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G E N E R A L

1. INTRODUCTION

Safety, health and the environment are matters which everyone who uses the Nijenborgh 4 and Bernoulliborg Complex will come into contact with at some point or other.
Just exactly how we are affected with regard to safety and health is set out in the Working Conditions Act, and with regard to the environment in the Environmental Protection Act.
You will find the consequences of this legislation for the Nijenborgh 4 and Bernoulliborg Complex set out in this Red Safety Book, translated into a number of safety tips, environmental regulations, house rules and rules for general behaviour.

Everyone who uses the Complex is expected to have taken good note of the contents of this book and to live and work within the complex according to the rules in order to create as good and as safe a working and studying climate as possible, not only for yourself but naturally also for others.

The advantages of following the rules are clear – a good and safe working environment with as little pressure as possible on the environment, both inside and outside.
Not obeying the rules not only means that unnecessary, dangerous situations may be created and calamities occur, both environmental and other, but also that the Labour Inspectorate may impose instant fines within the framework of its 'tit-for-tat' policy should it discover transgressions. In the event of environmental transgressions, the worst case scenario is that the complex's environmental permit could be withdrawn.

The Faculty Board assumes that the faculty community within the Complex, both staff and students, is responsible enough to contribute to a safe and healthy working environment and to work in such a way that consequences for the environment are kept to a minimum. This is in addition to the responsibilities set out in the Working Conditions Act for everyone with regard to their own safety, health and working conditions.

Prof. S. Daan
Dean of the Faculty of Mathematics and Natural Sciences.

2. IMPORTANT INFORMATION

General Orientation

- For suggestions and comments about this book contact one of these people:

NAME:	EXT.	EMAIL:	ROOM:
C.J. Groen	4618	c.j.groen@rug.nl	5161-0311
J. Jager	4427	Jack.jager@rug.nl	5116-0011 or 5161-0311
J.J. Zijlstra	4231 2953	j.j.zijlstra@rug.nl	5116-0011 or 5161-0309

- Chapter 3 contains 'Quick information'. This is knowledge that you need to have at your fingertips when working in the Complex.

- This book is not intended to be definitive. If you have any comments or suggestions, please do not hesitate to pass them on to the board or to the faculty's Health, Safety and the Environment coordinator. If you have a specific question, please consult the list of officials included in chapter 3.11. (page 17).

- You can find rules for personnel at:
  http://www.rug.nl/fwn/faculteit/bestuur/reglementen (*only in Dutch*).

- You can find information about the internal organization on the FWN website, at **http://www.rug.nl/fwn/**.

- A separate guide with information about the Nijenborgh 4 and Bernoulliborg Complex is available from the Personnel Department Beta-Cluster.

- There is also a website with information about Health, Safety and Environmental protection:
  http://www.rug.nl/fwn/informatievoor/medewerkers/index
  (in Dutch and English)

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 (CO_2, 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:	Hydrocarbons	Acids	Alkalis
	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).

Inside the Complex it is forbidden:

- TO SMOKE, EXCEPT IN THE SMOKERS' ROOM: 5114-0018
- to take alcoholic drinks and/or drugs into the building or to be under the influence of alcohol and/or drugs
- to harass or offend your fellows or colleagues
- to create noise or smells that can annoy others
- to use a bicycle, scooter, in-line skates, etc. inside the building, except with the permission of the site manager. Wheelchairs are of course excepted
- to place obstacles in public areas and corridors
- to block the emergency exits
- to park your car on the roads outside the car parks. You then run the risk of a fine or having your vehicle clamped
- to leave rubbish on the streets or outside the waste bins and containers in the building.

3.9. House rules and behaviour code for the laboratories

You must:

- fill in a permission form at Reception if you wish to turn on or leave on equipment after working hours, at the weekend or on national holidays
- wear a cotton lab coat and safety goggles and use adequate personal protective devices
- never be alone in the lab. Two or more people must be present in the interests of safety
- have written permission from the group leader to work outside working hours
- clear everything away after a practical or experiment
- know the specific regulations for the laboratory you are working in
- switch off the fume cupboards that can be switched off in buildings 5114, 5115, 5116 and 5118 when they are not in use, in order to save energy
- use safe and approved appliances, tools, machines and instruments. A CE mark is required for new equipment
- use electrical equipment that has been tested and approved according to NEN3140 standards. This concerns a compulsory regular inspection. Note the expiry/reinspection date on the green NEN3140 sticker.

Inside the laboratories it is forbidden:

- to eat, drink or smoke
- to block the walkways
- to put on make-up
- to use refrigeration or heating equipment for storing food or drink
- to leave the lab without clearing up first.

3.10. Behaviour code for the computer rooms

It is forbidden to:

- to reserve a computer or to leave your computer unattended for longer than fifteen minutes
- to eat, drink or smoke
- to hack, i.e. break into other computers
- to use someone else's account
- to play games
- to use excessive amounts of paper
- to engage in other unacceptable behaviour

3.11. Responsible officials

In the event of questions and/or problems, please consult the following officials:

Table 3.11 – Responsible officials

FOR	NAME	E-MAIL ADDRESS	EXT.
• ARBO matters • Environmental Matters	C.J. Groen	C.J.Groen@rug.nl	4618 / 95242
In-house Emergency Services (BHV)	J. Jager	jack.jager@rug.nl	4427 / 95394
Biological Agents and GMOs	A.M.W.H. Thunnissen	A.M.W.H.Thunnissen@rug.nl	4380
Building Maintenance	M.J. Koekoek	M.J.Koekoek@rug.nl	4827
Hazardous Waste	B.T.F. Bosma	B.T.F.Bosma@rug.nl	4103
Lasers	H.M.M. Hesp	H.M.M.Hesp@rug.nl	4340
Radiation	F. van der Horst	F.van.der.Horst@rug.nl	4831 / *81310 abbreviated number 95380
• NEN 3140 inspection • CE marking / NEN3140	N.A. de Groot	n.a.de.groot@rug.nl	4801

4. THE HEALTH AND SAFETY ORGANIZATION

4.1. In-house emergency services (BHV)

The in-house emergency service team is present between 9.00 a.m. and 5.00 p.m. and can always be called in the event of a calamity or potential calamity. The manager of the team is Commandant B.H.V., extension 4427, or phone **8050.**

Then there are two Under Managers from 9.00 a.m. – 5.00 p.m. they can be contacted by portable phone via the Reception (8050) for all matters concerning calamities

.

The in-house emergency service team (BHV) is made up of:

- a first-aid team
- qualified filter suit wearers
- qualified respirator wearers
- members of Fire Brigade
- people who help evacuate the building

4.2. Emergency plan for Nijenborgh 4 and Bernoulliborg Complex

There is an emergency plan for the Physics and Chemistry Building Complex. This emergency plan includes a list of all the rooms in the building and of the people who are responsible for these rooms. They are contacted in the event of a calamity.
The emergency plan also includes instructions for and the duties of the various teams and all maps. The Nijenborgh 4 and Bernoulliborg Complex emergency plan can be viewed at:

- Reception and Security at 5111-0004
- Building maintenance in 5161-0306
- Commandant BHV in 5116-0011 or 5161-0311

4.3. First Aid

First Aid is one of the elements in the BHV team. Every day, two people are assigned duty by de Commandant BHV-ploeg. They can always be called in the event of an accident. You must report an accident to Reception and Security using the emergency number 8050. For more information, please contact the Commandant BHV, J. Jager, extension 4427, abbreviated number 95394, email: **jack.jager@rug.nl.**

4.4. Reporting undesirable situations – SOS

For power cuts/calamities: see section 3.5 on page 14.

All thefts and losses must be reported to the police and to Reception, ext. 4133. The official report should be handed in to the building maintenance department, room 5161-0306, ext. 4827. To reduce the risk of theft or loss, it is important to lock the door of your room when you leave it. Do not leave any valuables unattended in your room or working space. Reception has a lost property service for articles that have been found.
Surveillance rounds are carried out every evening and at weekends.

Complaints about the following matters can be reported to M.J. Koekoek, ext. 4827 or via email: **M.J.Koekoek@rug.nl:**

- facilities for the disabled
- the maintenance and cleaning of the working spaces
- smoking
- the building in general

4.5. Personal protective devices

When working with chemicals you must wear safety goggles and a cotton laboratory coat.
Lab coats made of artificial materials are not permitted because of the danger of static charge and the adhesion of melted material to the skin in the event of fire.
Cotton lab coats, face protectors and gloves are available from the central store.
Lab coats should be washed regularly. The Secretary's Office of your department can tell you where to put your dirty lab coats.

