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Checklist for the prevention of accidents in laboratories

1. Introduction

A laboratory is a place where scientific research, clinical or diagnostic evaluation and experiments are conducted under controlled conditions. Laboratories are used in many scientific disciplines including research and the teaching of sciences such as chemistry, biology, medicine, physics and others.

The focus of this document will be on **chemical** and **biological** hazards in laboratories.

People who work or study in chemical or biological laboratories are exposed to many kinds of hazards. Laboratories involve a greater variety of possible hazards than most workplaces: many agents are highly flammable and/or explosive, and their careless handling and storage may result in fires and explosions. Toxic gases, biological agents, fumes and liquids may be produced and cause poisoning and/or infections. A special hazard exists when laboratories deal with new or unfamiliar chemical substances or biological agents.

Some chemical substances and biological materials may even be carcinogenic, mutagenic or embryotoxic.

New laboratory workers and students are at special risk because they are not yet fully aware of the dangers and risks related to the use of dangerous products and equipment. But even very experienced laboratory personnel may be at risk if they become complacent about working with hazardous substances and their attention wanders.

Safety is a top priority in chemical and biological laboratories. Even if every attempt has been made to minimise hazards in a laboratory, anything can become dangerous when it is used improperly or carelessly. To ensure that the laboratory remains a safe workplace for you and your colleagues you must be familiar with the rules and regulations and you should understand how to operate laboratory equipment safely and properly. Ensuring the safety of others is as important as ensuring your own safety.

Never underestimate the hazards associated with a laboratory. If you are unsure about what you are doing, get assistance. Do not use unfamiliar chemicals, equipment, or procedures alone.

The purpose of this checklist is to help to reduce risks and hazards for workers in laboratories, to verify the effectiveness of the protection which is offered to professionals and/or students involved in laboratory activities, and to promote the understanding of the risks associated with dangerous substances and biological agents.

The checklist is intended to be a tool to assist in the risk assessment and monitoring process for laboratory safety.

2. Legislation

All workers are protected by the framework Directive 98/391/EEC (http://osha.europa.eu/legislation/directives/A/1/1). This Directive's basic principle is risk prevention, which requires risk assessment by the responsible employer and imposes a general duty on employers to ensure the health and safety at work of all employees.
The Directive is supplemented by individual Directives which also cover the health and safety needs of laboratory workers.

These regulations had to be transferred into national legislation. Member States are allowed to include certain additional or more stringent provisions for the protection of workers, such as restrictions on certain work processes, or lower limit values, since the corresponding EU directives only lay down minimum requirements. It is therefore strongly recommended that you seek clarification of specific national legislation that may apply to the use of dangerous substances in the workplace. It is important to be aware that these regulations on issues such as risk assessment, technical measures and exposure limits also apply to the dangerous substances generated by the relevant work processes, for example wood dust or welding fumes.

2.1 Dangerous substances (Chemical hazards)

Health and safety requirements for laboratories are laid down in individual Directives, of which the most important are:

- 98/24/EEC (http://osha.europa.eu/legislation/directives/A/1/2/13) which sets out minimum requirements for the protection of workers from risks to their safety and health arising, or likely to arise, from the

effects of chemical agents that are present at the workplace or as a result of any work activity involving chemical agents.
- 2004/37/EEC, which protects workers from the risks related to exposure to carcinogens and mutagens at work.
- 83/477/EEC (http://osha.europa.eu/legislation/directives/A/2/2/2) which protects workers from the risks related to asbestos.
- 91/322/EEC, 96/94/EC, 2000/39/EC and 2006/15/EC, which establish indicative occupational exposure limits for Europe.
- 92/58/EEC regulations on classification and labelling, which determine important information such as safety labels, symbols and safety data sheets.

2.2 Biological agents (biological hazards)

With the aim of protecting workers against risks to their health and safety, arising or likely to arise from exposure to biological agents at work, the European Parliament and the Council issued the individual Directive 2000/54/EC of 18 September 2000 (http://osha.europa.eu/legislation/directives/A/1/2/07).
This Directive lays down particular minimum provisions designed to guarantee a better standard of workers' safety and health, and applies to activities in which workers are actually or potentially exposed to biological agents as a result of their work.
For the purpose of Directive 2000/54/EC, the following definitions were established:

- **biological agents**: micro-organisms, including those which have been genetically modified, cell cultures and human endoparasites, which may be able to provoke any infection, allergy or toxicity;
- **micro-organism**: a microbiological entity, cellular or non-cellular, capable of replication or of transferring genetic material;
- **cell culture**: the in-vitro growth of cells derived from multicellular organisms.

