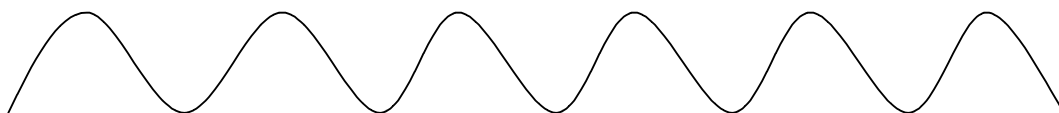


3. QUICK INFORMATION

3.1. The meaning of the alarm signals

Evacuation alarm: LEAVE THE BUILDING

The siren sounds a sine wave:



- The emergency doors are automatically unlocked.
- Instructions are provided via the public address system.

All-clear signal: YOU CAN RETURN TO YOUR WORK STATION

The siren sounds an interrupted signal:



- Instructions are provided via the public address system.

NOTE:

The alarms and the public address system are tested every first Monday of the month.

Make sure you know where:

- the emergency exits are, and how to open them
- the main shut-off valves are for gas, electricity and water
- the safety equipment is, and how to use it

3.2. The alarm number 8050 and its use

In the event of fire or an accident, you should always call the alarm number to alert the Main Control Room (CMK), by dialling **8050** or activating a manual fire alarm.

Please state:

- building number and floor
- hall/room number
- any other relevant information
- if there is an injury as a result of an accident, the nature of the injury.

In the event of an injury, please stay with the victim until a first-aid officer has arrived. Try to reassure the victim.

**Every phone should have
a sticker stating
8050 Alarmnummer**

3.3. Fire emergencies

In the event of fire, you should always call the alarm number by dialling 8050
or activate a manual fire alarm

You are on fire

- If possible, remove the burning lab coat and stand under the fire shower
- Do not run or attempt to beat out the flames, that only fans the fire
- If you are not able to reach the fire shower in time, lie down on the ground and roll over and over, if possible in a fire blanket.

Someone else is on fire

- **Call the alarm number 8050**
- first put the victim under the fire shower, then remove the lab coat, if possible
- If that doesn't work, roll the victim up in a fire blanket
- First wrap the fire blanket round the head and then down to the feet.

Minor fire on a table or in a fume cupboard

- **Call the alarm number 8050**
- Get a fire extinguisher
- Stand at a distance of about 3 meters from the fire
- Aim into the fume cupboard at an angle to extinguish the fire and avoid flames that might shoot out
- Let the fire team bring the fire under control and check the site
- Report the use of the extinguisher to Reception (ext. 4133).

Always inform Reception when safety equipment has been used!!

3.4. Extinguishers and their use

There are three types of small extinguishers in this building:

1. Hoses

These are located in the corridors of the building, marked by a sign.



Instructions on how to use the hoses:

- Turn on the main tap
- Roll out the hose
- Direct it towards the fire
- Open the nozzle.

N.B.

- **Never use water to extinguish fires in live electrical equipment or installations**
- **Beware of violent reactions (sodium)**

2. Portable fire extinguishers (CO₂, powder and foam extinguishers)

Instructions on how to use portable fire extinguishers:

- Stand at a distance of 2.5 to 5 meters from the fire
- Direct the spray from bottom to top
- Extinguish first the outsides then the centre; surround the fire with the flow
- Do not stop spraying a liquid fire until the fire has been completely extinguished.



3. Fire buckets

These can be found in the laboratories.

Instructions on how to use fire buckets (filled with sand):

- Specially for metal fires, for example sodium, potassium, etc.
- Suitable for confining escaping or flowing liquids
- Keep at a safe distance from the fire
- Put sufficient sand on the fire from the outside in, in the same way as extinguishing with a powder extinguisher.

Always inform Reception, ext. 4133, when extinguishers and fire buckets have been used!!

4. Escape Directions

- In an emergency follow the instructions of the safety crew or leave the building as quickly as possible by following the indicated escape routes.



3.5. Accidents

**In the event of an accident or someone becoming ill,
always call First Aid via the alarm number:
ext. 8050**

Always stay with the victim and reassure him/her!

Burn wounds

- Rinse immediately under the tap for at least 20 minutes in gently flowing, preferably lukewarm water

Freeze wounds

- Rinse immediately under the tap for at least 20 minutes in gently flowing, preferably lukewarm water

Chemicals in the eye

- There are eye-wash points in the halls. Follow the instructions when using them:
- Turn the bottle – it will release and open immediately
- Start washing immediately – every second counts
- Break the air valve in the bottom of the bottle. The fluid will flow gently and constantly. Do not squeeze the bottle
- Hold the head back while rinsing. Hold the eyelids open and rinse sideways, starting from the nose

| | | | |
|---------------|---------------------|---------------|-----------------|
| Rinsing time: | <u>Hydrocarbons</u> | <u>Acids</u> | <u>Alkalis</u> |
| | 1 – 3 minutes | 2 – 4 minutes | 10 – 20 minutes |

Chemicals on the skin

- Rinse under the tap for a long time.

Swallowing toxic substances

- Make the victim drink 2 to 4 glasses of water
- Do not induce vomiting, this may damage the oesophagus

Inhalation of toxic substances

- Take the victim outside into the fresh air.

Cuts

- Press arterial wounds closed with thumb or fist
- Only if the wound is dirty: put immediately under gently flowing lukewarm water for at least 20 minutes.

Electric shock

- Be careful when working with electricity: an electric shock may be fatal!!
- If someone is suffering an electric shock, try to switch off the power immediately, for example with the emergency switch or the main switch or by unplugging the equipment
- If you cannot switch the power off, try to remove the victim from the power. Your own safety is most important here! If you have to touch the victim, make sure that you are wearing sufficient insulation in the form of clothes and gloves, or use an insulation mat or other equipment.

3.6. Accidents with hazardous substances

Environmental incidents involving hazardous substances (emission or leakage into the air, ground or sewers) or odour nuisance:

- Limit further spreading of the hazardous substance and/or limit the effects
- Incidents involving emission or leakage into waste water, ground and/or air should be reported on the alarm number, ext. 8050. Leave your name and telephone number
- GMO incidents are regarded as environmental incidents
- Electric shock or electrocution.