The central store also has other protective devices, for example aprons and other special clothing. The safety officers must ensure that suitable protective devices are used during all activities and that these are available at the point in question, together with the appropriate instructions.

4.6. The General Health, Safety and Environmental Coordinator

The Faculty Arbo- en Milieucoördinator is C.J. Groen. You can contact him with any questions in the field of health, safety, environmental and working conditions, room 5161-0311, ext. 4618, email: **c.j.groen@rug.nl.**

4.7. Radiation protection unit

The Radiation Protection Unit (SBE), a university organization, is charged with implementing the obligations arising from the Nuclear Energy Act. F. van der Horst is the member of SBE for the Physics and Chemistry unit. Please contact him if you have any questions about ionizing radiation, room 5118-0002, ext. 4831 or ext. 95380.

4.8. University Health, Safety and Environmental Service

Since 1998, universities are obliged to have a certified Health and Safety Service. The University of Groningen has its own certified Health, Safety and Environmental Service (AMD).
In order to be able to fulfil these duties properly, the AMD has various expertise at its disposal. The following consultants are relevant for our faculty:

DEPARTMENT	NAME	EXT.
Health and hygiene at work	vacancy	6125
Work and Organization	M.C.M. van Aalsum	5468/5534
Health and Safety Consultant	I. Jensen	6950
Occupational Health Service	Dr G. Bleeker	5536/5534
Industrial Welfare Work	H.W. ter Heegde J.A. Niemeijer	5466 5466
Security	K. Verelst B. van Veen	3398 4820
Environmental Care	D. Jager B. van Veen	4575 4820
Radiation Protection	Dr H.F. Boersma	6124.

The AMD is located at Visserstraat 47, 9712 CT Groningen and can be reached on extension 8010. The internet site is: **http://www.rug.nl/bureau/expertisecentra/amd/.**
If you have any questions about your working conditions in relation to your health, please do not hesitate to contact the university doctor during the Working Conditions Surgery (AOS). To do this, please make an appointment with the university doctor, Dr G.W. Bleeker, ext. 5536/5534 and say that it is for an AOS. This option is separate from the other options for consulting the university doctor and/or the Health, Safety and Environmental Service.
Should you consult one or more of the above experts, with the exception of the university doctor, could you please also inform the Health, Safety and Environmental Service coordinator C.J. Groen, extension 4618, e-mail: **c.j.groen@rug.nl** as there may be consequences for the Faculty.

4.9. Labour Inspectorate

The Labour Inspectorate is a department of the Ministry of Social Affairs and Employment. It checks whether employers and employees are complying with the rules and regulations in the field of labour, for example the Working Conditions Act and the Working Hours Act.
The Labour Inspectorate is entitled to visit companies and institutions, or parts thereof, on its own initiative but can also take action if complaints are made during the inspections. In principle, anyone can approach the Labour Inspectorate, even if there is only a suspicion that the employer is not conforming to the legal working regulations. For the Northern Region, the address is:

Arbeidsinspectie Kantoor Groningen
Engelse kamp 4
9722 AX Groningen

or

Arbeidsinspectie Kantoor Groningen
P.O. Box 30016
9700 RM Groningen
Telephone: (050) 533 58 80

On the basis of the so-called 'tit-for-tat' policy, the Labour Inspectorate can impose fines if it discovers transgressions of the labour laws. The level of the fines is set out in the Penalty List. The Health, Safety and Environmental Coordinator has a copy of this list.

4.10. Environmental Inspectorate and District Water Board

The Municipality of Groningen has issued an environmental permit to the Nijenborgh 4 and Bernoulliborg Complex and for the performance of laboratory operations. The environmental permit sets out what the users of the complex must conform with. Many of the regulations are included in this book. In order to check whether the regulations are being followed, an environmental inspector from the Environmental Protection Service will come to inspect the building or parts of it. These inspections do not have to be announced in advance. A fine can be imposed if the environmental regulations are being transgressed. Should the transgressions continue, the permit can be withdrawn.

4.11. University of Groningen policy concerning undesirable behaviour

If you come into contact with undesirable behaviour, you can ask the P&O Service of the Faculty for advice. You can also make an appointment to speak to the University of Groningen mediator, Ms J. Dam. The address is:

Office of the University of Groningen Mediator
Ms J.M. Dam
Visserstraat 47 - 49
9712 CT Groningen
e-mail: **J.M.Dam@rug.nl**

You can also contact the mediator via the secretary of the Office of the University of Groningen Mediator, Ms A.M. Wildeboer-Baar, ext. 5435, e-mail: **A.M.Wildeboer-Baar@rug.nl**

Undesirable behaviour usually means matters such as sexual intimidation, aggression (including bullying), violence and discrimination.

The University of Groningen has issued a brochure concerning this:

- **'Brochure Bureau Vertrouwenspersoon' (Brochure Mediator's Office)**

The brochure (in Dutch) can be obtained from the personnel officer or at the above-mentioned address.

Please visit **http://www.rug.nl/studenten/voorzieningen/vertrouwenspersoon/** for more information.
The Office of the Mediator is open on working days from 9 a.m. to 5 p.m., by appointment.

The mediator can also help you and give you additional advice if you want to submit a complaint to the Complaints Committee for harassment, sexual harassment and aggressive, violent or discriminatory behaviour (SIAGD).
The address is:

SIAGD Complaints Committee
Ms J.C. Wolters
P.O. Box 72
9700 AB Groningen

5. ADDRESSES AT NIJENBORGH 4 AND BERNOULLIBORG COMPLEX

5.1. List of research institute secretariats

RESEARCH INSTITUTE	LOCATION	E-MAIL-ADDRESS	EXT.
Library	5161-0041E	a.c.e.van.ijsseldijk@rug.nl	4234
Biochemistry - GBB	5115-0103	s.a.haan@rug.nl	4209
Biophysical Chemistry / MD group – GBB	5117-0015	mdsecr@rug.nl	4323
Biophysical Chemistry / X-ray & EM – GBB	5118-0047	secbiofys@rug.nl	4378
Biomade	5115-0007	karakayali@biomade.nl	5246
Faculty (Internationalization)	5161-0404	M.J.Wiersema@rug.nl	7361
Centre for Isotope Research – CIO	5112-0030	H.E.Deenen@rug.nl	4760
Chemical Physics – MSC	5117-0002	h.van.mil-boddeveld@rug.nl	4440
Discrete Technology and Production Automation	5116-0126	sectbk@rug.nl. a.a.j.stokroos@rug.nl k.winters@rug.nl karen.meyer@rug.nl	8430 8492 8430 8493
Facility Department	5161-0302	l.koops@rug.nl	4269
Financial Administration of the Faculty Technical Support Unit	5121-0005	l.koops@rug.nl	5426
Faculty Dean, Board	5161-0506	D.J.Alfons@rug.nl G.Lap-Koekkoek@rug.nl	4615
Faculty, Promotions & examinations	5161-0407	Y.van.der.Weerd@rug.nl A.H.T.Korringa-de.Wit@rug.nl	4616 4504
Financial Policy Administration Department FBA	5161-0540	j.m.g.e.verstappen-remmers@rug.nl	7797
Physical Informatics	5114-0012	A.Nanning@rug.nl	4115
ICT Management	5116-0308	helpdesk@fwn.rug.nl	4341
Didactics and Curriculum Development IODID – (IOD)	5161-0420	G.de.Boer-Zeeman@rug.nl	8308
Science and Society / Energy and Environmental Studies	5117-0307	A.J.Huizinga@rug.nl	4609
Molecular Electronics – Zernike Institute for Advanced Materials	5118-0113	moleculair.electronics@rug.nl	8750
Micromechanics – Zernike Institute for Advanced Materials	5113-0112	a.j.sibma@rug.nl	8047
Materials Science –Zernike Institute for Advanced Materials	5113-0040	e.c.eekhof@rug.nl	4898