According to their level of risk of infection, biological agents were classified into four risk groups, as follows:

Group 1	biological agent means one that is unlikely to cause human disease;
Group 2	biological agent means one that can cause human disease and might be a hazard to workers; it is unlikely to spread to the community; there is usually effective prophylaxis or treatment available;

Group 3 biological agent means one that can cause severe human disease and present a serious hazard to workers; it may present a risk of spreading to the community, but there is usually effective prophylaxis or treatment available;

Group 4 biological agent means one that causes severe human disease and is a serious hazard to workers; it may present a high risk of spreading to the community; there is usually no effective prophylaxis or treatment available.

These classifications are linked to specific protection measures in the workplace.

Exposure to biological agents at work

Whenever people at work are in contact with:

- natural or organic materials like soil, plant materials (hay, straw, cotton, etc.)
- substances of animal origin (wool, hair, etc.)
- food
- organic dust (e.g. flour, paper dust, animal dander)
- waste, dirty water
- blood and other body fluids

they may be exposed to biological agents.

2.3 Pregnant workers and young workers

The Directive 92/85/EEC provides specific protection for pregnant workers or women who have recently given birth. In terms of this directive, employers must take all appropriate steps to ensure that neither the worker nor the unborn child is exposed to a health risk in the workplace.

Young workers are additionally protected by the Directive 94/33/EEC.

3. Hazards in chemical and biological laboratories

As a laboratory worker, researcher or student you are exposed to various hazards, depending on the type and functions of the laboratory. These hazards include:

- *Chemical hazards*

Chemicals in laboratories can present a variety of health and safety hazards. Toxic gases, fumes or liquids may escape from their container or spill while being handled and cause, for example, poisoning, cancer, allergies and

Hazards related to laboratory work

- infections
- burns
- cuts
- explosions
- poisoning
- allergies
- eye damage
- standing or sitting for long periods
- repetitive movements

respiratory problems. Acids and bases may cause irritations and burns of eyes or skin and respiratory tract. Certain chemicals are known or suspected to harm fetuses or the reproductive health of adults (e.g. anesthetic gases or lead compounds)

- *Biological hazards*

Biological agents such as viruses, bacteria, fungi or parasites can enter the body by inhalation, ingestion, skin or eye contact, animal bites and needle-stick injuries and cause infections, allergies and other diseases. Certain biological agents are dangerous to the unborn child, such as toxoplasmosis or rubella.

- *Explosive hazards*

Uncontrolled or unplanned chemical reactions can cause fires and dangerous explosions.
Experiments carried out in closed systems can cause explosions, as well as high-pressure gas equipment (pressure vessels) and autoclaves. Vacuum equipment may implode. All pressure equipment should be tested or inspected regularly.

- *General hazards*

Wet, uneven or damaged floors can cause slips and trips.
Glass bottles and glass apparatus are standard in laboratories. Dropped or burst glassware can cause severe cuts.
Entanglement of clothes, hair or fingers in rotating equipment such as centrifuges and mixers can cause bodily injury.
Noise and vibration produced from equipment such as centrifuges and stirrers can cause hearing loss and stress.

- *Ergonomic hazards*

Musculoskeletal effects may result from working in awkward positions such as standing or bending over a laboratory bench for a long time. Repetitive movements from pipetting or transferring fluids and samples can also cause musculoskeletal diseases.

3.1 Examples of laboratory accidents

- A 22-year-old employee at a US primate research centre died of complications from the herpes B virus. Her eye was splashed with an unknown substance as she was moving a caged rhesus. This substance inflamed her eye and she died four weeks later. She was not wearing eye goggles.[1]

- A chemistry professor died from mercury poisoning after a small drop of dimethylmercury apparently seeped through her latex gloves. Tests showed that she had 80 times the lethal dose of mercury in her blood. Research showed afterwards that the latex gloves were not appropriate for work with dimethylmercury.[2]

- A postdoctoral fellow was working with concentrated sulphuric acid. She splashed some of the acid onto her latex gloves and it quickly burned a hole through the gloves and caused a small second-degree burn. If the researcher had been wearing gloves made from polyethylene or butyl rubber, she would not have been burnt by the acid.[3]

- A UK researcher was testing the pH of a four-litre container of hazardous waste when the bottle fell and burst. The researcher fell in the slippery liquid, hitting his head extremely hard on the floor. The entire side of his body was saturated in the liquid solution. He suffered from lacerations and eye burns.[4]

3.2 What can be done to prevent laboratory accidents?

You have to know that EU legislation sets a hierarchy for exposure control measures to be applied if a risk assessment reveals risks:

- Elimination of the hazard by changing the process or product is at the top of the hierarchy.

