الدليل الارشادي لشعبة السلامة والامن الكيمياوي والبايلوجي والاشعاعي

اعداد

الأستاذ المساعد الدكتورة

تماضر عباس حمودي

مسؤولة شعبة السلامة والامن الكيمياوي والبايلولوجي والاشعاعي

Introduction:

Practical study, experiment, and observation are of great importance in developing students' perceptions, creativity and the degree of their information absorption. A new culture and contexts for occupational and community safety and security have emerged and developed now regarding education in laboratories and research centers in academic institutions. Working in laboratories requires full awareness of the importance and danger of the materials and devices used, as many of the materials are toxic, irritating to membranes, and materials that are incendiary or flammable, so before starting laboratory work, we must be aware of the importance and danger of the materials used, and take caution how to be careful and to follow the safety instructions recommended by each laboratory according to the requirements of quality and reliability. The rules of safety and security for employees come first. This guide deals with the general foundations of safety and security in scientific and biological laboratories that students must follow under the supervision of laboratory officials and supervisors to achieve the maximum levels of safety and security and to preserve the environment. It is also an important reference for all university employees, especially faculty members, so everyone is required to bear the responsibility entrusted to him in this regard, because **security and safety is everyone's responsibility to maintain the health of the work environment, the safety of individuals, and the property that falls under their responsibility**. The guide contains security and safety rules policies and procedures, emergency plans programs, and procedures that aim to reduce the risks to which laboratory workers are exposed to, by avoiding and limiting risks and minimizing losses that may result from damage to their property. Achieving safety and security requires the participation of all members of the college and university in applying the instructions, recommendations and procedures of the Safety and Security Committee at once , in order to reach our applied and educational laboratories to the degree of "**Good Trained Laboratories**" (GLP). During training and educational programs that reflect positively on them and their performance, therefore, emphasis must be placed on the quality of management, system and accreditation programs in public and private laboratories in order to determine the level of rapid change in **measuring the efficiency of performance**, so the application of this guide is one of the basic means to achieve the highest levels of quality and institutional accreditation.

This guide represents a high measure of safety and security levels and institutional quality, and we are working to implement the items and procedures contained in this book as possible, stressing our determination to develop in order to reach the optimum for the continuation of safety and institutional security levels for individuals and environment.

Chapter One

" Occupational Safety and Security of Technical college of health and medicine"

" Occupational Safety and Security policy and programs are well suited and confirmed in our college technical of health and medicine and implemented by all of our students and health care professionals stuff according to internal and external safety and security regulations laid by the international organizations and agencies on bases of World health organization. In this guide report, risk assessment, engineering and administrative controls, potential risks and emergency plans were discussed.

Technical college of health and medicine:

Table-1 lists the 23 scientific laboratories for the technical college of health and medicine regarding three departments:

1,1- Technical department of pathological analysis.

1,2- Department of optics.

1,3- Department of orthodontics.

1-Risk assessment:

Careful examination of any case in your work or workplace which cause harm to people or environment, so that **precautions or controls** are necessary to prevent such harm should be extensively determined via the following:

-**Collecting information** on chemical industries and sites where hazardous **chemicals are produced and/or stored.**

-Gathering of **information on toxic effects of involved chemicals**.
-Evaluation of information to determine possible risks associated with **exposure**.
- Systematic evaluation of the likelihood of an adverse effect arising from exposure in a defined **population**.

- Systematic process for describing, qualifying and characterize the risks associated with hazardous substances**, action or events as seen in table-2**.

Risk assessment will ensure a comprehensive analysis of the most current data related to a hazard and will result in an output; and provide several opportunities for control. The final intention is to prevent accidents or work-related damage to health in the workplace. It is important to remember that performing risk assessment entails **a great deal of computer work** with specialized software to help analyze the different type data and model different scenarios and it is a **teamwork** continuous process.

Risk assessment of hazards:

It is a process which entails the following: It is a process which entails the following:

1-Hazard identification:

1.1 Is to identify the adverse effects which a chemical, substance or a certain situation (case) has an inherent capacity to cause a particular effect in the assessment process.

1.2 Gather and evaluate data on types of health effect or disease that may be produced by exposure, neurological effects or cancer.

2-Exposure assessment:

Is the **determination/estimation of the emissions**, pathways, and rates of movement of a substance and its transformation or degradation in order to estimate the **concentrations/doses** to which human populations or environmental compartments are or may be exposed to.

3-Risk management:

Is a decision-making process that involves weighing **political**, **social**, **economic**, and **engineering** information against risk-related information to develop, analyze and compare regulatory options and **select the appropriate regulatory response and** solution to a potential health or environmental hazard.

Management of health care workers exposed to, colonized by, or infected with microorganisms; an outbreak management process for exposures and/or healthcare workers who are symptomatic or colonized with infectious disease; and access by occupational health professionals to utilize medical assessment and diagnostic services for timely follow-up for health care worker exposures.

4. Risk Characterization:

Is the estimation of the incidence and severity of the adverse effects likely to occur in a human population or environmental compartment due to actual or predicted exposure to a substance.

5.Risk reduction:

Risk reduction is achieved using risk assessment matrix (table-3) according to the value of the risk assessment process and the hierarchy of controls as seen by figure-1, thus **keeping people away from the hazard**, changing the way people work to reduce exposure to the hazard, allowing workers to be exposed to the hazard while **wearing personal protective equipment (PPE)** taking measures to **protect humans and/or the**

environment against the risks identified. Additional factors should be taken into account before a risk management decision is taken, including: **Effectiveness, practicality, monitor ability, objectivity, administrative simplicity, consistency, public acceptability, time, and the nature of the legislative mandate.**

Table – 3 Risk assessment matrix.

CONSEQUENCE	IMPACT	TIME (DAYS)	INJURY DEATHS	RISK ASSESSMENT MATRIX							RISK LEVEL
	MAJOR PERMANENT IMPACT	60-180	Multiple deaths	6	6	7	8	9	10	11	VERY HIGH SEVERITY RISK (10 – 11) CATASTROFIC – DEATH LOSS OF SYSTEM
	MODERATE PERMANENT IMPACT	30-60	Single death and/or multiple major injures	5	5	6	7	8	9	10	
	MINOR PERMANENT IMPACT	12-30	Major injures and hospitalization	4	4	5	6	7	8	9	HIGH SEVERITY RISK (8-9) CRITICAL - SEVERE INJURY MAJOR DAMAGE TO SYSTEM
	MAJOR TEMPORARY IMPACT	3-12	Injures requiring treatment by medical practioners - lost from workplace	3	3	4	5	6	7	8	
	MINOR TEMPORARY IMPACT	1-3	Minor injures or first aid treatment	2	2	3	4	5	6	7	MEDIUM SEVERITY RISK (5 – 7) MINOR INJURY/SYSTEM DAMAGE
	VERY LOW TEMPORARY IMPACT	0-1	No injury or fist aid treatment	1	1	2	3	4	5	6	VERY LOW (1) / LOW RISK (2-4) NO INJURY – NO SYSTEM DAMAGE
					1	2	3	4	5	6	
					VERY UNLIKELY 0-1%	UNLIKELY 1-5%	RARE 5-10%	MODERATE 10-25%	LIKELY 25-50%	ALMOST CERTAIN 50-100%	
					PROBABILITY OF OCCURRENCE						

RISK = ƒ(H, E, Po, Pr)
CONSEQUENCE = ƒ(H, E, Po)
LEVEL OF SEVERITY RISK = ƒ(Co, Pr)
H = Hazard
E = Exposure
Po = Population
Pr = Probability

10-11 CATASTROPHIC - STOP
8-9 UNACCEPTABLE-URGENT ACTION
5-7 MARGINAL-UNDESIRABLE - ACTION
2-4 ACCEPTABLE - MONITOR
1 NEGLIGIBLE - NO ACTION

Control Strategies to Mitigate the Risks

With such ergonomic hazards include:

1-Engineering controls:

Many engineering controls are available for controlling the hazard at the source and along the path of transmission. For chemical hazards, common engineering controls include and according to hierarchy of controls triangle as seen by figure 1:

1- Elimination.

2-Substitution.

3- Local exhaust ventilation.

4- General ventilation (only appropriate for non-toxic chemicals).

5- Isolation/enclosed processes.

6- Proper chemical storage.

7- Facility design.

Elimination:

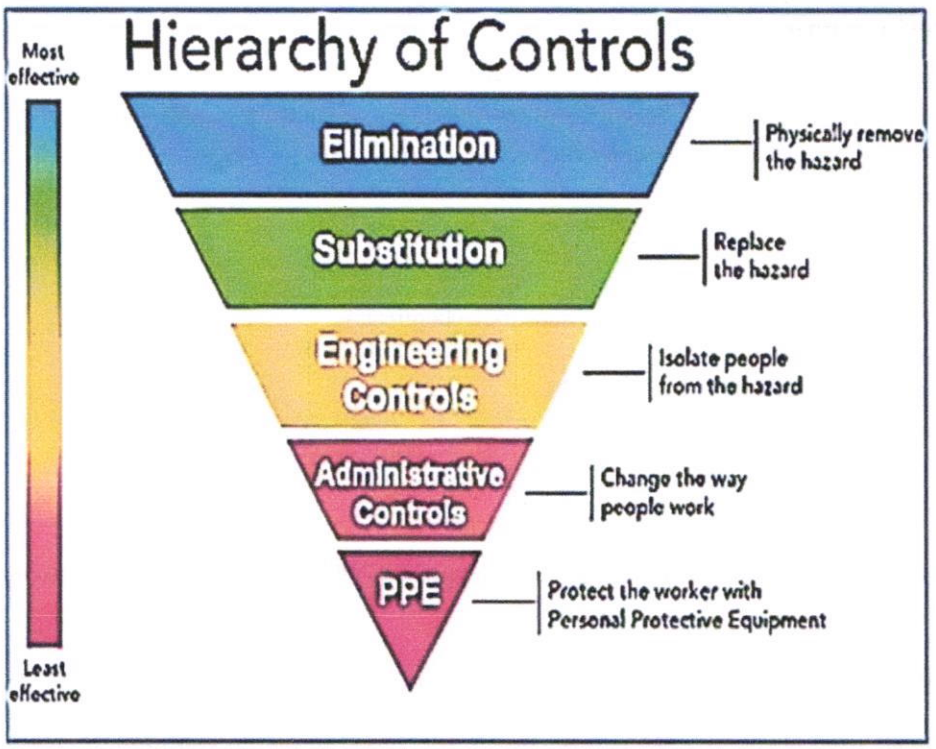
Elimination of a hazardous chemical from the workplace is always desirable but not always possible.

Substitution:

Some chemicals used in the process or experiment are chosen based on tradition or cost. In recent years, efforts have been made to find less hazardous alternatives to some of the chemicals commonly used.

2-Administrative controls:

As administrative controls, **policies and procedures** should be in place to ensure that there are safe work procedures for storing, using chemicals and discarding chemical wastes appropriately that health care workers may come into contact with a number of **chemicals** or infectious matters through their work. **Workplace Hazardous Materials Information System (WHMIS) training** should be provided to all health care personnel. In addition, emergency call lines that provide expertise and advice regarding toxic chemicals should be made available.
Administrative controls include **policies**, **procedures**, **work practices**, **rules**, **training**, and **work scheduling.**



Source: http://www.cdc.gov/niosh/topics/hierarchy/

Fig.-1 Hierarchy triangle control.

Hazardous Materials Information System (WHMIS) Program:

A WHMIS program is an **administrative control to reduce the risk of exposure to hazardous materials in the workplace and is a legal requirement for all employers who use controlled products in their work place.** Material Safety Data Sheets for all products in the workplace, ensuring all products are appropriately labelled and ensuring that all workers are instructed on how to use the chemicals safely.

Exposure follow-up emergency response equipment:

Two types of **exposure follow-up** are considered as administrative controls. **The first is the provision of appropriate emergency response equipment to reduce the impact of the exposure. The second is the medical follow-up for workers who have bio infected or had a**

chemical exposure. Emergency response equipment for healthcare workers usually refers to emergency eyewashes that can provide sufficient water to dilute the contaminant before it can cause extensive damage. **Wherever chemical exposure could pose a hazard to eyes and skin, emergency wash devices are required**. Appropriate signage that is easily visible must be provided to indicate where the eyewashes are kept. **A worker who has had a chemical exposure may require medical follow-up.** Guidelines are available to provide information on the treatment and monitoring of workers with exposure to specific hazardous agent.

Chemical waste handling and disposal:

Chemical wastes must be addressed with a good chemical waste management system. Municipal and or provincial codes address appropriate disposal requirements and aim to reduce contamination, possible injuries, illness or reactions related to chemical exposures.

Additional considerations for reducing risk of exposure:

It is prudent to be aware of the need for modification of the work environment, conditions or the required PPE for workers who may be medically vulnerable to the effects of some substances. Higher risk workers may include **pregnant workers, workers with allergies or those who are sensitized to certain chemicals.** Some common approaches to accommodate these workers include temporary reassignment to areas or tasks where the exposure potential is eliminated; **work scheduling** to reduce the amount of exposure, and changes to the PPE to accommodate limitations.

1- **Adjustment of the workstation** to the patient each time.
2- **Scheduling of patients** to reduce risk.
3- **Training** regarding ergonomic hazards and control strategies.

Training:

Training in biological hazards and controls should be provided to all health care professionals and workers who **must understand the employer's infection prevention control, IPC and occupational safety and health, OHS programs as they relate to his or her job duties. To ensure that health care workers understand and apply this information to their jobs, specific training should also be provided to address job-specific biological hazards. Periodic refresher training to reinforce policies and procedures and introduce any new practices will benefit all healthcare workers:**

1- **Education about vaccine-preventable diseases.**
2- Risk assessment to determine the need for immunization or surveillance based on potential exposure.
3 - Administration of immunizations (or referral for immunizations, as appropriate).

4-Documentation and follow-up of any baseline health assessments, communicable disease status and immunizations. Ideally, the immunization and surveillance programs should provide easy, authorized access to healthcare workers immune status records for follow up of exposure incidents and outbreaks. In some cases, immunizations or baseline testing may be required prior to commencement of work. Post-exposure follow-up management Post-exposure routine practices and additional precautions Procedural controls may include procedures that relate to the use of Routine Practices and Additional Precautions as directed, baseline health assessments and periodic screening of workers, and hazard identification and control processes. Awareness of the infectious disease status of patients is another good control, though this is not always possible for healthcare workers. All work procedures should include the consideration and control of the risk of exposure to workers. Routine Practices and Additional Precautions (where required) greatly assist in reducing the transmission of infectious agents from both known and unknown patient sources **by treating all contacts as potential risks.**

5- Early **reporting** system to capture symptoms of ergonomic concerns.