Incidents involving carcinogenic, mutagenic and reprotoxic substances, biological agents:

- Make sure that no-one enters the area
- Incidents should always be immediately reported on the alarm number, ext. 8050. Report the location of the accident, the victim's name and telephone number and the type of accident
- Assist the victim as indicated in the first-aid section of the safety leaflet or Chemistry Standards card, or wait for the first-aid officer's help.

Accidents involving radioactivity:

- In the event of radioactive contamination: take the necessary precautions to prevent radioactive contamination from spreading
- Any equipment should be switched off immediately
- Incidents should always be reported immediately to the local radiation expert or his/her deputy
- Also notify the in-house emergency services (BHV) via the alarm number, ext. 8050.

3.7. Power failures

Power failures during working hours (8 a.m. – 6 p.m.)

- Contact Reception, ext. 4133

Urgent power failures outside working hours (6 p.m. – 8 a.m.)

- Contact the Main Control Room (CMK), ext. 5520

3.8. General house rules and behaviour codes

The entire Nijenborgh 4 and Bernoulliborg Complex is subject to a number of rules and regulations.

You must:

- keep all areas as clean as possible and tidy up your workstation
- for the benefit of the environment, separate paper from the rest of your rubbish and conserve power and water
- contact the Main Control Room, ext. 8050, if you discover something amiss, theft, fire or an unsafe situation
- park your bicycle in the bicycle racks
- park your car in the car parks on the north or south sides of the building
- use only taps that are marked 'drinkwater' ('drinking water') when you need clean drinking water
- only use safe and approved electrical appliances, machines or instruments (CE marked and/or NEN3140 approved).

6. CHEMICAL HAZARDS

6.1. General

Chemicals can have one or more hazardous properties. Chemicals can be:

- combustible, spontaneously combustible, explosive
- oxidative
- pungent, corrosive, stupifying
- toxic
- carcinogenic, mutagenic, teratogenic
- irritating, sensitizing
- damaging to the environment

The mixing of various chemicals can also be hazardous.

Please check, before you start work:

- what the properties of the chemicals you will use are
- what reactions may occur
- whether the work should be performed in a hood
- which personal protective devices should possibly be used
- whether the correct protective measures have been taken (e.g. use of collection vessels or shielding)
- which measures, protective or other, must be taken should anything go wrong
- how the remains of the chemicals should be treated and removed after the experiment









6.2. Information about the risks associated with chemicals










There are various sources of information available about the risks associated with chemicals. We strongly recommend that you consult a combination of information sources.

Labels

The label on the packaging gives the hazard class symbols and captions. They are printed on orange rectangles. These symbols are explained in [Table 6.2.1](#).

Table: 6.2.1 Hazard class symbols for hazardous materials and their meaning

| RISK CATEGORY | CODE | SYMBOL | MEANING |
|---------------------|---------|---|--|
| Explosive | E |  | Substances that can explode on contact with a flame or are more sensitive than dinitrobenzene to knocks or friction |
| Oxidizing | O |  | Substances can have a strong exothermic reaction when in contact with other materials, especially flammable substances |
| Extremely flammable | F+ |  | Liquids with a flash point lower than 0° C and a boiling point of 35° C or lower |
| Highly flammable | F |  | <p><u>Substances which:</u></p> <ol style="list-style-type: none"> 1. can increase in temperature and ignite when exposed to normal air temperature, without additional energy 2. in a stable condition, after exposure to a source of ignition, can ignite and continue to burn after removal of the ignition source 3. when liquid have a flash point lower than 21° C 4. when gaseous, at normal pressure, can be flammable air, or: 5. when in contact with water or humid air can develop lightly flammable gases in a hazardous amounts |
| Flammable | No code | No symbol | Substances that when liquid have a flash point of between 21° C and 55° C |
| Very toxic | T+ |  | Substances which, after inhalation or absorption, can have very serious, acute or chronic effects and even result in death |
| Toxic | T |  | Substances which, after inhalation or absorption, can have very serious, acute or chronic effects and even result in death |
| Harmful | Xn |  | Substances which, by inhalation or absorption can have effects of a limited kind |
| Corrosive | C |  | Contact with these substances can damage living tissue |

| | | | |
|------------------------------|-------------|---|---|
| Irritant | Xi |  | Non-corrosive substances which can cause irritation after direct, long-term or continuous contact with the skin or mucous membranes |
| Carcinogenic | Xn, T or T+ |  | Substances which, after inhalation or absorption can cause cancer or increase the chances of developing cancer |
| | |  | |
| Toxic for reproduction | Xn, T or T+ |  | Substances which after inhalation or absorption can damage the reproductive system |
| | |  | |
| Mutagenic | Xn, T or T+ |  | Substances which by inhalation or absorption can cause hereditary genetic damage |
| | |  | |
| Sensitized | Xi or Xn |  | Substances which after inhalation or absorption can cause allergic reactions |
| Hazardous to the environment | |  | Substances which on emission into the environment can damage the environment |

You will also find the R (Risk) and S (Safety) phrases on the label, indicated by codes. The R phrases warn about the hazardous properties of the substance. For example, R37 means 'irritating to respiratory system'. The S phrases give recommendations on how to work safely – for example, S30 reads 'never add water to this product'. The meanings of the R and S phrases are listed in [Appendix 1](#).

Chemiekaarten

The Chemiekaarten (Chemistry Cards) are a collection of about 1300 safety cards for industrial chemicals. They can be consulted either in book form (Library CFM 801 A 37 and practicals rooms) or electronically (Main Menu: Guides and Dictionaries). The electronic version is always the most up to date. Unfortunately, the Chemistry Cards are only available in Dutch.

Chemiekaarten provide an overview of the properties that are relevant for assessing the risks, for example the flash point, vapour pressure and explosion limit, the various ways that the substance can be absorbed into the body (inhalation of gas, vapour or particles or dust, permeation through the skin), and the most important health risks, both the direct consequences (irritating and corrosive effects on eyes, skin and respiratory organs) and the long-term effects of extensive or repeated exposure. The Chemiekaarten also list preventive measures, extinguishers and first aid as well as suggestions about how to handle spilt products and waste.

The Chemiekaarten are primarily intended for the use of chemicals by companies and in industrial processes, thus in greater amounts and usually under different circumstances than in laboratories. This also means that the number of substances for which cards are available is limited. Nevertheless, Chemiekaarten are a valuable and convenient source of information.