Zernike Institute for Advanced Materials	5111-0131	m.h.derix@rug.nl	4843
Neurobiophysics /BMT	5114-0036	D.G.Stavenga@rug.nl	4732
Organic and Molecular Inorganic Chemistry – OMAC	5115-0209	H.H.Biemold@rug.nl	4235
Institute for Undergraduate and Postgraduate Studies	5114-0012	A.Nanning@rug.nl	4115
Personnel Department - P&O	5161-0518	H.L.van.Ingen@rug.nl S.M.Lindeboom@rug.nl	7009
Polymerchemistry – Zernike Institute for Advanced Materials	5117-0322	c.j.woudstra@rug.nl	4510
Chemical Engineering – Stratingh	5118-0245	secst@chem.rug.nl m.m.van.der.Duin-de.Jonge@rug.nl	4484
Stratingh Institute	5115-0206	stratingh@rug.nl	4233
Technical Services	5121-0025	n.a.de.groot@rug.nl	5426
Theoretical Physics – Zernike Institute for Advanced Materials	5111-0153	i.de.roo-kwant@rug.nl S.A.A.Rob@rug.nl	4950
Optical Condensed Matter Physics (OCMP)	5117-0010	J.K.de.Boer@rug.nl	9038
Solid State – Zernike Institute for Advanced Materials	5113-0104	solidstate@rug.nl	4974

5.2. List of General Health, Safety and Environment contact persons, Nijenborgh 4 complex

Gron. Inst. Biomolecular Sciences & Biotechnology - GBB

Biotechnology	P. Wietzes	p.wietzes@rug.nl
Electron Microscopy	vacancy	vacancy
Enzymology	R. Duurkens	r.duurkens@rug.nl
Molecular Dynamics	vacancy	vacancy
X-ray Crystallography	T.Pijning K.H. Kalk	t.pijning@rug.nl k.h.kalk@rug.nl

Stratingh Institute

Chemistry of (Bio)organic Materials and Devices	R. Gooijaarts	R.Gooijaarts@rug.nl
Physical Organic Chemistry	vacancy	vacancy
Molecular Inorganic Chemistry	A.M. van Leusen	a.m.van.leusen@rug.nl
Synthetic Organic Chemistry	E.P. Schudde	e.p.schudde@rug.nl
Combustion Technology	A.V. Mokhov	a.v.mokhov@rug.nl

Zernike Institute for Advanced Materials

Physics of Nanodevices	S. Bakker	s.bakker@rug.nl
Ionogenic Materials	vacancy	vacancy
Material Science	vacancy	vacancy
Micromechanics	E. van der Giessen Please c.c. to A.J. Sibma	E.van.der.Giessen@rug.nl A.J.Sibma@rug.nl
Surfaces and Thin Films	L. Venema	l.venema@rug.nl
Optical Physics of Condensed Matter	A.F. Kamp	a.f.kamp@rug.nl
Physics of Organic Semiconductors	vacancy	
Polymer Chemistry and Bioengineering	vacancy	vacancy
Polymers at Surfaces and Thin Layers	vacancy	vacancy
Polymer Mixtures and Computer Simulations	G.O.R. Alberda van Ekestein	g.alberda.van.ekestein@rug.nl
Computational Physics	vacancy	
Theoretical Chemistry	J.J. Heijnen	j.j.heijnen@rug.nl
Theory of Condensed Matter	vacancy	vacancy
Solid-State Chemistry	J. Baas	j.baas@rug.nl

Energy and Environmental Studies - IVEM

Energy and Environmental Studies	A.J. Schilstra	a.j.schilstra@rug.nl

Isotope Research - CIO

Centre for Isotope Research	B.A.M. Kers	b.a.m.kers@rug.nl

Neurobiophysics - BCN

Neurobiophysics	vacancy	vacancy

Theoretical Physics

High Energy Physics	B.J. Hoenders	b.j.hoenders@rug.nl

ITM - Institute for Technology and Management – Chemical Engineering

Product Technology	E. Wilbers	e.wilbers@rug.nl
Chemical Reaction Engineering	E. Wilbers	e.wilbers@rug.nl
Transport Phenomena	E. Wilbers	e.wilbers@rug.nl

5.3. List of radiation contact persons/environment contact persons

NAME / E-MAIL	DEPARTMENT / UNIT	EXT.	BUILDING
R u G:			
Dr H.F. Boersma H.F.Boersma@rug.nl	Health, Safety and Environment Service Radiation specialist	6124	4411
Vacancy	Central Radiation specialist Health, Safety and Environment Service	5552 2410	4411 6523
Faculty:			
F van der Horst F.van.der.Horst@rug.nl	X-ray equipment /Electron accelerator and closed sources Physics Radiation commissioner Nijenborgh 4	4831 95380	5118
K.H. Kalk K.H.Kalk@rug.nl	X-ray equipment Biophysical Chemistry	4388	5118
H.W. van den Dool H.W.van.den.Dool@rug.nl	Materials Science	4884	5113
A. Keizer-Gunnink A.Keizer-Gunnink@rug.nl	Biochemistry – Enzymology	7957	5116
A. Meetsma A.Meetsma@chem.rug.nl	X-Ray equipment Chemical Physics	4368	5118
H. Jordens H.Jordens@rug.nl	Physics practicals	4856	5113
P. Wietzes P.Wietzes@rug.nl	Closed Ni63-source (gaschromatograph) Biochemistry	4185	5116
S. Wijma S.Wijma@rug.nl	Accelerator C.I.O.	4758	5112

5.4. List of Biohazard contact persons

NAME	DEPARTMENT	FUNCTION	EXT.
A.M.W.H. Thunissen A.M.W.H.Thunnissen@rug.nl	Biophysical Chemistry	Biological security officer	4380
D.B. Janssen D.B.Janssen@rug.nl	Biotechnology	Responsible staff member	4008
B.W. Dijkstra B.W.Dijkstra@rug.nl	X-ray Crystallography	Responsible staff member	4381
B. Poolman B.Poolman@rug.nl	Biotechnology	Responsible staff member	4190

SPECIFIC INFORMATION

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

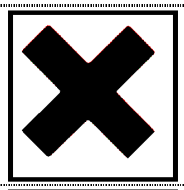
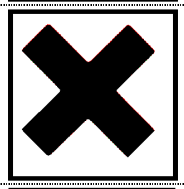
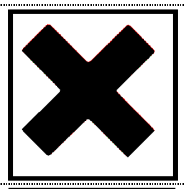
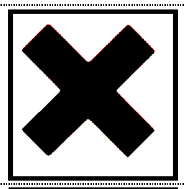
6.2. Information about the risks associated with chemicals

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		<u>Substances which:</u> 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 0º C are called 'extremely flammable' (code F+), liquids with a flash point lower than 21º C are called 'highly flammable' (code F). Both categories have a pictogram with a flame. Liquids with a flash point between 21º C and 55º 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 (100º C – 200º 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 20º 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 *LD_{50} and LC_{50} 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

		LD_{50} (rat, oral)	**LD_{50} (dermal)**	**LC_{50} (rat, inhalatory)**
Type	WMS code	mg/kg bw	mg/kg bw	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

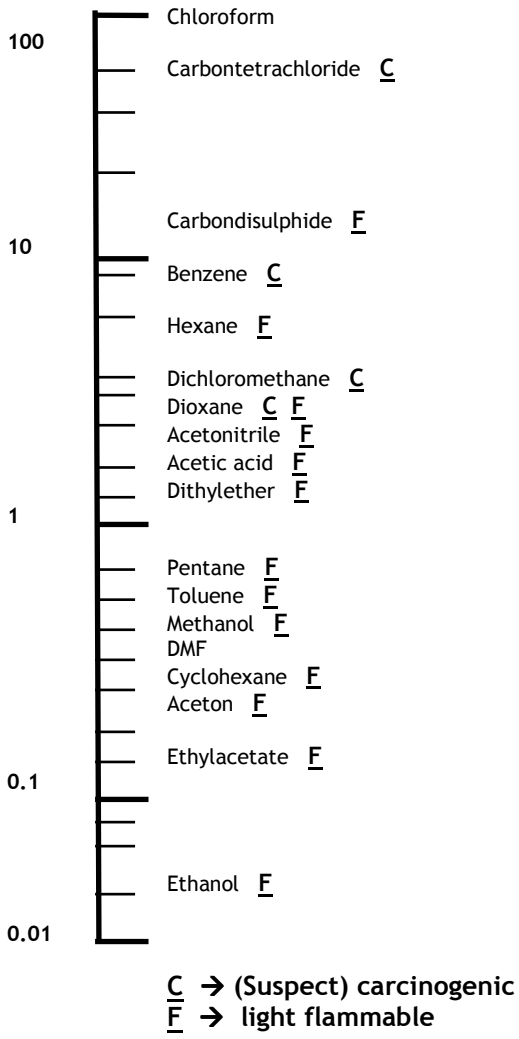
MAC VALUE (PPM)	TOXICITY	MEASURES
> 50	Low	No specific measures
10 – 500	Medium	Experiment in hood
0.1 – 10	High	Weigh off and wash up in hood
< 0.1	Very high	Closed system, Glove box

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) benzydine (+ 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

7. PHYSICAL HAZARDS

7.1. Working with electricity

Working with electricity is subject to strict rules. These are laid out in broad terms in the Working Conditions Decree and in more detail in the regulations included in, among others, the NEN sheets (for example: NEN 3140 – low voltage). The required safety measures depend on the voltage being used. A difference is made between low voltage and high voltage.

