SAFETY COMPENDIUM 2020

Bachelor of Engineering in Chemical Engineering
Bachelor of Engineering in Biotechnology
Bachelor of Engineering in Food Technology

AARHUS UNIVERSITY
SCHOOL OF ENGINEERING

CONTENT

SAFETY
IN CHEMICAL ENGINEERING, BIOTECHNOLOGY AND FOOD TECHNOLOGY

Introduction

At Aarhus University School of Engineering (ASE) laboratory work and workshop exercises are a natural part of the degree programmes. The practical exercises are a crucial element in achieving the practical competences required of an engineer in today's Denmark.

During your first projects in the laboratory, the experiments will be relatively simple and harmless. You will expand upon what you learned in upper secondary school, become acquainted with Good Laboratory Practice (GLP), use the equipment and work in a safe manner. The requirements in the projects will then gradually increase and, ultimately, you will be expected to work both independently and correctly in the laboratory.

The way ASE has designed the laboratory work can be compared to the way in which you learn how to drive: From the very beginning, you have to drive the car yourself. This takes place in a very protected environment at first, but you then gradually have to take on more and more of the responsibility.

No workplace is absolutely without risk.

This applies to laboratory work as well! There will always be risks, but by following the rules and having the proper protective equipment, the risks can be reduced to an acceptable level.

You are responsible for learning how to assess risks and prevent accidents. In the beginning, your supervisor, instructor or technical staff will help you to assess risks and prevent accidents, but it is crucial that you work on developing these skills yourself throughout your studies.

This booklet describes the GLP guidelines and the division of roles and responsibilities between you, your supervisor and your instructors. Thus, it also describes the demands and expectations placed on you as a student in the laboratories. In addition, the booklet will review procedures for handling accidents and emergencies as well as guidelines for labelling chemicals and managing waste.

DIVISION OF ROLES AND RESPONSIBILITIES

SUPERVISORS, STUDENTS AND TECHNICIANS

This section deals with matching expectations and making it clear who is responsible for what.

Who is responsible for what?

Who do you ask which protocol to use?

Who assesses the safety of a chemical agent?

Who can help with the use of analytical equipment?

Your responsibilities as a student

- Always show up to class **well-prepared**. You must **read the exercise manual** beforehand, assess the risks of your experimental set-up before you begin and take the necessary precautions.
- You must have considered **waste management** and how to collect and dispose of waste.
- Purchase of non-chemical materials or laboratory equipment (e.g. soap, textiles, oil etc.).
- Make sure that your experimental set-up and risk assessment has been reviewed and **approved by your supervisor** before you go into the laboratory.
- **Never work alone** in the laboratory.
- Keep yourself informed of where different **safety and emergency response equipment** is located before you go into the laboratory and conduct experiments.
- Students at Danish universities are not covered by the Danish Workers' Compensation Act. You are responsible for taking out an **accident insurance.**
- Please inform the school if you become **pregnant** so that we can help you plan your activities in the laboratory.
- Please inform the school if you have an **illness** that may affect your activities in the laboratory.
- During your first semester, you must participate in a **compulsory safety course.**
- Each semester you must complete the **compulsory safety quiz and demonstration of the Safety cabinet** before you start working in the laboratory.
- Inform the Occupational Health and Safety Group of any irregularities.
- **Daily laboratory safety.**

Your supervisor's responsibilities

- Anything that has to do with **theory.**
- **Safety assessment** of the given protocol/method.
- **Choice** of analysis/purification/measurement method.
- **Guidance** in relation to the purchase of chemicals.
- **Safety assessment** of chemicals before purchase.

The laboratory technician's/assistant's responsibilities

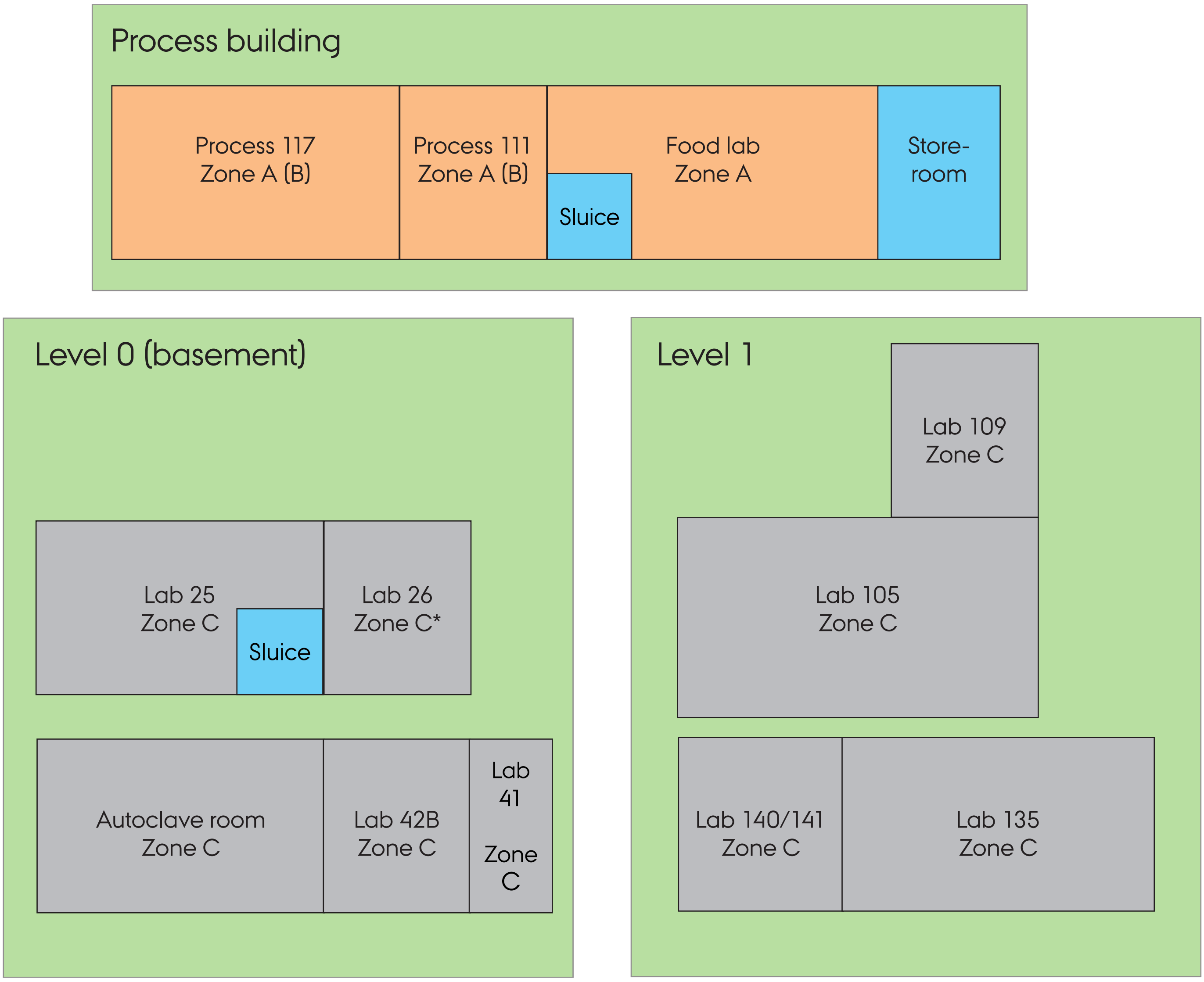
- Anything that has to do with the **practical** aspects
- **Assist with the purchase** of laboratory equipment and chemicals.
- Information on which equipment is in stock (including pots, hotplates, buckets etc.)
- **Guidance in relation to the practical execution** of standard unit operations (pH measurement, centrifugation, HPLC, GCMS etc.) – i.e. not design of the protocol/method.
- Compulsory demonstration of the Safety cabinet.
- Announcement on Blackboard regarding supervision hours in the laboratory.

GOOD LABORATORY PRACTICE (GLP)

THE DOS AND DON'TS

GLP can essentially be translated into THE DOS AND DON'TS of the laboratory. GLP is the predominant approach to good behaviour, which not only supports your safety in the laboratory, but also makes you a better scientist. In addition, it is a **very** important part of the workplace culture in all large Danish companies.

At Aarhus University School of Engineering we have divided our **laboratories and process areas into zones**. Rules regarding attire and safety equipment are determined by the zone. The rules are meant to ensure that objects from a "normal" laboratory does not enter into areas where we have to be able to taste the things we produce. Think of it like this: **If an object has been in a Zone C area, it must not be transferred to a Zone A area.** The only exception is safety glasses, which we have deemed will always be clean enough to not be a problem.



Zone A

- Areas where it must be possible to **taste the product being produced**. However, it is still **not permitted to bring/consume packed lunches, coffee etc**. NB: "taste" means consuming only a small amount.
- Unsupervised access is permitted only after passing the food quiz (will be handed out and checked by the supervisor), passing the safety course and passing the safety quiz (must be renewed every six months).
- **Blue lab coat,** safety glasses and safety shoes are always required.
- **No white lab coats.**
- **No glassware.**
- Areas referred to as "Zone A (B)" may be downgraded to Zone B for periods of time.

Zone B

- Hygienically similar to a kitchen at home.
- Unsupervised access is permitted only after passing the safety course and passing the safety quiz (must be renewed every six months).
- Safety glasses and safety shoes are always required.
- **No white lab coats**. Workwear or ordinary clothes are permitted.
- **No glassware.**
- No chemicals without prior permission from supervisor or Occupational Health and Safety Group (must be food approved).
- Food production always observes the rules for Zone A.

Zone C

- Unsupervised access is permitted only after passing the safety course and passing the safety quiz (must be renewed every six months).
- Safety glasses and lab coat are always required.
- Zone C*: Primarily intended for food analyses. Classified as Zone C, but no chemicals and access only after having received permission from supervisor and passing the food quiz.