Material Safety Data Sheets (MSDS)

The Material Safety Data Sheets (MSDS) are a collection of safety sheets that are provided jointly by the major chemical suppliers. The suppliers are legally obliged to provide certain information about the risks to safety, health and the environment of the product in question on delivery. This information is also available electronically, just like the Chemiekaarten, under 'Guides and Dictionaries' in the Main Menu. The information is more extensive than that in the Chemiekaarten and is also in English. The MSDS contain all the chemicals in the catalogues of the suppliers; the number of substances is thus significantly more extensive than in the Chemiekaarten. "Exotic" chemicals also appear in them.

Books

Section 801-A in the CFM library contains a number of books and reference works in the field of laboratory safety. They include:

- Bretherick: *Handbook of Reactive Chemical Hazards* (801 A 26), a standard work about dangerous combinations of substances.
- Zwaard: *Gevaren in het laboratorium* (801 A 42), an accessible textbook about the most important risks.
- Udo and Leene: *Het chemisch practicum* (300 S 3), an overview of materials and techniques in chemistry practicals paying particular attention to safety rules and aspects.
- Verberk and Zielhuis: *Giftige stoffen uit het beroep* (925 B 18), a concise and readable overview of toxicology at work and the risks of industrial chemicals.
- Hommel: *Handbuch der Gefährlichen Güter* (801 A5, can also be found in the corridor of 5116 on the ground floor.

6.3. Assessing the data about chemical hazards

The physical and toxicological data in the Chemiekaarten and the MSDS allow a general assessment of the risks of a substance to be made. Please pay attention to the particular conditions for the lab.

Risks of fire and explosion

A major criterion for measuring the fire hazard level of a liquid is the *flash point*, that is, the temperature at which the vapour concentration above the liquid is just high enough to form a combustible (explosive) mixture that can be ignited by an igniter. Remember that igniters are not only open flames, but also hot surfaces, sparks from switches or thermostats and static electricity.

Liquids with a flash point of less than 0° C are called 'extremely flammable' (code F+), liquids with a flash point lower than 21° C are called 'highly flammable' (code F). Both categories have a pictogram with a flame. Liquids with a flash point between 21° C and 55° C are called 'flammable'. When making the assessment, pay particular attention to situations with high temperatures during the experiment. Be extremely careful when clearing up chemical waste; internal heating can occur in damp paper (tissue, filter) or absorbent materials. When the heat cannot escape sufficiently from the material it will start a chain reaction, which may eventually lead to fire.

A second measure of the fire hazard is the *auto-ignition temperature*, the lowest temperature at which a liquid can ignite without an igniter. The Chemiekaarten/MSDS list the auto-ignition temperature for the undiluted liquid. Auto-ignition can actually occur in practice at lower temperatures in the event of pollution with catalyser residues, degradation products or other pollutants. The auto-ignition temperature of most liquids (solvents) is far above room temperature but well within the temperature range of cookers and other heat sources, which are thus a risk. Examples of solvents with a low auto-ignition temperature (100° C – 200° C) include diethylether, carbon disulphide, and dioxane. Within the temperature range between the flash point and the auto-ignition temperature, an explosive mixture of vapour and air can build up above a liquid. The concentration range within which the mixture is explosive is indicated by the *explosion boundaries*, expressed in volume percentages in the air. Explosive combustion can occur within this range.

An unusual type of explosive combustion is dust explosion, which can occur within finely distributed solid material. *Unstable compounds* must be particularly carefully monitored with regard to the explosion risk because they can violently or even explosively decompose or polymerise, even without the addition of energy, without having to react with other substances. The Chemiekaarten list warnings about instability and the chances of explosive decomposition or polymerization under the section 'important information'. 'Instable' groups include alkynes, azo and diazo compounds, nitro and nitroso compounds, 1,2 epoxides, peroxides and N or O halogen compounds. The instability of substances is increased by the presence of ether, nitrile or oxime groups. Ethers are particularly notorious because of the formation of explosive peroxides when stored for a long time – a stabilizer is often added. With instable compounds, particular attention must be paid to storage, the maximum permitted amounts in storage and the sensitivity to shocks and knocks.

Exposure risk

The risk of internal poisoning is determined by the toxicity of a substance in combination with the chance of internal exposure. If a toxic substance must be used, then it is essential to assess and where possible reduce the chance of exposure. Substances are absorbed by the body by inhalation, through the skin or by mouth. The chances of exposure are usually determined by the levels of hygiene during and after the work. This is why it is absolutely forbidden to smoke, eat or drink in the laboratory; it is essential to wash your hands before a break and after work. Pipetting toxic liquids by mouth is extremely foolish and completely unnecessary.

Absorption through the skin usually occurs after direct contact with a liquid, vapour or solution. Absorption of vapours through the skin does not usually result in significant exposure, although some substances in vapour form can pass through the intact skin (e.g. phenol and aniline). Lipophylic substances can pass through the epidermis easily, hydrophylic substances less easily. The section *water solubility* in the Chemiekaarten gives an indication of the lipophylic properties. 'Small' lipophylic molecules with a polar group (e.g. phenol) are the most likely to be absorbed through the skin; they are then transported quickly through the blood vessels. The section 'important information' on the Chemiekaarten lists whether a substance can be absorbed by the skin. Substances which when absorbed by the skin can contribute significantly to the overall exposure are given the *designation 'H'* next to the MAC value (listed in the same section). The wearing of gloves when working with these substances is highly recommended. This is particularly applicable if the skin is damaged or dry; absorption can then be significantly higher.

Inhalation is the most important means of exposure to volatile substances and finely distributed solids. In particular, when working with organic solvents outside the hood, the concentration in the air you breathe in can rise to several hundred ppm, especially while decanting liquids. When working in the hood, the concentration in the respiratory zone is kept to 1 – 5 ppm. The evaporation depends on the vapour pressure above the liquid (usually listed for 20° C). In a ventilated laboratory, the

concentration above the workbench during decanting is roughly 1 ppm/mbar, expressed with regard to the vapour pressure of the liquid. In a good, often used, hood the concentration is a factor 1000 lower, in a bad, rarely used one a factor 10 lower. The *relative vapour density* (as compared to air) is less important for determining the exposure under normal circumstances in the laboratory. ‘Heavy vapours’, such as ether (r.d. 2.6), remain in relatively high concentrations above the workbench after decanting; however, normal ventilation will ensure expansion to the respiration zone. It is important to assess the vapour density to determine the fire hazard; the ‘creeping behaviour’ of ether is infamous and can lead, for example, to accumulation and unexpected combustion of the vapour in gullies.

