |
| Risk related to exposure to a high level of acoustic noise from the testing machines. | | **Amber** | |
| Risks related to ~~heat stocks~~heat-stroke after resulting from direct exposure to the sun for long periods. | **Red** | | |
| Risk related to danger of direct contact with chemicals. **Cont.** | | **Amber** | |

| Description of Risks (Health, Safety & Security) | High Risk | Moderate Risk | Minor Risk |
|---|---|---|---|
| Computers and smart board theft or sabotage. | | | **Green** |
| Electrical power failure. | | **Amber** | |
| Internet failure. | | **Amber** | |
| Failure in labs' equipment. | | **Amber** | |

# 3. Risk Treatment

Risks treatment can be summarized in the following categories:

## a. Risk Avoidance

- Risks of electrical shocks are avoided by using central circuit breakers and following the guiding principles and rules (Section **I.4**).
- Risk of x-ray radiation leakage are avoided by following the guiding principles and rules (Section **I.4** & Appendix **1**).
- Risk of misusing laser sources are avoided by following the guiding principles and rules (Section **I.4** & Appendix **2**).
- Risk of misusing microwave sources are avoided by following the guiding principles and rules (Section **I.4** & Appendix **1**).
- Risks of chemical materials handling and storing are avoided by following the guiding principles and rules (Section **I.4,** Appendix 3 section d).
- Risks of high electric and magnetic fields are avoided by following the guiding principles and rules (Section **I.4** & Appendix **1** & **2**).
- Risks of misusing electrical machines are avoided by following the guiding principles and rules (Section **I.4**).
- Risks of nuclear radiation are avoided by following the guiding principles and rules (Section **I.4**).
- Risks related to machine safeguards can be avoided by using the guiding principles and rules (Section **I.4**) (Further details and guiding principles can be found in section a, Appendix 3).
- Risks of creating new hazards, such as actions leading to create new pinch points or objects falling into moving parts. can by using the guiding principles and rules (Section **I.4**) (Further details and guiding principles can be found in section a, Appendix 3).
- Risks related to PPE in the laboratory/workshop are avoided by using the guiding principles and rules (Section **I.4**) (Further details and guiding principles can be found in section c, Appendix 3).

- Risks related to the control of hazardous energy (lockout/tagout) are avoided by using the guiding principles and rules (Section **I.4**) (Further details and guiding principles can be found in section b, Appendix 3).
- Risks related to Hazcom are avoided by using the guiding principles and rules (Section **I.4**) (Further details and guiding principles can be found in section e, Appendix 3).
- Risks related to chemical fume hoods are avoided by using the guiding principles and rules (Section **I.4**) (Further details and guiding principles can be found in section f, Appendix 3).
- Risks related to the environmental conditions, such as: temperature, humidity, illumination, noise,.etc are avoided by using the guiding principles and rules (Further details and guiding principles can be found in section g , appendix 3). Required actions taken in cases of emergency can be found in (section h, Appendix 3).
- Risks related to vapors resulting from incineration of testing materials by using the guiding principles and rules (Section **I.4**). Required actions taken in cases of emergency can be found in (Appendix 3).
- Risk related to danger of direct contact with chemicals by using the guiding principles and rules (Section **I.4**). Required actions taken in cases of emergency can be found in (Appendix 3).
- Risk related to exposure to a high level of acoustic noise from the testing machines by using the guiding principles and rules (Section **I.4**). Required actions taken in cases of emergency can be found in (Appendix 3).
- Risks related to ~~heat stocks~~heatstroke after resulting from direct exposure to the sun for long periods by using the guiding principles and rules (Section **I.4**). Required actions taken in cases of emergency can be found in (Appendix 3).
- Computers and smart board theft or sabotage are avoided by following the guiding principles and rules (Section **I.4**).
- Electrical power failures are avoided by following the guiding principles and rules (Section **I.4**).
- Internet failures are avoided by following the guiding principles and rules (Section **I.4**).
- Failures in the equipment of the labs are avoided by following the guiding principles and rules (Section **I.4**).