The difference is as follows:

- for alternating current, the low voltage range is between 0 and 1000 Volts (between the phases), or between 0 and 600 Volts (between phase and earth).
- for direct current, the low voltage range is between 0 and 1500 Volts (between the phases), or between 0 and 900 Volts (between phase and earth).
- Higher voltages are referred to as high voltage.

The following safety facilities are available:

- **protective earthing**
  every room has protective earthing facilities. In the event of a fault, the electricity is cut off. You should then contact Reception and Security on extension 4133 immediately.

- **emergency switches**
  emergency switches are installed in rooms where electronic equipment is used. They can be recognized by their red buttons. In the event of a power failure, please contact Reception and Security on extension 4133.

- **cold rooms**
  these rooms also have a red button. The system should be used to warn Reception and Security should the temperature rise or someone become unwell.

If you have any questions about working with electricity, please contact N.A. de Groot, ext. 4801/2361 or 95039 or in room 5121-0024 or the University Internal Services Department, ext. 5222.

7.2. Working with radioactive substances and equipment that emits ionizing radiation

Radioactive substances and/or equipment that emit ionizing radiation are in use at about 50 places within the University of Groningen. A complex permit has been issued to the University of Groningen for these applications. Within the framework of this complex permit, a radiation protection unit (SBE) has been formed to define and monitor policy concerning radiation safety.

The University of Groningen is divided into four entities:

- KVI
- Nijenborgh 4 and Bernoulliborg complex
- Medical Sciences and Pharmacy complex
- Biology Centre

The Health, Safety and Environment Service plays a central, supervisory role with regard to the applications within the boundaries of the complex permit. A special radiation expert, Dr H.F. Boersma, ext. 6124, has been appointed to this end. He is supported at the entity level by four radiation commissioners. The radiation commissioners coordinate the supervision of local applications within an entity. A radiation expert is appointed for every local application to supervise the activities/applications. The following site experts have been appointed:

The radiation commissioner for Chemistry / Physics is F. van der Horst. He is supported by the site experts.

NAME	UNIT	BUILDING
F. van der Horst	Radiation commissioner	5118
Dr H.F. Boersma	Health, Safety and Environment Service	4411
F. van der Horst	Accelerator	5113
K.H. Kalk	X-Ray equipment Biophysical Chemistry	5118
H.W. van den Dool	Materials Science – SEM /TEM Electron microscope	5112 / 5113
A. Meetsma	X-ray equipment	5112 / 5118
H. Jordens	Physics practicals	5113
A. Keizer-Gunnink	B and C labs Biochemistry/ECD	5114
S. Wijma	Accelerator Centre for Isotope Research/Depleted uranium	5112

Working with radioactivity is subject to a battery of rules and regulations. They are set out in the Nuclear Energy Act file and are maintained by the site experts.

The following rules apply:

- **isotope laboratories**
  Working with radioactive substances is only permitted in isotope laboratories. It is forbidden to work with radioactive substances outside the isotope laboratory.

- **access to isotope laboratories**
  The isotope laboratories are only accessible to people with suitable training. Before carrying out radiological activities, you must report in good time to the site expert.

- **Radioactivity orders**
  Radioactive links may only be ordered after permission has been received from the site experts.

7.3. Working with non-ionizing radiation

The spectrum of electromagnetic radiation can be divided into a number of wavelength ranges, each with its own specific characteristics and fields of application. Radiation with a wavelength shorter than 100 nm (x-rays, gamma rays) is ionizing and will be discussed separately (see ‘ionizing radiation’).

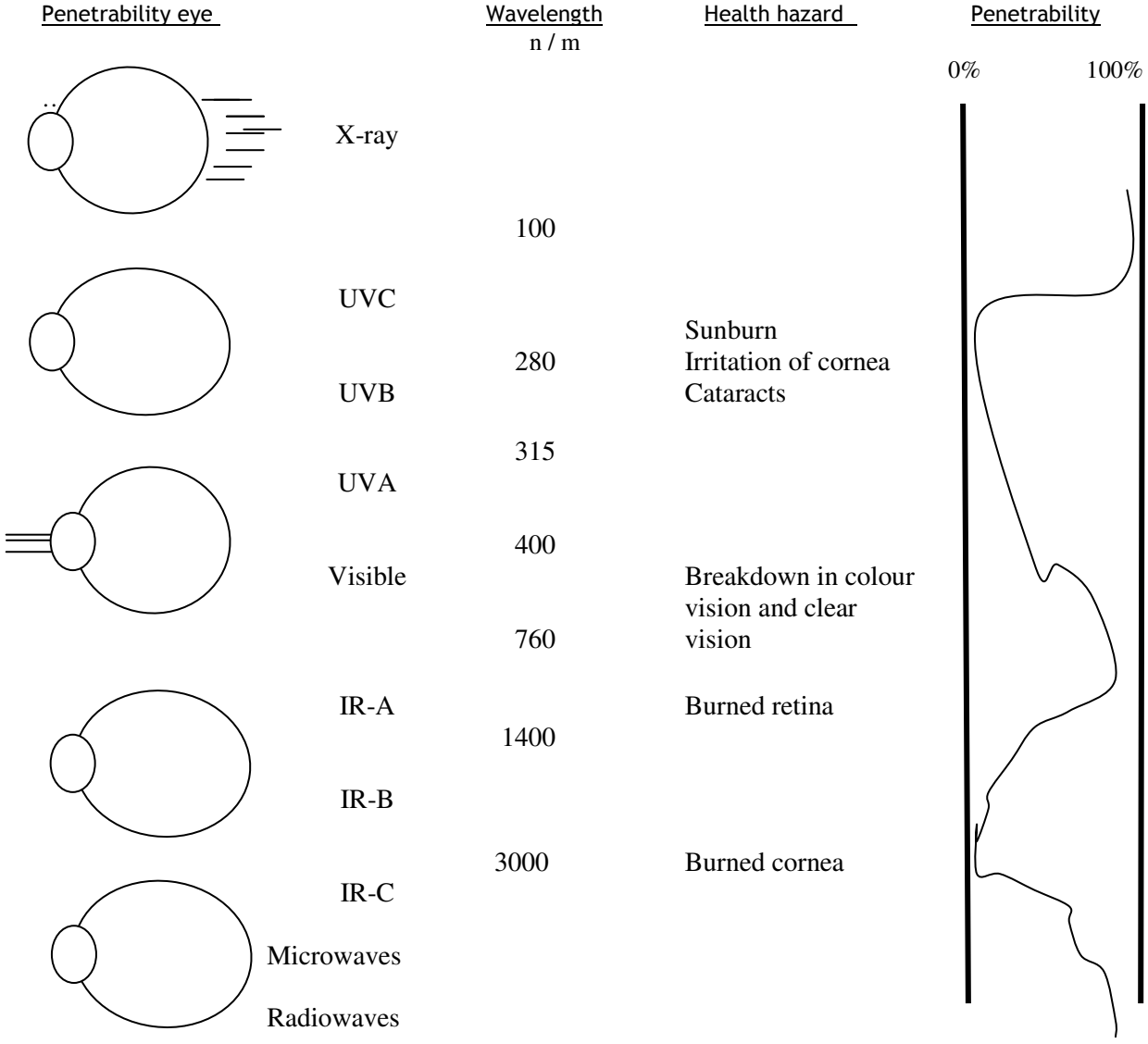
Important applications of electromagnetic radiation in laboratories include (UV) lamps and lasers.
Intense light is also released when working with flames, for example when blowing glass or welding.