Incidentally, smell is not a good means of measuring exposure to volatile substances. The sensitivity of the nose in registering and recognizing smells can vary significantly from person to person. The olfactory threshold is set with the help of an olfactory panel. The lowest concentration that half of the panel can detect or recognize or experience as irritating becomes the olfactory threshold for detection or hindrance, respectively. The average detection threshold for many solvents is at a much lower concentration than the hygienic norm for exposure (MAC value) and thus is sufficient to warn the ‘average’ nose. However, this does not apply to chloroform or hexane, for example; detection occurs far above the MAC value. The concentrations that are recognized by 100% of the panel are more often above or near the MAC value.

Toxicity

The health risks can be divided into those that are a direct result of contact of a substance with skin, eyes or respiratory organs (contact effect) and systemic effect, the effect they have inside the body. The latter are either acute – occurring in the short term and usually the result of brief exposure – or chronic – long term, usually the result of sustained or repeated exposure. The symptoms of contact effects (for example, irritation, burns, sore throat) are explained in the section ‘symptoms’ of the Chemiekaarten; systemic effects are listed under ‘important information’. The *LD₅₀* and *LC₅₀* values (lethal dose, lethal concentration, respectively), listed in the MSDS, are an indication of the acute lethal effect for a certain animal species. These values have limited significance in the laboratory (a situation with daily recurring exposure). The relative size of the values helps to compare the substances on the basis of acute toxicity (Table 6.3.3.A).

Table 6.3.3.A – Division into acute danger categories

| Type | WMS code | LD ₅₀ (rat, oral) mg/kg bw | LD ₅₀ (dermal) mg/kg bw | LC ₅₀ (rat, inhalatory) g/m ³ , 4 hour |
|-------------------------|----------|---|--|--|
| Low toxicity | -- | > 2000 | > 2000 | > 20 |
| Dangerous | Xn | 200 – 2000 | 400 – 2000 | 2 – 20 |
| Toxic | T | 25 – 200 | 50 – 400 | 0.5 – 2 |
| Very toxic | T+ | < 25 | < 50 | < 0.5 |
| Reference: Zwaard, 1996 | | | | |

The MAC value (Maximum Allowed Concentration) or TLV (Threshold Limit Value) is a way of measuring the possible long-term health consequences; it is the maximum accepted (8-hour time weighted average) concentration in the air at the workstation. The premise for determining a MAC value is that long-term exposure, up to and including the entire working life, must not damage health; however, economic criteria also play a role. Table 6.3.3.B gives a simple rule of thumb for interpreting MAC values.

Table 6.3.3.B – Interpreting MAC values

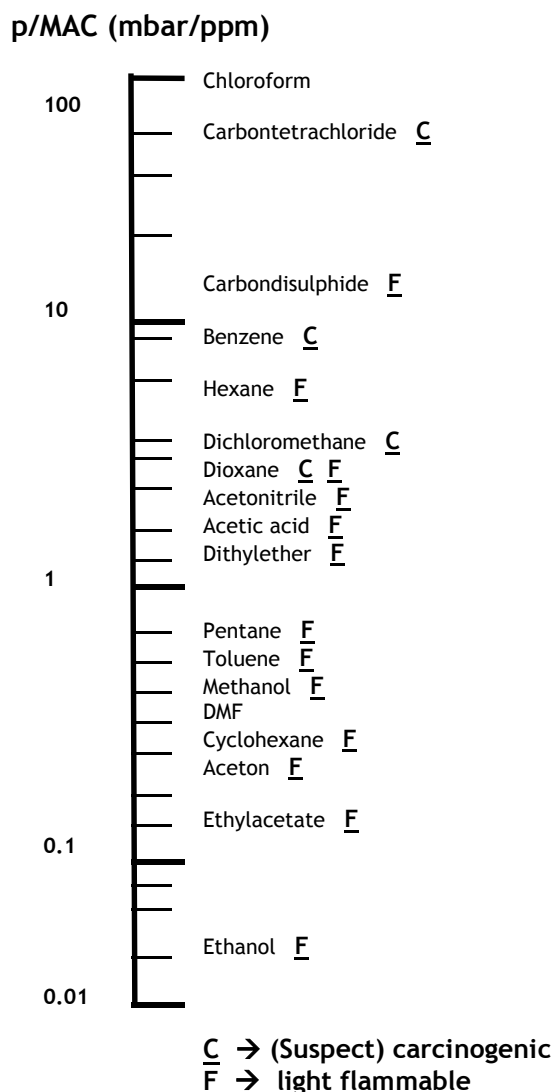
| MAC VALUE (PPM) | TOXICITY | MEASURES |
|-----------------|-----------|-------------------------------|
| > 50 | Low | No specific measures |
| 10 – 500 | Medium | Experiment in hood |
| 0.1 – 10 | High | Weigh off and wash up in hood |
| < 0.1 | Very high | Closed system, Glove box |

With designation H (substantial absorption by the skin), the substance should be rated one level higher. Some substances also have a MAC value for short exposure, the MAC TCG-15 min. (time weighted average concentration for 15 minutes). This is to protect against the acute effects of short exposure to high concentrations. An average short exposure time of 3 x MAC TGG 8h is assumed if none is listed. The addition of a C to the MAC value (MAC-C: ceiling) means that exceeding this concentration should be avoided at all costs. This designation is absolutely not a time weighted average concentration but an instantaneous concentration; here, too the aim is to protect against acute effects.

Relative risks of inhalation

By combining the vapour pressure of a volatile substance with the MAC value, it is possible to compare the risks of, for example, organic solvents with each other and to choose the least dangerous of the various options when preparing an experiment. The MAC value gives an indication of the chances of damaging your health by inhaling the vapour. The vapour pressure gives an indication of how easily that concentration can be reached. The quotient (p/MAC) is a way of measuring the inhalation risk; classifying the values results in a ‘risk barometer’ for the various solvents (Figure 7.3.4). Solvents that score highly include chloroform and carbon tetrachloride (possible substitutes: dichloromethane or ethyl acetate), carbon disulphide, benzene (carcinogenic, possible substitute: toluene) and hexane (specifically toxic for the nervous system, possible substitutes: pentane or heptane).