Attire

- Requirements differ depending on which zone you are in. See above.
- **The lab coat must be taken off when you leave the room.**
- Long trousers are preferred.
- Use a sealed plastic bag to transport your lab coat in if you want to bring it to or from school.
- No high heels or open shoes.
- As a general rule, scarves, niqab, hijab or the like are permitted as long as there are no unfastened or loose parts. Long sleeves must be covered by the lab coat. The material must be made of cotton or similar flame-retardant material. It must be possible to take off quickly in case of an emergency (e.g. acid spill). It must still be possible to comply with other safety requirements (e.g. safety glasses).
- Please note that some assignments may be given where wearing a scarf, niqab, hijab or the like will be considered unsafe.
- Contact lenses are not recommended in the laboratories and process areas (prevents proper flushing in case you get chemicals in your eye). If you wear contact lenses, write it clearly on your lab coat or workwear ("I wear contact lenses").
- **Long hair must be tied back** to prevent it from being caught in rotating machines or ignited by open flames, e.g. gas burners.
- **Avoid wearing jewellery during laboratory work.** They may be damaged by chemicals and prevent effective rinsing and cleaning, thus bringing chemicals and microorganisms into contact with your skin.

Behaviour

- **Wash your hands** as the final step before leaving the room.
- **Walk calmly and quietly**. Never run and do not make sudden movements.
- Ensure order and cleanliness, clean up after yourself, and leave the work area in the condition you would like to find it.
- Experimental set-ups, which will be used over the course of several days, must be marked with name, class number, email/phone number (unmarked set-ups will be removed without notice).
- **Bags are prohibited in the laboratories and process areas** and should be kept to a minimum in the hallways.
- Mobile phones and computers are only permitted in the laboratories and process areas by agreement with the supervisor. You can find plastic mats to place your computer on in all Zone C laboratories. The mats must be cleaned after use and hung back in their place.
- **Food and beverages are prohibited in the laboratories and process areas, just as it is prohibited to use laboratory, glassware or other equipment for beverages or food.**
- Working in the laboratories or process area **after consumption of alcohol** is prohibited.
- Wipe the tables before and after using them. Use a cloth with a cleaning agent. Clean with 70% ethanol if your work has included microbiology.
- At the end of the work day, **chemicals** must be placed either **back in the chemical cupboard** or in a temporary storage room, if one has been assigned.
- Chemicals with a toxic hazard label must always be kept locked. After use, these chemicals must be returned to the laboratory technician or supervisor.
- If you are working with hazardous chemicals, consider the substitution principle – whether you can replace the hazardous substances with less hazardous substances.
- Mouth pipetting is prohibited.
- **Never pour excess chemicals back into the container** or bottle (avoid contamination).
- For acid/water mixtures: Always Add the Acid.
- Do not attempt to steal chemicals, glassware or other laboratory equipment – it can have consequences for the remainder of your degree programme.

Photo: AU Foto, Lars Kruse

PROTECTIVE EQUIPMENT

PERSONAL PROTECTIVE EQUIPMENT, VENTILATION AND EMERGENCY RESPONSE EQUIPMENT

Protective equipment covers **all equipment that protects you**, both preventively and in the event of emergencies. It can be divided into personal protective equipment (e.g. glasses, gloves, lab coat), ventilation (e.g. fume hoods, local exhaust ventilation, LAF benches) and emergency response equipment (e.g. fire extinguishers, fire blanket, safety shower).

PPE (Personal Protective Equipment)

Safety glasses

- **Safety glasses must always be worn in all zones** unless a clear exemption has been granted.
- **Contact lenses are not recommended**. If they are used anyway, this must be made visible on the lab coat with the text: "I wear contact lenses".
- Safety glasses must be made of clear impact-resistant plastic (polycarbonate) with the certification EN166F, and equipped with a side shield to protect the eyes against any splashes.
- Safety glasses can have one of the following ratings: EN166S < EN166F < EN166B
- EN166F means that the safety glasses can withstand a steel ball of Ø6 mm, weight 0.86 g and speed 45 m/s.

Lab coat

- Lab coats are not just worn to protect your normal clothes, but also to protect against harmful substances and fire.
- A lab coat should be washed or discarded immediately if it has come into contact with hazardous substances and materials.
- The lab coat must be buttoned in the front as it must be possible to take off quickly, e.g. in case of fire or chemical burns.
- A lab coat must be made of cotton or a different flame-retardant material.

Gloves

- Used for **protection against absorption of substances through the skin.** Use gloves with discernment and moderation. Please note that excessive use of gloves may cause skin irritation. Should always be used when working with corrosive, harmful or infectious substances.
- Chemicals may permeate the glove, in which case we need to consider **breakthrough times**. You can find information on breakthrough times for different chemicals on www.handskeguiden.dk (Danish only).
- If a glove is contaminated, it must be changed immediately.
- The school uses a TouchNTuff nitrile glove, which is a good all-round glove.
- 4H gloves are also available from the Safety cabinet or by request.
- **Gloves must be removed after completion of the work**. Do not walk around with dirty gloves as you risk contaminating handles, objects etc.
- Always remove the gloves when you leave the laboratory.

Safety shoes

- Must be approved for security grade S1 or higher.
- Safety shoes can have one of the following ratings: S1 < S1P < S2 < S3
- Safety grade S1: Steel or aluminium cap over the front foot, shock-absorbing, closed heel, antistatic insole, oil-resistant.

Hearing protection

- You **may be required to use hearing protection** when using some of our process equipment.
- The Danish Working Environment Authority recommends the use of hearing protection if the noise exposure exceeds 80 dB (avg. of an 8-hour working day), if peak values exceed 130 dB, or if the noise exposure is otherwise harmful or uncomfortable.
- You should always wear hearing protection if the sound level is so loud that it hurts your ears, or **if ultrasound is used.**
- Ear defenders are available at Aarhus University School of Engineering. These ear defenders have a noise reduction rating of 36 db and works on both high-frequency sounds (including ultrasound) and low-frequency sounds.
- If in doubt about the noise exposure, always wear hearing protection. Alternatively, you can test the noise exposure with an app (e.g. https://www.av.se/en/health-and-safety/noise/noise-exposure-app/)

Ventilation

LAF benches

- **Protects the sample** from being contaminated by its surroundings.
- Some LAF benches also protect the person against contamination from the sample. Look at the LAF bench to see what it covers.
- Used for microbiological work to protect the biological purity of the product and to protect the person working.
- Sterile air is blown into the bench and picks up particles.
- Switch on the LAF bench for 10 minutes prior to beginning your work in order to reduce the total bacterial count in the work area.
- To ensure sterile conditions:
  - Avoid excessive arm movement (turbulence).
  - Remove unnecessary bottles and equipment.
  - Always work with the smallest opening possible.
  - Wash your hands before and after you work in the cabinet to avoid contamination.
  - The table must be cleaned with 70% ethanol before and after working on it.
  - Place bin liner stands with autoclave bags in the back of the cabinet. At the end of the work day, close the bag with autoclave tape and autoclave it.
  - Avoid movements over any material that must be kept germ-free.

Fume hood

- **Protects the surroundings** from being contaminated by the sample.
- Used for all work in which harmful or odorous gases, vapours or dust are formed.
- When switched on, the air in a fume hood is changed and ventilated.
- To ensure optimum conditions:
  - Avoid violent arm movements (turbulence).
  - Remove unnecessary bottles and equipment.
  - Always work with the smallest possible opening in order to ensure proper exhaust of the fume hood.
  - Always keep your head and face higher than the bottom edge of the fume hood.
- If a fume hood displays an alarm, follow the procedure below:
  1. Pull down the door and see if the alarm disappears.
  2. Check the suction with a small piece of paper taped to the bottom of the fume hood door.
  3. Put a sign on the fume hood with the message: "Out of order, do not use".
  4. Contact a laboratory assistant, supervisor or technician.

Local exhaust ventilation

- **Partially protects the surroundings** from being contaminated by the sample.
- May only be used to reduce non-hazardous odours.
- Only works properly if the suction is 15 cm or closer to the product being suctioned.

Emergency response equipment

- **The safety shower** is optimal for extinguishing fire on a person or for rinsing chemical spills on a person's clothes and body.
- **CO2 fire extinguishers** can be found in different locations in the building. These extinguishers are suitable for extinguishing fires in fluids, gases and current-carrying systems. They are not optimal for extinguishing fires in solid substances. Extinguishing fire on a person is also not recommended as the low temperature of the carbon dioxide has a high risk of causing frostbite.
- **Fire blankets** are recommended for extinguishing small fires in pots, bins and the like. They are very well-suited for extinguishing fire on a person lying down. If the person is standing up, they must be laid down in order to reduce the risk of the fire spreading to the face.
- **Eye wash bottles** can be found in multiple locations in each laboratory. After use, the rest of the bottle must be discarded.

DAILY LABORATORY SAFETY

Which consequences could this reaction have? What would you do if you or the person next to you gets the contents of a test tube slung into their eye? When responding to an accident or emergency, you typically have seconds, not minutes. Get used to thinking about safety.

As a minimum, working safely in the laboratory means:

- considering whether the chemicals you are working with are **hazardous** and which **protective equipment** to use.
- **risk assessing** your experimental set-up.
- investigating how to **handle any waste**.
- receiving **instructions** on how to use equipment that can become very hot, includes rotating or sharp parts or poses a risk in any other way.
- inform yourself of **the location of emergency response equipment and emergency exits**, as well as which procedures to follow in case of accidents or emergencies.

Chemicals

All chemicals are stored in specially designed cupboards with ventilation. They are sorted alphabetically, either by their common name or by their IUPAC name. In addition, they are divided into the following categories: All chemicals are also marked with a unique number – **the CAS number** – which identifies the chemical agent.

Chemicals from the chemical cupboards (referred to as "stock") are divided into three categories: **Red, Yellow and Green**, based on how hazardous they are.	**Each category has a specific set of precautions, which are listed below**
Red category covers toxic, carcinogenic, mutagenic and explosive substances.	**Red** category is locked inside a toxic storage cabinet. In order to use any of these substances, you must have completed the form "Risk assessment for work with toxic substances and products" or "Risk assessment for work with cancer-causing substances" with your supervisor. You are not permitted to work with the substance outside of regular opening hours.
Yellow category covers concentrated acids/bases, oxidising substances, peroxide-forming chemicals and organic solvents.	**Yellow** category is kept locked. Can be retrieved if you have been granted permission by your supervisor.
Green category covers common salts, diluted acids/bases, substances that cause local irritation and all non-hazardous substances.	**Green** category is not kept locked. You must have been granted permission from your supervisor in order to use any of these substances.