## b. Risk Reduction

- Risks of electrical shocks are reduced by using indicators for electrical shock hazard areas.
- Risks of x-ray radiation leakage is reduced by using proper detectors for x-ray radiation areas.
- Risk of misusing laser sources are reduced by using indicators for laser hazard areas.
- Risk of misusing microwave sources are reduced by using indicators for microwave hazard areas.
- Risks of high electric and magnetic field radiations are reduced by using indicators for high electric and magnetic fields areas.
- Risks of misusing electrical machines are reduced by using indicators for heavy machines areas
- Risks of nuclear radiation are reduced by using indicators for nuclear radiation areas.
- Risks of removing or trying to defeat machine safeguards are reduced by using indicators of unsafe working areas and machines and by the proper use of machine guards.
- Risks of creating new hazards, such as actions leading to create new pinch points or objects falling into moving parts. are reduced by using indicators of unsafe working areas and machines by the proper use of machine guards.
- Risks related to PPE in the laboratory/workshop are reduced by using indicators of lack of use or misuse of PPE and by the proper use of PPE and proper training.
- Risks related to the control of hazardous energy (lockout/tagout) are reduced by using indicators of unsafe working areas and machines and by the proper use of the lockout/tagout procedures.
- Risks related to Hazcom are reduced by using indicators of unsafe working areas and machines and by the proper use of hazard communication procedures and documents.
- Risks related to chemical fume hoods are reduced by using indicators of unsafe working areas and machines and by the proper use of engineering controls.
- Risks related to the environmental conditions, such as: temperature, humidity, illumination, noise,…etc. are reduced by using indicators of unsafe working areas and machines and by the proper use of engineering controls.

- Risks related to vapors resulting from incineration of testing materials are reduced by using indicators of unsafe working areas and machines and by the proper use of engineering controls.
- Risk related to danger of direct contact with chemicals are reduced by using indicators of unsafe working areas and machines and by the proper use of engineering controls.
- Risk related to exposure to a high level of acoustic noise from the testing machines reduced by using indicators of unsafe working areas and machines and by the proper use of engineering controls.
- Risks related to ~~heat stocks~~heatstroke after resulting from direct exposure to the sun for long periods reduced by using indicators of unsafe working areas and machines and by the proper use of engineering controls.

### c. Risk Mitigation

This involves action plans (see Section **IV**).

### d. Risk Transfer

Risk transfer can be accomplished by shifting the burden of risks and possible losses to professional safety & security companies to execute and follow up with all tasks related to all possible risks.

## 4. Risk Monitoring

Monitoring of risks can be accomplished by implementing statistical study of the following:

- Continuous reports from the labs, research centers and classrooms about any injury due to previously mentioned risks.
- Continuous reports for any damage in laboratory equipment.
- Weekly reports about the status of the classrooms; including light, smart boards and computers.

# III. Accountability

## 1. Implementation

The implementation of the risk management process and policy will be the responsibility of an internal team/committee assigned by each department chair and approved by the department council, followed by a College Council approval.

## 2. Compliance

- Internal team composed of senior lab engineers/technicians is accountable for the health and safety risks within their labs.
- Staff and faculty members are individually responsible to safeguard their own properties and confidential information from theft or sabotage by following the above mentioned rules.
- Safety officials at university car parking area are accountable for any external risks of theft or sabotage by outsiders and they have to comply with University processes and rules.

## 3. Monitoring and Evaluation

Monitoring of the risk management process and policy is managed by internal and external monitoring body:

- ***Internal**:* Risk management team/committee assigned by each Department chair and approved by the Department and College councils.
- ***External**:* Security Department of the University or any contracted professional safety & security company.

## 4. Approval Authority

- ***At Department level:*** Department Chairman.
- ***At College Level:*** College Dean

# IV. Action Plan Form

Table 3 shows a checklist form of the possible risks and their periodical taken actions

**Table 3:** Checklist form of the possible risks and periodical actions to be taken by each relevant department

**Name of Department:** Department of …………………………………….. Engineering

**Date (dd/mm/yyyy):** ..........................................................................................................

| Description of Risk Health, Safety & Security | Existing Controls/ Mitigation | Proposed Control Measures | Time Scale/ Months | Current Rating of Risk | Action Carried out by: |
|---|---|---|---|---|---|
| Risks of electrical shocks. | | | **3** | **Red** | |

| | | | | | |
|---|---|---|---|---|---|
| Risk x-ray radiation leakage | | | **3** | **Red** | |
| Risk of misusing laser sources (see appendix 2). | | | **3** | **Red** | |
| Risk of misusing microwave sources (see Appendix 1 ). | | | **6** | **Amber** | |
| Risks of chemical materials handling and storing. | | | **3** | **Red** | |
| Risks of high electric and magnetic fields radiation (see Appendix 1 &2). | | | **6** | **Amber** | |
| Risks of misusing electrical machines. | | | **3** | **Red** | |
| Risks of nuclear radiation | | | **6** | **Amber** | |
| Risks related to machine safeguards. | | | **6** | **Red** | |
| Risks of creating new hazards, such as actions leading to create new pinch points or objects falling into moving parts. | | | **6** | **Red** | |
| Risks related to PPE in the laboratory/workshop. | | | **6** | **Red** | |
| Risks related to the control of hazardous energy (lockout/tagout). | | | **6** | **Red** | |
| Risks related to Hazcom. | | | **12** | **Red** | |
| Risks related to fume hoods. | | | **12** | **Amber** | |
| Risks related to the environmental conditions, such as: temperature, humidity, illumination, noise,…etc. | | | **6** | **Red** | |
| Risks related to vapors resulting from incineration of testing materials. | | | **6** | **Red** | |
| Risk related to danger of direct contact with chemicals. | | | **3** | **Red** | |
| Risk related to exposure to a high level of acoustic noise from the testing machines. | | | **6** | **Amber** | |
| Risks related to ~~heat stocks~~heatstroke after resulting from direct exposure to the sun for long periods. | | | **6** | **Red** | |