Table 7.3.A – Some applications of non-ionizing radiation

RADIATION	WAVELENGTH RANGE	APPLICATION
UV	100 – 400 nm	Sterilizing equipment Detection lamps Irradiation equipment
Visible	400 – 760 nm	Irradiation equipment Lasers Culture setups
IR	760 – 1 mm	Ovens Heating equipment Lasers
Microwaves	1 mm – 10 m	Microwave ovens
Radio waves	1 mm – 100 km	NMR

The risks of non-ionizing radiation for the eyes and the skin in particular are heavily dependent on the wavelength, the intensity and the length of exposure. Figure 7.3.B sets out the perviousness of the skin and the eyes to the various types of radiation, with accompanying effects.

Figure 7.3.B:



UVC (100 – 280 nm) and UVB (280 – 315 nm) radiation are adsorbed by the cornea and intense exposure can result in painful effects such as keratitis ('snow blindness') and cataracts. UVA (315 – 400 nm) is adsorbed by the lens in the eye but can also partially reach the retina. UV radiation causes sunburn on the skin; chronic exposure can cause certain types of skin cancer. Light in the wavelength range 400 – 1400 nm (visible and IR-A) will reach the retina. Intense exposure can damage the retina by the development of heat. High intensity IR-B (1400 – 3000 nm) and IR-C (3000 – 1 mm) can result in damage to the cornea due to development of heat.
Microwaves and radio waves can easily penetrate the body. The best-known effect of microwaves is the development of heat after absorption by water in the body. This is particularly hazardous in those organs with little blood circulation; the effect is usually present in the wavelength range 30 – 100 m (frequency 1000 – 3000 MHz), which also covers the microwave oven frequency.
There are exposure limits set out in W/m^2 for each radiation type, but these have no official status.

Rules for handling sources of radiation

- adapt the source if possible – choose a low capacity and/or a less hazardous wavelength range.
- provide clear instructions for use and any necessary warnings at the source of radiation.
- perform activities with intense sources of radiation in separate areas if possible, provided with clear indications.
- if necessary, use protective goggles with a filter for the relevant wavelength range. It is essential that the goggles match the type of light source being worked with; check the transmission spectrum of the goggles you intend to use.

Working with lasers

A laser creates light of a very high intensity by stimulated emission in a very concentrated (non-divergent) bundle. The radiation is usually in the visible or infrared range, and sometimes in the ultraviolet range. The penetration depth of this radiation in the body is limited; the most vulnerable organs are the eyes and the skin. The irradiation effect on the retina from a laser bundle is much higher than from lamps as a result of the high intensity of the light, the focusing of the bundle through the lens of the eye and the diameter of the pupil when working in darkened areas. This means that the radiation on the retina (in W/m^2 for continuous lasers) for an mW laser can be a factor 100,000 higher than that of a 100 W bulb. Burning or damage to the retina is a possible consequence. Non-visible radiation is the greatest risk in this context because the natural reflex to close the eyes does not occur.

There are other important risks when using lasers. Lasers use high electrical voltages (in the order of 5 – 25 kV), thus there is a risk of electrocution or burns. The capacitor can retain their charge even after the power supply voltage has been switched off. When using voltages of 15 kV or higher, it is possible that x-rays will be emitted. When using UV radiation, ozone is created from oxygen in the air, which can have an irritating effect on eyes and mucous membranes. Pulsating high energy lasers can achieve high sound levels and this necessitates hearing protection.

Sources of radiation, whether continuous or not, are divided into hazard classes on the basis of their emission capacity:

Table 7.3.6: Laser classes

CLASS	CHARACTERISTIC	EXAMPLE
1. Safe	Limited power No radiation escape	Light bulb, 1 μW laser
2. Not completely safe	Visible radiation, dangerous after > 0.25 sec. looking (> reflex)	Sun, 1 mW laser
3a. Dangerous	Visible/invisible radiation, only a chance of eye damage when using optical instruments	1 to 5 mW lasers with optically converging beams
3b. Dangerous	Visible/invisible radiation, damage by direct and reflected beam, not from diffuse reaction	Midday sun, 10 mW laser
4. Very dangerous	Eye damage from direct/reflected and diffuse reflection; direct beam causes burns	1 W laser

Rules and tips for working with lasers:

- the laser may only be used and the laser room may only be entered by authorized persons. Working with and on lasers must be well thought out and carefully performed.
- rooms with lasers in classes 3b and 4 must have a warning sign on the door.
- the radiation source must be shielded as much as possible. Beware of reflective objects. Remember that a beam can also be emitted out the back of a high capacity laser.
- as far as possible, prevent light beams tracking through the area at random; avoid eye height at all costs.
- it is forbidden to look into the laser beam.
- when working with lasers in classes 3b and 4, laser focusing goggles or laser safety goggles must be worn. Don't forget to check the correct wavelength.
- outlining must be performed at minimum power and with the largest possible attenuating filter at the exit point. If possible, outline with a low capacity laser.
- be careful of parasitical wavelengths (e.g. when using dielectric mirrors, use beam stops)
- beware of parasitical reflection (e.g. with beam splitters)
- beware of mirrored reflection, for example when watching along the beam. Use a shield with a diaphragm opening to protect against these reflections. Transparent surfaces reflect. Surfaces that reflect visible light diffusely may have mirror reflection with other wavelengths.
- use a He-Ne laser (beam splitter) with lasers with invisible beams to make the beam visible.
- the beam diameter is easy to measure with a piece of paper, florescent shield or infrared viewer; be careful of reflection, diffuse and ordinary.

8. BIOLOGICAL HAZARDS

8.1. Working with biological agents and GMOs

The responsibility for working with biological agents rests with the Biological Safety Officer **Dr A.M.W.H. Thunnissen**, ext. 7290. If you want to work with biological agents, whether or not genetically modified, you must contact him or, in the event of absence, **Prof. D.B. Janssen**, ext. 4008.

Working with biological agents is becoming increasingly important in laboratories. Biological factors in a broad sense are microorganisms (viruses, bacteria and moulds), endoparasites and inanimate substances or structures from living organisms, such as flakes of skin and grain dust.
Biological factors can cause a wide range of health complaints, divided into infections (from working with infectious microorganisms), poisoning (for example from endotoxins or wood dust) and allergies.
Special care must be taken when working with genetically modified organisms (GMOs). Depending on the nature of the work, special permits and regulations apply that are designed to prevent the dissemination of the microorganisms. This applies to both pathogenic microorganisms and GMOs. The rules for controlling the risks related to both groups of organisms overlap in many areas. The legislation concerning pathogens aims to protect people from infections, that for GMOs is primarily concerned with preventing escape into the environment. In the Chemistry Laboratories, working with non-pathogenic microorganisms and GMOs is most relevant; contact with pathogens is particularly relevant for hospitals, the Medical Faculty and their laboratories.
Before a permit can be issued, a risk evaluation of the research in question must be performed. The national Committee for Genetic Modification (COGEM) advises the government about the acceptability of the research and the standards that must be applied to it. Then there are training and instruction regulations for every new worker in the field of Safe Microbiological Techniques (VMT). The Biological Safety Officer can inform you about instruction material and courses.

The laboratories where biological agents are worked with are equipped according to the VMT rules. This is indicated at the entrances to the labs. There are stringent regulations and classified rooms (CI laboratories) for certain microorganisms and activities. The stricter classes, CII and CIII, are not represented in the building. The facilities can include biological safety cabinets and filters (HEPA) in the air ducts. Unlike hoods, biological safety cabinets have a vertical air flow directed downwards that is sucked away at the front and the back of the bench. This ensures that not only the laboratory worker and the surroundings are protected, but also the vulnerable microorganisms. You must work carefully in the biological safety cabinet. Prevent the creation and spraying of aerosols as a result of rapid movements in or in front of the cabinet, open doors and windows or equipment that creates heat build-up (Bunsen burners). Make sure that the ventilation gaps are not blocked. Ensure that expert checking and maintenance of the safety cabinet is performed.

When working with biological agents, the ‘11 commandments’ for VMT must be strictly followed.