Figure 6.3.4 – Risk barometer for various solvents:



6.4. Strategy

Preventive measures:

- check beforehand, in consultation with the head of your work group, whether the substances to be worked with constitute a health hazard.
- substances with an unknown toxicity must be assumed to be toxic.
- keep your immediate environment informed.
- **if you are working with very toxic substances – even during the day – you must report this to the reception desk using a permission form. This form must be handed in at least 24 hours before the experiment is begun. You can get these forms at the reception desk.**
- check whether any special legal regulations apply to the use and/or transport of the substances. This will apply, for example, to working with carcinogenic substances and reprotoxic substances; you must ensure that registration and a careful (written) assessment of the choice of substance and the way it will be used has taken place. These substances will be discussed in the next sections. Special substance-specific regulations are listed in Table 6.4.A.

Table 6.4.A – Substance-specific regulations

| SUBSTANCES | ARBO DECISION | REGULATION |
|---|---------------|--|
| Vinyl chloride | 4.25 – 4.35 | More specific risk inventory and evaluation and limiting values. |
| Benzene carbon tetrachloride pentachloroethane 1,1,2,2-tetrachloroethane | 4.36 | Use as solvent/cleanser or thinner for products with > 1 vol% forbidden, unless in a closed system or in a manner that provides the same protection. |
| Asbestos | 4.37 – 4.57 | Handling, processing or storing is forbidden. In exceptional circumstances, there are conditions for working with asbestos and products containing asbestos. |
| 1,3-propanesultone | 4.58 | Production, storage and use is forbidden. |
| 2-naphtylamine (+ salts) 4-aminobiphenyl (+ salts) benzidine (+ salts) 4-nitrobiphenyl | 4.59 | Production, storage and use is forbidden. Dispensation from the Labour Inspectorate is possible for research purposes. Use in concentrations < 0.1 weight% is permitted. |
| Lead and inorganic lead compounds | 4.63 – 4.81 | More specific risk inventory and evaluation conditions; various action levels and limiting values. |

Once you have gained an impression of the risks of a proposed experiment or of the possible exposure to the chemicals used, the next step is to assess the possible and desirable measures that need to be taken. This stage needs to be approached systematically ([Table 6.4.B](#)).

Table 6.4.B – Basic strategy for controlling risk

- prevention at source
- shielding the source
- adapting the environment
- protecting people
- personal protection

The most effective measure is eliminating the source of the risk. Where possible, choosing less damaging chemicals is to be preferred. Solvents, in particular, often have a choice of option. With regard to the synthesis route, you can also consider whether toxic or otherwise hazardous intermediaries can be avoided. Adaptations to the experiment setup or to the equipment also fall under this consideration.

If it is not possible to tackle the source, then the next possibility is shielding the source. Depending on the type of risk source, this could mean the use of hoods, glove boxes or explosion screens. Adapting the environment, the third step, concerns, among other things, choosing special working areas, adapting the ventilation in the room or the local extractor fans for vapours above or near an experiment. The fourth step, protecting people, can be achieved by working from control rooms (in an industrial environment) or by limiting access to certain areas. The final step, and usually the least effective, is taking special personal protective measures. Some of these are standard, for example the lab coat and safety goggles, but other means of protection, such as respiratory protection and special gloves, can often be a hindrance while working so that wearing them is limited to exceptional situations.

6.5. Working with hazardous substances

Labelling of chemicals and preparations

All bottles, pots, ampoules etc. used to store chemicals must be clearly and legibly labelled. This also applies to preparations you have made yourself.

The label must state the following data at least:

- name and formula of the substance or substances
- CAS number(s)
- the relevant hazard symbols for the contents
- name of the owner
- date

Stickers for the hazard symbols can be obtained from the Chemicals Store.

Storage of chemicals and preparations in the laboratories

It is not permitted to have more chemicals in the labs than are needed to work with. You must dispose of superfluous chemicals and regularly reorganize the inventory. If a surplus of chemicals is discovered during governmental checks, then sanctions can be imposed.

The storage of chemicals in the laboratories is subject to the following conditions:

- only the amount of flammable and other chemicals needed for a proper performance of the activities may be present in the laboratory.
- chemicals stock building is not permitted in the laboratories.
- if you have more than 3 litres of a flammable solvent in stock, we advise use of a safety jug.
- flammable chemicals (with a flash point lower than 21°C) must be stored in one of the fireproof cupboards. Please use sealed flasks and jars for this.
- corrosive substances may not be stored in the fireproof cupboards. They could damage the cupboards and their safety features.
- no flammable or other chemicals may be stored in the hoods.
- acids and bases may be stored in the areas underneath the hoods on condition that the space is ventilated and the bottles are placed in drip trays (acids and bases separately)
- bottles with liquid and/or hazardous chemicals must be placed in drip trays.
- chemicals that react (violently) with each other may not be placed in the same drip tray.
- bottles and glassware used to store volatile substances must be kept closed as much as possible.

Prevention of exposure to toxic substances:

- avoid the dissemination of toxic substances as much as possible by working in a clearly defined area such as a hood or a basin with raised borders
- as far as possible, keep material that has been contaminated with toxic substances (glassware, equipment, etc.) separated from clean material
- use clear labelling so that fellow workers in the immediate vicinity can clearly see what the contents of the various glassware are
- prevent contamination of things that are not directly involved in the experiment (log book, regulations, books, jackets, etc.) by having them in the laboratory as little as possible
- as far as possible, prevent the creation of aerosols. Use pipettes and needles in the correct manner
- never pipette orally
- when using volatile substances, the glassware and pottery must be kept closed as much as possible
- clean up any spillages immediately and carefully. Prevent evaporation from residues on tissues, etc.
- ensure that the glassware is promptly and carefully cleaned. If necessary, perform the cleaning in the hood
- when transporting glass flasks, use buckets or baskets

Fire prevention

- only heat flammable substances using a water bath, insulating sheath or special equipment.
- be extremely careful with oil baths. It is strongly recommended that you use a thermostat.
- prevent dissemination of flammable vapours – limit the amounts you use, work in the hood. Clean up spillages immediately. Prevent evaporation from residues on tissues, etc.
- prevent flask breakage by using unbreakable packaging as much as possible (safety cans, etc.).
- only use approved, and if necessary spark-free electrical equipment.
- prevent sparkover as a result of static electricity by using an earth grounding when transferring flammable volatile substances by pumping and draining.