| | | | | | |
|---|---|---|---|---|---|
| Computers and smart board theft or sabotage. | | | **12** | **Green** | |
| Electrical power failure. | | | **6** | **Amber** | |
| Internet failure. | | | **6** | **Amber** | |
| Failure in labs' equipment. | | | **6** | **Amber** | |

# V. Risk Review Sheet

Table 4 shows a risk review sheet actions for all possible risks and any status changes of risk (if any).

**Table 4:** Risk review sheet actions for all possible risks and any status changes of risks taken by each relevant department

**Name of Department:** Department of ………………………………………… Engineering
**Date (dd/mm/yyyy):** ......../............/............./....................................................................................

| Description of Risk Health, Safety & Security | Changes due to Actions plans/ Contingency plans/Initiatives | Changes in Status of Risk | Review No. | Comments/ Further Actions | Action carried out by: | Date of Review |
|---|---|---|---|---|---|---|
| Risks of electrical shocks. | | | | | | |
| Risk x-ray radiation leakage (see Appendix **1**) | | | | | | |
| Risk of misusing laser sources (see Appendix **2**) | | | | | | |
| Risk of misusing microwave sources (see Appendix **1**) | | | | | | |
| Risks of chemical materials handling and storing. | | | | | | |
| Risks of high electric and magnetic fields radiation (see Appendix **1** & **2**). | | | | | | |
| Risks of chemical materials handling and storing. | | | | | | |
| Risks of misusing electrical machines. | | | | | | |
| Risks of nuclear radiation | | | | | | |
| Risks of removing or | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| trying to defeat machine safeguards. | | | | | | |
| Risks of creating new hazards, such as actions<br>**Cont.**<br>leading to create new pinch points or objects falling into moving parts. | | | | | | |
| Risks related to PPE in the laboratory/workshop. | | | | | | |
| Risks related to the control of hazardous energy (lockout/tagout). | | | | | | |
| Risks related to Hazcom. | | | | | | |
| Risks related to fume hoods. | | | | | | |
| Risks related to the environmental conditions, such as: temperature, humidity, illumination, noise,…etc. | | | | | | |
| Risks related to vapors resulting from incineration of testing materials. | | | | | | |
| Risk related to danger of direct contact with chemicals. | | | | | | |
| Risk related to exposure to a high level of acoustic noise from the testing machines. | | | | | | |
| Risks related to ~~heat stocks~~heatstroke after resulting from direct exposure to the sun for long periods. | | | | | | |
| Computers and smart board theft or sabotage. | | | | | | |
| Electrical power failure. | | | | | | |
| Internet failure. | | | | | | |
| Failure in labs' equipment. | | | | | | |

# Appendix 1

# Radiation Hazards

## (a) RF and Microwave

### ❖ Safety with RF & Microwave Radiations

When studying microwave systems, it is very important to develop good safety habits. Although microwaves are invisible, they can be dangerous at high levels or for long exposure times. The most important safety rule when working with microwave equipment is to avoid exposure to dangerous radiation levels. In order to develop good safety habits, you should, whenever possible, set the power switch to the OFF position or disconnect the Gunn Oscillator power cable before placing yourself in front of the transmitting antenna. Lab instructor should outline additional safety directives for such systems.

### ❖ Sample Warning for RF & Microwave Systems

For your safety, do not look directly into the waveguides or Horn Antennas while power is being supplied to the Gunn Oscillator.

## (b) Other Sources of Radiation Hazards

- **X-rays:**
  Some of the high voltage systems with potentials greater than 15 kV may generate x-rays at significant dose rates such as diagnostic x-ray devices used in Medical imaging lab (Radiography and CT). Plasma systems and ion sources operated at high voltages should also be checked for **X-rays**. High power electron pump excimer lasers can generate significant **X-ray** levels (see Appendix **2** for Laser Hazards). These devices need to be checked by Radiation Safety upon installation to ensure adequate shielding is included. Also, frequent monitoring of radiation leakage using proper radiation detection equipment for assurance. According to the manufacturer specifications of the diagnostic x-ray devices used in medical imaging lab, the radiation leakage does not exceed 1µSv/h at distance of 0.1 if the units are operating at maximum operating inputs (kVp and mA) which are considered as safe rates.