6- **Alternating working posture frequently** and performing stretches during any micro-breaks.

7- Including ergonomic considerations in all workstation/work equipment procurement policies.

8-Maintenance of all work equipment as per **manufacturer's recommendations.**

Levels of Bio Clinical Laboratory

A Biological Safety Level (BSL 1, 2, 3 & 4) is assigned to a biological lab as a safeguard to protect laboratory personnel, as well as the surrounding environment and community.

The assignment of the biosafety level of a biological laboratory can be seen in table-4, takes into consideration the **organism** (**pathogenic agent**) to be handled with, the **available facilities**, **equipment** as well as **practice programs** for the **laboratory officials training as well as** the **procedures** required to conduct work There are individual safeguards designed to protect laboratory personnel, as well as the surrounding environment and community.

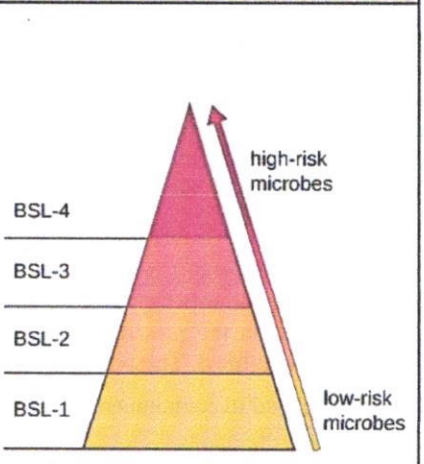
These levels, which are ranked from one to four, are selected based on the agents or organisms that are being researched or worked on in any given laboratory setting. For example, a **basic lab setting specializing in the research of nonlethal agents that pose a minimal potential threat to lab workers and the environment are generally considered BSL-1 which is the lowest biosafety lab level**. A specialized research laboratory that deals with potentially deadly infectious agents like Ebola would be designated as BSL-4 which is the highest and most stringent level.

The Centers for Disease Control and Prevention (CDC) sets BSL lab levels as a way of exhibiting specific controls for the containment of microbes and biological agents. Each BSL lab level builds upon on the previous level, thereby creating layer upon layer of constraints and barriers as seen in **table 4**. These lab levels are determined by the following

1. Risks related to containment.
2. Severity of infection.
3. Transmissibility.
4. Nature of the work conducted.
5. Origin of the microbe.
6. Agent in question.
7. Route of exposure.

The reason biosafety levels are so important is because they dictate the type of work practices that are allowed to take place in a laboratory setting. They also heavily influence the overall design of the facility in question, as well as the type of specialized safety equipment used within it.

Table-4 Biosafety levels of bio laboratories with respect to pathogen, practice and equipment according to risk assessment.

Biosafety Levels			
Biological Safety Levels	**Description**	**Examples**	**CDC Classification**
BSL-4	Microbes are dangerous and exotic, posing a high risk of aerosol-transmitted infections, which are frequently fatal without treatment or vaccines. Few labs are at this level.	Ebola and Marburg viruses	
BSL-3	Microbes are indigenous or exotic and cause serious or potentially lethal diseases through respiratory transmission.	*Mycobacterium tuberculosis*	
BSL-2	Microbes are typically indigenous and are associated with diseases of varying severity. They pose moderate risk to workers and the environment.	*Staphylococcus aureus*	
BSL-1	Microbes are not known to cause disease in healthy hosts and pose minimal risk to workers and the environment.	Nonpathogenic strains of *Escherichia coli*	

Bio safety level -1 (BSL–1):

Biosafety level 1 as seen in figure 2 applies to laboratory settings in which personnel work with low-risk microbes that pose little to no threat of infection in healthy adults such as a nonpathogenic strain of *E. coli*. This laboratory setting typically consists of research taking place on **benches without the use of special contaminant equipment. A BSL-1 lab, which is not required to be isolated from surrounding facilities, houses activities that require only standard microbial practices, such as:**

1. Mechanical pipetting only (no mouth pipetting allowed).
2. Safe sharps handling.
3. Avoidance of splashes or aerosols.
4. Daily decontamination of all work surfaces when work is complete.
5. Hand washing.
6. Prohibition of food, drink and smoking materials in lab setting.

7. Personal protective equipment, such as; eye protection, gloves and a lab coat or gown.
8. Biohazard signs.

BSL-1 labs also requires immediate decontamination after spills. Infection materials are also decontaminated prior to disposal, generally through the use of an autoclave.

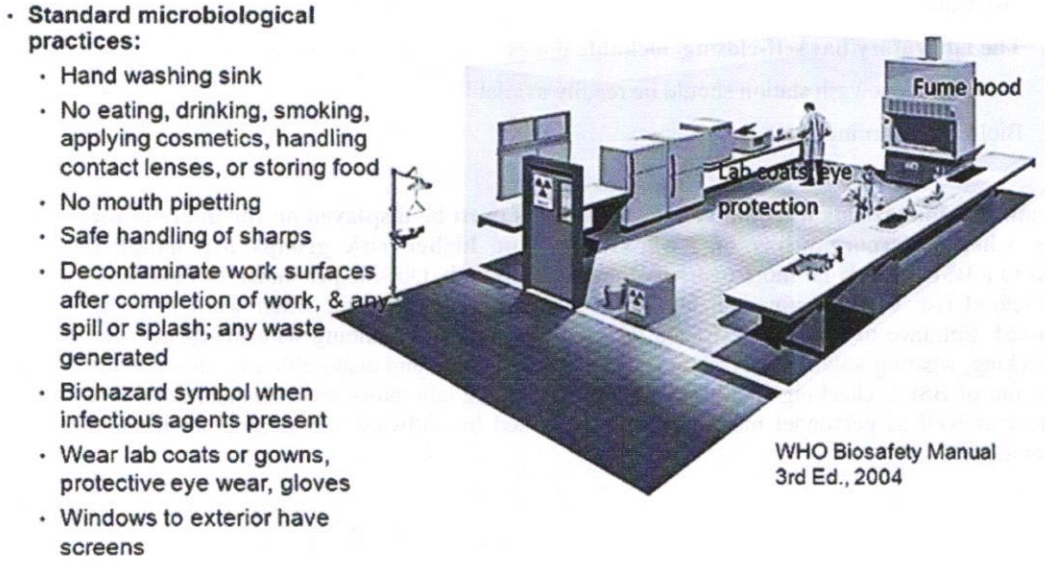


Fig.- 2 A typical biosafety laboratory of level-1

Bio safety level-2 (BSL–2):

This biosafety level covers laboratories that work with agents associated with human diseases (i.e. pathogenic or infections organisms) that pose a moderate health hazard which include equine encephalitis viruses and HIV, as well as *Staphylococcus aureus (staph infections)* as seen by figure 3, BSL-2 laboratories maintain the same standard microbial practices as BSL-1 labs, but also **includes enhanced measures due to the potential risk of the aforementioned microbes.** Personnel **working in BSL-2 labs are expected to take even greater care to prevent injuries such as cuts and other breaches of the skin, as well as ingestion and mucous membrane exposures**. In addition to BSL 1 expectation, the following practices are required in a BSL 2 lab setting:

1. Appropriate personal protective equipment (PPE) must be worn, including lab coats and gloves. Eye protection and face shields can also be worn, as needed.

2. All procedures that can cause infection from aerosols or splashes are performed within a biological safety cabinet (BSC).
3. An autoclave or an alternative method of decontamination is available for proper disposals.
4. **The laboratory has self-closing, lockable doors**.
5. A sink and eyewash station should be readily available.
6. Biohazard warning signs.

International biohazards warning symbols and signs must be displayed on the doors of the rooms where microorganisms of Risk Group-2 or higher risk groups are handled. Access to a BSL-2 lab is far more restrictive than a BSL-1 lab. Outside personnel, or those with an increased risk of contamination, are often restricted from entering when work is being conducted. Entrance to BSL2 is restricted to trained personnel, beginning with interphase area for checking, wearing gowns with personnel measuring devices and disposable overshoes, when getting out of BSL2, checking should be implemented using laboratory measures and analytical detectors as well as personnel movements are governed by software access program through electronic gates.

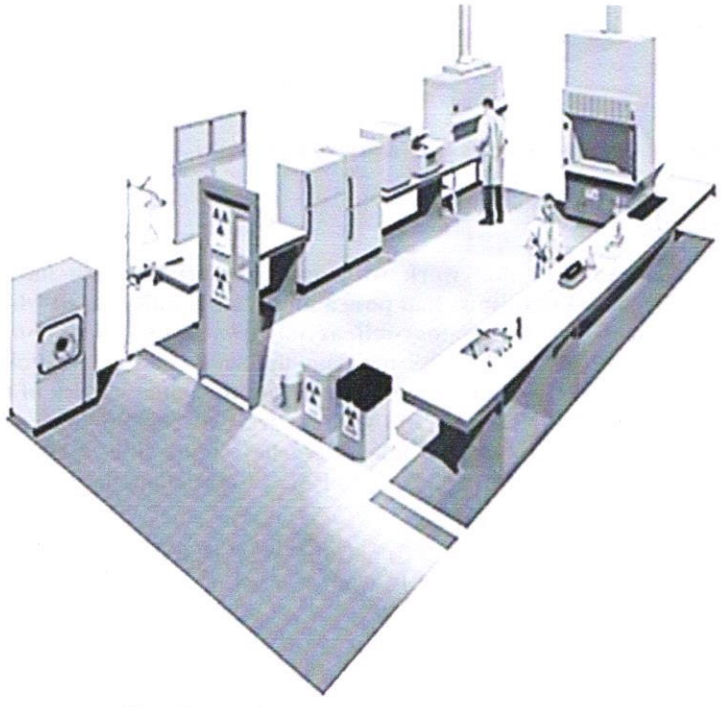


Fig.- 3 A typical biosafety laboratory of level-2.

Bio safety level-3 (BSL-3):

BSL-3 laboratory typically includes work on microbes that are either **indigenous or exotic**, and can cause serious or potentially lethal disease through inhalation which include yellow fever, west Nile virus, and the bacteria that causes tuberculosis (figure 4). **The microbes are so serious that the work is often strictly controlled and registered with the appropriate government agencies**. Laboratory personnel are also under medical surveillance and could receive immunizations for microbes they work with. Common requirements in a BSL-3 laboratory include:

1. Standard personal protective equipment must be worn, and respirators might be required.
2. Solid-front wraparound gowns, scrub suits or coveralls are often required.
3. All work with microbes must be performed within an appropriate BSC.
4. **Access hands-free sink and eyewash are available near the exit.**
5. **Sustained directional airflow to draw air into the laboratory from clean areas towards potentially contaminated areas (Exhaust air cannot be re-circulated)**
6. **A self-closing set of locking doors with access away from general building corridors.**
7. **Access to a BSL-3 laboratory is restricted and controlled at all time.**

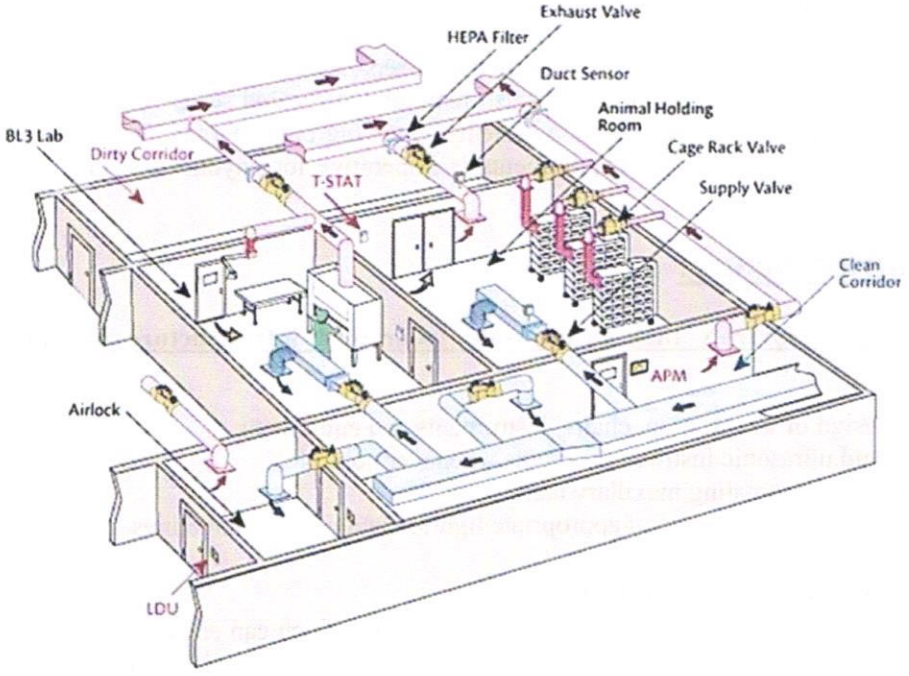


Fig.- 4 A typical biosafety laboratory of level-3

Bio safety level-4 (BSL-4):

BSL-4 labs are rare. However some do exist in a small number of places in the US and around the world. As the highest level of biological safety, a BSL-4 lab **consists of work with highly dangerous and exotic microbes. Infections caused by these types of microbes are frequently fatal, and come without treatment or vaccines. Two examples of such microbes include Ebola and Marburg viruses.**

In addition to BSL-3 considerations, BSL-4 laboratories have the following containment requirements:

1. Personnel are required to change clothing before entering, shower upon exiting
2. Decontamination of all materials before exiting.
3. Personnel must wear the recommended personal protective equipment as well as a full body, air-supplied, positive pressure suit.
4. A Class III biological safety cabinet.

A BSL-4 laboratory is extremely isolated, often located in a separate building or in an isolated and restricted zone of the building. The laboratory also features a dedicated supply and exhaust air, as well as vacuum lines and decontamination systems. Knowing the difference in biosafety lab levels and their corresponding safety requirements is imperative for anyone working with microbes in a lab setting.

Laboratory Infrastructure:

Engineering thoroughly controls that ensure safe laboratory infrastructure are the following tasks:

1- Good ergonomic design of workstation, chairs, instruments and equipment.
2- Use of automatic and ultrasonic instruments / tools whenever possible.
3-Use of indirect vision when treating maxillary teeth.
4- Minimization of glare through the use of appropriate lighting and window coverings.

1-Local exhaust ventilation hoods (LEV):

LEV-Hood is a defined as a suction device, regardless of its shape which can enclose or capture (remove) any contaminants close near the working zone (figures 5-7) used for different purposes, also it is called as a fume hood or fume cupboard. The fume hood should be checked to the recommended design withdrawal velocity regarding each hazardous agent, **cubic feet per minute (fpm)** values as seen in table-5 using a mechanical vinometer (figure- 8) or electronic vinometer (figure- 9).