Photo: AU Foto, Lars Kruse

Labelling of mixtures and solutions

A requirement for working safely in the laboratory is labelling your containers with chemicals correctly so that others can see what they contain and which safety measures to take when using the substances. Label printers and guidelines can be found in laboratory 1.35.

Storage containers – includes all containers that contain a chemical agent **for an extended period of time** (>1 working day), must be labelled in accordance with the CLP rules (see below).

Minimum:

- **Contents**
- **Who made it**
- **Hazard pictograms**
- **H and P statements**
- **Signal words**

In addition, it is a good idea to note:

- Date of production
- Shelf life

Work containers – includes all containers that contain a chemical agent **for only a brief period of time** (<1 working day).

Minimum:

- **Contents**
- **Who made it**
- **Hazard pictograms**

All stock chemicals are labelled in accordance with the **CLP regulation** (see below) when they are received from the supplier. All this information can be found in the **safety data sheet**, which comes with the chemical agent or can be downloaded from the supplier's website. Safety data sheets are also referred to as **MSDS** or **SDS**, which are abbreviations of **Material Safety Data Sheet** and **Safety Data Sheet**, respectively.

Your responsibility is to make sure that the solutions and mixtures you produce are labelled correspondingly. Guidelines for how to do this can be found in the next section.

CLP regulation

CLP is an acronym for Classification, Labelling and Packaging of substances and mixtures. The regulation was implemented in Europe in 2009 and replaced a previous directive (the one with the orange hazard symbols). The old directive is fully phased out, but you can still come across chemicals that have been labelled in accordance with the old system. Teaching at ASE will only focus on the new system. The CLP regulation is based on UN's global guidelines for classification and labelling: GHS (Globally Harmonised System). It ensures that employees and consumers in the European Union are clearly informed of the hazards associated with chemicals by means of classification and labelling. All chemical substances and materials must be classified and labelled in accordance with the CLP regulation.

H statements

- **Hazard (H) statements** specify the hazards associated with handling the hazardous material or product
- **H200-H299** specify physical hazards
- **H300-H399** specify health hazards
- **H400-H499** specify environmental hazards

P statements

- **Precaution (P) statements** specify which precautionary measures to take, how to handle, store and dispose of the material or product, or what to do in case of an accident or emergency.
- **P200-P299** specify preventive measures
- **P300-P399** specify precautions in relation to possible reactions
- **P400-P499** specify precautions in relation to storage
- **P500-P599** specify precautions in relation to disposal

Hazard pictograms

PHYSICAL HAZARDS

GHS01 – **Explosive**
This pictogram indicates **explosives, self-reactive substances and organic peroxides, which may cause explosions when heated.**

Please note the meaning of these two pictograms, which look similar.

GHS02 - **Flammable**
This pictogram warns against flammable gases, aerosols, liquids and solids:
- **Self-heating substances and mixtures.**
- **Pyrophoric liquids and solids, which may ignite when in contact with air.**
- Substances and mixtures that develop flammable gases in contact with water.
- Self-reactive substances or organic peroxides, which may cause fires when heated.

GHS03 – **Oxidising**
If you find this pictogram on the label, it means that you are handling **oxidising gases, solids and liquids, which may cause or intensify fire and explosion.**

GHS04 – **Gas under pressure**
Chemicals with this pictogram indicate:
- **Gas under pressure; may explode if heated.**
- **Refrigerated gas; may cause cryogenic burns or injury.**
- **Dissolved gases**

Gases, which are normally safe, may be hazardous under pressure

HEALTH HAZARDS

GHS05 – **Corrosive**
When you use a chemical agent with this pictogram, you should be aware that it is **corrosive** and can cause severe **skin burns and eye damage.** It can also be **corrosive to metals.**

GHS06 – **Acute toxicity**
Be aware that you are handling a chemical agent, which is **acutely toxic** if it comes into contact with skin or is inhaled or swallowed. It can even be **fatal**.

GHS07 – **Health hazard**
This pictogram can mean one or more of the following:

- **Acutely toxic (harmful)**
- **Causes skin sensitization and skin and eye irritation**
- **Causes respiratory irritation**
- **Narcotic, causes drowsiness or dizziness**
- **Harms the ozone layer**

GHS08 – **Serious health hazard**
A substance or mixture with this pictogram has one or more of the following effects:

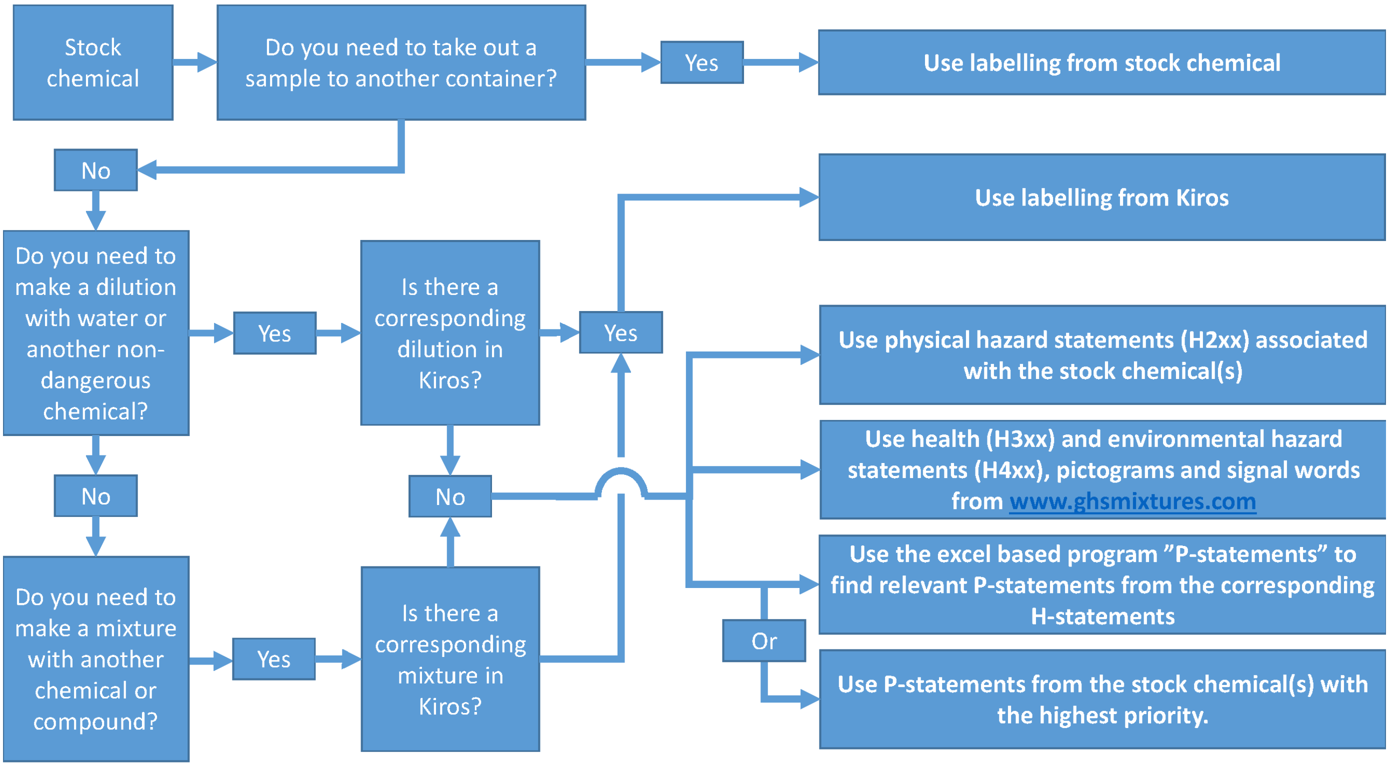
- **Causes cancer**
- **Damages fertility and the unborn child**
- **Causes genetic defects**
- Causes respiratory sensitization and may **cause allergy, asthma or breathing difficulties if inhaled**
- **Causes damage to certain organs**
- Hazardous if inhaled, **may be fatal or harmful if swallowed or if it comes into contact with the airway**

ENVIRONMENTAL HAZARDS

GHS09 – **Hazardous to the environment**
This pictogram indicates that the substance is **hazardous to the environment and toxic to aquatic life.**

Procedure

Labelling chemical is complicated and requires experience. For easy reference and guidance, you can use the **flow chart** below to determine the correct approach.



Using Kiros

- Open **www.kiros.dk**
- Under "Login", select "Navigator"
- Enter
  Username: **ASE_STUDENT**
  Password: **ASE_STUDENT**
- Search for the chemical agent. You can use the chemical's CAS number or parts of its name in Danish or English if there are not enough search results. Use your common sense – chemicals in Kiros are not always labelled 100% correctly.

Calculating H statements, hazard pictograms and signal words at ghsmixtures.com

Enter the information you have on the pure chemicals (e.g. acetonitrile 99,9% or formic acid 96%). Then make a mixture of the pure chemicals by specifying which percent by weight the chemical agent constitutes in the final mixture. The calculator assumes that non-specified percentages are made up of non-hazardous chemicals (e.g. water). Thus, 10% acetonitrile diluted in water is calculated by making a mixture with 10% acetonitrile as the only compound.

- Obtain the safety data sheet for the chemical agent. You have various options here.
  - Search on KIROS
  - Download from the supplier's website (e.g. https://www.sigmaaldrich.com/denmark.html)
- Open a browser and go to https://ghsmixtures.com/.
- Create a new user by clicking "Get started".
- Log on.
- Click "Add a compound/mixture" and select "Add A Compound".
- Enter relevant information on the chemical agent. This includes information on H statements, which can be found in section 2 and section 3 of the safety data sheet (see Figure 2 and Figure 3). If there is no known information, the section must be left blank. Please note that physical H statements (H2xx) cannot be calculated. Instead, you must use the statements on the stock chemical agent or mixture.
- Repeat for each chemical that you are working with. NB: The free version only allows the user to enter a limited number of compounds/mixtures. Create a new user if you need to make more.