- **Plasma Radiation**
  Materials can be made incandescent when exposed to laser radiations. These incandescent spots are very bright and cause serious photochemical injuries to the eyes. The laser protective eyewear may not protect against such exposures. View such spots through suitable filters; use video cameras, etc., as may be appropriate (see Appendix **2** for Laser Hazards).

# Appendix 2

## Laser Hazards and Safety Measures

### (a) Beam Hazards

The laser produces an intense, highly directional beam of light. If directed, reflected, or focused upon an object, laser light will be partially absorbed, raising the temperature of the surface and/or the interior of the object, potentially causing an alteration or deformation of the material. These properties which have been applied to laser surgery and materials processing can also cause tissue damage.

In addition to these obvious thermal effects upon tissue, there can also be photochemical effects when the wavelength of the laser radiation is sufficiently short, i.e., in the ultraviolet or blue region of the spectrum. Today, most high-power lasers are designed to minimize access to laser radiation during normal operation. Lower-power lasers may emit levels of laser light that are not a hazard.

The human body is vulnerable to the output of certain lasers, and under certain circumstances, exposure can result in damage to the eye and skin. Research relating to injury thresholds of the eye and skin has been performed in order to understand the biological hazards of laser radiation. It is now widely accepted that the human eye is more vulnerable to injury than human skin. The cornea (the clear, outer front surface of the eye's optics), unlike the skin, does not have an external layer of dead cells to protect it from the environment. In the far-ultraviolet regions of the optical spectrum, the cornea absorbs the laser energy and may be damaged. At certain wavelength in the near-ultraviolet region and in the near-infrared region, the lens of the eye may be vulnerable to injury. Of greatest concern, however, is laser exposure in the retinal hazard region of the optical spectrum, approximately 400 nm (violet light) to 1400 nm (near-infrared) and including the entire visible portion of the optical spectrum. Within this spectral region collimated laser rays are brought to focus on a very tiny spot on the retina. In order for the worst case exposure to occur, an individual's eye must be focused at a distance and a direct beam or specular (mirror-like) reflection must enter the eye. The light entering the eye from a collimated beam in the retinal hazard region is concentrated by a factor of 100,000 times when it strikes the retina.

Therefore, a visible, 10 milliwatt/cm$^2$ laser beam would result in a 1000 watt/cm$^2$ exposure to the retina, which is more than enough power density (irradiance) to cause damage. If the eye is not focused at a distance or if the beam is reflected from a diffuse surface (not mirror-like), much higher levels of laser radiation would be necessary to cause injury. Since this ocular focusing effect does not apply to the skin, the skin is far less vulnerable to injury from these wavelengths.

## (b) Non-Beam Hazards

In addition to the direct hazards to the eye and skin from the laser beam itself, it is also important to address other hazards associated with the use of lasers. These non-beam hazards, in some cases, can be life threatening, e.g. electrocution, fire, and asphyxiation. The only fatalities from lasers have been caused by non-beam hazards.

## (c) Other Related Hazards to Laser Systems

❖ **Chemical Hazards:**

- Compressed gases – care should be taken with tanks of compressed gas.
- Fumes from lasing of target material – industrial hygiene considerations should be addressed to determine adequate ventilation.
- Laser dyes or solvents – may be toxic or carcinogenic and should be handled appropriately.

❖ **Electrical Hazards:**

- Power supplies – high voltage precautions should be designed to prevent electrocution.
- Voltages greater than 15 kV – may generate **X-rays**.

❖ **Non-Beam Optical Hazards:**

- Ultraviolet radiation – can cause burns to skin or corneas of eyes.

❖ **Explosion Hazards:**

- Some lamps and capacitor banks – should be enclosed or protected to avoid injury to personnel in the event of explosion.
- Personnel should be protected should lasing of the target material create flying fragments.

❖ **Fire Hazards:**

- Electrical components, gases, fumes and dyes – can constitute a fire hazard; use of flammables should be avoided, and flame resistant enclosures should be used.

## (d) Eye Protection

Laser protective eyewear is specific to the types of laser radiation in the lab. Each laser laboratory must provide laser-specific appropriate eye protection for persons working with the laser. Windows where Class 2, 3, or 4 beams could be transmitted causing hazards in uncontrolled areas shall be covered or otherwise protected during laser operation. The following guidelines are suggested for maximum eye protection:

- Whenever possible confine (enclose) the beam, provide non-reflective, nonflammable beam stops, to minimize the risk of accidental exposure or fire.

Use fluorescent screens or secondary viewers to align the beam; avoid direct intra-beam exposure to the eyes.