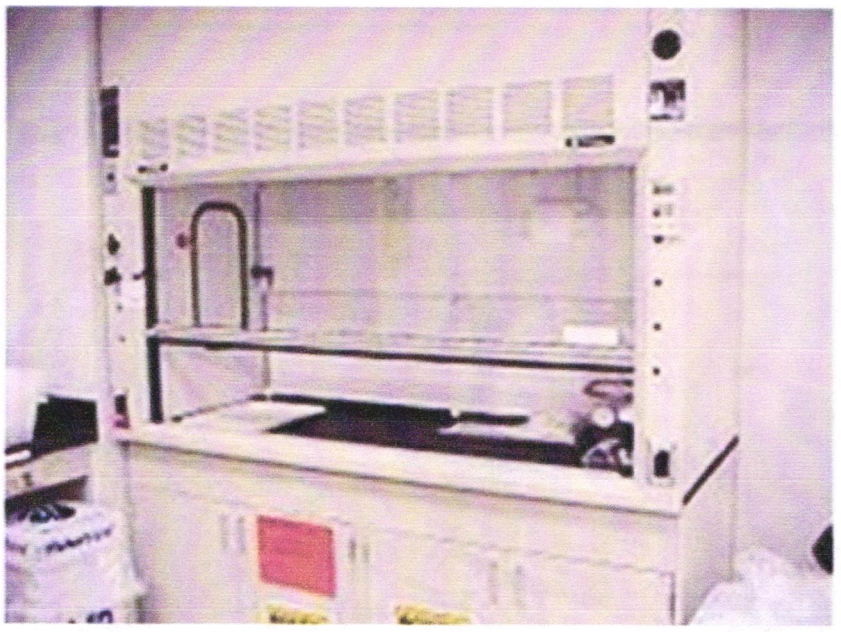


Fig.- 5 Laboratory chemical fume hood for chemicals.

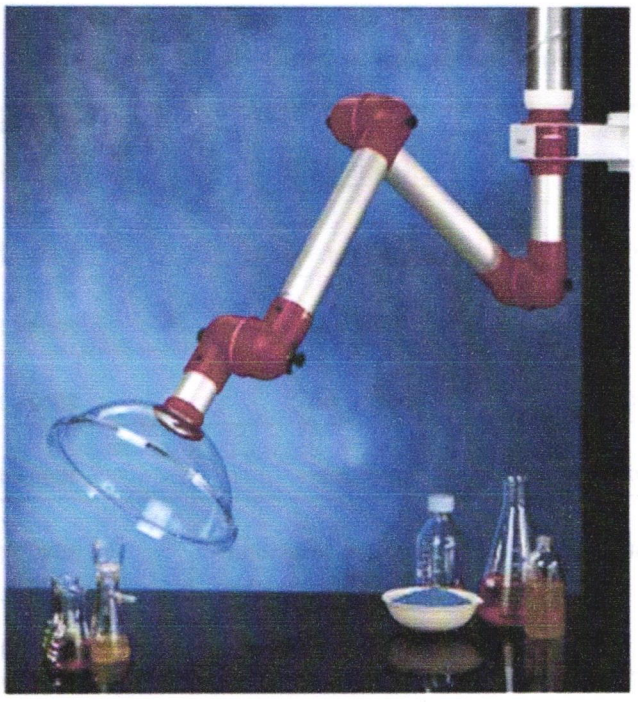


Fig.-6 LEV elephant trunk hood.

Fig.-7 Canopy fume hood for bench type work.

Table-5 Recommended air capture flowrates for duct design for different hazardous agents.

CONTAMINANT	EXAMPLES	DESIGN VELOCITY (fpm)
Vapors, gases, smoke	Vapors, gases, smoke	1000 – 2000
Fumes	Welding	2000 - 2500
Very fine dust	Cotton lint	2500 - 3000
Dry dusts & powders	Cotton dust	3000 - 4000
Industrial dust	Grinding dust, limestone dust	3500 - 4000
Heavy dust	Sawdust, metal turnings	4000 - 4500
Heavy/moist dusts	Lead dusts, cement dust	> 4500

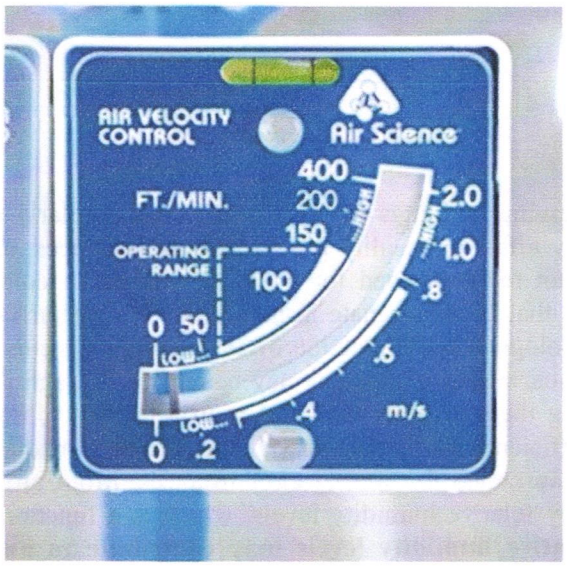


Fig.-8 Air anemometer (vinometer) showing air flow rate criteria.

Fig.-9 Air velocity meter anemometer calibration for Lab services.

2-General ventilation:

General ventilation systems serving buildings must be maintained regularly and inspected for conditions that could adversely affect air quality provided to work spaces, also it is called as dilution ventilation which is not recommended for working with pathogenic or contaminated agent. Accumulations of water that could stagnate in humidification systems or drip trays may become sources of potential biological contamination of air handling systems that need regular monitoring and inspection. Biohazardous organisms may be carried through general ventilation systems, potentially distributing them to other workspaces in a facility. Ultraviolet germicidal irradiation units, and or high efficiency particulate air (HEPA) filtration media incorporated into air handling systems may be warranted for special circumstances. Mold growth in the indoor environment can be affected by relative humidity levels, which is a function of some general ventilation systems. **High relative humidity levels may contribute to an increase in the growth of some molds and lead to condensation developing on surfaces. Control of indoor relative humidity levels is an important factor in preventing mold growth.**

For biological hazards, local exhaust ventilation systems are used in some dental instruments that create aerosols and is widely used as suction to remove saliva and particles from patients during procedures into closed and isolated system (figures 10-13) .

1-Dry (line) suction system:

This system removes solids and liquids within the surgery leaving the pipeline from the separator to the suction pump dry.

2-Semi-dry (line) suction system:

This system removes solids from one or a number of surgeries at a central collection point adjacent to the surgery or surgeries. The pipeline from the separator to the suction pump is dry.

3-Wet (line) suction system:

This system discharges to waste solids less than 600 nm mesh size and liquids through a "wet" pipeline via a suction pump.

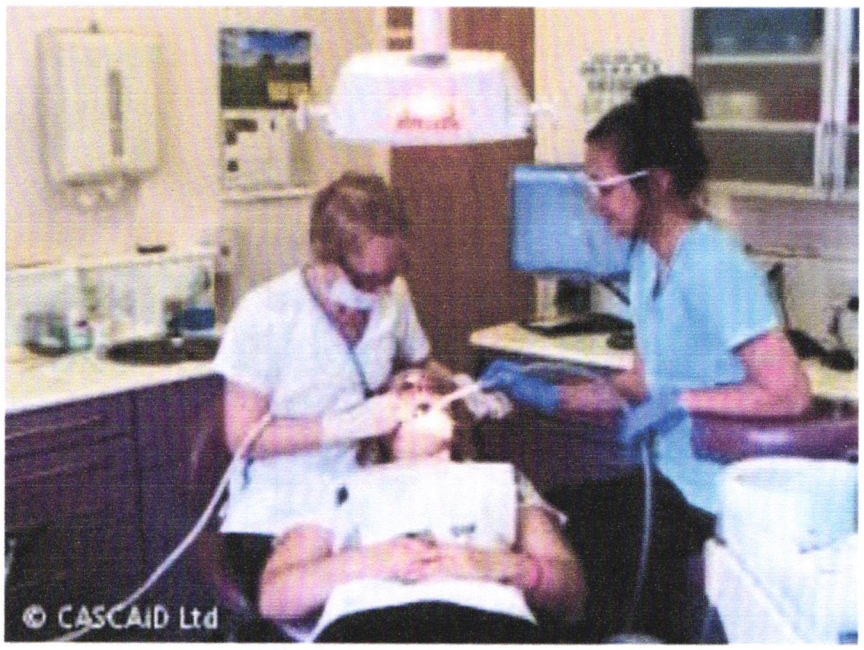


Fig.-10 Dental suction system showing dental ducting tube.

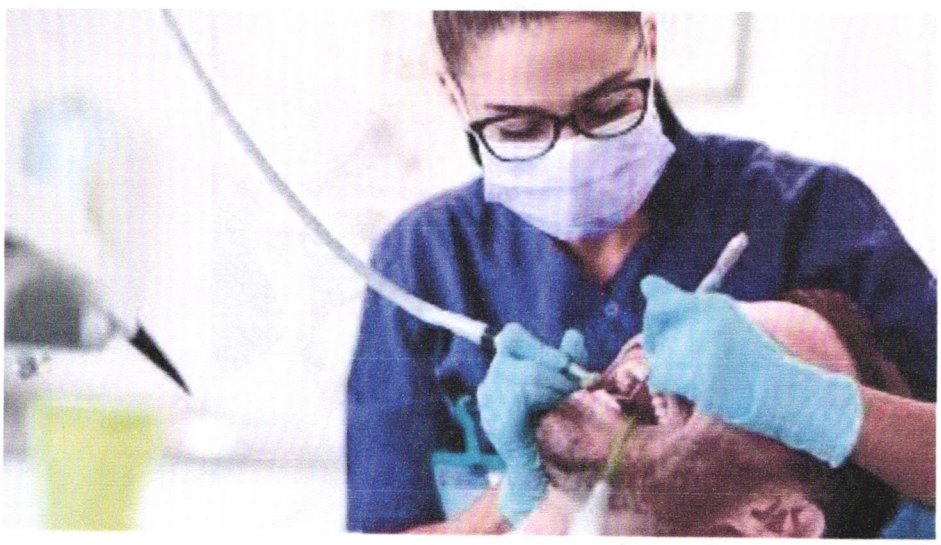


Fig.-11 Dental suction system showing dental ducting tube.

Fig.-12 Dental suction system of 50-liter capacity.

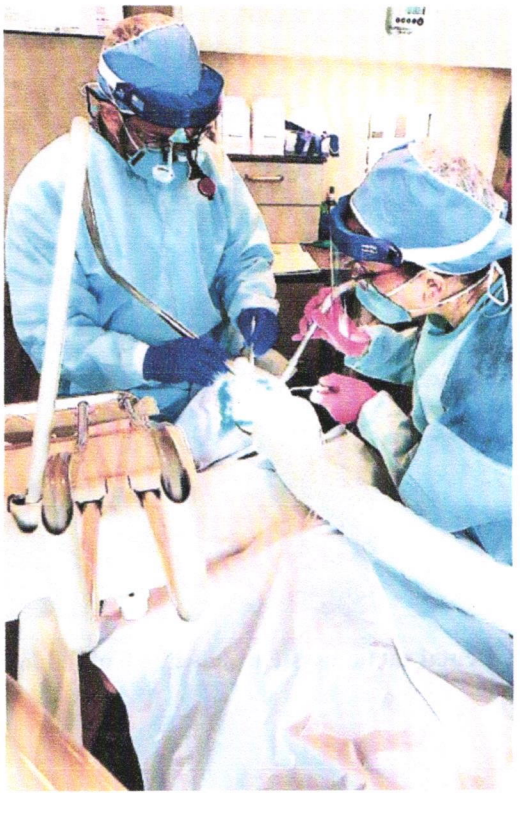


Fig. 13 The Safe Mercury Amalgam Removal Technique (SMART).

3-Biological safety cabinets:

Since the early times of microbiology, the most dangerous techniques with aerosol formation during microbiological laboratory operations, like sub culturing, handling suspensions, centrifuging, etc. which were restricted to separated chambers within the laboratory, supplied with UV air disinfection which was called "**inoculating rooms**", as a form of **primary containment**. Increased efforts to strengthen chemical laboratory work safety led to the development of **safety hoods**. Parallel efforts to protect against (micro)biological exposure led to the development of biological safety cabinets (BSCs) which are closed cabinets designed for easy decontamination, **with a view screen protecting from splashing and splintering**, and **continuous air flow** through the cabinet with **exhaust decontamination** as seen by figures. Today, BSCs are manufactured in **three general classes**, and are **combined with HEPA filters**, providing clean "particle free", **almost sterile air** work benches due to laminar airflow. The use of HEPA filters assumes the **presence of internal fans** in BSCs to provide adequate, directed air flow in the cabinet. BSCs may be ducted (connected to an exhaust) or not ducted. Exhaust air is usually similarly decontaminated with the use of HEPA filters; and in some instances, activated carbon filters may be built into the internal and/or exhaust air stream to adsorb toxins or other hazardous biological/chemical agents. BSCs are equipped with HEPA filters to protect the product/biological procedure (aseptic/sterile operation in the workspace) and provide primary containment (keeping contaminated air in the cabinet). Class 1 cabinets (figure 14) and are used in the biological laboratories of **level 1**.

Fig.-14 Biological safety cabinet class 1

Non-ducted class 2 cabinets with HEPA filtered exhaust air fed back into the laboratory are the most common in biological laboratories of levels 1 and 2 microbiological laboratories (figure 15). These provide **protection to the operator and the work simultaneously**. In case of class 2a cabinets, the air-blower recirculates 70 % of the air through a HEPA filter into the workspace, while 30 % is forced through another HEPA filter back into the laboratory air. On the suction side, 30 % fresh air enters at the fringe of the contamination of the laboratory, together with 70 % contaminated air from the workplace. This way, the cabinet provides through the HEPA filter a downward particle free (almost sterile) laminar air stream over the work-bench, and maintains a continuous air intake through the opening of the view window/work opening (which should not be higher than 20-30 cm during work). The cabinet is sensitive to the disruption of the vertical laminar airflow by objects or devices causing turbulence, e.g. the upward airflow caused by gas burners can cause faults, as can the littering of the workbench with unnecessary objects. Class 2b of biological safety cabinets maintain a higher fringe inflow air velocity (0.5 m/s), and have ducted exhaust outside the building.