Hazardous combinations of substances

Hazardous reactions can occur when combining various substances. Oxidizing substances in particular are extremely prone to exothermic reactions and fire hazard situations, especially in combination with the use of flammable organic solvents. It is strongly recommended that you thoroughly assess any possible hazardous reactions when designing the experiment. The handbook by Bretherick, *Handbook of Reactive Chemical Hazards* (see Chapter 7.2: Books), is an excellent source of advice. [Appendix 2](#) lists a number of combinations that can result in hazardous reactions. It goes without saying that this table can only provide a rough indication; the reactivity depends heavily on factors such as temperature and pressure.

It is thus essential to assess the possible reactive combinations when choosing how to deal with leftover chemicals and for the choice of waste bin. A relatively high number of laboratory accidents are caused by careless handling of leftovers and subsequent uncontrolled reactions in a waste bin – just imagine the combination of cyanide with acid or perchloric acid with organic substances. Always check carefully whether a waste product needs special handling.

Disposal of chemicals

It is forbidden by law to dispose of chemicals down the sink; laboratory waste is considered to be 'hazardous waste'. In practice, there are a few exceptions to this. The way that chemical waste should be disposed of and the rules for discharges are set out in the 'Environmental Regulations' chapter.

6.6. Working with carcinogenic substances

Working with carcinogenic or suspected carcinogenic substances requires special measures. Some of these have legal requirements (AI-blad 6, Werken met kankerverwekkende stoffen en processen) and these can be consulted at the office of the Health, Safety and Environment coordinator, C.J. Groen, room number 5161-0311, ext. 4618, e-mail: c.j.groen@rug.nl.

Recognition: which substances are carcinogenic?

Only epidemiological research on humans can prove unequivocally that a compound is carcinogenic for humans. Only a few chemicals have had a sufficiently large number of people exposed to them to demonstrate the carcinogenic properties of a compound. This is why long-term experiments with laboratory animals are an acceptable alternative.

There are various lists of carcinogenic substances, based on different kinds of criteria. In Dutch legislation, the list in the Working Conditions Decree is the approved one. This is regularly updated and can be found on <http://arbo.nl/topics/subject/bedrijfsgezondheidszorg/beroepsziekten1.stm> under 'toxic substances'. Other relevant lists of carcinogenic substances include those in the Chemical Substances Act (these substances are marked by the Risk Code R45 on the label or safety leaflet of the substance) and those of the International Agency for Research on Cancer (IARC).

It would be going too far to include the complete 'List of carcinogenic substances' here. We shall confine ourselves to a number of compounds that are relevant to the chemical industry and laboratories.

Table 6.6.1.A: Some 'recognized' carcinogens

| Name: | CAS number: |
|-------------------------------|-------------|
| Acrylamide | 79-06-1 |
| Acrylonitrile | 107-13-1 |
| Arsenic and arsenic oxides | |
| Benzene | 71-43-2 |
| Benzidine | 92-87-5 |
| Beryllium and beryllium salts | |
| Cadmium compounds | |
| Chromium VI compounds (some) | |
| 1,2-dibromoethane | 106-93-4 |
| 1,2-dichloroethane | 107-06-2 |
| Diethyl sulphate | 64-67-5 |
| Dimethyl sulphate | |
| Epichlorohydrin | 106-89-8 |
| Ethylene oxide | 75-21-8 |
| Hexamethylphosphoramide | 680-31-9 |
| Hydrazine | 302-01-2 |
| Potassium carbonate | 7758-01-2 |
| Nickel compounds | |
| Propylene oxide | 75-56-9 |
| Styrene oxide | 96-09-3 |

Suspected carcinogens

For some compounds there are indications of carcinogenic properties but the evidential value is limited. As a precaution, it is a good idea to be particularly careful when using or handling these compounds. Substances used in chemical laboratories that are suspected of being carcinogenic include:

Table 6.6.1.B: Some 'suspected' carcinogens

| Name: | CAS number: |
|-------------------------|--------------------|
| Acetic aldehyde | 75-07-0 |
| Acetamide | |
| Chloroform | 67-66-3 |
| Dichloromethane | 75-09-2 |
| 1,4-Dioxane | 123-91-1 |
| Formaldehyde | 50-00-0 |
| Lead and lead compounds | |
| Methyl iodide | 74-88-4 |
| Styrene | 100-42-5 |
| Tetrachloromethane | 56-23-5 |

Suspect structures

It goes without saying that the carcinogenic assessments confine themselves to compounds that are in general use in industry, health or laboratories. 'Exotic' compounds, for example your own preparations, are not covered by these assessments. In such cases, structural characteristics can give an idea of possible carcinogenic properties. The following classes of compounds are suspect:

Table 6.6.1.C.: Structural characteristics for possible carcinogenic properties

| |
|-------------------------------------|
| Alkylating substances |
| Polycyclic aromatic hydrocarbons |
| N-nitroso compounds |
| Aromatic amines and nitro compounds |
| Aliphatic hydrazines |
| Azo and azoxy compounds |

Rules for working with carcinogenic substances

The legal procedure for working with carcinogenic substances is designed to reduce exposure to these substances to a minimum. Their use and the users are carefully registered. The registration process also includes an assessment of preventive measures, with the possibilities of replacement at the top of the list. The registration form is available from the Chemicals Store. It must be filled in completely, signed by the head of the work group and handed in to the Store. Only then can the Store supply you with the compound you require. The registration process includes:

- the identity of the compound
- the hazards of the compound (for example in R phrases)
- the aim and motivation of the use. It is essential to provide a well-founded assessment of the possibilities of replacing the carcinogenic compound by one that is less hazardous. You must use a substitute compound if possible.
- where the use will take place and the number of workers who will be exposed
- the type of exposure and the preventive measures to be taken.

The aim is to provide the Chemical Laboratories with an automated registration process for individual members of staff who either work with or have worked with carcinogenic substances; this is also with an eye to medical checks.