1. The work may only be performed by people who have permission to do so from the BVF (Biological Safety Officer). Always follow the rules, even if you think there is no risk.
2. During the work, doors and windows must be closed. Check the working area for the presence of insects and other vermin.
3. Wear closed laboratory clothing. You may only wear this lab coat outside the working area if parts of the experiment are performed elsewhere. If the lab coat becomes contaminated by spillage or accident, this must be decontaminated or sterilized before washing.
4. In the event of contamination, perform instant decontamination; serious contamination must be reported immediately to the BVF.
5. It is forbidden to eat, drink or smoke in the working area, or to have food or drink with you.
6. Pipetting with the mouth is forbidden; dispose of used pipettes in a liquid disinfectant.
7. Prevent aerosol formation. Actions that can create aerosols include:
   – drips
   – pouring liquids
   – blowing out pipettes
   – opening damp stoppers
   – centrifuging open pipes
   – use of an inoculating needle that is too hot (improper use).

   Injection needles may only be used if there is no alternative.
8. Glassware and instruments that have been in contact with GMOs must be sterilized or decontaminated before they are washed, reused or disposed of. Biological waste must be disposed of in a refuse bag that can be sterilized, marked with indicator tape and sterilized.
9. Wash your hands with soap after the work is completed.
10. At the end of every working day, the work surfaces must be decontaminated. Keep the working area clean and tidy.
11. The nature of the work must be registered clearly in the lab journal.

Careful working methods reduce the chances of exposure to biological agents by inhalation, swallowing or self-injection.

Tips for preventing inhalation:

- only use small inoculating loops (diameter < 3 mm), use disposable inoculating loops.
- make only gentle movements when working with loops.
- do not blow out pipettes.
- transfer liquid cultures very carefully and do not use a pipette to mix them.
- prevent droplets falling on the table.
- prevent aerosol formation during centrifuging; always use sealed tubes.
- as far as possible, avoid ultrasonic vibrations and the blending of suspensions.
- open tubes, flasks and ampoules very carefully and not too soon after homogenization.
- use plastic petri dishes instead of glass ones.
- transfer liquids using a funnel whose end is under the upper surface of the liquid.

Tips for preventing swallowing:

- never pipette by mouth and do not blow pipettes out.
- use gloves and prevent contamination of your hands.
- apply high personal hygiene; wash your hands, do not wear rings or wristwatches, cover wounds with water-resistant plasters.

Tips for preventing self-infection:

- use injection needles as little as possible; pipettes are safer.
- use needle beakers to transport used injection needles; do not put the needles back into their protective covers.
- shield the needles when using automatic sampling equipment.
- where possible use plastic Pasteur pipettes.
- use good quality undamaged culture tubes.
- should contamination occur as a result of a minor accident (pricking, cutting, splashing yourself), wash the affected part of the body or the wound well with soap and water and disinfect it with 70% alcohol. If necessary, bacterial infections can be treated with antibiotics.

9. TOOLS AND EQUIPMENT

9.1. Working with glassware

Most accidents in chemistry laboratories are caused by the breaking or shattering of glassware. Luckily, the consequences are usually confined to surface cuts, but careless use of glassware can lead to more extensive damage. Please be aware of the risks associated with this material, choose the correct glassware for the activity in question and check it for cracks or other hidden flaws.

Be particularly careful when using glassware in a vacuum. Round-bottomed flasks are able to withstand the external pressure created when used in a vacuum, for example with the film evaporator. However, a crack in the glassware can lead to an implosion and perhaps even to the splattering around of chemicals. Some new types of rotary film evaporators are equipped with safety shields and PVC-coated glassware.
Erlenmeyer flasks are not suitable for use in a vacuum, with the exception of extractor Erlenmeyer flasks, recognizable by the connection point for a vacuum tube.
Vacuum desiccators must be shielded with a tightly tied textile bag or with a protective cover of metal gauze to prevent splinters of glass or chemicals from splattering around in the event of an implosion.

The heating of glass must also follow certain guidelines. Some types of glassware may not be heated.

- thick-walled glass, such as extractor Erlenmeyer flasks and desiccators, which have to be able to resist a partial vacuum or overpressure. The tension in this glass can cause shattering even with a slight rise in temperature.
- measuring glassware, such as pipettes, measuring flasks and burettes. Because the expansion of the glass when heated cannot be reversed, the glassware is subsequently useless for measuring. This can also occur when dissolving or diluting substances that create heat, for example concentrated sulphuric acid.

Thin-walled glassware (round-bottomed flasks, beakers, ordinary Erlenmeyer flasks) is suitable for heating. Make sure that you always use heat-resistant materials. Localized heating of glassware with an open flame at reduced pressure is not recommended because this can lead to localized tensions in the material. It is much better to perform gradual and evenly distributed heating (oil bath, insulating sheath, not too hot hairdryer).

Tips for working with glassware:

General:

- use the correct glassware for the intended application (high pressure, low pressure, heating, cooling).
- throw damaged, scratched or corroded glassware away immediately or have it repaired.
- try not to scratch the glassware when cleaning it.

Setup

The golden rule when clamping glass parts into setups is ‘make sure it’s tight, but not too tight’! Do not use too much force. Check the rubber of the clamps you are going to use in advance. Prevent stoppers getting stuck, for example by using silicone grease. When attaching or removing (PVC) hoses, protect your hands by using a towel. Point the connecting piece away from you and do not use too much force. Use a hairdryer to heat up a PVC hose that has hardened; a soft hose is easy to remove. When cutting a glass tube: score around the tube and then break it off in a towel.

Heating
Choose the correct glassware. Heat it up gradually and do not cool it down too fast.

Vacuum
Choose the correct glassware. Take the necessary protective measures; dessicators must be in a cloth bag, if necessary use a protective shield when using the film evaporator.

Transport
Do not carry flasks by the neck. Use a carrying bucket or basket.
Use metal or plastic Dewar flasks, or those with metal or plastic shielding. Always secure small Dewar flasks when filling them, for example with a separating funnel ring.

Breakages and accidents
- cuts: let cuts bleed.
- if possible, wash with soap and water.
- have deep cuts stitched.
- do not put ointment on the cut.
- do not put any 'antidotes' on the cut.
- if in doubt about the seriousness – go to the hospital.

Possible:	**Preferred:**
glass hose connection	plastic connection
pipetting from a bottle	dosing pump/dispenser
washing up by hand	dishwasher
glass dessicator	plastic dessicator or PVC layer
glass (powder) funnels	plastic (powder) funnels

9.2. Working with gas cylinders

In various places, gas cylinders have been installed in ventilated corridor cupboards. The secondary piping must be fitted with a main stopcock. The cylinders must be secured in an approved manner. Special braces have been fitted to this end.
You must indicate which gases are being used on the corridor side of the doors.
At the place of use, gas cylinders must be secured with a clamp or a chain so that they cannot fall over. If there is the slightest chance that the reactions mixture could be sucked back into the cylinder, you must install a non-return valve. Should a return nevertheless occur, you must report this to the handing-in point.
When conducting experiments with gases, overpressure protection must be installed. The overpressure protection that is built into some pressure reducers only protects the pressure reducer itself and is no guarantee of the safety of the rest of the setup.
After use, you must close the main tap of the cylinder and relieve the pressure reducer.
The changing of a gas cylinder and the connection of a pressure reducer must be performed by an expert.
You can obtain more information from the following two members of staff, U. Linstra on ext. 4125, if there is no answer try number 95129, or his replacement J. Kuiper, ext. 4934 or 7766.

Gas cylinders are tested for a certain maximum pressure. With stable or inert gases, there is little or no risk as long as this maximum pressure is not exceeded. Reactive or unstable gases, particularly if they have been stored for a long period of time, can damage the walls of the cylinder (e.g. chlorine, hydrogen chloride) or start to decompose (e.g. ethene, acetylene). In such instances there is a risk of explosion as a result of weakened walls or pressure build-up. It is thus very important to keep an eye on the test date. In order to be able to recognize the contents of cylinders quickly, they each have a certain colour. However, particularly with foreign cylinders, this is not always standardized. Some of the characteristics for gases and their cylinders are listed in Table 9.2.