Fig.-15 Biological safety cabinet class II (type2A)

Class3 BSCs are maximum containment instruments used in biological laboratories of levels 3&4 **(figure 16)**. They are likely ducted glove boxes with HEPA filters for clean-air workbenches, where materials are transferred into the work area through an isolated tunnel interchange. The workspace of the BSC is usually equipped with UV lamps, which enable

disinfection at layoff, and have optional access to public/laboratory services (gas, vacuum, pressure air, water, etc.) They are constructed leak-proof, of corrosion resistant materials to withstand the chemicals generally used, and the terminal decontamination with formaldehyde vapor at filter change, and other service/repair operations.

Fig.- 16 Biological safety cabinet class III

4-Personal Protective Equipment controls, PPE:

Personal Protective Equipment (PPE) such as gloves, respiratory protection and eye protection should be used based on the risk assessment. **PPE is often used in conjunction with other controls (engineering and administrative) to provide additional protection to workers.** The primary types of PPE are designed to protect the worker from infectious disease by breaking the chain of infection at the "portal of entry or exit" of the microorganisms. This means that all PPE is designed to reduce exposure via specific routes of transmission. **Gloves, gowns and other protective clothing reduce exposure through the dermal (skin) contact route and help contain the microorganisms to the work environment.** Employees should be trained how to

contain the microorganisms to the work environment. Employees should be trained how to choose and use the recommended PPE properly (figures 17-19) by training as well as storage, maintenance and disposal of PPE. **Personal protective equipment (PPE) is considered the lowest level of protection in the hierarchy of controls.** This reflects the reliance on proper selection, fit, use and maintenance of the equipment by the organization and individual workers. Eye and face protection reduce exposure through skin and mucous membrane contact. Respirators reduce exposure to the respiratory system. PPE is required when there is the potential for exposure of the face to splashes or sprays of infectious material. **The selection of eyewear depends upon the tasks being conducted. Types of eye protection include safety glasses, goggles, visors, face shields and table mounted barrier shields. Regular prescription eyewear and contact lenses are not considered effective as PPE**. Safety eyewear should fit the wearer, be clean and well maintained and stored. If necessary, goggles may be fitted with prescription lenses or worn over glasses. **Face shields should cover the forehead, extend below the chin, and wrap around the side of the face. Masks protect the mucous membranes of the nose and mouth from exposure to large droplets that may contain infectious materials.** Masks are commonly used to contain droplets at the source (for example, the dental worker or patient with a cough). **Masks should fully cover the nose and mouth and fit snugly**. Masks worn by patients to reduce exposure through droplets containment at the source, and respirators worn by health care workers to reduce exposure to the respiratory system. **There are many types of gloves produced by novel companies suitable for protection against any job whether it is chemical, clinical, surgical, biological and for engineering purposes such as cutting, welding and thermal** ..... etc.

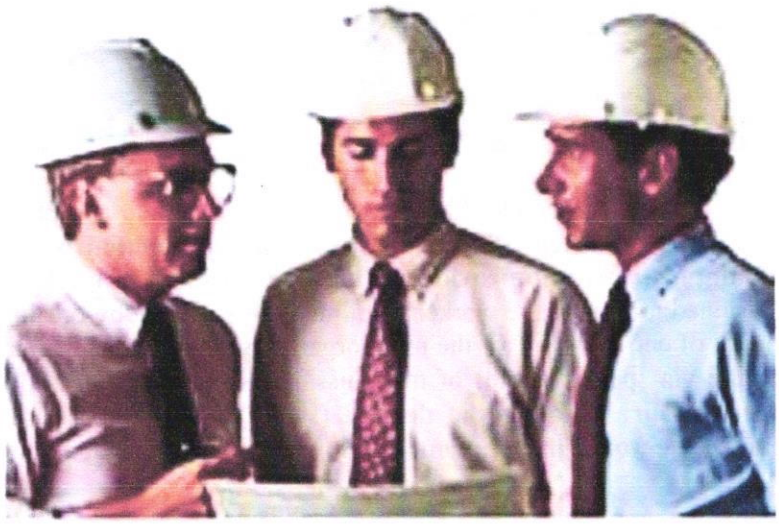


Fig.-17 Engineers wearing head protecting hat.

Fig.-18 Safety glasses, goggles and face shields against UV and IR radiations.

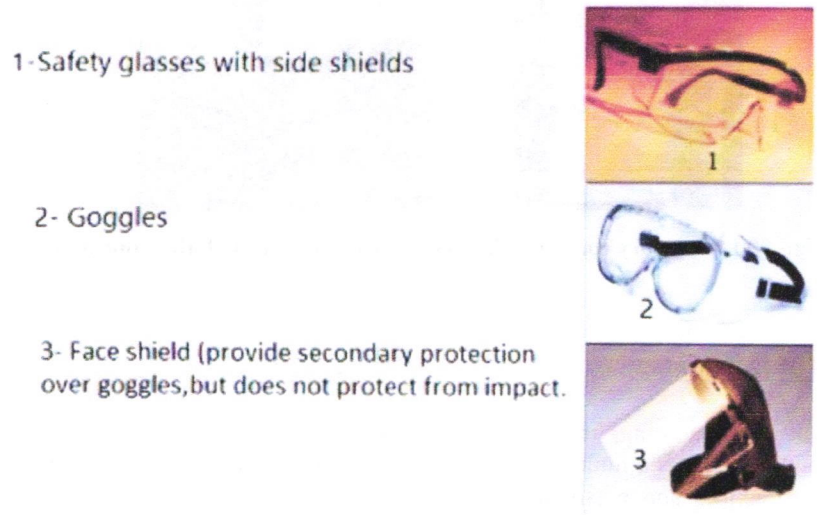


Fig.- 19 Safety glasses, goggles and secondary face protection shield.

Laboratory coat uses:

When lab coats properly are used:

1-**Provide protection of skin and personal clothing** from incidental contact and small splashes as seen by figure-20 which is showing an accident had been happened unexpectedly when a chemical reaction went vigorously and splashed out the hot flammable reaction mixture upon the official lab. coat. Lab. coats should be warning even at hot weather.
2-Prevent the spread of contamination outside the laboratory **(provided they are not worn outside the lab).**
3 -Provide a removable barrier in the event of an incident involving a spill or splash of hazardous substances.

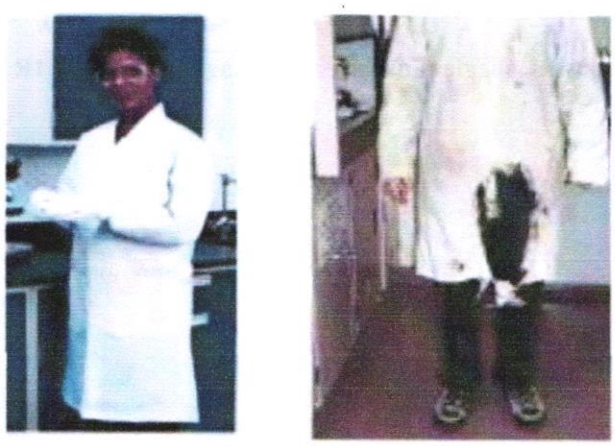


Fig.- 20 Laboratory coats are the first barrier to protect clothes and skin.

Limitations of lab coats:

In general, protective clothing, including lab coats, should not be used as a substitute for engineering controls such as a fume hood, a glove box, process enclosure, etc., or as a substitute for good work practices and personal hygiene. For significant chemical handling, **it will be necessary to supplement laboratory coat use with additional protective clothing,** for example, a rubber or vinyl apron for handling large quantities of corrosives or hydrofluoric acid, or it may be preferable to use chemical resistant coveralls for full body protection. Conversely, use of engineering controls such as fume hoods do not preclude the need for wearing the proper PPE, including lab coats.

Flame Resistant (FR) Laboratory Coats:

Work with pyrophoric, spontaneously combustible, or extremely flammable chemicals presents an especially high potential for fire and burn risks to the skin, according to the chemical hygiene plans (CHP) template, use of a fire retardant or fire resistant (FR) lab coat is required when handling pyrophoric chemicals outside of a glove box. An FR lab coat is recommended when working with any flammable materials. **The primary materials used for FR lab coats are FR-treated cotton or Nomex**. There is also a newer flame resistant and chemical resistant (FR/CP) lab coat that offers additional protection against many chemicals

Laboratory coat use:

When lab coats are in use, the following should be observed:

1-**Wear lab coats that fit properly**. Lab coats are available in a variety of sizes. Some lab coat services also offer custom sizes (e.g., extra-long sleeves, tall, or woman's fit). Lab coats should fasten close to the collar to provide optimal protection.
2-**Lab coats should be worn fully buttoned** or snapped with sleeves down.
3-Wear lab coats only when in the lab or work area. **Remove lab coats when leaving the lab/work area to go home, to lunch, to the restroom, or meetings in conference rooms, etc.**

Spill or splash:

Laundry services are not equipped to handle significant contamination of lab coats with hazardous materials. In the event of a significant spill of a hazardous material on the lab coat, remove the coat immediately. If skin or personal clothing is impacted, it will be necessary to **proceed to an emergency shower**. Remove any contaminated clothing, and shower. Generally, significantly contaminated coats and clothing will be considered a hazardous waste, and must be managed based on the type of contamination.

Laboratory coat cleaning:

Personnel are not allowed to launder lab coats at home. Clean non-disposable soiled lab coats routinely by use of a laundry service or work area washers and dryers. Frequency of cleaning will depend on the amount of use and contamination.

Gloves:

Gloves are the most common type of PPE used for medical, dental and chemical tasks. Gloves are made from a variety of materials including latex, nitrile, neoprene, copolymer, and polyethylene and are available in various levels of thickness and forms. **When dealing with infectious materials, gloves must be waterproof. Suitable gloves for biological, surgical, chemical and engineering (thermal, cutting and abrasion) purposes or activities because the use of unrecommended gloves would be very dangerous.**

Most patient care activities require non-sterile gloves, whereas any invasive procedure should be performed using sterile surgical gloves. Latex gloves should be avoided due to the risk of latex allergy unless there is a demonstrated safety requirement for latex to be used. **The choice of gloves must often balance the needs for protection and dexterity.** While thicker gloves (or double gloves) may appear to provide greater protection, it may make tasks more difficult and increase the exposure risk. **In recommendations the selection of the best glove for a given task should be based on a risk analysis of the type of setting, type of procedure, likelihood of exposure to blood or fluid capable of transmitting blood borne pathogens, length of use, amount of stress on the glove, presence of latex allergy, fit, comfort, cost, length of cuffs, thickness, flexibility, and elasticity (figures 21-24).** The most frequently used PPE by dental workers to prevent exposure to chemicals is gloves. When choosing gloves, the following must be considered:

1-**The nature and concentration of the chemicals.**
2-**The amount of time the gloves will be exposed to the chemical**.
3-**Dexterity required** to perform the task.
4-**Extent of protection needed** (to wrist or higher).
5-**Decontamination and disposal requirements.**

Nitrile Gloves:

Nitrile is quickly becoming the material of choice for single-use gloves, which is a natural rubber, nitrile is synthetic and does not cause allergic reactions as seen by figure-25. According to the **American Latex Allergy Association** between 8 and 17% of healthcare workers report allergies **to latex Choosing the proper disposable nitrile glove depends on the application**. There are two main categories of nitrile gloves, they are industrial and medical grade.

Industrial Grade:

Industrial-grade nitrile gloves are best suited for applications that involve handling harsh chemicals and solvents. They are used for automotive, janitorial, food services. Along with chemical resistance, an important feature of industrial-grade gloves is a high level of puncture resistance, meanwhile for industries like food services are not as stringent as medical-grade gloves.

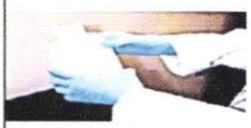
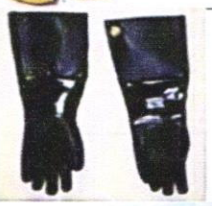
material			
Latex (natural rubber)	Incidental contact	Good for biological and water-based materials. Poor for organic solvents. Little chemical protection. Hard to detect puncture holes. Can cause or trigger latex allergies	
Nitrile	Incidental contact (disposable exam glove) Extended contact (thicker reusable glove)	Excellent general use glove. Good for solvents, oils, greases, and some acids and bases. Clear indication of tears and breaks. Good alternative for those with latex allergies.	
Butyl rubber	Extended contact	Good for ketones and esters. Poor for gasoline and aliphatic, aromatic, and halogenated hydrocarbons.	
Neoprene	Extended contact	Good for acids, bases, alcohols, fuels, peroxides, hydrocarbons, and phenols. Poor for halogenated and aromatic hydrocarbons. Good for most hazardous chemicals.	
Norfoil	Extended contact	Good for most hazardous chemicals. Poor fit (Note: Dexterity can be partially regained by using a heavier weight Nitrile glove over the Norfoil/Silver Shield glove.	
Viton	Extended contact	Good for chlorinated and aromatic solvents. Good resistance to cuts and abrasions. Poor for ketones. Expensive.	

Fig.-21 Recommended gloves biological, chemical and engineering purposes.

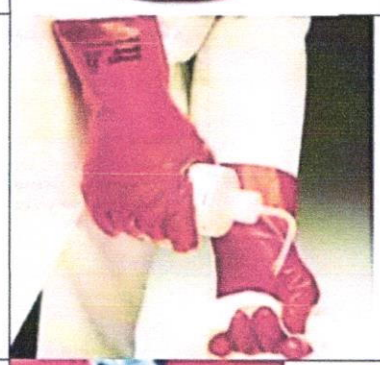
Polyvinyl chloride (PVC)	Specific use	Good for acids, bases, oils, fats, peroxides, and amines. Good resistance to abrasions. Poor for most organic solvents.	
Polyvinyl alcohol (PVA)	Specific use	Good for aromatic and chlorinated solvents. Poor for water-based solutions.	
Stainless steel **Kevlar** **Leather**	Specific use	**Cut-resistant gloves.** Sleeves are also available to provide protection to wrists and forearms. (If potential for biological or chemical contamination: wear appropriate disposable gloves on top of your cut-resistant gloves and discard after use).	

Fig.-22 Compatible gloves for chemicals and mechanical purposes.