- If elimination is not possible, then the dangerous substances or the process should be substituted with another, non-hazardous or less dangerous one.

- Where the risks to workers are not prevented, control measures should be implemented to remove or reduce the risks to workers' health. The following control hierarchy should be followed:
    a. Design work processes and controls, and use adequate equipment and materials to reduce the release of dangerous substances.

b. Apply collective protection measures at the source of the risk, such as ventilation and appropriate organisational measures.

c. Apply individual protection measures including personal protective equipment where exposure cannot be prevented by other means.

The best way to prevent laboratory accidents is to be prepared, well trained and informed about what you are working with. Ensure that you are protected by personal protective equipment if exposure cannot be prevented by other means. Is appropriate protective equipment for your work available? Are you trained on how to use the protective clothes?

Ensure that the gloves you use are appropriate to the specific risk. If in doubt, consult your supervisor, the supplier, producer or product literature.

Plan your work and follow instructions. If you are unsure how to do a certain job ask your employer, laboratory supervisor or teacher. And please follow these rules:

- ☑ Request information and training when unsure how to handle hazardous chemicals or procedures
- ☑ Contact your supervisor, teacher or safety officer if you have any doubts
- ☑ Absolutely no pipetting by mouth
- ☑ Use laboratory equipment for its designed purpose only
- ☑ Never leave an open flame unattended
- ☑ Handle chemicals carefully
- ☑ Use warning signs to designate particular hazards
- ☑ Confine long hair and loose clothing
- ☑ Use appropriate personal protective equipment at all times
- ☑ Wear goggles or safety glasses at all times
- ☑ Be aware of hygiene

If you are a teacher, you are responsible for the health and safety of your students. You can help to prevent laboratory accidents if you keep in mind some rules:

- ☑ Set a good example when demonstrating experiments by adhering to safety techniques such as wearing aprons and goggles.

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- ☑ Help students develop a positive attitude towards safety. Students should not be fearful of doing experiments or using reagents or equipment, but they should always be alert for potential hazards.
- ☑ Always demonstrate procedures before allowing students to begin the activity. Look for possible hazards and alert students to potential dangers.
- ☑ Explain and post safety instructions each time you do an experiment. Ensure that all students have understood the instructions.
- ☑ Ensure that all students know about the chemical risks: hazard symbols, R- and S-Phrases.
- ☑ Maintain constant supervision of student activities. Never allow students to perform unauthorised experiments or conduct experiments in the laboratory when alone.

Risk information "R-phrases" provide more detailed information than the hazard symbols on the dangers that various chemicals present. They are prescribed by law and are standardised internationally. Whilst the R-phrases describe the risks inherent in chemicals, the "S-phrases" (Safety information phrases) give information on how these dangers can be avoided.[5]

Everyone entering a laboratory, including maintenance staff, cleaning staff and service engineers, must be informed about the hazards inherent in laboratories. If you are a cleaner, maintenance worker or engineer you are responsible for taking the correct safety precautions, just as you have the right to work in a safe environment. It is important that you are fully aware of and understand all safety information. In addition:

- ☑ Always wear the lab coat that has been provided and see that it is properly fastened. Keep your lab coat away from your outdoor clothing and do not take your lab coats home to wash. Do not wear your lab coat in the staffroom or canteen; take it off when you go for your break.
- ☑ Do not touch anything whilst in the laboratory, unless you have been specifically told it is safe for you to do so.
- ☑ Wash your hands regularly, and always when you have finished work or stop for a break.
- ☑ When cleaning sink areas, always wear gloves.
- ☑ Immediately report any accidents or incidents (including cases where something is leaking or has been knocked over) to the person in the laboratory or your supervisor.[6]

4. Checklist

- ☑ Know the safety rules and procedures that apply to the work being done.
- ☑ Determine the potential hazards and appropriate safety precautions before beginning any new operations.
- ☑ Be alert to unsafe conditions and actions. Report them so that they can be rectified as soon as possible.