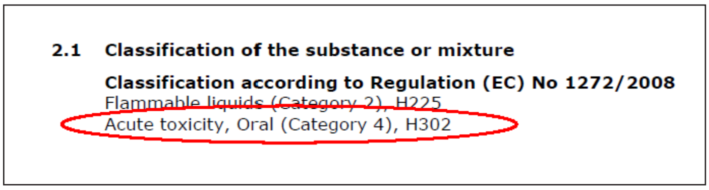


Figure 2: Extract of H statements from SDS for Acetonitrile

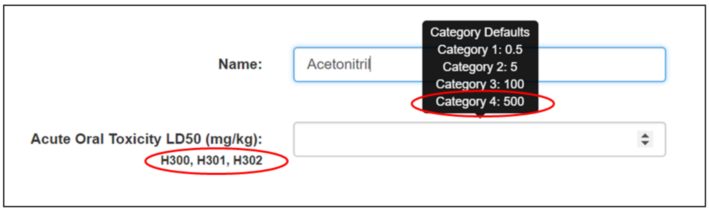


Figure 3: Information on H302 from the safety data sheet for acetonitrile is entered by writing the value (500) corresponding to Cat. 4.

- Click "Add a compound/mixture" and select "Add A Mixture".
- State the percentage of each chemical agent in the finished mixture. Do not enter non-hazardous solvents (e.g. water).

Calculating P statements

P statements cannot be calculated as their effect in mixtures/dilutions cannot be put into a formula. Consequently, there is no "correct" way to find P statements and some element of personal assessment will always be included.

At Aarhus University School of Engineering, we have decided on two methods for determining which relevant precautions to take based on a given set of H statements.

Method 1:

- Use all P statements specified for the stock chemicals
- Remove duplicates
- Remove lower-priority statements (e.g. P261 "Avoid breathing dust" has a lower priority than P260 "Do not breathe dust").

Method 2:

- Use the Excel programme "P-sentences" to find the P statements corresponding to the H statements obtained from ghsmixtures.com
- Remove lower-priority statements

Example of correct labelling

There are many ways of making a **correct label for a storage container**, but what they all have in common is that they must, at a minimum, indicate:

- **Contents**
- **Who made it**
- **Hazard pictograms**
- **P and H statements**
- **Signal words**

In addition, it is a good idea to note:

- Date of production
- Shelf life

- You can use your own computer to **print labels** – either directly from Kiros or by **using the label printer in laboratory 1.35.** At ghsmixtures.com, **the label can be copied** or transferred by hand to a label. **Hazard pictograms and labels are available** for this purpose on a shelf in the chemical cupboard in lab 1.05. Below is an example of an approved label for a 10% acetonitrile/0.1% formic acid mixture.

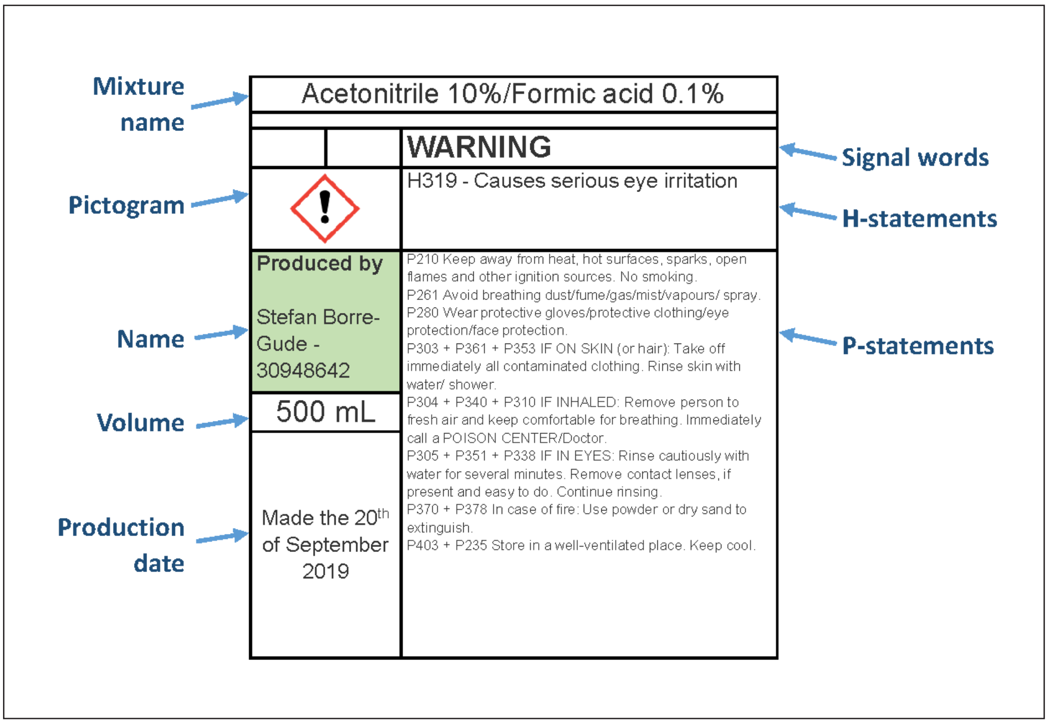


Figure 4 Example of correct labelling

Prevention and risk assessment

In order to minimise any risks associated with working in the laboratory or process centre, it is extremely important to make a risk assessment before initiating any work.

This is something you are used to doing in your everyday life without having to think about it. For instance, when you go for a bike ride, you assess whether or not to wear a helmet, whether the brakes work, whether there are lights on your bike, and whether the batteries have enough power. All of this can contribute to reducing the risk always associated with going for a bike ride.

When making a risk assessment in the laboratory or process centre, it can be a good idea to use the table below, **which is commonly used in the industry to assess the hazards associated with work performance.**

RISK = PROBABILITY X CONSEQUENCE			
	Consequence		
Probability	**1** (No/minimal injury)	**2** (Discernible injury)	**3** (Serious injury)
3 (High probability)	Moderate risk	Significant risk	Critical risk
2 (Medium probability)	Low risk	Moderate risk	Significant risk
1 (Low probability)	Insignificant risk	Low risk	Moderate risk
Before beginning a new exercise, you must first identify the hazards and then assess the risks and take the necessary measures in order to reduce the risks to an acceptable level.			

Figure 5 Risk assessment matrix for estimating the necessity of taking measures to minimise the probability of a hazardous incident occurring.

Imagine that you need to get started on an assignment and no measures have been taken yet.

- Identify the **Hazards** (which bad things could happen?)
- Assess the Probability of the hazards actually occurring
- Assess the worst-case **Consequence** of the hazard (how bad is it if the hazard occurs?)
- Calculate the **Risk** (“Risk = Probability x Consequence”)
- Take **Measures** to reduce the Probability, Consequence or both in order to reduce the Risk of a given Hazard to an acceptable level (≤2/green area).

Example of everyday risk assessment

When riding a bike, falling down is a Hazard. The Probability may be a category 1 (you are an experienced cyclist who knows what they are doing), but the worst-case Consequence would be very serious, which puts it in a category 3. This makes the calculated Risk 1x3=3 (Moderate risk).

To reduce the Consequence, you could take the Measure of wearing a bike helmet. We now assess that the Consequence has been reduced to category 2. Thus, we have brought the risk down to 2 (Low risk).

Example of risk assessment in the laboratory

A Hazard of organic synthesis could be inhalation of vapours from acetonitrile. The H statement is H332 (Harmful if inhaled). The Probability could easily be 3, and the Consequence could be 1 (headache). The calculated Risk is therefore 3x1=3 (Moderate risk). You could take the Measure of using a fume hood, thereby reducing the Probability to 0-1. This puts the risk in one of the green areas (Insignificant risk).

Prevention

Ask yourself:

- Do I know all the Hazards of this assignment?
- Are my surroundings tidy and safe (can I get away easily if something goes wrong)?
- Do I have the skills to carry out this assignment?
- Do I have the proper equipment?
- Which safety instructions are specified in the P statements?

Assess all of your experiments in relation to:

Risk of scalding, e.g.:

- Heating large quantities of water or oil
- Diluting acids and bases (exothermic reactions)

Risk of burns, e.g.:

- Leak in gas tubes
- Loose clothes/hair
- **Hot surfaces** on process equipment

Risk of explosions, e.g.:

- Formation of dust
- Formation of flammable gases
- **Pressurisation in closed containers** (e.g. gas-forming reactions, heat input, unintentionally closing off exits).

Risk of inadvertent contact with hazardous substances, e.g.

- Intense gas-forming reactions
- Splashes from boiling liquids
- Penetration of gloves
- Risk of electric shock, e.g.:
    - Lack of ground connection in electrical outlets
    - Poorly insulated wiring
    - Electrical outlets on floors or in other places where there could be water

Risk of mechanical accidents, e.g.:

- Heavy set-ups that are not securely fastened
- Rotating parts
- Getting stuck in presses, doors etc.

In the event of an accident, you must keep yourself **informed of the location of protective equipment** such as fire extinguishers, fire blankets, eye wash bottles, safety showers, emergency exits, Safety cabinets etc. before initiating your experiment.

Clearing-up and cleaning

“Please clean up after yourself. Your mother doesn’t work here.” Many cafeterias have notifications like that. We do not, **because it is not necessary.** We do clean up after ourselves, because we know that it makes our workplace safer and our laboratory work higher quality.

Everyone is responsible for keeping the laboratories looking tidy. This includes keeping all emergency exits unobstructed by e.g. boxes or trolleys.

Chemicals

- Chemicals must always be kept in cupboards or on shelves and never on the floor.
- Once you have completed your work in the laboratory, all chemicals must be stored in chemical cupboards.
- Handling of waste, see “Waste management” below.

Paper, gloves, glass and needles

- Paper and gloves that have not been microbiologically contaminated go into regular waste.
- Glass waste: Clean glass (without chemicals) goes into the glass waste container in the courtyard. Dirty glass (which has been in contact with chemicals) goes into “chemical glass waste” (blue bins with clamp lids located in the laboratories).
- Needles go into yellow bins designed for needles and scalpels. **Must never be placed in other waste containers.**

Figure 6: Yellow waste container for needles and scalpels

- Microbiological waste must be autoclaved before disposal.
- **Everyone is responsible for emptying the regular waste bins** as needed (into the waste container in the courtyard). Note: ONLY the laboratory technician is allowed to empty chemical waste containers in the fume hoods.