Light latex, vinyl or nitrile gloves		**Disposable latex** Powdered or un-powdered	Working with biological hazards (human blood, body fluids, tissues, blood-borne pathogens, specimens), BSL1, BSL2, BSL2+, BSL3
		**Disposable nitrile** Puncture, abrasion resistant, protection from splash hazards	Working with biological hazards and chemical splash hazards
		**Disposable vinyl** Economical, durable, similar to latex	Working with biological hazards, BSL1, BSL2, BSL2+, BSL3
Light chemical resistant gloves		**Natural rubber latex** Chemical resistant, liquid-proof	Working with small volumes of corrosive liquids, organic solvents, flammable compounds
Light to heavy chemical resistant gloves		**Nitrile** Chemical resistant, good puncture, cut, and abrasion resistance	Using apparatus under pressure, air or water reactive chemicals
Heavy chemical resistant gloves		**Butyl** High permeation resistance to most chemicals	Working with large volumes of organic solvents; small to large volumes of dangerous solvents, acutely toxic or hazardous materials
		**Viton® II** High permeation resistance to most chemicals	Same as butyl gloves, plus hazardous material spills

Fig.-23 Compatible gloves for biological, surgical, chemical and engineering purposes.

The first square in each column for each glove type is color coded. This is an easy to read indication of how we rate this type of glove in relation to its applicability for each chemical listed. The color represents an overall rating for both degradation and permeation. The letter in each square is for Degradation alone...

GREEN: The glove is very well suited for application with that chemical.

YELLOW: The glove is suitable for that application under careful control of its use.

RED: Avoid use of the glove with this chemical.

CHEMICAL	LAMINATE FILM BARRIER			NITRILE SOL-VEX			UNSUPPORTED NEOPRENE 29-865			SUPPORTED POLYVINYL ALCOHOL PVA			POLYVINYL CHLORIDE (Vinyl) SNORKEL			NATURAL RUBBER CANNERS AND HANDLERS*			NEOPRENE/ NATURAL RUBBER BLEND CHEMI-PRO*		
	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate
1. Acetaldehyde	■	380	E		—	—	E	10	F		—	—		—	—	E	7	F	E	10	F
2. Acetic Acid	■	150	—	G	270	—	E	60	—		—	—	F	180	—	E	110	—	E	260	—
3. Acetone	▲	>480	E		—	—	E	10	F		—	—		—	—	E	10	F	G	10	G
4. Acetonitrile	▲	>480	E	F	30	F	E	20	G	■	150	G		—	—	E	4	VG	E	10	VG
5. Acrylic Acid	—	—	—	G	120	—	E	390	—		—	—		—	—	E	80	—	E	65	—
6. Acrylonitrile	E	>480	E	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7. Allyl Alcohol	▲	>480	E	F	140	F	E	140	VG		—	—		60	G	E	>10	VG	E	20	VG
8. Ammonia Gas	■	19	E	▲	>480	—	▲	>480	—	—	—	—	■	6	VG	—	—	—	■	27	VG
9. Ammonium Fluoride, 40%	—	—	—	E	>360	—	E	>480	—		—	—	E	>360	—	E	>360	—	E	>360	—
10. Ammonium Hydroxide	E	30	—	E	>360	—	E	250	—		—	—	E	240	—	E	90	—	E	240	—
11. Amyl Acetate	▲	>480	E	E	60	G		—	—	G	>360	E		—	—		—	—		—	—
12. Amyl Alcohol	—	—	—	E	30	E	E	290	VG	G	180	G	G	12	E	E	25	VG	E	45	VG
13. Aniline	▲	>480	E		—	—	E	100	P	F	>360	E	F	180	VG	E	25	VG	E	50	G

Fig.-24 Compatible gloves for chemicals.

Fig.-25 Nitrile gloves.

Nitrile medical grade gloves:

Medical gloves are used in areas where there's a risk of contact with blood-borne pathogens or environmental contaminants. Also known as examiner gloves, medical gloves are used in hospitals, laboratories, clean rooms and dental offices. Since the risks are so high, medical grade gloves must be rigorously tested and have to meet specific guidelines from the Food and Drug Administration (FDA). Medical gloves are divided into three classes:

Class I:

This type of gloves is used in low risk cases and have the least regulatory controls.

Class II:

This type of gloves is used in higher risk cases than Class I and have greater regulatory controls to ensure the safety and effectiveness.

Class III:

This type of gloves is used in the highest risk cases and have the highest level of regulatory control. Class III devices must typically be approved by FDA before they are marketed.

Nitrile, also known as acrylonitrile butadiene rubber (NBR), is a copolymer that's derived through the emulsion polymerization of butadiene and acrylonitrile. These molecules provide two specific advantages to nitrile gloves:

1-Acrylonitrile improves chemical resistance.

2-Butadiene creates flexibility and tear resistance.

The pinhole leak test:

One test based on standards from the **American Society for Testing and Materials** (ASTM) and regulated by the U.S. **Food and Drug Administration** (FDA) is **the pinhole leak test**. A selection of gloves is filled with water and hung upside down for **two minutes** to see they can hold the water as seen by figure-26. These tests adhere to acceptable quality limits (AQLs), which are percentages indicating how many gloves in a batch can fail the test to determine if the entire batch fails. If the nitrile gloves pass these quality assurance tests, they are then packed in boxes and shipped.

Thicknesses of disposable nitrile gloves:

Advantages and Disadvantages: The thickness of disposable gloves is measured in mils. A mil equals one-thousandth of an inch (0.001 inch). Disposable nitrile gloves can be as thick as 8 to 15 mils, but general purpose **nitrile gloves are typically four mils thick.**

Fig.-26 Leak test for disposable gloves.

Tensile strength:

Tensile strength is a material's ability to resist tension when being pulled apart. It's measured by the greatest stress a material can withstand when stretched without breaking. The industry standard for tensile strength of disposable gloves is **14 mega Pascal (MPa).** Approximately 20 million Americans get sick from norovirus each year. The number one cause for norovirus outbreaks in the US is contaminated foods – 54% of which involved food workers touching ready-to-eat foods with their bare hands. According to the FDA 2013 **Food Code, single-use gloves can only be used for one task**, i.e. working with ready-to-eat food or with raw animal food but not both. These gloves must also be disposed of when damaged or soiled or if there were interruptions that happened during operation, like a shutdown.

How to properly remove a disposable glove:

The point of disposable gloves in most industries is to serve as a barrier between your skin and potentially harmful substances. That's why they are single-use items, can be used, removed and thrown away without worrying about contamination. However, the way that your gloves are taken off after being used plays a big part in making sure that contamination does not spread.
Putting your gloves on properly takes a bit of care to make sure that the material does not stretch too much, this can cause small tears that leave your skin vulnerable. But taking your gloves off (doffing) is a vital part in keeping you safe. This section looks at the proper way to remove disposable gloves. It's probably a smart idea to practice doffing disposable gloves that aren't contaminated for takes you won't have to worry about what your bare skin may have come into contact with as seen by figure 27.

Here is the step-by-step method:

1-Pinch the outside of the glove about an inch or two down from the top edge of the wrist.
2-Peel the used or contaminated glove downwards, away from the wrist by turning the glove inside out.
3-Remove the used or glove away until it's removed from the hand. Hold the inside-out glove with the gloved hand.
4-With your gloveless hand, slide your fingers under the wrist of the glove, do not touch the outside surface of the glove, may be it has been contaminated or polluted.
5-Repeat step 3. Peel downwards, away from the wrist, turning the glove inside out.
6-Continue pulling the glove down and over the first glove. This ensures that both gloves are inside out, one glove enveloped inside the other, with no contaminants on the bare hands.
7-Dispose of the gloves in a proper bin (for waste), this may differ depending on company policies.

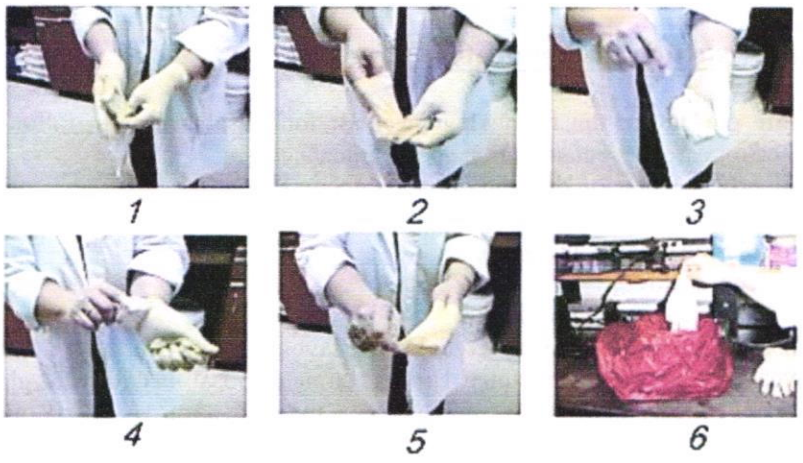


Fig.- 27 The proper steps for removing used gloves.

Nitrile compared to latex and vinyl:

Figure-28 shows a comparison for natural latex, nitrile and vinyl to resist abrasion, cutting, tearing, puncture, oil and grease handling and price cost. Factors that will increase the price of gloves, regardless of material such as thickness, powder free, additives and type.
Thickness: The more material that is used, the more you can expect to pay.
Vinyl: Vinyl is the least expensive material for producing disposable gloves.
Latex: Latex is approximately 82 percent more expensive than vinyl.
Nitrile: Nitrile is double the price of vinyl and roughly 15 percent more expensive than latex.

Raw Material / Charasteristics	Natural Latex	Nitrile	Vinyl
Abrasion	★ ★	★ ★ ★ ★	★ ★ ★
Cut	★ ★ ★ ★	★ ★ ★	★
Tear	★ ★ ★ ★	★	★
Puncture	★ ★	★ ★ ★ ★	★ ★
Oil and Greases	★	★ ★ ★ ★	★ ★
Price	★ ★ ★	★ ★ ★ ★	★ ★

Fig.-28 Comparison of physical properties for natural latex, nitrile and vinyl.

Rules for glove use according to chemicals:

1-**Wear the appropriate gloves for the task when needed;** for reusable gloves, follow the manufacturer's guidelines for care, decontamination and maintenance.
2-Ensure gloves fit properly and are of the appropriate thickness to offer protection; ensure adequate supplies of gloves in appropriate sizes.
3- Avoid using latex gloves (due to latex allergies).
4- Do not use worn or defective gloves.
5- Wash hands once gloves have been removed.
6- Disposable gloves must be discarded once removed. Do not save for future use.
7-Dispose of used gloves into the proper container. Have separate disposal locations for gloves contaminated with chemicals which pose a toxic hazard if mixed.
8- Non-disposable/reusable gloves must be washed and dried, as needed, and then inspected for tears and holes prior to reuse.
8-Remove used gloves according to the traditional proper steps before touching personal items, such as phones, computers, pens and one's skin.
9-Do not wear gloves into and out of areas. If gloves are needed to transport anything, wear one glove to handle the transported item. The free hand is then used to touch door knobs, elevator buttons, etc.
10- Do not eat, drink, or smoke while wearing gloves. Gloves must be removed and hands washed before eating, drinking, or smoking.
11- If for any reason a glove fails, and chemicals come into contact with skin, remove the gloves, wash hands thoroughly and obtain first aid or seek medical attention as appropriate. For most dental workers who use chemicals, goggles or face shields are necessary. In most cases, goggles are considered reusable. All reusable PPE must be properly decontaminated and maintained.

Gloves are the most common type of PPE used for biolaboratories and dental tasks. Gloves are made from a variety of materials including latex, nitrile, neoprene, copolymer, and polyethylene and are available in various levels of thickness. **When dealing with infectious materials, gloves must be waterproof**. Most patient care activities require non-sterile gloves, whereas any invasive procedure should be performed using sterile surgical gloves. Latex gloves should be avoided due to the risk of latex allergy unless there is a demonstrated safety

requirement for latex to be used. The choice of gloves must often balance the needs for protection and dexterity. While thicker gloves (or double gloves) may appear to provide greater protection, it may make tasks more difficult and increase the exposure risk. **In Recommendations the selection of the best glove for a given task should be based on a risk analysis of the type of setting, type of procedure, likelihood of exposure to blood or fluid capable of transmitting blood borne pathogens, length of use, amount of stress on the glove, presence of latex allergy, fit, comfort, cost, length of cuffs, thickness, flexibility, and elasticity.**

Karen Wetter Hahn a 40 years' expert chemist died affected by mercury poison because she used to wear a not recommended gloves for work on Methyl mercury as seen by figure 29.

Karen Wetterhahn
Died 8 June 1997 due to toxic exposure of $HgCH_3$
Lyme , New Hampshire , U , S .

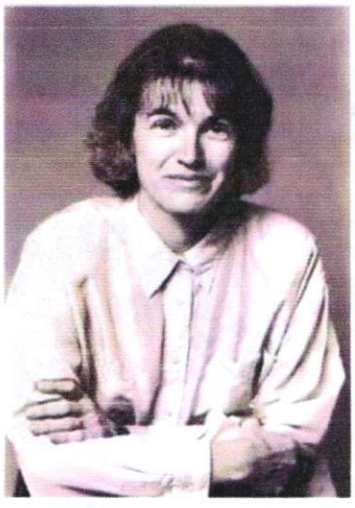


Figure-29 Karen Wetterhahn died by mercury poisoning because she used to wear incompatible gloves for mercury methyl.

Proper eye wear selection:

Selection of protective eyewear should take into account:

1- Level of protection required.
2- Comfort of the wearer.
3- Secure fit that does not interfere with vision or movement.
4-Ease of cleaning and disinfection.
5- Durability.
6- Compatibility with prescription glasses and other PPE that must be worn at the same time (e.g. respirators).

Chapter-3

1-PHYSICAL HAZARDS

1-1 Musculoskeletal(Ergonomic hazards):

Ergonomic hazards (i.e. posture) are the most important personal protective to control ergonomic hazards using appropriate footwear with gripping soles and good support as well as implementing some exercise. During dentistry procedures, the dentist's posture is strained, which induces stress injury on the musculoskeletal system. This occurs in 37 .7% of work time as seen by figures 30-32.