Table 9.2: Characteristics of a number of gases obtainable in cylinders

Gas	Colour cylinder	Critical temperature	Boiling point (1 bar)	Vapour pressure (21°C)
Nitrogen	black	- 147 °C	-196 °C	
Hydrogen	red	-140 °C	-253 °C	
Oxygen	grey/white	119 °C	-183 °C	
Helium	brown	-268 °C	-267 °C	
Ammonia	grey/yellow	132 °C	- 33 °C	8.8 bar
Hydrogen chloride		51 °C	- 85 °C	43.0 bar
Chlorine		144 °C	- 34 °C	6.8 bar
Ethyne		36 °C	- 75 °C	44.0 bar
Butane		152 °C	- 0 °C	2.1 bar
Carbon dioxide	dark grey	31 °C	- 78 °C (subl.)	

Gas bottles with non-corrosive gases under high pressure must have a suitable pressure reducer fitted (see Figure below). This enables the high pressure of the gas in the cylinder to be reduced to a lower pressure. It is important that the pressure reducer is used in the correct way.

Opening

1. Unscrew the large set screw, close the precision adjustment tap.
2. Open the main tap by 1 or 2 turns; the contents pressure gauge indicates the pressure of the gas in the bottle.
3. Turn the large set screw to the right until the working pressure gauge shows a pressure of about 1 bar.
4. Turn the precision adjustment tap until the gas flow is at the required level.

Closing

1. Close the precision adjustment tap
2. Turn off the main tap
3. Break the link between the cylinder and the setup.
4. Open the precision adjustment tap until both pressure gauges are at zero.
5. Turn the set screw to the left and close the precision adjustment tap.

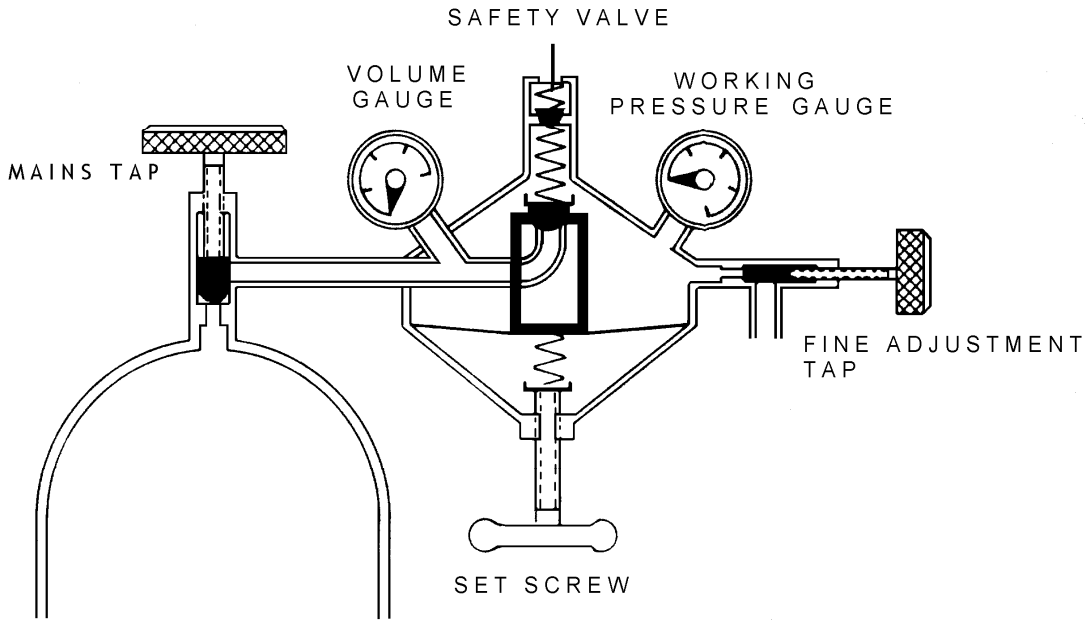


Diagram of a pressure reducer

Working with gas cylinders and their use:

Always follow these rules when using gas cylinders:

- every gas cylinder must clearly indicate the kind of gas it contains.
- when using gas cylinders, ensure that you have the correct hose clamps, couplings, pressure reducers, etc.
- the number of cylinders in the setup must be kept as low as possible.
- the piping linked to the gas cylinder must be as short as possible.
- check all the hose clamps, couplings, pressure reducers, etc. for leaks after turning on the gas cylinder and at regular intervals using a soap solution (e.g. Snoop).
- always stand gas cylinders vertically and protect them from falling over by securing them with a chain and brace.
- always leave the tap key on the gas cylinder.
- always use a pressure reducer that matches the type being used.
- never put the gas cylinder anywhere near sources of heat.
- after use, close off the gas cylinder and let the pressure escape from the pressure reducer.
- the head of the gas cylinder is very vulnerable; always put the cap on the cylinder when transporting it.
- when transporting a gas cylinder, always make use of a gas cylinder car closed with a brace or chain.
- never use oil/grease with turnbuckles or pressure reducers.

9.3. Working with cryogenic fluids

Cryogenic fluids can be divided into inert gases cooled to a fluid, such as nitrogen, helium and carbon dioxide (dry ice), and reactive gases cooled to a fluid, such as oxygen and hydrogen.
The building has centralized facilities to supply liquid nitrogen and helium. The facilities are indicated with the pictogram for low temperatures.

The transport and use of cryogenic fluids is subject to certain rules.

Transport

The transport of inert gases cooled to a fluid is permitted in the building on condition that:

- use is made of glass Dewar vessels of up to 5 litres or of metal Dewar or expansion vessels.
- lifts are not used to transport people and cryogenic fluids at the same time. It is forbidden to use lifts intended for people. There is a lift with external controls for transporting cryogenic fluids in building 18.
- it is **forbidden** to transport reactive gases cooled to a fluid in open vessels. These gases must be condensed at the work station.

Use

Cryogenic fluids can cause burns if they come into contact with skin or eyes.
Long-term inhalation of cold gases can lead to lung damage. Thus:

- never let cryogenic fluids come into contact with unprotected parts of the body.
- do not touch pipes etc. through which cryogenic fluids are flowing with your hands – they could freeze to them.
- always wear heat-isolating, roomy gloves, safety goggles and a face shield when working with cryogenic fluids.
- wear closed footwear with your trousers covering the shoes.

After evaporation, cryogenic fluids can ‘drive out’ the oxygen from the air. For example, remember that the evaporation of a litre of liquid nitrogen can produce about 700 litres of gaseous nitrogen. In a closed area, suffocation can occur quickly as a result of lack of oxygen. Thus:

- ensure that there is sufficient ventilation.
- if possible, do not expose liquid nitrogen to the air.
- do not pour cryogenic fluids but use draining equipment as much as possible.

When cryogenic fluids are used in a closed system, vaporization can cause unexpected pressure increases. Thus:

- when using open (Dewar) vessels, ensure that evaporating liquid can always escape from the storage vessel.
- closed Dewar vessels should preferably be equipped with double overpressure protection. This protection must be checked regularly.

When using liquid hydrogen or oxygen, there is a risk of fire. Thus:

- ensure that there are no sources of ignition nearby when working with liquid oxygen, liquid hydrogen or liquid air.
- prevent the creation of liquid oxygen when working with liquid nitrogen, helium or air.

9.4. Working with hoods

Hoods are one of the most important means to reduce exposure of the laboratory technician to gases and vapours. The sliding windows have safety glass installed and provide protection against splashes and small explosions.
The hoods are also essential for the general ventilation of the laboratories; in order to guarantee sufficient dissipation of air, polluted or otherwise, a number of the hoods are turned on permanently. The ventilation ratio of the rooms should generally be maintained at 6 h^{-1} . The ventilation ratio is the number of times per time unit that the air in the room is completely replaced. Rooms where large amounts of hazardous substances and/or a great deal of heat-producing equipment are worked with need a higher ventilation ratio. Specialized laboratories are subject to special regulations; for example, B and C laboratories must have a ventilation ratio of 8 h^{-1} according to the regulations for Radionuclide laboratories. The ventilation system maintains a slight underpressure in the laboratories as compared with the corridors and other surrounding areas so that pollution does not enter those surrounding areas.
The effectiveness of the performance of the hood depends on the installation, the location and the maintenance, but also on how it is used.
Users of the hoods must be able to see immediately whether it is working or not. The easiest way is to hold a piece of tissue paper in the window opening. You can get a better impression by measuring the air velocity in the opening. If you do not trust the hood, do not take any risks and have it measured. Most modern cupboards have a built-in flow meter.
When correctly placed and used, and with the right location and performance of the air supply, a linear air velocity of 0.25 m/s in the window is usually sufficient; if these conditions are not met then an air velocity of 0.4 m/s is recommended. The air velocity may not vary too much (no more than 20%) at different places in the window.