Cleaning glass equipment and volumetric pipettes

Always clean glass equipment and pipettes after use. If there is chemical residue on the glass equipment, it can change the results of your experiments.

- Use the sorting key to make sure that your waste goes into the correct container (see below).
- Leave the residue on the equipment to evaporate in the fume hood overnight (if it has been in contact with organic solvents such as pentane).
- Cleaning by hand: Clean with regular water, rinse three times with demineralised water, place in the storage cabinet (to dry).
- Cleaning in a dishwasher: Follow the instructions by the dishwasher in the autoclave room.

Waste management

Handling of waste is an important part of laboratory safety. A large proportion of registered accidents are caused by incorrect handling of chemicals. If waste is not handled correctly, you risk mixing two incompatible substances in the waste container. This may cause unintentional chemical reactions and thereby very serious work-related injuries.

Companies/public institutions that produce hazardous waste are obligated to dispose of it in a lawful manner and thus responsible for making sure that hazardous waste is not mixed with other categories of hazardous waste. Hazardous waste is sorted into different groups (see sorting key, Figure 2, page 18).

If you are disposing a mixture of chemicals, use the sorting key. Consider each statement from the top in relation to the mixture in question. The waste must be disposed of in the waste container consistent with the first category that applies.

O*	Does the waste contain strong oxidising agents (e.g. organic peroxides) or does it react with water (vigorous reaction, formation of flammable or acid gases)?	NO
K	Does the waste contain mercury (e.g. mercury batteries, light sources, amalgam, activated carbon)?	NO
Z	Does the waste contain spray cans, pressure cylinders, empty packaging, medicine, isocyanates, mercury-free batteries or mixed waste in small packaging?	NO
T	Does the waste contain biocides (e.g. pesticides) or empty packaging that has contained biocides?	NO
X**	Does the waste contain only inorganic substances (e.g. hydrochloric acid, sulphuric acid, nitric acid, soda lye, cyanide baths, metal salts or fertiliser and fertiliser residue)?	NO
A	Does the waste contain only mineral oil products (e.g. lubrication oil, fuel oil or diesel oil), but no emulsifying agents?	NO
B	Does the waste contain substances with sulphur, flouride, chlorine, bromine or iodine (e.g. trichloride, freon, mercaptans or PCB)?	NO
C	Is the waste liquid, does it have a calorific value of at least 18 MJ/kg (e.g. benzine, turpentine, thinner, toluene, alcohols or acetone), and is the water content no more than 50%?	NO
H	Is the waste an organic chemical substance that does not contain halogen or sulphur (e.g. water-based glue, varnish or paint), or is it a mix of organic and inorganic substances?	

*Figure 7: Sorting key. * Includes the subgroups O_1, O_2, O_3 and O_4.*
** * Includes the subgroups X_{acid}, X_{base} and $X_{nitric\ acid}$. See text for further explanation.*

Waste category O. We distinguish between the following subgroups:

- O1, oxidising substances
- O2, organic peroxides
- O3, forms acid vapours in contact with water
- O4, forms flammable gases in contact with water

Waste category X. We distinguish between the following subgroups:

- X_{acid}, inorganic acid where the solution has a pH < 7
- X_{base}, inorganic base where the solution has a pH < 7
- $X_{nitric\ acid}$, nitric acid
- If in doubt, check the pH value and dispose of the waste in the appropriate waste category.

All acids and bases must be diluted to <2M before disposal. Remember to always add acid to water and never water to acid (mnemonic rule: Always Add the Acid). The reason for this is that concentrated acids can have very violent reactions with other substances.

Further information and examples of substances ending up in different waste categories can be found here: https://www.fortum.dk/sites/g/files/rkxjap216/files/documents/sorteringsvejledning.pdf (Danish only)

Examples of waste sorting

- An aqueous solution of 4M sulphuric acid must be diluted to 2M and poured into the container marked X_{acid}, since none of the waste categories above apply to the solution.
- A titration of I2 in a starch solution must be poured into B waste, since iodine is a halogen and none of the waste categories above apply to the solution.
- Solutions containing peroxides such as hydrogen peroxide or potassium persulfate must go into O_1 waste, since they are oxidising. O waste has the highest priority in the sorting key, which means that no further consideration is necessary here.
- Alcohols, ethers and most HPLC chemicals such as methanol and acetonitrile are disposed of in C waste, since they are organic compounds without halogens and have a calorific value of at least 18MJ/kg. If they are diluted by more than 50%, however, they must be disposed of as H waste.
- In addition to weak solutions of organic compounds such as alcohols and ethers etc., organic acids (such as acetic acid) are also disposed of as H waste (not to be confused with X_{acid}, which can only contain inorganic acids).
- **See more examples of waste management in the section "Additional material"**

When disposing of solid waste, e.g. if there is leftover salt after having measured the correct amount on a scale, all of the solid material must be collected in a zip-lock bag. Zip-lock bags are available by all stationary scales. The bag must be marked H2-solid waste and deposited in the large beaker next to the scale and under the ventilation. If the beaker is full, like in the picture, call a laboratory technician.

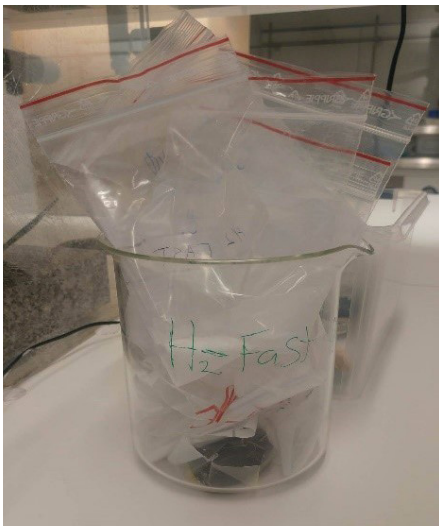


Figure 8: Beaker filled with H_2 - Solid waste

- Before working with chemicals, you must obtain information on the hazardousness of the substances you are working with, as well as how to dispose of the waste.
- **The sorting key gives an overview of the individual waste groups** – i.e. how to prioritise and sort correctly and in accordance with the characteristics of the waste.
- Fume hoods are always used when transferring chemical waste to plastic containers. The waste is carefully transferred to labelled plastic containers, which indicate the symbol of the waste group. Leave any residue on used glassware to evaporate in the fume hood overnight (mark with date). When the residue has evaporated, clean the glass equipment.
- Afterwards, the empty containers/bottles go into "chemical glass waste" (blue bins with clamp lids in the laboratories).
- If the waste container is full (see the line indicated in the picture), or if a waste category is missing, a new, empty plastic container can be retrieved from the storeroom. Remember to indicate the waste category clearly with a marker.

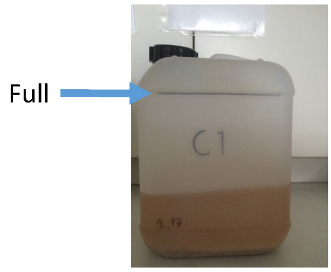


Figure 9: Waste container for chemical waste

- **Biological material must be inactivated.** Waste (inoculation needles, used petri dishes etc.) must be collected in autoclave bags, sealed with autoclave tape and autoclaved. It can then be disposed of a regular waste. Remember to **loosen bottle caps** when autoclaving.
- **NB: The plastic containers do not have lids.** This prevents pressure buildup in the container.
- **NB: Only the laboratory technician is allowed to remove full plastic containers from the fume hoods.** Accidents may occur during the transfer, and the laboratory technician takes the necessary precautionary measures before handling the containers.

Use of equipment

It is important to receive instructions for the following equipment before use, not just for safety reasons, but also to keep them from breaking.

Watch videos on the Youtube channel "BioChemFoodASE" (https://www.youtube.com/channel/UCR2fqmbK5WQ-s2e_16QOXCiw).

Weighing, scales

- Scales are subject to calibration and must be level to provide correct measurements. Do not move scales.
- Always clean scales after use. Brushes are available by the scales to clean any spills. Collect waste in a paper towel and dispose of in the table top waste bins by the scale.
- Do not put excess chemicals back in the stock container. Instead, put them in the small plastic bags by the scale and handle them like chemical waste.
- Be careful when using the scales. Only take small quantities at a time and only use clean instruments.
- Wash the instruments after use and put them back in their place.

Use of HPLC, GCMS, Fermentors, Autoclave

- Do not attempt to perform maintenance on malfunctioning equipment. Contact the laboratory technician or your supervisor first.
- Make a note in the log/books by the equipment if problems arise during an analysis.

Centrifuges

- Centrifuges must always be equilibrated before use. If a centrifuge shakes during operation, it must be stopped immediately. Weigh out the centrifuge tubes with content to make sure the tubes weigh the same. Create counterweight by filling a tube with water and making sure that the total weight is the exact same as the sample.

Process equipment

- All pilot-scale process equipment (freeze dryer, spray dryer, extraction unit, crane, brewing equipment etc.) must only be used after receiving oral or written instructions.

Electrical safety

As an engineer, you are expected to have a broader expertise than pure chemistry and biology. You are also expected to have a basic understanding of electricity and safety.

Regular modern sockets

- Voltage: 230 V alternating current
- Frequency: 50 Hz
- Power: 10-13 amp
- Number of conductors: 1 live conductor (typically brown), 1 neutral conductor (blue), 1 ground connection (striped yellow/green)

High-power sockets

- Voltage: 400V alternating current
- Frequency: 50 Hz
- Power: Typically 16 amp, but as much as 32 amp.
- Number of conductors: 3 lives (typically brown, white and black), 1 neutral (blue), 1 ground connection (striped yellow/green)

Fuse boards contain

- **GFCI relay:** Breaks the electrical circuit quickly in the event of residual current leakage.
- **Fuse groups:** Gathers a number of sockets into one group. Each group is protected by one fuse.
- **Fuses:** Keeps conductors from melting in the event of electric overload. If you connect two electric boilers to the same group, for example, the fuse will interrupt the power to protect the conductors.

Theory

The energy in a current-carrying cable is created by the power plant pulling and pushing the electrons with a frequency of 50 Hz.

The push/pull effect always takes place in three separate conductors, which are called "live conductors". Electricians always connect either one live conductor (230V) or all three live conductors (400V) to a socket.