- Use the lowest power possible for beam alignment procedures. Use lower class lasers for preliminary alignment procedures, whenever possible. Keep optical benches free of unnecessary reflective items.
- Confine the beam to the optical bench unless necessary for an experiment, e.g., use barriers at side of benches or other enclosures. Do not use room walls to align Class 3b or 4 laser beams.
- Use non-reflective tools. Remember that some tools seem to be non – reflective for visible light may be very reflective for non – visible spectrum.
- Do not wear reflective jewelry when working with lasers. Metallic jewelry also increases electrocution hazards.
- Wear protective glasses whenever working with Class 4 lasers with open beams or when reflections can occur.

## (e) Control of Laser Areas

Procedural methods may be used to control entry, provided that all personnel have been trained in laser safety, and protective equipment is provided upon entry. Conditions related to control of laser areas include the following:

- Keep the exposure at the entryway below the Maximum Permissible Exposure (MPE) by use of a barrier inside of the door. Do not direct the laser beam toward the entry.
- Use shields and barriers around the laser work area so that the beam, reflections and scatter are contained on the optical table. Try to keep the unenclosed beam path out of the normal eye-level zone. (The normal eye-range is from 4 to 6 feet from the floor.)
- Ensure that only diffuse reflection materials are in or near the beam path to minimize the chance of specular reflections.
- Ensure that locks or interlocks do not prevent rapid egress from the area in the event of an emergency situation.
- Have lighted warning signs (preferably flashing) and/or audible signals to indicate when a Class 4 laser is energized and operating. Signage must clearly explain the meaning of the lights.

## (f) Training

Only qualified and trained employees may operate Class 3b and 4 lasers. To be qualified, a laser operator must meet both the training requirements outlined below, and operational qualifications established by Radiation Safety. The Laser Registrant is responsible for ensuring that all persons who work in areas where Class 3b or 4 lasers are used are provided with appropriate training and written safety instructions (work rules), so that the workers can properly utilize equipment and know and follow safety procedures.

Radiation Safety assesses safety training during periodic site visits. The University of Texas policy states that safety training is to be provided before the persons are permitted to operate a laser without supervision. Completion of the training must be documented. For personnel who work with Class 3b and 4 lasers, the training will include the following topics:

- The biological effects of laser radiation.
- The physical principles of lasers.
- Classification of lasers.
- Basic safety rules.
- Use of protective equipment.
- Control of related hazards including electrical safety, fire safety, and chemical safety.
- Emergency response procedures.

Because of the hazard of electrocution, it is a recommendation that the lab personnel take a course in cardiopulmonary resuscitation (CPR) and proper rescue techniques to follow in the event of electrocution.

# Appendix 3

# Hazards and safety measures

(See sources below)

## a. Machine safeguarding

Any machine part, function, or process which may cause injury must be safeguarded. When the operation of a machine or accidental contact with it can injure the operator or others in the vicinity, the hazards must be either controlled or eliminated.

## b. General Requirements for all Machines

### a. Machine Guarding (212(a))

(1) Types of guarding. One or more methods of machine guarding shall be provided to protect the operator and other employees in the machine area from hazards such as those created by point of operation, ingoing nip points, rotating parts, flying chips and sparks.

(2) General requirements for machine guards. Guards shall be affixed to the machine where possible and secured elsewhere if for any reason attachment to the machine is not possible. The guard shall be such that it does not offer an accident hazard in itself.

**Concerns with E-Stops (emergency stopping devices)**

- E-Stops must NOT be used to routinely  control processes.
- E-Stops must be periodically tested.
- E-Stops must be accessible.

(3) Point of operation guarding.

(i) Point of operation is the area on a machine where work is actually performed upon the material being processed.

(ii) The point of operation of machines whose operation exposes an employee to injury, shall be guarded. The guarding device shall be in conformity with any appropriate standards therefore, or, in the absence of applicable specific standards, shall be so designed and constructed as to prevent the operator from having any part of his body in the danger zone during the operating cycle.
(iii) Special hand tools for placing and removing material shall be such as to permit easy handling of material without the operator placing a hand in the danger zone. Such tools shall

not be in lieu of other guarding required by this section, but can only be used to supplement protection provided.

Exposure of blades 212(a)(5): When the periphery of the blades of a fan is less than seven (7) feet above the floor or working level, the blades shall be guarded. The guard shall have openings no larger than one-half (1/2) inch.

Machines designed for a fixed location shall be securely anchored to prevent walking or moving.

- Safeguards must meet these minimum general requirements:
  - Prevent contact
  - Be securely attached
  - Protect from falling objects
  - Create no new hazards
  - Create no interference
  - Allow safe lubrication
- There are many ways to safeguard machines. The type of operation, the size or shape of stock, the method of handling, the physical layout of the work area, the type of material, and production requirements or limitations will help to determine the appropriate safeguarding method for the individual machine.
- Safeguards can be grouped under five general classifications.
  - Guards
  - Devices
  - Location/Distance
  - Potential Feeding and Ejection
  - Miscellaneous Aids

### b. Machine lockout/Tagout

- All machines and equipment use or manipulate energy to perform work. That energy may be electrical, mechanical, hydraulic, pneumatic, chemical, or thermal. That energy may be stored (such as in springs, steam or pressurized air or liquids), even after the equipment has been shut off. An employee can be seriously injured if this energy is accidently discharged during servicing or maintenance.