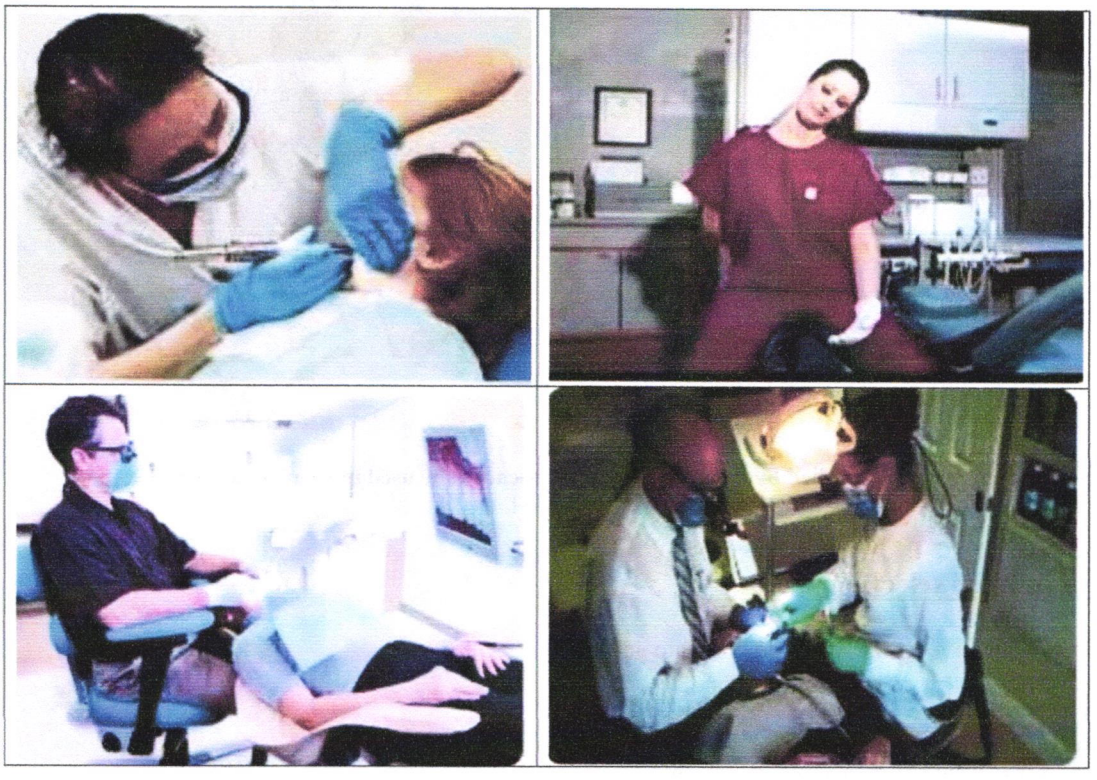


Figure-30 Awkward postures of dentists.

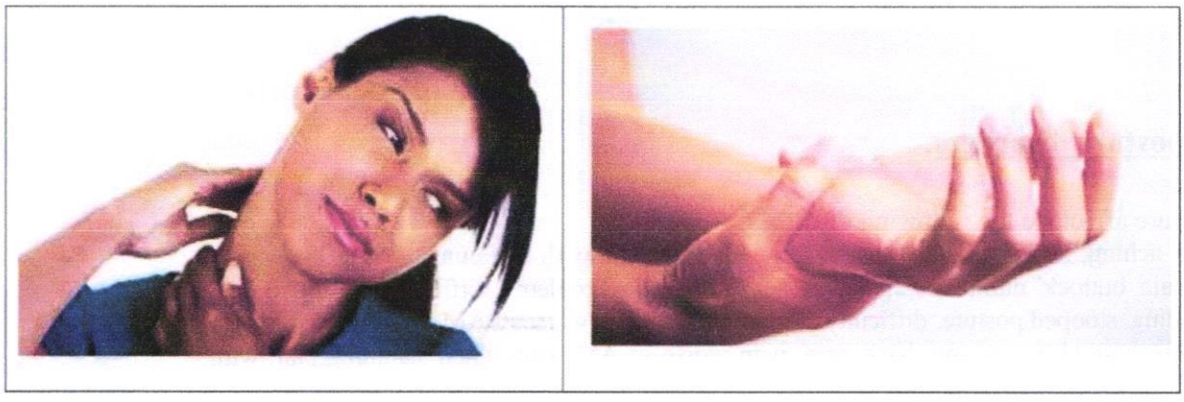


Figure-31 Poor posture cause real pains.

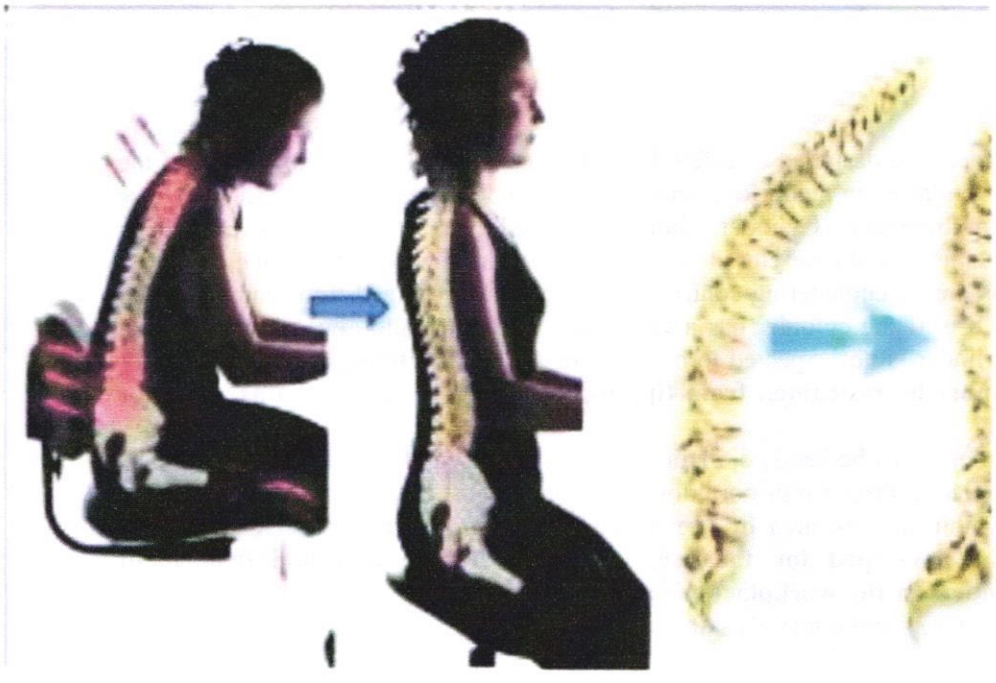


Figure-32 Exerscise for ergonomic postures.

Improper posture disorders:

Improper posture affects to the following disorders:
Pain, stiffness, aching, burning, muscle pain when standing, pain with movement, lower back pain, upper back pain, buttock numbness, pinched nerve, posture problems, difficulty sitting down, difficulty standing, stooped posture, difficulty sleeping, symptoms worse in AM, symptoms worse in evening, unrefreshing sleep, aching, back pain, pain worse in AM, pain when standing, pain with movement.

Triggers: exercising, heavy lifting, lying down, pushing or pulling repetitive motions, twisting, overdoing it, sitting too long, standing too long, using machinery, vibration, injury, workplace injury, anxiety, stress, poor posture

Treatments: muscle strengthening, stretching, improve posture by proper exercise.

Pressure:

Compressed gas cylinders are designed to safely hold their contents during regular use and the demands expected to be placed on them. Regulators, fittings and delivery systems must likewise meet manufacturers' requirements. Cylinders should be stored away from any heat sources or combustible material; they should be stored upright and not be able to move freely or fall. **Protective valve caps** are an engineering control to protect the valve head from damage when the cylinder is not in use. If the cylinder has a valve cap, the cap should always be placed on cylinders when the cylinder is not expected to be used for a period of time, such as for a work shift. All **cylinders must be restrained from tipping by means of racks, chains, strap or other suitable means.**
Compressed gas cylinders must be handled, maintained and stored carefully to prevent cylinders from falling or a gas release. Proper transportation of cylinders must also be considered whether it be by vehicle or within a work area by use of a hand cart or other means. **A safe work procedure should be developed for the use, transport, storage and maintenance of compressed gas cylinders in the workplace**. Keys for compressed gas safe work practices are detailed by the manufacturers and materials safety data sheets.

1-2 Pressure Equipment:

Typical pressure equipment used in dentistry includes:
1- Compressed gas cylinders,
2- Autoclaves, and
3- Compressed air systems (fixed and portable).

1-2-1 Compressed gas cylinders:

Nitrous oxide-oxygen sedation is used widely as anesthesia in dental surgery (figures 33&34) because of its relative safety and efficacy. The most important safety consideration is the prevention of hypoxia. Safety features have been designed to prevent hypoxia by ensuring a minimal oxygen flow, thus limiting the amount of nitrous oxide that can be administered. Nitrous oxide-oxygen delivery systems as seen by figure-35 are typically limited to a maximum of 70 percent nitrous oxide and 30 percent oxygen delivery, which ensures that the patient is receiving at least 9 percent more oxygen than found in ambient air. It is worth to look over the MSDS of oxygen and nitrous oxide gases.

Oxygen cylinders should not slide or come into contact with sharp edges. Cylinders of oxygen should not be stored near cylinders of acetylene or other combustible gases because they are incompatible. Prevent dirt, grit of any sort, oil or any other lubricant from entering the cylinder valves, and store cylinders well clear of any corrosive influence, e.g. battery acid. Release of **nitrous oxide** gas may cause hazard to plants and animals in the environment, the hazard of frostbite in event of rapid release from the cylinder.

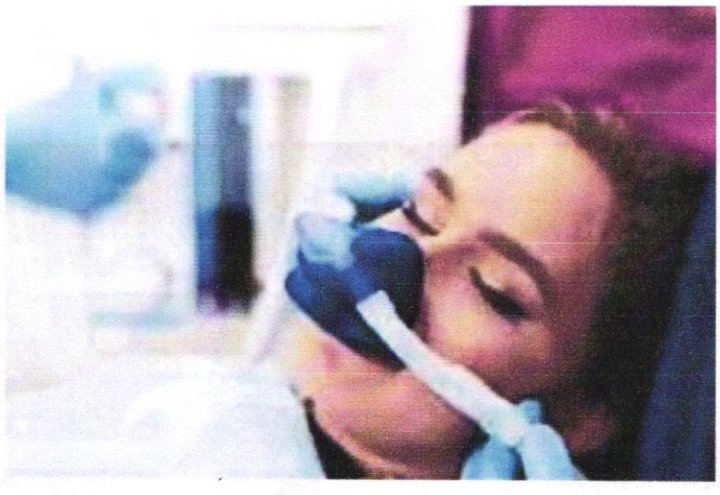


Fig.-33 Nitrous oxide anesthesia gas system.

Fig.-34 Nitrous oxide – Oxygen cylinders.

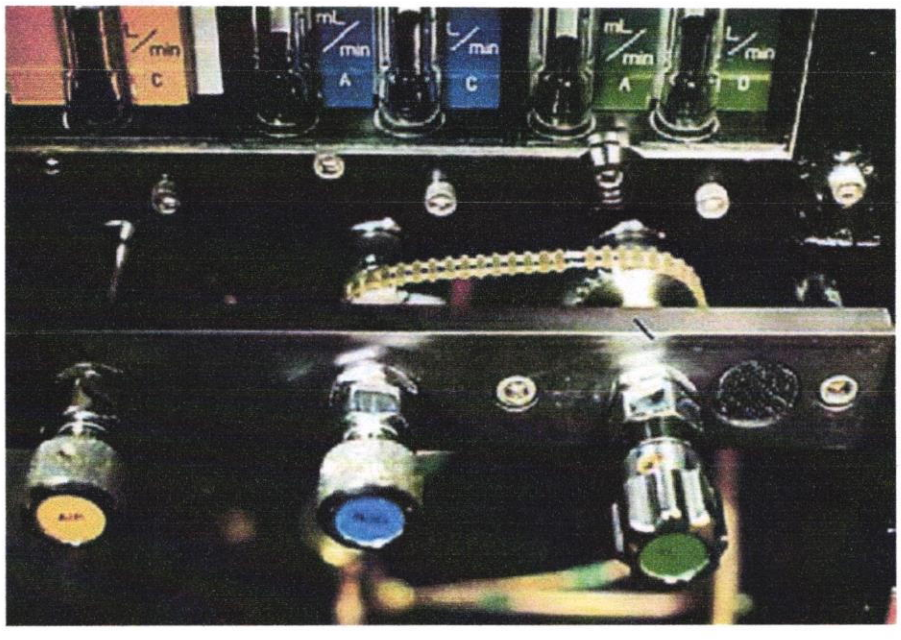


Fig.-35 Aesthesia gas machine.

The failure of handling a pressure equipment can result in serious injuries to staff/patients and cause major damage to structure / property.
Control requirements is too important to prevent such failures which relate to the mechanical integrity of the equipment involved and increase safety factors.

Compressed gas cylinders' control:

The main control strategies to mitigate the risks associated with compressed gas cylinder hazards include:

1- Store as per manufacturer/supplier recommendations (for instance upright, secured in place, well ventilated and appropriate area) as seen by figures-36-39, since uncontrolled handling, transferring or using unrecommended gauges and connections would cause a serious accident sooner or later as seen by figure 40.
2- Ensure labelling as per manufacturer's recommendations; and all staff involved in delivery, connection and disposal of cylinders must be **trained** and **competent**. Gas cylinders could be identified by their color coding as seen by figure-41, to avoid accidents of crashing, unsafe handling (recommended handling) and to avoid chemical incompatibility for safe storage.

Figure- 36 a- Unsafe storage of gas cylinders, b- Safe storage of gas cylinders.

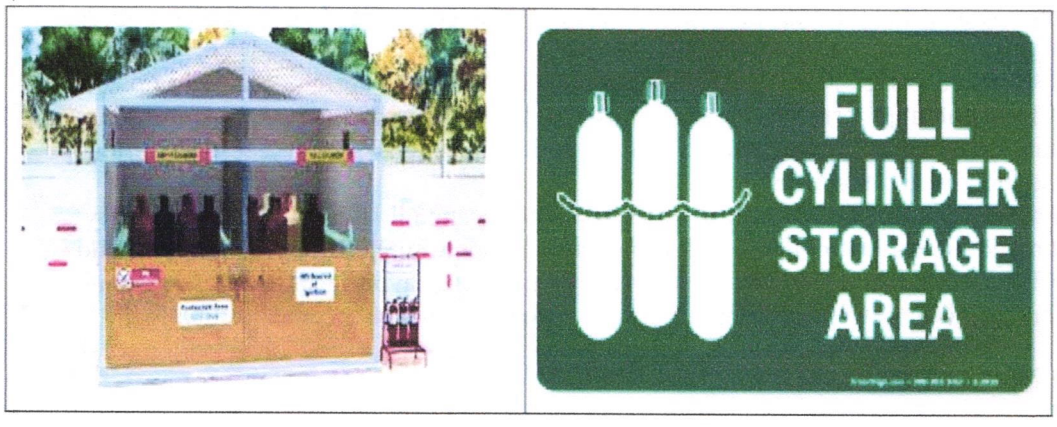


Figure- 37 Typical store for gas cylinders with indicative instruction stickers.