The purpose of this checklist is to promote safety awareness and encourage safe work practices in the laboratory. This checklist should serve as a reminder of things you can do to work more safely. Although this checklist is applicable to all research, teaching and academic laboratories, your laboratory may require more specialised rules that apply to specific materials and equipment.
Please see your laboratory supervisor for more information before you begin to work in the laboratory. Ensure that you are well trained and informed.

The checklist comprises of a series of questions to determine whether or not the laboratory conforms with the regulation and methods of best practice. All questions have to be answered with yes or no. In the latter case remedial action is needed.

GENERAL Laboratory safety	***YES***	***NO***
Are staff and/or students adequately trained and supervised to ensure safe work procedures?		
Are new and young workers appropriately supervised and informed?		
Are hazard warning signs posted on the door indicating any hazards that may be present (e.g. biological, radioactive materials, or high noise emitting equipment)?		
Is there a door that can be closed to keep visitors out of the lab while work with the dangerous substances or biological agents is in progress?		
Where required, is access to the lab restricted to authorised persons only?		
Are storage areas (rooms, refrigerators, freezers, cupboards) where infectious and/or toxic materials are kept labelled accordingly?		
Are all chemicals clearly labelled, including hazard symbols?		
Are all biomaterials clearly labelled, including the hazard symbol where appropriate?		
Are glass bottles stored where they cannot be knocked or kicked over?		
Are all pressure vessels (including pressurised liquid nitrogen dewars) periodically inspected and certified?		
Is the safe working pressure clearly marked on all pressure vessels?		
Are all pressurised gas cylinders properly secured by restraining chains, bench clamps or similar?		
Are gas cylinders sited away from doors or escape routes?		

Is all portable electrical equipment periodically tested and labelled with the date of test?		
Is the use of laboratory equipment (such as electrophoresis for instance) covered by safety instructions?		
Are the power supply leads to electrophoresis equipment covered?		
Do all centrifuges have interlocked lids?		
If no, is a suitable warning sign affixed to the centrifuge lid?		
Are floors clean?		
Are floor coverings intact and non-slip?		
Are passageways clear of tripping hazards (cables, stock, waste, etc.)?		
Are work surfaces easily cleaned and decontaminated after use?		
Is lighting adequate and in working order?		
Are noise levels acceptable? (you do not have to raise your voice to talk to people at your workplace)		

Information for workers	***YES***	***NO***
Do staff and/or students know about the findings of the risk assessment?		
Do staff and/or students know what hazards they are being exposed to?		
Do staff and/or students know how they may be affected?		
Do staff and/or students know about possible risks of harm to the unborn child or reproductive health?		
Do staff and/or students know what they have to do to keep themselves and others safe (i.e. how the risks are to be controlled)?		
Do staff and/or students know how to check and spot when something goes wrong, and to whom they should report any problems?		
Do staff and/or students know about the results of any exposure monitoring or health surveillance?		
Do staff and/or students know about preventive measures to be taken in case of maintenance work?		

Chemical safety	***YES***	***NO***
Are Material Safety Data Sheets available for all hazardous substances used in the lab?		
Are all chemicals and containers correctly and clearly labelled?		
Are staff and students informed about compatibility of chemicals?		
Are heavy items stored on/in low shelves or cupboards?		
Is storage of chemicals above eye level avoided?		
Are flammable reagents and solvents, etc., stored in suitable closed vessels, within fire-resistant cupboards, cabinets or bins containing spill trays?		
Are the flammable stores properly labelled?		
Are bottles containing strong acids or strong alkalis stored on spill trays?		
Do all staff and students wear appropriate personal protective		

equipment?		
Do staff and students know what to do in case of chemical emergency or if chemicals spill?		
Where Occupational Exposure Limits are assigned to a substance, is exposure controlled below that limit?		
Is use of pipettes by mouth prohibited?		