- The standard for the control of hazardous energy sources (lockout-tagout) covers servicing and maintenance of machines and equipment in which the unexpected energization or startup of the machines or equipment or release of stored energy could cause injury to employees.

- Lockout/tagout means deenergizing or controlling all energy sources and physically locking all power sources (i.e., circuit breakers, switches, valves, etc.) in the "OFF" (deenergized) position.

- The purpose of lockout/tagout is to prevent the accidental release of stored energy by locking all energy sources in the "OFF" or deenergized position.

- Normal production operations are *not* covered by this standard (See Subpart O). Servicing and/or maintenance which takes place during normal production operations are covered by this standard only if:

  - An employee is required to remove or bypass a guard or other safety device; or
  - An employee is required to place any part of his or her body into an area on a machine or piece of equipment where work is actually performed upon the material being processed (point of operation).

- Exception. Minor tool changes and adjustments, and other minor servicing activities, which take place during normal production operations, are not covered by this standard if they are routine, repetitive, and integral to the use of the equipment for production, provided that the work is performed using alternative measures which provide effective protection.

- "Affected employee." An employee whose job requires him/her to operate or use a machine or equipment on which servicing or maintenance is being performed under lockout or tagout, or whose job requires him/her to work in an area in which such servicing or maintenance is being performed.

- "Authorized employee." A person who locks out or tags out machines or equipment in order to perform servicing or maintenance on that machine or equipment. An affected employee becomes an authorized employee when that employee's duties include performing servicing or maintenance covered under this section.

- "Energized." Connected to an energy source or containing residual or stored energy.

- "Energy source." Any source of electrical, mechanical, hydraulic, pneumatic, chemical, thermal, or other energy.

- The established procedures for the application of energy control (the lockout or tagout procedures) shall cover the following elements and actions and shall be done in the following sequence:

  - Preparation for shutdown, notification of affected employees.
  - Machine or equipment shutdown.
  - Machine or equipment isolation.
  - Lockout or tagout device application.
  - Relief of stored energy.
  - Verification of isolation.

- Before lockout or tagout devices are removed and energy is restored to the machine or equipment, procedures shall be followed and actions taken by the authorized employee(s) to ensure the following:

  - Inspection of machine or equipment and safe positioning of employees.

- Employee notification.
- Removal of lockout/tagout devices.

- The employer shall provide training to ensure that the purpose and function of the energy control program are understood by employees. The training shall include the following:
  - Each authorized employee shall receive training in the recognition of applicable hazardous energy sources, the type and magnitude of the energy available in the workplace, and the methods and means necessary for energy isolation and control.
  - Each affected employee shall be instructed in the purpose and use of the energy control procedure.
  - All other employees whose work operations are or may be in an area where energy control procedures may be utilized, shall be instructed about the procedure, and about the prohibition relating to attempts to restart or reenergize machines or equipment which are locked out or tagged out.

- Locks, tags, chains, wedges, key blocks, adapter pins, self- locking fasteners, or other hardware shall be provided for isolating, securing or blocking of machines or equipment from energy sources.

- Lockout devices and tagout devices shall be singularly identified, shall be the only devices used for controlling energy. Procedures shall be developed, documented and utilized for the control of potentially hazardous energy. Lockout devices and tagout devices shall be singularly identified, shall be the only devices used for controlling energy, shall <u>not</u> be used for other purposes, and shall meet the following requirements:
  - Durable
  - Standardized
  - Substantial
  - Identifiable (and indicate identity of employee)

- Tagout devices shall warn against hazardous conditions if the machine or equipment is energized and shall include a legend such as the following: "Do Not Start. Do Not Open. Do Not Close. Do Not Energize. Do Not Operate."

- Tagout devices shall warn against hazardous conditions if the machine or equipment is energized and shall include a legend such as the following: "Do Not Start. Do Not Open. Do Not Close. Do Not Energize. Do Not Operate."

- The employer shall establish a program consisting of:
  - energy control procedures
  - employee training
  - periodic inspections

- The program should ensure that <u>before</u> any employee performs any servicing or maintenance on a machine or equipment where the unexpected energizing, startup or release of stored energy could occur and cause injury, the machine or equipment shall be isolated from the energy source and rendered inoperative.