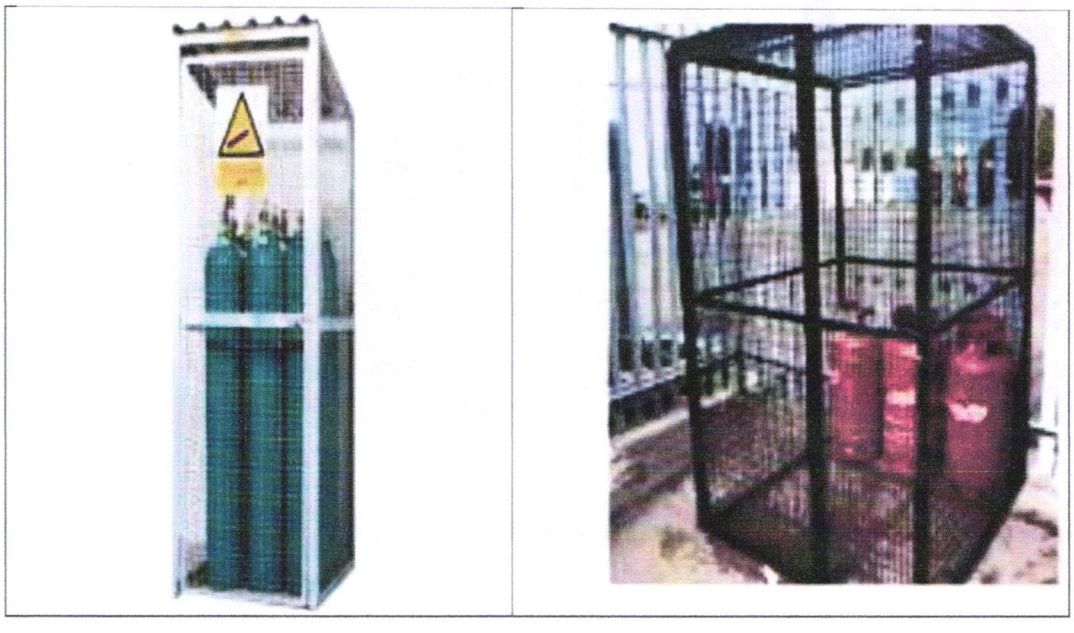


Figure-38 Safe storage of gas cylinders.

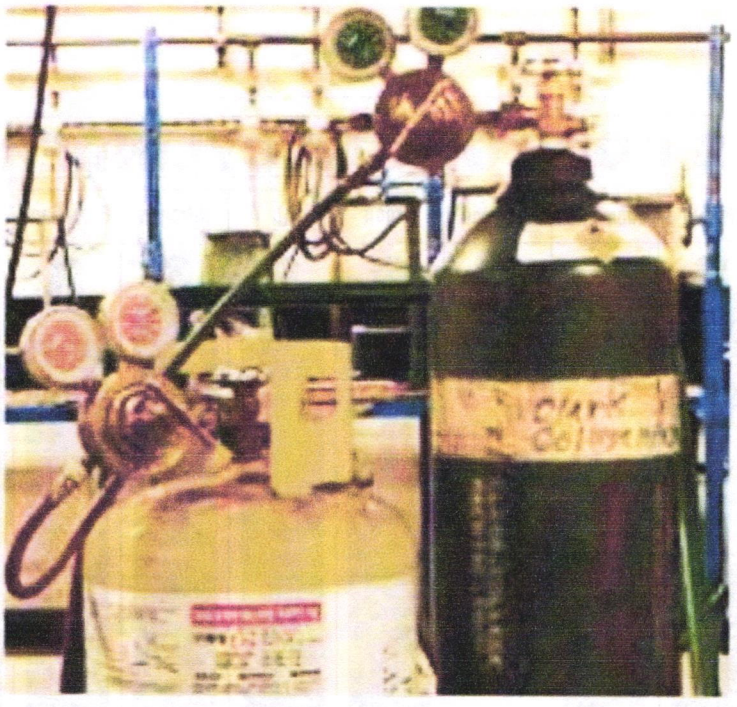


Figure-39 Industrial gas cylinders with recommended gages and valves.

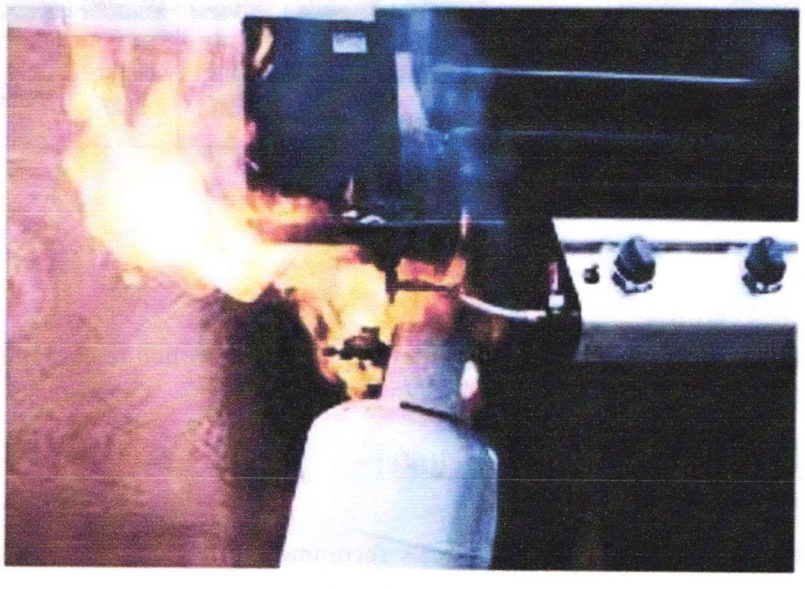


Figure-40 Fire accident due to unsafe LPG gas handling.

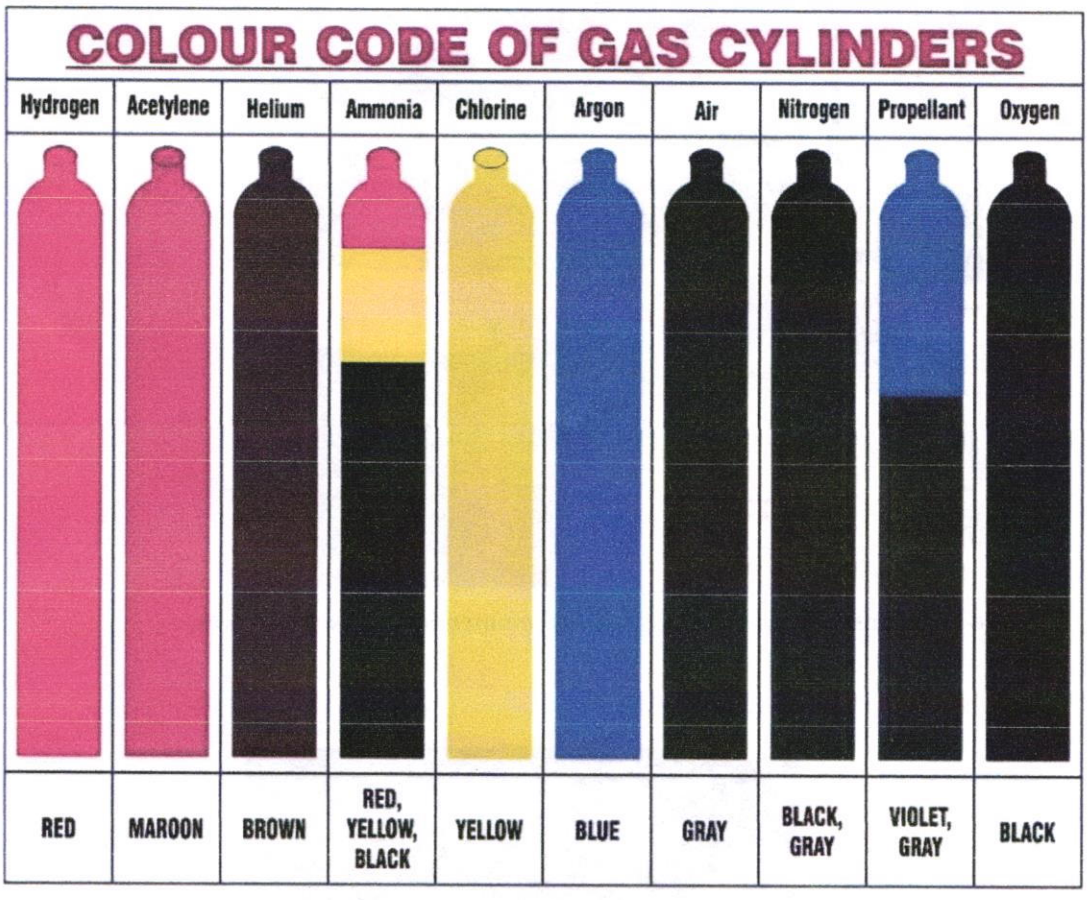


Fig.- 41 Color coding's of industrial gas.

1-2-3 Compressed air systems:

The most serious risks associated with air receivers come from the uncontrolled release of stored energy (for example catastrophic failure of vessel whilst under pressure).

Control measures to mitigate such risks include:

1- **Thorough examination** of air receivers and valves.

2-**Maintenance and inspection** (as per manufacturer's recommendations and undertaken by competent person).

Sterilization and disinfection

Disinfection and sterilization are essential for ensuring that medical and surgical instruments are free of infectious pathogens to patients as seen by figure 42.

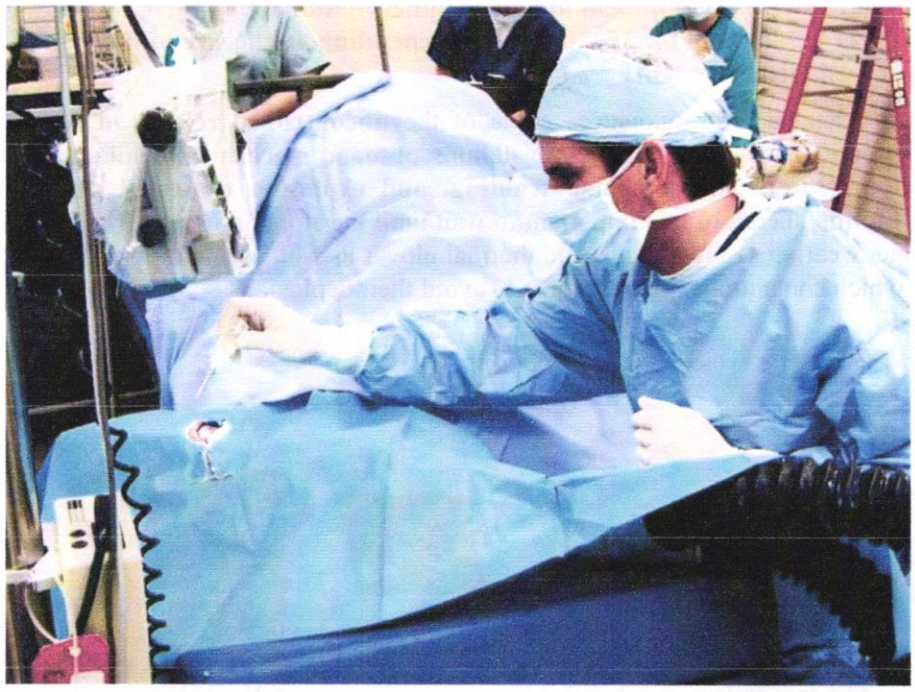


Fig. -42 Sterile field of operation.

Disinfection: ***is*** the process that eliminates many or all pathogenic microorganisms, except bacterial spores, on inanimate objects by liquid chemicals or wet pasteurization.

A sterilization is the process: which destroy transmissible agents such as spores, bacteria and viruses that may contaminate equipment and supplies by subjecting them to high-pressure of saturated steam at 121 °C (249 °F) for around 15–20 minutes depending on the size of the load and the contents. Sterilization is also used for equipment, clothes, Bedding, sheets, plates and all tools that used in health activity.

Autoclaves:

An **autoclave** is a pressure chamber (figures 43- 45) used to carry out sterilization processes for the contaminated equipment and/or supplies by pathogenic organisms which is requiring

elevated temperatures and pressures more than ambient air pressure. Autoclaves are used in medical applications and hospitals to perform **sterilization** and in the chemical industry.

Many autoclaves are used to sterilize equipment and/or supplies by subjecting them to high pressures (2.5-3 atm) at 121 °C (249 °F) for 15–20 minutes depending on the size of the load and the pathogenic microorganisms content.

The most serious risks associated with autoclaves come of the **uncontrolled release of the stored energy** (for example inadvertent opening or failure of door mechanism while the autoclave is still under pressure). Others include **scalding, and explosion of sealed glass containers containing liquids**, therefore it is important to wait until the stored pressure drops to the normal pressure value, wearing safety goggles and thermal gloves as well as slightly vent the lids of glass containers which containing organic liquids to avoid their explosions.

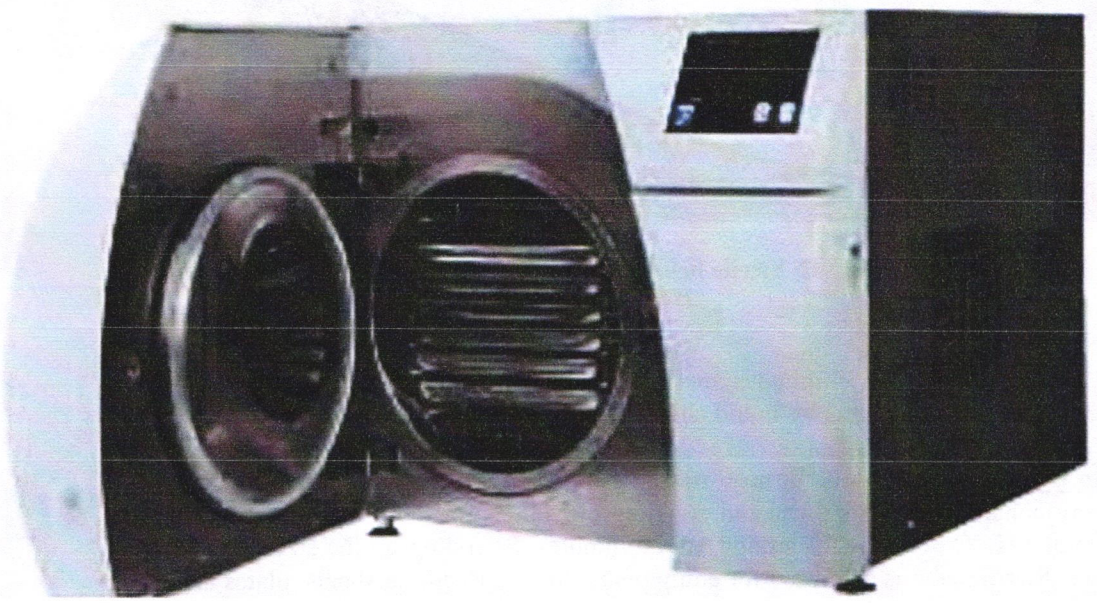


Figure-43 Hospital autoclave.