Biological safety	***YES***	***NO***
Are procedures regarding the use of sharps (e.g. needles, syringes, pipettes, scalpels, razors, broken glass, etc.) in place to minimise the risk of cuts, sticks and infection?		
Are there puncture- and leak-proof containers to discard intact needles and syringes, butterfly needles and associated tubing, and similar devices?		
Are the receptacles for sharps disposal properly labelled?		
When work is done on the open bench, are plastic-backed absorbent pads placed on the work surface to collect splatter or droplets associated with the work?		
Are contaminated waste procedures developed and followed (e.g., treatment by chemical disinfectants or by steam autoclaving)?		
Are waste materials segregated according to hazard type, and is there an appropriate chemical decontamination tray for collecting contaminated implements?		

Hygiene	***YES***	***NO***
Is the production of aerosols minimised and contained?		
Is there a hand-washing sink available (preferably near the door) with liquid soap and paper towels?		
Are there hand-washing instructions for all persons when they finish their work or when they exit the laboratory?		
Is smoking, eating, drinking and the application of cosmetics prohibited in the lab?		
Are there welfare facilities available outside the laboratory area where personnel can eat and/or drink?		
Is there provision for the secure storage of outdoor clothing out of the laboratory area, or in secure cupboards/lockers within the area as appropriate to prevent contamination?		
Are mechanical pipetting devices used?		
Are single-use needles and syringes used?		
Where microbiological safety cabinets are used to control exposure to biological agents:		
Are they subject to containment and filter penetration tests, at appropriate intervals?		
Is a valid operator protection test certificate available for each cabinet in the lab?		

Emergency procedure	***YES***	***NO***
Are safety rules clearly displayed?		
Have plans been drawn up to deal with accidents?		
Are staff and/or students adequately trained in safety procedures and do staff know how to contact the emergency services?		
Are emergency procedures and emergency phone numbers clearly posted on all laboratory doors?		
Is there a person, with appropriate experience and knowledge, designated to deal with spills/leaks involving dangerous substances and/or biological hazardous substances?		
Is the emergency exit clearly signposted, illuminated and unobstructed?		
Are staff and/or students aware of the nearest fire exit route?		
Is a first aid kit present and filled with appropriate and up-to-date supplies?		
Is there a trained first-aider available?		
Are handwashing sinks available?		
Is an eyewash fountain present, functioning and unobstructed?		
Is an emergency shower present, functioning and unobstructed?		
Do staff and students know what to do in the event of an emergency involving dangerous substances and/or biologically hazardous materials?		
Are there appropriate spill kits available to deal with spills/leaks of hazardous substances?		
Is suitable PPE, especially respiratory equipment, available to protect laboratory and/or maintenance personnel in the event of control measures failing, or to deal with a spillage?		
In the case of biological agents, do the plans specify appropriate decontamination and disinfection procedures?		
Is there relevant fire fighting equipment readily available and unobstructed?		
Are staff and/or students familiar with the location of fire fighting equipment and the action to take in the event of fire?		
Has each member of staff or student been given access to a copy of the fire routine procedure?		

Personal Protective Equipment (PPE)	***YES***	***NO***
Are staff and students protected by lab coats or overalls?		
Is the protective equipment appropriate to European Standards and CE marked?		
Are safety goggles and/or face shields available and worn?		
Are appropriate protective gloves available and worn? (Experience has shown that many safety data sheets contain insufficient information on gloves; if in doubt consult supplier, producer or literature)		
Is appropriate respiratory protection available?		
Is the respiratory protection regularly cleaned and inspected?		
Are staff and students trained on how to use the protective equipment?		
Is there sufficient stock of protective equipment, especially respiratory, so as to allow replacement if a defect is found?		
Do staff and students wear fully covered shoes?		
Do staff and students confine long hair and avoid loose clothing?		
In the case of PPE for work with biological agents:		
Is the protective equipment stored where it cannot be contaminated by biologically hazardous substances and where it will not contaminate outdoor clothing?		
Is it always removed on leaving the lab?		
Is it kept apart from uncontaminated clothing or equipment?		
Is the "one shift" disposable PPE safely disposed?		
If it is not "one shift" disposable, is the PPE regularly inspected, cleaned and maintained?		

Hazardous waste	***YES***	***NO***
Are waste management procedures in place?		
Are waste receptacles emptied regularly?		
Are waste types segregated and stored correctly?		
Is hazardous waste properly labelled?		
Are infectious waste materials decontaminated before disposal?		
Are contaminated needles and syringes placed in special puncture-resistant containers for disposal?		

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