## c. Personal Protective Equipment (PPE)

**General requirements**

- **Personal Protective Equipment**

  Application 1910.132(a). Protective equipment, including personal protective equipment for eyes, face, head, and extremities, protective clothing, respiratory devices, and protective shields and barriers, shall be provided, used, and maintained in a sanitary and reliable condition wherever it is necessary by reason of hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation or physical contact.

- Personal Protective Equipment
  - Employee-owned equipment 1910.132(b). Where employees provide their own protective equipment, the employer shall be responsible to assure its adequacy, including proper maintenance, and sanitation of such equipment.
  - Design 1910.132(c). All personal protective equipment shall be of safe design and construction for the work to be performed.
  - Hazard assessment and equipment selection 1910.132(d).

(1) The employer shall assess the workplace to determine if hazards are present, or are likely to be present, which necessitate the use of personal protective equipment (PPE). If such hazards are present, or likely to be present, the employer shall:

» **(i) Select**, and have each affected employee use, the types of PPE that will protect the affected employee from the hazards identified in the hazard assessment;

» **(ii)** Communicate selection decisions to each affected employee; and,

» (iii) Select PPE that properly fits each affected employee. Note: Non-mandatory Appendix B contains an example of procedures that would comply with the requirement for a hazard assessment.

– (2) The employer shall verify that the required workplace hazard assessment has been performed through a written certification that identifies the workplace evaluated; the person certifying that the evaluation has been performed; the date(s) of the hazard assessment; and, which identifies the document as a certification of hazard assessment.

Defective and damaged equipment 1910.132(e). Defective or damaged personal protective equipment shall not be used.

**Training** 1910.132(f).

- The employer shall provide training to each employee who is required by this section to use PPE. Each such employee shall be trained to know at least the following:
- When PPE is necessary; What PPE is necessary; How to properly don, doff, adjust, and wear PPE; The limitations of the PPE; and, The proper care, maintenance, useful life and
- When the employer has reason to believe that any affected employee who has already been trained does not have the understanding and skill required by paragraph (f)(2) of this section, the employer shall retrain each such employee. Circumstances where retraining is required include, but are not limited to, situations where:

» (i) Changes in the workplace render previous training obsolete; or

» (ii) Changes in the types of PPE to be used render previous training obsolete; or

» (iii) Inadequacies in an affected employee's knowledge or use of assigned PPE indicate that the employee has not retained the requisite understanding or skill.

- The employer shall verify that each affected employee has received and understood the required training through a written certification that contains the name of each employee trained, the date(s) of training, and that identifies the subject of the certification.
- Employers must protect employees from workplace hazards such as machines, hazardous substances, and dangerous work procedures that can cause injury.
- Employers must: Use all feasible engineering and work practice controls to eliminate and reduce hazards. Then use appropriate personal protective equipment (PPE) if these controls do not eliminate the hazards.
- (a)(1): The employer shall ensure that each affected employee uses appropriate eye or face protection when exposed to eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation.
- (a)(2): The employer shall ensure that each affected employee uses eye protection that provides side protection when there is a hazard from flying objects.
- (a)(1): The employer shall ensure that each affected employee wears a protective helmet when working in areas where there is a potential for injury to the head from falling objects.
- (a)(2): The employer shall ensure that a protective helmet designed to reduce electrical shock hazard is worn by each such affected employee when near exposed electrical conductors which could contact the head.
- (a): General requirements. The employer shall ensure that each affected employee uses protective footwear when working in areas where there is a danger of foot injuries due to falling or rolling objects, or objects piercing the sole, and where such employee's feet are exposed to electrical hazards.
- (b)(1): Protective footwear purchased after July 5, 1994 shall comply with ANSI Z41-1991.
- (a): General requirements. Employers shall select and require employees to use appropriate hand protection when employees' hands are exposed to hazards such as those from skin absorption of harmful substances; severe cuts or lacerations; severe abrasions; punctures; chemical burns; thermal burns; and harmful temperature extremes.

**d. The Occupational Exposure to Hazardous Chemicals in Laboratories Standard** (29 CFR 1910.1450),

- Commonly referred to as the Laboratory standard, requires that the employer designate a Chemical Hygiene Officer and have a written Chemical Hygiene Plan (CHP), and actively verify that it remains effective.
- The CHP must include provisions for worker training, chemical exposure monitoring where appropriate, medical consultation when exposure occurs, criteria for the use of personal protective equipment (PPE) and engineering controls, special precautions for particularly hazardous substances, and a requirement for a Chemical Hygiene Officer responsible for implementation of the CHP.
- The CHP must be tailored to reflect the specific chemical hazards present in the laboratory where it is to be used. Laboratory personnel must receive training regarding the Laboratory standard, the CHP, and other laboratory safety practices, including exposure detection, physical and health hazards associated with chemicals, and protective measures.