Tips for limiting exposure to carcinogens:

- prevent the dissemination of carcinogenic substances as much as possible by working in a clearly defined area such as a hood or a basin with raised borders.
- as far as possible, keep material that has been contaminated with carcinogenic substances (glassware, equipment, etc.) separated from clean material.
- use clear labelling so that fellow workers in the immediate vicinity can clearly see what the contents of the various glassware are.
- prevent contamination of things that are not directly involved in the experiment (log book, regulations, books, jackets, etc.) by having them in the laboratory as little as possible.
- as far as possible, prevent the creation of aerosols. Use pipettes and needles in the correct manner.
- never pipette orally.
- when using volatile substances, the glassware and pottery must be kept closed as much as possible.
- clean up any spillages immediately and carefully. Prevent evaporation from residues on tissues, etc.
- ensure that glassware is promptly and carefully cleaned. If necessary, perform the cleaning in the hood.
- check at the end of the experiment whether the work area and the material used have been contaminated.

6.7. Working with reprotoxic and mutagenic substances

The compulsory registration of carcinogenic substances also applies to a number of ‘recognized’ reprotoxic and mutagenic substances. Reprotoxic substances are harmful to the reproductive system. They increase the chances of infertility or of offspring with abnormalities. Such effects can occur with both men and women who have come into contact with these substances. There are additional rules for working with hazardous substances during pregnancy.

Just as with carcinogenic substances, the number of ‘recognized’ reprotoxic and mutagenic substances is limited by the lack of epidemiological data. In addition, this field of research is still relatively young when compared with that of the carcinogens. The law regulates non-limitative lists of reprotoxic and mutagenic substances or substance groups. They are regularly updated and can also be found on <http://arbo.nl/topics/subject/bedrijfsgezondheidszorg/beroepsziekten1.stm> under ‘toxic substances’. They are distinguished by the Risk phrases R 60 and/or R 61 and R 46 respectively on their labels and safety leaflets. When working in chemistry laboratories, the following are particularly relevant:

Table 6.7: Some ‘recognized’ reprotoxic and mutagenic substances

| Name | CAS number |
|---------------------------|-------------------|
| Reprotoxic | |
| • Dimethyl formamide | 68-12-2 |
| • 2-ethoxy ethanol | 110-80-5 |
| • 2-ethoxy ethyl acetate | 111-15-9 |
| • Lead compounds | |
| • 2-Methoxy ethanol | 109-86-4 |
| • 2-Methoxy ethyl acetate | 110-49-6 |
| Mutagenic | |
| • Acrylamide | 79-06-1 |
| • Diethyl sulphate | 64-67-5 |
| • Ethylene oxide | 75-21-8 |

11. ENVIRONMENTAL REGULATIONS

11.1. Waste products

The first step in a good and efficient separation and removal of waste products is to decide whether the waste is hazardous or not. The starting point for this division is the legal regulations in the Decree on Determining Hazardous Waste Products (EURAL). The industrial and hazardous waste produced by the University of Groningen laboratories is divided up into sub-streams.

Office waste is also collected in separate streams. We differentiate between paper waste (suitable for recycling), solid hazardous waste (to be collected in the blue Environment Box in the secretariats), and other office waste. Solid hazardous office waste includes floppies, marker pens, batteries, correction fluid, etc. Empty toner cartridges from printers are collected by the Store.

There are separate procedures for radioactive waste. The only body in the Netherlands that is permitted to transport this type of waste is the Central Organization for Radioactive Waste (COVRA). It imposes special conditions on the collection, packaging and administration of the waste. For more information, please consult the radiation expert [**F.van.der.Horst@rug.nl**](mailto:F.van.der.Horst@rug.nl) (ext. 4831 or abbreviated 95380).

Hazardous Waste

According to the EURAL, waste from laboratory work is in principle always hazardous waste, regardless of the composition or the concentration of hazardous substances. There are a few exceptions, see 'Office Waste'. The collection, transportation and processing of hazardous waste is subject to legal regulations. Companies who collect and/or process it must have a permit from the Ministry of Housing, Spatial Planning and the Environment (VROM) and conform to special conditions. For this reason, the University of Groningen has outsourced the collection of hazardous waste to a specialized company (ATF Drachten), who collects the waste from the university buildings. However, the University of Groningen remains responsible for correct collection, separation and packaging within the buildings.

Hazardous waste can be roughly divided into three sub-streams – liquid hazardous waste, solid hazardous waste, and biological and microbiological waste (before autoclaving). These sub-streams can also be subdivided.

An overview of the annual production of hazardous waste in the complex can be found in the Purchasing and Removal Logbook, available from [**c.m.ree@rug.nl**](mailto:c.m.ree@rug.nl), ext. 4132.

Liquid hazardous waste

The EURAL divides liquid hazardous waste into six categories (Table 11.1). These categories are separately collected in the laboratories in 10 litre jerry cans clearly marked with the correct information and danger labels. Empty, labelled jerry cans are available from Goods Reception (5161.0306), [**r.a.k.verstrate@rug.nl**](mailto:r.a.k.verstrate@rug.nl).

Liquid hazardous waste is collected twice a month, usually on the second and fourth Tuesday of the month. You may then present the waste between 9 a.m. and 12 noon at the Waste Depot (5116.0002, [**b.t.f.bosma@rug.nl**](mailto:b.t.f.bosma@rug.nl)).

Once it has been processed administratively, a licensed waste transporter will collect the waste from there within 24 hours.

The jerry cans must be clearly labelled when delivered to the Waste Depot. The labels must state at least the category of the waste, the qualitative composition, and the source (work group/practical and the head of the work group). You can find more information about collection dates and the conditions under which you should present the waste from the Chemistry Store, ext. 4103, [**b.t.f.bosma@rug.nl**](mailto:b.t.f.bosma@rug.nl), or from the 'chemical waste' coordinators for the research groups and practicals.