The sockets also contain a conductor, which connects back to the power plant and makes it possible to create a closed circuit. This conductor is called a "neutral conductor" and does not carry current until it is connected to the live conductors. This happens when you connect a plug (and an electronic device) to the socket and turn on the power switch.

All sockets also contain a conductor to prevent fatal accidents. This conductor is called "ground", and in the event of a residual current leakage, current is diverted into the ground via this conductor. The unit that detects residual current leakages is called a ground fault circuit interrupter (GFCI). The GFCI relay is mandatory and located on the fuse board. The GFCI measures the amount of power that goes in and out of a building. If the two numbers are not identical, it means that the power is being leaked (e.g. by a person touching a live conductor).

The GFCI registers this immediately and, if the difference is above 30 milliampere, it quickly breaks the electrical circuit to prevent serious injury from from an ongoing electrical shock.

In light of this, Aarhus University School of Engineering has decided that only extension cords with earth ground connection are allowed (see Figure 10 and Figure 11). For more detailed information, see the video "Intro til el-sikkerhed" on https://www.youtube.com/channel/UCR2fqmbK5WQ-s2e_16QOXCiw (Danish only)

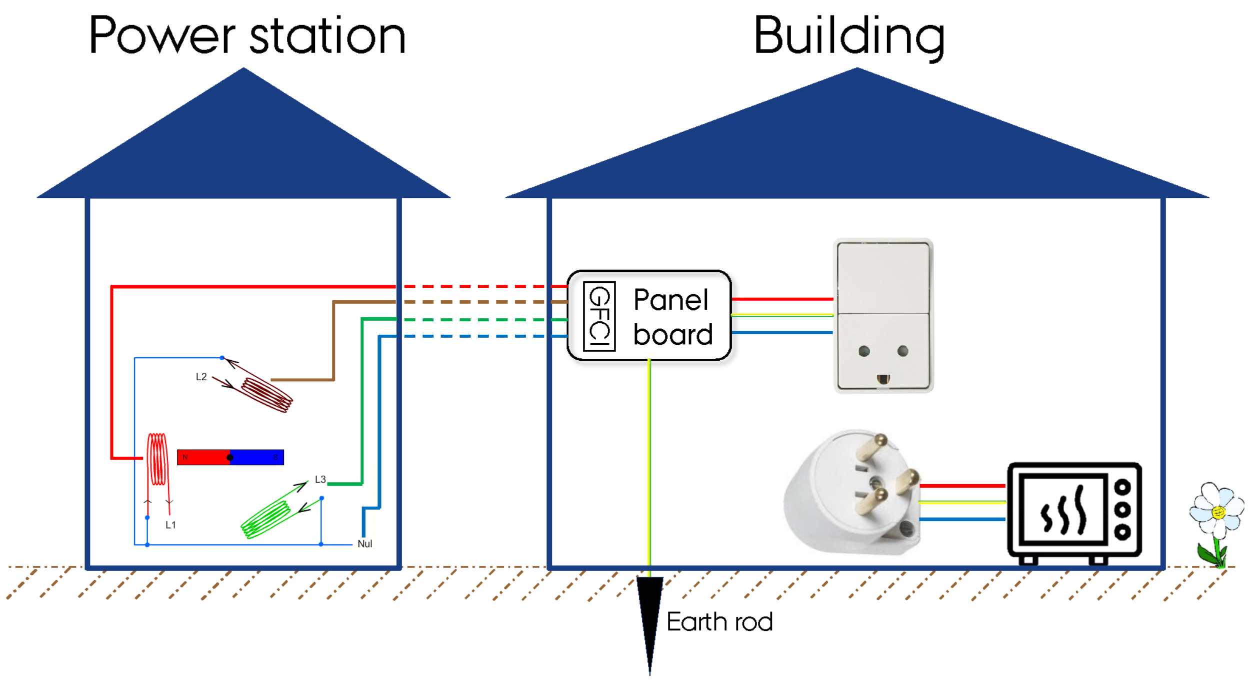


Figure 10: Overview of how power is distributed from the power plant to the consumers. Consumers are protected from residual current leakages in buildings by the GFCI relay leading power out and into the earth rod via the ground connection.

Figure 11:
Socket without ground

Figure 12:
Socket with ground

Figure 13:
Plug without ground

Figure 14:
Plug with ground

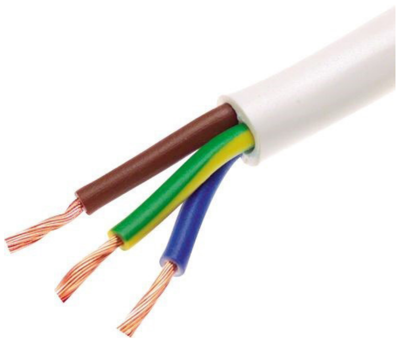


Figure 15: Cable with three conductors: one live (brown), one neutral (blue) and one ground (green/yellow)

ACCIDENTS AND EMERGENCIES IN THE LAB

An "**accident**" is defined as a sudden event causing minor injury to an object or person.

An "**emergency**" is defined in the same way, but with more significant injury.

A "**near-miss**" is a situation that could have potentially developed into an accident or emergency.

In the same way that it is impossible to guard yourself 100% against accidents and emergencies in a car, it is also impossible to guard yourself 100% in a laboratory. **The most common types of accidents and emergencies in the laboratory are stabs and cuts or pressure buildup in closed containers.** This is followed by chemical spills, splashes of liquid striking the eyes and small fires in liquids. Although we are fortunate that these incidents rarely occur, you still have to know which measures you need to take if they do. You will usually **not have time to read up on procedures and courses of action** once you find yourself in the situation.

A **simple spill**:

- does not spread quickly
- does not endanger people or objects, except by direct contact, and
- does not endanger the environment.

A **complex spill** contains one or more of the following parameters:

- Risk of fire or explosion (e.g. a heat source close to flammable material)
- Chemicals with the hazard label GHS06 (Acute toxicity) or GHS08 (Serious health hazard)
- Strong oxidising agents (e.g. HNO_3, permanganates, perchlorates, peroxides, nitrites, chlorites)
- Environmentally hazardous substances
- Concentrated acids/bases

Chemical spill without personal injury (accident)

All spills are different, and there are no definitive guidelines for how to handle all types of spills. **That is why you should always use your own common sense and judgement.**

In biotechnological and chemical laboratories, we work with two types of spills: **simple spills**, which you can clear up yourself, and **complex spills**, which require assistance from a laboratory technician or supervisor.

Below are some examples of simple and complex spills. If you do not know which substance has been spilled, or if you do not know which reactions could occur when mixed with water/air, the spill must be treated as a complex spill.

Examples of simple spills outside of fume hoods

- 100 mL concentrated acid/base
- 0.5 L diluted acid/base (< 2 molar)
- 0.5 L ethanol
- 100 grams $NaHSO_3$ powder

Examples of complex spills outside of fume hoods

- Organic solvents such as methanol, acetonitrile, xylene, toluene, THF, phenol (toxic vapours)
- Multiple substances dropped at the same time (possibility of unforeseen reactions due to mixing)
- $KMnO_4$ (causes damage to objects due to staining of floors)
- Large amounts of concentrated acid/base (oxidising reactions, harmful vapours)

A spill in a fume hood requires an individual assessment of whether it still constitutes a complex spill. As a rule of thumb, you can assume that it takes approximately 5x as much to be considered a "complex spill". For instance, organic solvents are no longer a health hazard because of vapours. However, they may become a fire hazard if the they spread over a large area and there is a heat source nearby. If the spill spills out of the fume hood, it must of course be handled like a spill outside of a fume hood.

Handling simple spills

- **Stay calm and analyse the situation.**
- Inform all people in the vicinity that a chemical spill has occurred.
- Prevent dust and vapours from spreading by closing doors and increasing ventilation. In the process centre, turn the ventilation button. In the laboratories, press "Max" on the fume hoods.
- Prevent liquids from spreading. You can make a dike of granules (vermiculite or sand) from the Safety cabinet.
- Liquid acids and bases **must be neutralised with sodium bicarbonate** (acids) or **citric acid** (bases). These are located by the laboratory islands in all laboratories. Use indicator strips to check whether the pH is between 6-8. **Watch out for heat development and boiling!**
- Liquids must be absorbed with granules (vermiculite or sand). Start from the edge of the spill and work your way in towards the centre.
- Remaining granules, chemical powder etc. must be removed with a broom and dustpan and placed in the waste container from the Safety cabinet (blue barrel with clamp lid). The waste container must be placed in the courtyard and under the lean-to roof, sheltered from the elements.
- Always inform a member of the occupational health and safety group after the event.

Chemical spill with personal injury (emergency)

- Follow the guidelines for first aid (see below)

Evacuation

Consider whether the entire building should be evacuated, or whether it is sufficient to evacuate part of the building.

If the entire building needs to be evacuated:

- Press the **fire alarm call point** (i.e. press the button on the alarm).

Figure 16: Fire alarm call point

- **Call 1-1-2** and tell them why the fire alarm has been pressed. This must also be done if it turns out to be a false alarm. Emergency response to a false alarm **costs DKK 6,000**.
- Put on the **yellow vest (Evacuation Marshal),** and make sure someone puts on the **orange vest (Assembly Point Marshal).** The vests can be found on the wall on all floors, as well as in the process centre. Thus, in case of an alarm, there should always be at least four evacuation marshals and four assembly point marshals, who are responsible for coordinating their efforts.
- Follow the steps on the laminated instruction sheets by the vests.
- If your clothes have been contaminated, remove them and take a shower.

Handling complex spills

- **Stay calm and analyse the situation.**
- **Inform** all people in the vicinity that a chemical spill has occurred and evacuate the room/building to the extent necessary.
- Leave the room and **close the door to the room** where the spill has occurred.
- **Put up this sign** from the Safety cabinet: "We are clearing up after a chemical accident – no unauthorised access!"
- **Contact your supervisor, laboratory technician or a member of the occupational health and safety group.**
- If you are uncertain about which vapours could spread in the building, contact the operation control centre by calling 112.
- Replace your lab coat if you have spilled on it.