**e. The Hazard Communication Standard**

Sometimes called the HazCom standard (29 CFR 1910.1200). The standard requires evaluating the potential hazards of chemicals, and communicating information concerning those hazards and appropriate protective measures to employees. The standard includes provisions for: developing and maintaining a written hazard communication program for the workplace, including lists of hazardous chemicals present; labeling of containers of chemicals in the workplace, as well as of containers of chemicals being shipped to other workplaces; preparation and distribution of material safety data sheets (MSDSs) to workers and downstream employers; and development and implementation of worker training programs regarding hazards of chemicals and protective measures.

This OSHA standard requires manufacturers and importers of hazardous chemicals to provide material safety data sheets to users of the chemicals describing potential hazards and other information. They must also attach hazard warning labels to containers of the chemicals. Employers must make MSDSs available to workers. They must also train their workers in the hazards caused by the chemicals workers are exposed to and the appropriate protective measures that must be used when handling the chemicals.

**f. Fume hoods and lab ventilation**

A chemical fume hood is critical in a lab. A well-designed hood, when properly installed and maintained, offers a large degree of protection to the user, provided that it is used appropriately and its limitations are understood. It is used to control chemical exposure to the user and lab occupants and helps prevent chemical release into the laboratory. A fume hood can also limit the effects of a spill by partially enclosing the work area and drawing air into the enclosure through an exhaust fan. An exhaust fan installed on top of the laboratory building pulls air and airborne contaminants through ductwork out of the building. In a well-designed, properly functioning fume hood, only about 0.0001% to 0.001% of the material released within the hood actually escapes from the hood into the laboratory.

A hazard analysis can help determine if a fume hood is necessary for an experiment. Such an analysis should include: a review of the physical characteristics; the quantity and toxicity of the materials to be used; the experimental procedure; the volatility of the materials present during the experiment and the probability of their release; the number and sophistication of manipulations; and the skill level of the person performing the work.

The emergency action plan for your department should be clear and easily identifiable. Employers must provide appropriate safety equipment and first aid kits in case of emergency. Safety equipment may include fire extinguishers, fire blankets, AEDs, safety showers, eye wash fountains, spill control materials and fume hoods. These items should be tested or checked monthly. An appropriate supply of first aid equipment should be provided as well as instructions for their proper use.

## g. Environmental factors

- Heat-related illness, exposure to noise and poor illumination should be a concern for workplaces with poor working environments. Several guidelines need to be followed in such cases as listed in OSHA guidelines.
- As per OSHA requirements employers need to implement a hearing conservation program when noise exposure is at or above 85 decibels averaged over 8 working hours, or an 8-hour time-weighted average (TWA). Hearing conservation programs strive to prevent initial occupational hearing loss, preserve and protect remaining hearing, and equip workers with the knowledge and hearing protection devices necessary to safeguard themselves.
- Several guidelines are required by OSHA for proper illumination levels per the place of work. (https://www.osha.gov/dts/osta/otm/otm_iii/otm_iii_4.html)

## h. What to Do in the Event of:

1. **Fire or Explosion**

   Dial 911. If fire or explosion occurs, public safety should be notified immediately. Notify a supervisor or manager in charge immediately so that emergency procedures can be followed.

2. **Medical Injuries or Chemical Poisoning**

   Dial 911. If any injury or illness occurs and assistance is needed, contact public safety. If an ambulance is needed, public safety will arrange for one. Notify a supervisor or manager in charge immediately so that the appropriate emergency procedures can be followed.

3. **Personal Chemical Exposure/Response**

   How a chemical exposure affects a person depends on many factors. The dose is the amount of a chemical that actually enters the body. The actual dose that a person receives depends on the concentration of the chemical and the frequency and duration of the exposure. The sum of all routes of exposure must be considered when determining the dose. In addition to the dose, the outcome of the exposure is determined by (1) the way the chemical enters the body, (2) the physical properties of the chemical, and (3) the susceptibility of the individual receiving the dose. In all cases, the incident should be reported to your laboratory manager, supervisor or principal investigator, regardless of severity.

4. **Chemicals on Skin or Clothing**

   1. Immediately flush with water for no less than 15 minutes.
   2. While rinsing, quickly remove all contaminated clothing or jewelry.
   3. Use caution when removing pullover shirts or sweaters to prevent contamination of the eyes.
   4. Check the Material Safety Data Sheet (MSDS) to determine if any delayed effects should be expected.
   5. Discard contaminated clothing or launder them separately from other clothing. Leather garments or accessories cannot be decontaminated and should be discarded.

**Sources**

- https://www.osha.gov/laws-regs
- OSHA Standard 1910.1450 Occupational Exposures to Hazardous Chemicals in Laboratories
- https://www.grainger.com/know-how/safety/safety-management/safety-compliance/kh-359-lab-safety-standards-qt

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