Table 11.1 – Categories of liquid hazardous waste

| CATEGORY | DESCRIPTION (NON-LIMITATIVE) |
|---|--|
| Category I Anorganic acidic and neutral substances in solution (pH 0-7) | Solutions of HCl, H ₂ SO ₄ , HNO ₃ , H ₃ PO ₄ , acidic solutions of heavy metals, salts and complexes, battery acid, fixer, mordant and etching solution, Kjeldahl remains |
| Category II Anorganic alkaline substances in solution (pH 8-14) | Solutions of NaOH, KOH, NH ₄ OH, basic solutions of heavy metals and metalloids, salts and complexes, cyanides, sodium hypochlorite solution, developer, Nessler remains |
| Category III Halogen-poor organic substances | Acetone, ether, alcohols, hexane, toluene, petrol, turpentine, waste oil, coolant, solutions of organic acids |
| Category IV Halogen-rich organic substances | Dichloromethane, chloroform, tetra, trichloroethane, freons |
| Category V Unusual waste products | Deposits and solid salts from heavy metals, organometallic compounds |
| Category VI Solutions with extraordinary risks | Extremely flammable and self-igniting substances, explosive substances, strongly oxidizing substances (perchlorates, H ₂ O ₂ , peracetic acid) Extremely corrosive substances (POCl ₃ , SOCl ₂), extremely toxic substances, carcinogenic substances, unknown substances |

There are facilities for the temporary storage of the jerry cans in use in the laboratories. A hood is usually reserved for this, but it can also be a separate facility with positioned ventilation. Store the jerry cans in the correct place and seal them after use as well as possible. Open jerry cans, with or without funnel, can cause significant dispersion of vapours, particularly when volatile substances are stored in them (categories III and IV). Storage under ventilation is thus essential for guaranteeing good working conditions; a cap also prevents unnecessary dispersal into the environment. A sealable funnel is also worth considering.

It is extremely important that you check carefully to which category (and thus which jerry can) your waste belongs. Don't forget that a waste jerry can is in fact an undefined mixture and that addition of, for example, an oxidator or another reactive substance could lead to an uncontrolled reaction that could be accompanied by heat production and spattering. This is one of the most common 'chemical' accidents in laboratories. It's very easy to make a mistake.

The Chemiekaarten list the category a substance belongs to in the section 'Labelling'. With mixtures, make your choice based on the substance with the highest numbered category. A mixture of chloroform and hexane, for example, belongs in category IV. If in doubt, consult the list of 'Hazardous mixtures' (appendix 2) or a handbook (Bretherick).

It is not advisable to work up or process liquid waste in the laboratory yourself. The mixture is usually too complex to regain raw materials of sufficient quality and the process itself can lead to hazardous situations or the production of waste. An exception can be made for the destruction of

some reactive waste streams from category VI (extraordinary risk), for example cyanide waste. Many toxic cyanides are easily decomposable (complexes of cyanide with iron or nickel are difficult to decompose, but are not very toxic either). The remains of a solution of cyanide must first be made extremely basic (pH > 10) and can then be oxidized with an excess of sodium hypochlorite solution or hydrogen peroxide (24 hours in the hood). Any precipitation can be filtered off and disposed of in category V, the oxidized remaining solution goes into category II.

Solid hazardous waste

Solid hazardous waste can be divided into the following substreams:

- laboratory chemicals in solid form
- other solid hazardous waste, including contaminated glass waste.

The procedure for the collection and removal of solid hazardous waste is the same as that for liquid hazardous waste (see previous section). The waste streams are collected separately and removed by a licensed waste transport. More information is available from the Chemical Store, ext. 4103, b.t.f.bosma@rug.nl.

Laboratory chemicals in solid form

Solid hazardous waste, just like liquid hazardous waste, is divided into six categories in accordance with the EURAL (Table 11.1). Relevant waste streams for the Chemistry-Physics complex include:

- remains of metals and metal salts
- emulsions
- non-cured remains of polymers
- chromatographic waste
- autoclave waste (lactose/glycose)
- silicon waste
- starch waste
- mercury remains from thermometers and pressure gauges.

These waste streams are collected separately. The remains of mercury from thermometers and pressure gauges is recycled internally as much as possible. The government has imposed strict regulations on the use of 'new' mercury for environmental reasons (Chemical Substances Act 1998). In time, this will lead to the replacement of equipment containing mercury.

The EURAL makes exceptions for certain types of waste. They are a number of 'inert' products such as ceramic and enamelled products and a number of products of biological origin such as plant and animal carbohydrates, proteins, fats and fatty acids. These are not considered to be hazardous waste substances as long as they consist exclusively of the components listed above and may be disposed of with the industrial waste. The department of Environmental Protection in Central Services is responsible for the separation and removal of industrial waste.

Other hazardous solid waste

In the Chemistry-Physics complex, 'other hazardous solid waste' includes:

- asbestos
- batteries
- packaging (steel/tin and plastic)
- glassware (contaminated)
- glassware (clean)
- office waste ('environment box')
- needles/blades
- cleaning cloths, etc.

- fluorescent lamps
- scintillation vials (counting vials)

These waste streams are also collected separately and removed as hazardous waste.

Please pay particular attention to the collection of glass waste. Rolling containers are available to this end. There are separate liquid-proof containers for contaminated and clean glassware. Only clean glass should be put in the 'clean' containers; do not put glassware that is contaminated with chemicals into them, and that includes stoppers and the like. Remove the washers and caps from clean bottles and pots and either remove or cover the labels. Ensure that the bottles and laboratory glassware to be removed are always as clean and empty as possible. A steaming glass container is unpleasant for everyone. Dispose of the chemical remains as liquid hazardous waste. Seal bottles of smelly liquids with the cap.

Scintillation vials and phenol cups (biochemistry) are collected separately and do not need to be as empty as contaminated glass or plastic. However, it is more expensive to process that waste.

The wheeled containers are collected on the days mentioned above (see 'liquid hazardous waste'); they must be parked in their allocated places at the ends of the wings of the building and in the stairwell. For more information contact the Chemistry Store, ext. 4103, b.t.f.bosma@rug.nl.

The Chemistry-Physics complex intends to introduce an automated system for managing chemicals. This is the result of provisions in the Working Conditions Act regarding the localization and stock management of toxic substances. The system will 'log out' empty chemicals packaging from the Store using the barcodes. You will be informed in good time of the change and be provided with instructions.

Contaminated plastic (e.g. capsules, eppendorf cups, gloves), filters, tissues etc. should be put into the closed container in the laboratory. Please ensure that the disposables are as empty as possible; dispose of the chemical remains as liquid hazardous waste.

Needles, including injection needles, must always be collected separately in the injection needle box and disposed of as hazardous waste. It is forbidden to put injection needles into industrial waste – this is understandable, the waste processor cannot tell whether a needle has come from a laboratory, a hospital or a junkie.

Microbiological and biological waste

Microbiological and biological waste contains biological agents and/or has come into contact with biological agents. Biological agents include: cell cultures, whether or not genetically modified, human endoparasites and microorganisms. Microbiological and biological waste can be divided into hazardous (chemically contaminated) and non-hazardous (non-chemically contaminated) waste. The diagram below functions as a guiding principle when dividing microbiological and biological waste for disposal.