After clearing up

- Clean the area with soapy water.
- If you have used a broom and dustpan, the dustpan must be cleaned with the soapy water. The broom must either be cleaned or discarded, depending on what it has been used for.

Figure 17: Vests for evacuation marshal and assembly point marshal

Safety cabinets

- **A Safety cabinet is an emergency response cupboard**, which contains safety equipment and aids you may need in case of an accident or emergency.
- There are three Safety cabinets at the school: one by the main entrance, one by the back entry, and one on the first floor, in the middle of the corridor.
- Throughout your studies, you will receive regular introductions to the cabinets and their content.
- **Only use the Safety cabinet in case of an emergency** – otherwise, contact a member of staff.
- Extra eyewash bottles can be found by each Safety cabinet.

Content of the Safety cabinets:

- The sign **"We are clearing up after a chemical accident – no unauthorised access!"** and tape, which can be hung on the door of the laboratory in which an accident has occurred.
- **Boiler suit, single use lab coats** to change into in case someone has to take off their own clothes – e.g. if the clothes are wet from chemicals.
- **Shoe covers** to prevent your own shoes from coming into contact with spilled chemicals.
- **Rubber boots** to use instead of your own shoes.
- A **blanket** to keep a person warm or to use as a pillow.
- **5-litre containers with demineralised water, sponge and bucket**, so that you can pour the water into the bucket and use the sponge to irrigate a burned area if it is not possible to get to a safety shower.
- **First aid kit** for ordinary first aid.
- **Nitrile gloves** for simple spills and **H gloves** for complex spills.
- **Bucket with sand**, which can be used to collect oil-containing liquids or to extinguish metal fires.
- **Bucket with vermiculites**, which are soft granules that can be used to absorb liquids.
- **Blue barrels with clamp lids** to collect chemical waste, including granules and sand.
- **Dustpan and broom** to collect waste for bags and buckets.
- Always contact a member of the occupational health and safety group if the Safety cabinet has been opened.

Examples of accidents and emergencies

Over an eight-year period, the following accidents and emergencies have been registered at the Bachelor of Engineering degree programme. **The first two took place before the introduction of our current safety concept**. In each case, a comprehensive assessment was made regarding the probability of it happening again, as well as the worst-case consequence. Then a **concrete solution** was developed and implemented.

Eye damage
A student added acid to a solution of $CaCO_3$. The mixture took place in a 5L blue-cap bottle with a tightly screwed-on lid. The reaction caused the carbonate to convert into CO_2 gas, thereby creating **overpressure in the bottle**, which shattered. The student was not wearing safety glasses, and one of the glass fragment struck the eye. The person was taken to hospital and attended by a doctor. Permanent eye damage.

Solution: All experiments are subject to approval by the supervisor. Strict enjoining of the rules regarding mandatory use of safety glasses.

Fire damage
An exercise involving heating of a glass container with a Bunsen burner was initiated without the set-up being checked beforehand. At one point, **the gas tube fell off the Bunsen burner.** This resulted in a shooting flame, which struck the student's body and face. The student was wearing a lab coat and safety glasses, but received second-degree burns on the nose and around the lips. The student received ordinary first aid and was subsequently attended by a doctor. No permanent damage.

Solution: Clear division of responsibilities. All Bunsen burners removed and replaced by small gas burners.

Stab injury
In connection with the fermentation course, a student needed a needle to inject a liquid through a septum. **The needle was unused and firmly attached to its protective cap.** Pulling the needle out required force. As the needle released from the protective cap, the student reflexively made a movement in the opposite direct, thereby receiving a stab injury in the finger. The student received ordinary first aid. No permanent damage.

Solution: Focus on using the correct technique when releasing needles.

Cut injury
In connection with the fermentation course, one of the groups wanted to clean the heating mantle for the glass reactor. In order to clean the heating mantle, tap water was connected to the bottom of the heating cap, while the tube normally leading the cooling water back to the controller unit was still attached to the top discharge point of the heating mantle. However, this tube is designed so that there is no passage through it unless it is directly connected to the controller unit. In this way, **pressure built up in the mantle, which finally exploded** and scattered broken glass across a large area. The student received ordinary first aid for cuts on the arm and hand. No permanent damage, but the consequences could have been far worse.

Solution: Clear information that **students must never attempt to clean heating mantles for glass reactors.**

Eye damage
A student had to clean containers containing 0.1M HCl and 0.1M NaOH. During the cleaning process, a plastic tube slipped and **splashed a few drops of liquid into the student's eye.** The student was not wearing safety glasses. The eye was flushed quickly, and because the student could not say whether the splash had contained base or acid, the person was taken to hospital for a check-up. No permanent damage.

Solution: Stricter enjoining on the course regarding compliance with the safety rules.

Near-miss
A group was heating a mixture with KI in 1000 mL volumetric flasks. The flask was sealed with a rubber bung, and when the reaction required heat, the flask was placed on a hotplate, which was then turned up to 130 degrees Celcius. After a period of time, the **pressure buildup was so great that the bung blew off**. The flask did not break, but the hot content was spread throughout the entire fume hood. There were no people in the vicinity when the accident happened.

Solution: Enjoining the hazards of heating up a closed system.

COMMUNICATION PROCEDURE

The communication procedure in the event of an emergency is described below. The advantage of an established framework for communication is that you know when and from whom you can expect to receive more detailed information. In case of an accident or near-miss incident, the procedure is followed to the extent that is deemed relevant.

Action	Responsibility	Time
First aid and, if necessary, alarm call	Members of teaching staff/ instructors/students	Immediately
Report to immediate supervisor and occupational health and safety representative immediately after the incident	Responsible member of teaching staff/supervisor	As soon as possible
Contact the injured person for clarification of the incident	Occupational health and safety representative (Trine Thomsen)	As soon as possible
Contact the family of the injured person	Occupational health and safety manager (Stefan Borre-Gude)	Depends on the extent of the damage
Contact members of teaching staff/instructors for clarification of the case	Occupational health and safety representative (Trine Thomsen)	No later than 3 days after the incident
Contact fellow students for psychological debriefing and information	Occupational health and safety manager (Stefan Borre-Gude)	Information email no later than the next day. Personal information no later than the next lesson.
Assessment of accident/near-miss incident and implementation of any initiatives	Trine Thomsen/ Stefan Borre-Gude	No later than two weeks after the incident

FIRST AID

Each laboratory has a **registration system for first aid procedures**, which contains the same information as the following sections. These pages can be **taken down and brought to the scene of the accident**, or outside the building in case of evacuation. On the back of each page is an overview of relevant emergency phone numbers. Please note that first aid procedures do not always follow the order of the three main points of first aid (see below). The reason for this is that the three main points of first aid are general and have been developed by the Danish Emergency Management Agency, whereas the action plans for each specific type of injury have been developed by medical doctors.

All laboratories are equipped with safety showers or hand showers, which can be used to extinguish fire on a person or to rinse people in the event of a chemical spill.

You can also find **Safety cabinets with safety equipment several places in the building, which can be used to continue emergency aid outside in the event of evacuation.** The next pages contain the first aid procedures available in the laboratories.

The three main points of first aid (remember that first aid must be learned through a course):

1

Stop the accident (overview and protection), e.g. by:

- Extinguishing fire
- Disconnecting the power
- Moving an injured person
- Closing the fume hood/door
- Evacuating the room and, if necessary, the building

2

Give first aid in accordance with the ABC principle:

- **A - Airway** (Make sure the injured person's airway is open)
- **B - Breathing** (Check for breathing – see, feel, listen)
- **C - Circulation** (Check for and treat any bleeding)

3

Call for help, e.g. by calling 1-1-2

- Inform of where the accident has occurred (name, address, city, phone number)
- What has happened (the specific incident, chemicals, people who are stuck, special help required)
- How many injured
- Send someone out to receive the first responders

Provide ordinary first aid while waiting for the ambulance, e.g. by:

- Following the first aid guidelines in the laboratory
- Talking to the injured person
- Protecting the injured person against the weather conditions
- Bandaging
- Providing psychological first aid

Figure 18 – The three main points of first aid. More information: https://beredskab.dk/robustborger/foerstehjaelp/.

CHEMICAL BURNS IN THE EYE

- Begin treatment as quickly as possible to prevent permanent damage.
- If possible, begin flushing the eye immediately at the scene of the accident. You can use an eyewash bottle, tap water or other noncorrosive liquids available.
- The eyes must be held open actively to ensure effective flushing.
- Check for contact lenses, which may prevent flushing.
- Flush for at least 20 minutes.

More information:

www.sundhed.dk/borger/patienthaandbogen/oejne/sygdomme/oejentraumer/aetsning-af-oejet/ (Danish only)

CHEMICAL BURNS ON SKIN

- Remove the cause of the chemical burn. Rinse the chemical agent off the skin with warm running water (25-34 degrees). If the corrosive chemical agent is a powder-like material, brush it off before you start rinsing.
- Remove clothes and jewellery that have been contaminated by the chemical agent.
- Rinse for a least 20 minutes under a tap or safety shower. Some burns must be rinsed for several hours.
- Small chemical burns (a few centimetres) usually heal without further treatment.
- For larger chemical burns, contact the emergency department.

More information:

www.sundhed.dk/borger/patienthaandbogen/akutte-sygdomme/foerstehjaelp/varme-og- kulde/brandskade-kemisk-aetsninger/ (Danish only)

POISONING

CALL POISON CONTROL CENTRE – 82 12 12 12

Base and acid, chemicals:

- Remove any visible remnants of the substance. Give the person something to drink – water or milk – quickly, but do NOT induce vomiting. Call a doctor. While you wait for help to arrive, you can:
- Place the patient in a lateral position and monitor
- Treat any residue on the skin by rinsing with plenty of water
- If there is residue in the eyes, see eye damage.

Toxic gases:

- If the person is conscious:
  Take the person to clean air. Place the person warmly and comfortably in a half-seated position. Call for help.
  Monitor whether the patient is breathing. If they stop breathing – provide CPR.
- If the person is unconscious, but breathing independently:
  Take the person to clean air. Make sure the person's airway is unobstructed. Place the patient in a lateral position and monitor. Call for help.
  Monitor their breath. If they stop breathing – provide CPR.