Figure-44 Dental autoclave.

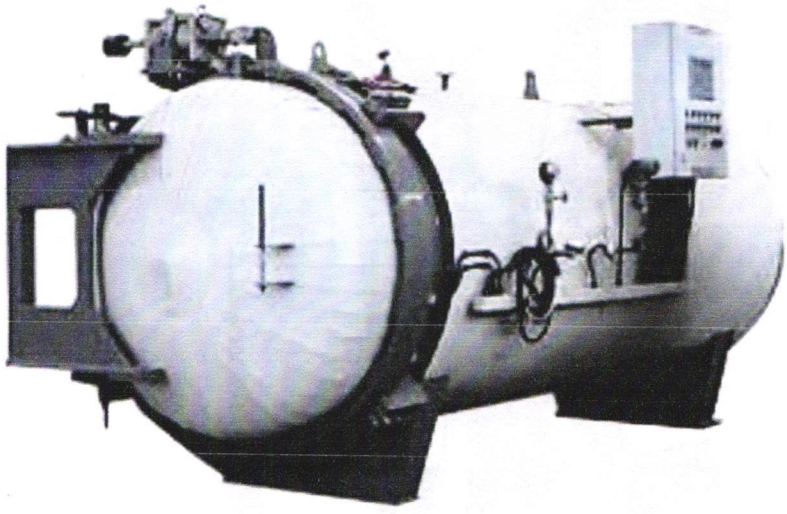


Figure-45 Large scale medical waste treatment autoclave.

Control to mitigate such risks include:

For safety purposes, working with autoclaves should be considered a risk of high severity according to risk assessment matrix (figure 46), therefore a training program should have implemented for all worker in the sterilization and cleaning department, as well as the following steps should be seriously followed:

1-Determine the type of equipment (for example **size**, **operating pressure**, pressurizing medium) and **control system (manual or automated)**.
2-Assess the risk of door opening violently under pressure.
3- Verifying "Nil" pressure before opening the door.
4- **Location** and shield.
5- Operator **training** and **instruction**.
6-Thorough **examination of pressure equipment** at the following frequency: 14 months for self-generating autoclaves; and 26 months for all other autoclaves.
7-**Maintenance and inspection** (as per manufacturer's recommendations and undertaken by competent person).

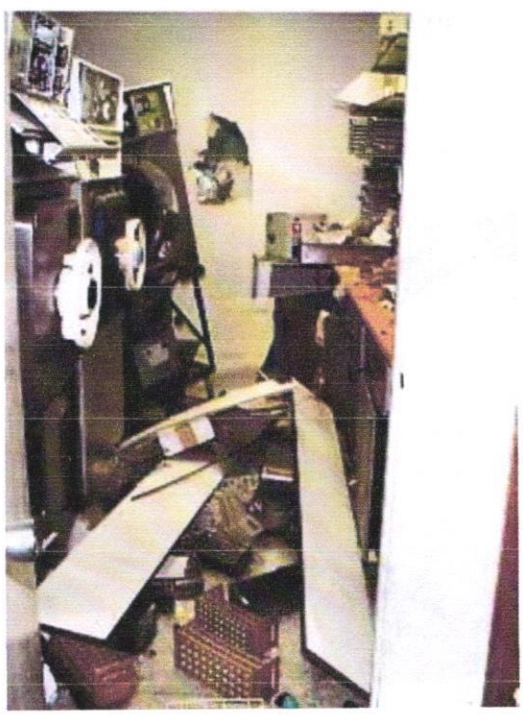


Fig.-46 An autoclave explosion in isolated area.

Safety precautions:

Materials to be loaded almost contain potentially infectious materials, so the required laboratory protective precautions must be followed seriously, this includes:

1- Safety eye goggles and face protection shield to minimize the risk of probable accidental facial steam burns as seen by figure-47.

2- Gloves (latex or nitrile) to prevent contact with contaminated materials, while heat resistant gloves (figure-48) must be used when loading and unloading the autoclave.

3- Laboratory coats with long sleeves must be used to protect wrists and forearms, plus an apron if a hazard spill exists. Although the autoclave trays may be cool, the door and walls of the chamber may still be hot enough to cause a burn!

Waste Packaging:

Consideration must be given to the **primary container** which containing the contaminated waste, volume of liquid, amounts of material, and the secondary container which would contain the primary container (figure -49). The structural integrity of the container is an important consideration because not all containers can withstand the demands placed on them during the autoclave process. The desirable characteristics needed for these cases are heat resistance, good thermal conductivity, puncture proof and impervious to water.

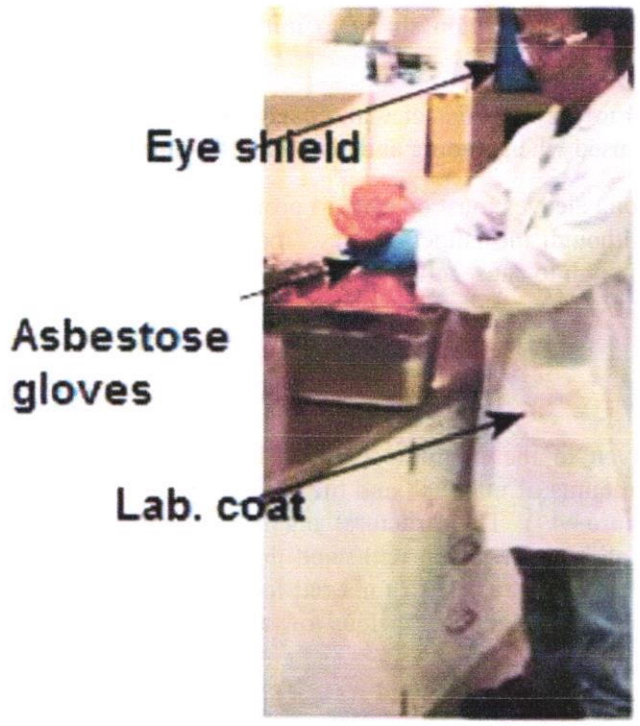


Figure- 47 Safety face mask and laboratory coat with heat resistant gloves when work with an autoclave.

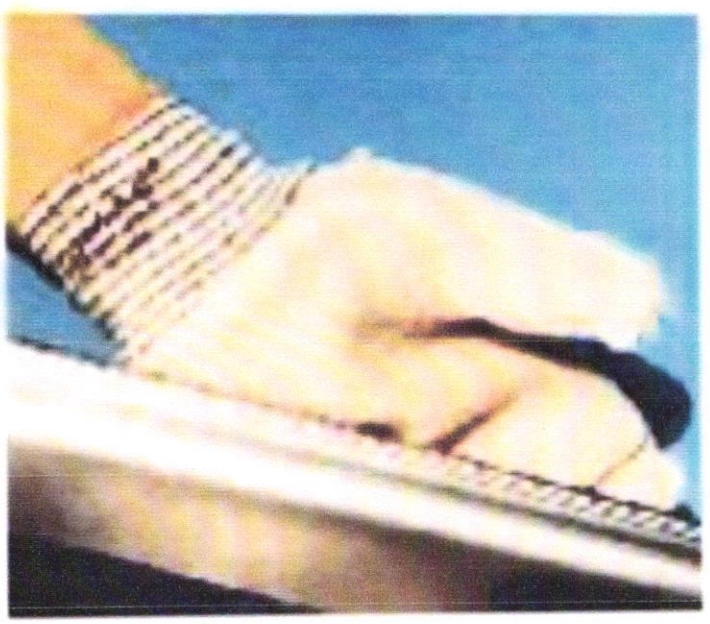


Figure – 48 Heat resistant gloves.

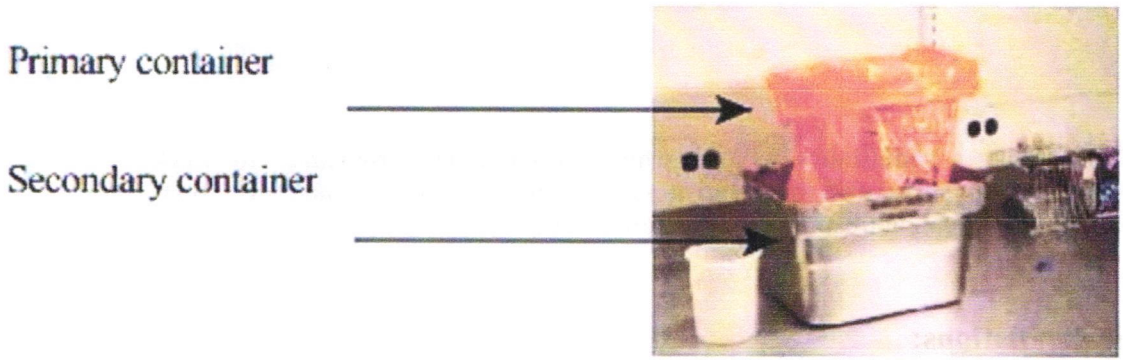


Figure- 49 Waste packaging containers.

1,2-Radiation

Radiation:

Depending upon the **nature of the radiation** and **the specific tasks the worker is performing**, a range of **PPE may be used as additional controls** (engineering and administrative controls) to reduce exposures. Examples include **protective eyewear** used when working with lasers, UV, infrared or ionizing radiation that is specifically made to reduce exposure to each type of radiation. **Protective clothing** is also used when working with various forms of radiation. For ionizing radiation, **protective clothing (commonly called lead aprons) includes shielding materials**. **All ionizing radiation protective clothing must be uniquely identified and inspected annually with an x-ray machine for any cracks or holes in the shielding material**. **These inspections results must be recorded and saved**. Clothing also protects against exposure to UV rays. **Gloves protect workers from contamination with radioactive material** and must be worn when there is potential contamination.

Administrative controls include policies and procedures and on-going assessment of possible exposures to radiation. The policies and procedures are designed to ensure that workers are informed about the hazards of both **ionizing** and **non-ionizing radiation** and are trained in the safe work procedures necessary to prevent exposure. **Some administrative**

controls include having a radiation safety program, a laser safety program, safe work practices, monitoring exposures, and proper disposal practices. Minimize contact with body substances from patients receiving treatment with radionuclides.

1,2,1- Ionizing radiations:

Ionizing radiations are **Alpha (α), beta (β), neutron particles(n), gamma (γ)** and **X-rays(x)**. All types are caused by unstable nuclei of the atoms, which have either an excess of energy or mass (or both). In order to reach a stable state, they must release that extra energy or mass in the form of radiation. The penetration ability for the ionizing radiations by paper, wood, lead and water are seen by figure 50.

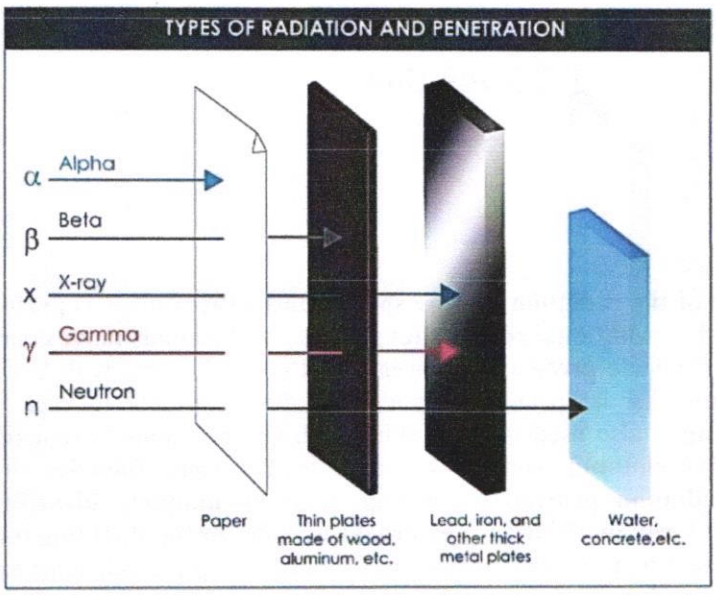


Fig.- 50 Ionic radiations penetration ability through different materials.

X rays are electromagnetic radiations **that differentially penetrates structures within the body and creates images of these structures on photographic film or a fluorescent screen.** These images are called diagnostic x rays. The most radiation exposure to the population is **medical and dental diagnostic radiology** by **X-rays which are electromagnetic radiations produced by electronic transitions within the atom during excitation, when the excited electrons drop down to fill a vacancy in an inner atomic electronic shell (more tightly bound shell)**, such as going from M shell to fill a vacancy in the L shell or L shell to K.

Diagnostic x rays are useful in **detecting abnormalities within the body**. **They are a painless, non-invasive way to help diagnose problems such as** broken bones, tumors, dental decay, and the presence of foreign bodies. Wear aprons or **Lead aprons** when persons holding or supporting patients during x-ray or γ-radiation and **thyroid collar shields** for patients whose thyroid will be exposed, recommended safety glasses for each radiation case. Table-6 show the attenuation of air, water, adipose tissue, muscle, bone and lead, that is the denser bones appear in the x-ray film more transparent than air in lungs.

Table-6 Mass attenuation coefficients for typical tissues in μ/ρ.

μ/ρ given in cm^2/g	50 keV	100 keV	200 keV
Air ρ=0.0013 g/cm³	0,208	0,154	0,122
Water ρ=1.00 g/cm³	0,227	0,171	0,137
Adipose tissue ρ=0.95 g/cm³	0,212	0,169	0,136
Muscle ρ=1.05 g/cm³	0,226	0,169	0,136
Bone ρ=1.92 g/cm³	0,424	0,186	0,131
Lead ρ=11.35 g/cm³	8,041	5,549	0,999

X-Rays tube:

High atomic number metals are suitable for x-rays rotating anode elements(9000-10000 rpm) in manufacturing x-ray tubes (Figures 51) due to its efficiency since their recoilless energy according to Mössbauer relationship according to equation-1 , and to their very high melting points property (3410 ^{0}CF) to withstand the Bremsstrahlung radiations generated in the tube by operating voltages 50-70 Kev. The operating tube voltage 150 KV for x-ray images & 40 KV for mammography. (A=183.85 g & Z= 74).