More information:

www.sundhed.dk/sundhedsfaglig/laegehaandbogen/akut-og-foerstehjaelp/ tilstande-og-sygdomme/forgiftning/ (Danish only)

SMALL BURN

- Cool down the burn as quickly as possible by dipping the burned area in cool water. Alternatively you can use tempered running water (12-18 degrees) for at least 30 minutes.
- If the above-mentioned method is inconvenient, use cold compresses. Cooling the burn down reduces swelling by leading heat away from the skin. Do not put ice on the burn.
  If you rinse quickly, 30 minutes can be sufficient. After three hours, additional rinsing is usually ineffective, but may provide pain relief.

More information:

www.sundhed.dk/borger/patienthaandbogen/akutte-sygdomme/foerstehjaelp/varme-og- kulde/forbraendinger-brandskader/ (Danish only)

LARGE BURN

- Call 112.
- While waiting for the ambulance or doctor to arrive, follow these guidelines:
- Do not removed burnt clothes, but make sure that the injured person is no longer in contact with red hot material or exposed to strong smoke or heat.
- Make sure the injured person is breathing. If the person has stopped breathing, check whether their airway is obstructed. If necessary and possible, provide CPR.
- If possible, rinse with cool water immediately. If not, cover the burnt area with a cool, damp, sterile bandage or clean cloth.
- Check for signs of shock. If possible, lay the injured person down with the legs lifted.
- Monitor vital functions such as consciousness, pulse and breathing – until help arrives.

More information:

www.sundhed.dk/borger/patienthaandbogen/akutte-sygdomme/foerstehjaelp/varme-og-kulde/forbraendinger-brandskader/

BURN, FACE AND HEAD

- Call 112 for an ambulance immediately.
- Explain that you suspect airway burn, and that the injured person has difficulty breathing.
- Improve breathing conditions.
- Do what you can to improve the injured person's ability to breathe, for instance loosening tight-fitting clothes around the neck.
- If the injured person is unconscious:
- Check whether the injured person is breathing.
- Place the injured person in a lateral position and check whether they are breathing.
- Prepare to perform resuscitation if necessary.
- Cool down the burned area.
- If possible, use a bottle, a water jug or something similar, so you can pour the water over the head. Place a towel or something similar over the shoulders to collect the water. Allow the water to run for 10-20 minutes.

More information:

www.sundhed.dk/borger/patienthaandbogen/akutte-sygdomme/foerstehjaelp/varme-og-kulde/forbraending-ansigt-og-hoved/ (Danish only)

ELECTRIC SHOCK

- Call 112.
- Look first. Do not touch the person as they may still be in contact with the electrical source. If you touch the person, you may also receive an electric shock.
- If possible, disconnect the power. If this is not possible, move the source away from the injured person by means of a non-conductive object made of e.g. cardboard, plastic or wood.
- As soon as the person is free of the electrical source, check whether the person is breathing and has a pulse.
- If there is no response, or if the pulse is alarmingly slow and faint, provide CPR.
- If the person has fainted, is pale or shows other signs of shock, lay the person down with the head slightly lower than the body and the legs lifted. If the person is unconscious but breathing and with a pulse, they must be moved into recovery position.
- Cover large burns to prevent evaporation.

More information:

www.sundhed.dk/borger/patienthaandbogen/akutte-sygdomme/foerstehjaelp/varme-og- kulde/elektrisk-shock/ (Danish only)

IMPORTANT PHONE NUMBERS

Person/unit	Name	Phone number
Occupational health and safety manager ASE	Stefan Borre-Gude	3094 8642
Occupational health and safety representative ASE	Trine Thomsen	6095 0785
Emergency dispatch centre		1-1-2
Emergency doctor service/department	Central Denmark Region	7011 3131
Poison control centre		8212 1212
Facility staff AU	Jan Creutsberg	2778 2851
Falck (non-urgent)		7010 2030
Securitas (outside of opening hours)		7026 3650

BASIC FIREFIGHTING

Basic firefighting covers the knowledge and skills necessary to act appropriately in the event of a fire.

Four main points of firefighting

1

RESCUE PEOPLE

Warn people in danger, including, if necessary, evacuating the building via the fire alarm call point. Rescue people who cannot move themselves. If anyone is injured, providing first aid, e.g. artificial respiration, is also part of this step.

2

ALERT THE FIRE DEPARTMENT

Call 112 on the phone or activate a fire alarm call point. If you call 112, you must be prepared to provide information about: the reason for your call (a fire), where the fire is (exact address), additional information about any injured people etc., and which phone number you are calling from.

3

LIMIT FIRE SPREAD

Close doors and windows. Turn off the gas and remove any pressure bottles and flammable material without endangering yourself and others.

4

FIGHT THE FIRE

Use the correct extinguisher.

FIREFIGHTING CLASSIFICATIONS

Type of fire extinguisher	**Fire class A** Solid materials such as wood, paper, textiles etc. (Embers)	**Fire class B** Liquids	**Fire class C** Gases	**Fire class D** Metals such as magnesium, aluminium etc.	**Fire class E** Current-carrying systems	**Fire class F** Vegetable oil, fats etc.
Pressurized water extinguisher	YES	NO	NO	NO	YES/NO*	NO
Powder extinguisher ABC	YES	YES	YES	YES	YES**	YES
CO_2 extinguisher	NO	YES	YES	NO	YES	NO
Foam extinguisher	YES	YES	NO	NO	YES/NO*	NO
Wet chemical extinguisher	YES	YES/NO***	NO	NO	YES/NO*	NO

* Depends on approval in accordance with DS/EN3, typically up to 1000V at a distance of 1.0 m.
** Electronics and IT equipment may be damaged
*** Depends on approval in accordance with DS/EN3

OCCUPATIONAL HEALTH AND SAFETY ORGANISATION STRUCTURE

In all Danish companies, work environment, including safety, is managed by the occupational health and safety organisation.

AU's occupational health and safety organisation has four levels:

The Main Occupational Health and Safety Committee is the uppermost body in Aarhus University's occupational health and safety organisation

The Main Occupational Health and Safety Committee advises the senior management team on occupational health and safety at AU. The Main Occupational Health and Safety Committee plays an important role in that it lays down and coordinates the university's occupational health and safety efforts at a general level, across the faculties.

The Faculty Occupational Health and Safety Committees and the Administration Occupational Health and Safety Committee ensure systematism

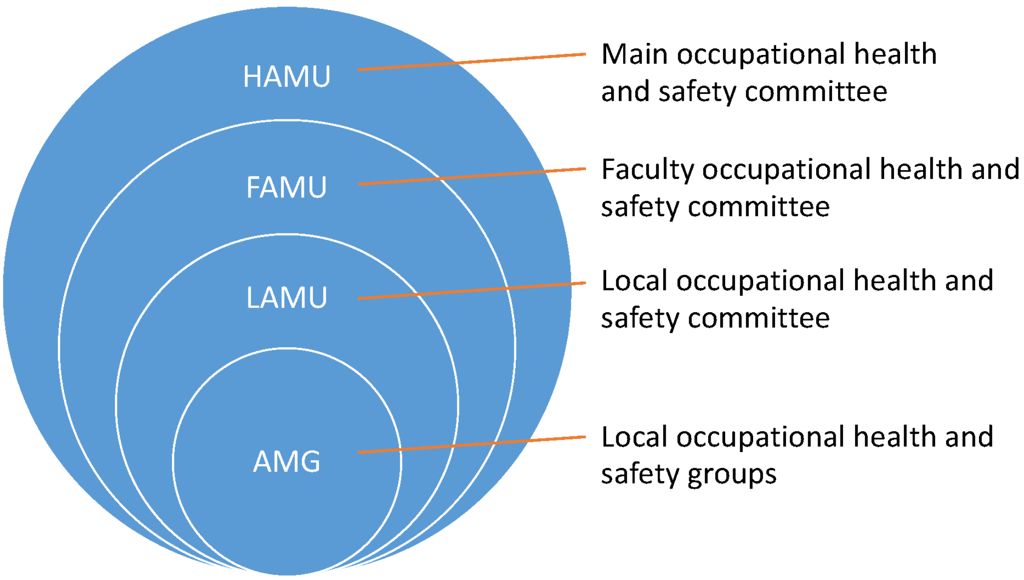
The Faculty Occupational Health and Safety Committees and the Administration Occupational Health and Safety Committee plan and coordinate the faculties' and the administration's occupational health and safety work. The Faculty Occupational Health and Safety Committees (FAMU) set objectives for the efforts and ensure that decisions are implemented in practice throughout the faculties/administration.

The local occupational health and safety committees plan, advise and address specific occupational health and safety issues.

The occupational health and safety groups can receive guidance and support for their work via the local occupational health and safety committee. The committee analyses the occupational health and safety efforts, advises on the resolution of specific occupational health and safety issues and follows up on whether the occupational health and safety activities are effective and preventive.

The occupational health and safety groups provide support for colleagues and students on a day-to-day basis

All departments/schools and administrative divisions at AU have one or more occupational health and safety groups. The occupational health and safety group is responsible for the health and safety framework of the department/school/unit. In order to be successful, an occupational health and safety group requires backing from colleagues and students, and the group must inform of their results and continually address and resolve any occupational health and safety issues that are raised.



OCCUPATIONAL HEALTH AND SAFETY GROUP, ASE

BUILDING 5250, HANGØVEJ 2, 8200 AARHUS N

Occupational health and safety manager/Supervisor representative

Stefan Borre-Gude

Tel.: +45 3094 8642

Email: stbg@ase.au.dk

Occupational health and safety representative

Trine Thomsen

Tel. +45 6095 0785

Email: tt@ase.au.dk

ADDITIONAL MATERIAL

University of Copenhagen has developed a few excellent and easy-to-understand videos on safety.
See: https://absalon.ku.dk/courses/23466/pages/laboratoriesikkerhed-for-studerende-interaktive-videoer

The Chemical Safety Board in the US has developed several informative videos on dust explosions.
See: https://www.csb.gov/recommendations/combustible-dust-investigations/

The Bachelor of Engineering degree programmes in Chemical Engineering, Biotechnology and Food Technology have a Youtube channel to which instructional videos are uploaded.
See: https://www.youtube.com/channel/UCR2fqmbK5WQs2e_16QOXCiw