The performance of the hood can be affected by various causes:

- air movement in front of the hood can disturb the flow profile. This can allow polluted air to escape from the cupboard. The walking area should thus preferably be some way away from the cupboard. When working in the hood, avoid any unnecessary fast movements. The cupboard should not be installed near windows and doors that are frequently opened. The air supply should be as far away as possible from the cupboard.
- the hood window must stay closed as much as possible. When working in the cupboard, the sliding window is intended to protect your head at least. Always close the door during and after your work.
- the emptier the cupboard, the better it works. Extraction cannot function properly in a hood that is too full. Do not use functioning hoods as storage areas for equipment, chemicals or waste. Tidy the hood regularly and avoid unnecessary clutter.
- always construct assemblies as far to the back of the hood as possible. It goes without saying that you should avoid having to work with your head in the cupboard.
- large setups and objects may block the extractor process across the working surface. If necessary, raise them up on blocks of at least 10 cm.
- burners and hot air blowers can cause heat build-up and turbulence, resulting in polluted air escaping from the cupboard. Please use insulating sheaths and heat lamps where possible.
- a hood is not designed to extract dust particles or aerosols. When working with extremely toxic substances in the form of fine powders, you need to take extra measures, for example a glove box.
- the sliding window cannot withstand explosions. Extra measures are needed if there is a chance of explosion, such as a face shield or an explosion shield.

In case you have an experiment which needs to be continued during a longer time you need to fill a security card. So the hood will not autmatically be switched off. You can have these cards at the reception desk.

RIJKSUNIVERSITEIT GRONINGEN
FACULTEIT WISKUNDE EN NATUURWETENSCHAPPEN

AANLAATFORMULIER VOOR IN BEDRIJF STAANDE APPARATUUR
Security card for active equipment

Gebouwnummer *Buildingnumber*		Permanente opsstelling *Permanent preparation*	JA / NEE *YES / NO*
Ruimtenummer *Room number*			
Zuurkastnummer *Number Fumehood*		Tot datum *Till date*	
Opstelling aanlaten van datum *Leaf preparation on from date*			
Apparaat *Device*			

Gebruikte Chemicaliën, oplosmiddelen, reactieschema en bedrijfsomstandigheden
Used chemicals, solve resources, response diagram and circumstances

Namen en Synoniem *Names and synonymous*	

		1	2	3	4
Specifieke gevaren *Specific danger*	Gevaar voor gezondheid / *Danger for health*				
• Z.o.z. *See reverse side*	Brand gevaar / *Possibility for fire*				
	Reactie omstandigheden / *response circumstances*				

Noodstopprocedure *Emergency procedure*			
Naam *Name*		In geval van storing bellen *In case of disorder call*	
Naam ruimtebeheerder *Name administrator*		Handtekening *Signature*	

Breng 1 exemplaar naar de receptie / *bring one example to the reception desk.*
Houdt 1 exemplaar bij de opstelling / *Leaf one example at the preparatiopn*

Toelichting / *explanation*

1. Vul de kaart in zo duidelijk en volledig mogelijk, met balpoint en in tweevoud.
   Fill in de form as clear and complete as posible, written whith a balpoint and duplicate.

2. Er moeten maatregelen genomen zijn om calamiteiten te voorkomen, bijvoorbeeld:
   There has to be made some precaution measures to prevent calamities, for example:
   - Procesbeveiliging / *process guard*
   - Slijpstuk klemmen / …… *clamps*
   - Vloeistofopvangbak */ fluid relief barge*
   - Vastzetten slangen / *fixaded the hose*

3. Indien de invuller zelf niet in het bezit is van een telefoon, dient een naam van een terzake kundige te worden vermeld die wel telefonisch bereikbaar is.
   When the person who fills in this form does not have a telephone, must be mentioned a name of a skilled person who's telephone contactable is.

4. Het vakje "specifieke gevaren", dient naar eigen inzicht ingevuld te worden. Aan te raden is om enige veiligheisliteratuur door te nemen. Veiligheidsliteratuur (bibliotheek), die daarvoor gebruikt kan worden is:
   The box specific dangers, must be filled in to own insight. We advise to go through some safety literature, like:
   - SAXS "dangerous properties of industrial materials" (A8,5A)
   - HOMMEL, "Handbuch der gefahrlichenguter" (A8,54 I,II)
   - STEERE, "Handbook of laboratory (A8,8)

GEVAAR VOOR GEZONDHEID
0 = geen gevaar
1 = gering gevaar
2 = gevaarlijk
3 = uiterst gevaarlijk

DANGER FOR HEALTH
0 = no danger
1 = small danger
2 = dangerous
3 = extremely dangerous

BRANDGEVAAR
0 = geen brandgevaar
1 = brandgevaar bij verhitting
2 = brandgevaar bij normale verwarming
3 = brandgevaar bij alle temperaturen

DANGER OF FIRE
0 = no fire danger
1 = fire danger at warming
2 = fire danger at normal heating
3 = fire danger at all temperatures

REACTIEOMSTANDIGHEDEN
0 = geen reactiegevaar
1 = bij verhitting onstabiel
2 = heftige reactie
3 = explosiegevaar

RESPONSE CIRCUMSTANCES
0 = no response danger
1 = at warming up unstable
2 = extreem reaction
3 = explosion danger

- Bij 0 en 1 zijn geen uitgebreide voorzorgsmaatregelen nodig.
  At 0 and 1 no precaution measures are necessary.
- Bij 2 is het raadzaam veiligheidsliteratuur te raadplegen.
  At 2 is advisable consult safety literature.
- Bij 3 moet de ruimtebeheerder of de veiligheidsbeheerder van de vakgroep geraadpleegd worden.
  At 3 the administrator or the security administrator of the profession group must be consulted.

9.5. Working with autoclaves

An autoclave is used to sterilize tools, glassware and liquids at high temperatures and under high pressure. Careless use can lead to exposure to hot vapours or spurting liquids. Always follow the instructions for use.
Large autoclaves are checked once a year. This significantly reduces the risk of explosions as a result of high pressure. Table-top autoclaves are checked during manufacture and must bear the CE quality mark.

- the autoclave must never be heated or cooled too fast, nor should the pressure become too high. With too great a pressure, the sealed glassware in the autoclave can break and hot vapours or liquids can spurt out of the overpressure protection. If the autoclave is too full, the risks of this happening increase.
- never open the autoclave too soon. The glassware can shatter as a result of too fast or irregular cooling. The high pressure can cause hot vapours or liquids to escape and cause burns.
- use the correct glassware and check it in advance for damage.
- check the rubber stopcock regularly and prevent desiccation or damage.
- keep your face well out of the way when opening the autoclave. Always use heat-resistant gloves and goggles.
- never autoclave toxic substances in open glassware. Always clean glassware that is contaminated with toxic substances first.
- never autoclave radioactive biological waste but disinfect it with 70% alcohol and dispose of it as radioactive waste.

9.6. Personal protective devices

Standard: Safety goggles and lab coat

When working with chemicals, you must always wear safety goggles and a cotton laboratory coat.
Safety goggles are available in the lab for incidental visitors. 'Ordinary' glasses, even those with plastic lenses, do not provide sufficient protection against splattering chemicals that could get into your eyes over the top or round the sides of the glasses. If you wear glasses, use an attachment with side flaps when working with chemicals, or else prescription safety goggles. Special goggles are needed when working with lasers and other sources of non-ionizing radiation (UV/IR), depending on the wavelength of the light in question (see 'lasers').

A lab coat that buttons properly is adequate protection against splattering solutions and in the event of fire is easy to remove. It also prevents contamination via clothing. Lab coats should be washed regularly. It is not permitted to wear lab coats containing synthetic materials. These are highly flammable and the melted material can stick to skin. They can also become statically charged.

Sometimes: gloves

When working with very toxic, aggressive, carcinogenic or mutagenic substances, we recommend wearing gloves, disposable or not. However, do not forget that gloves only offer temporary protection against dangerous substances. Sooner or later they will penetrate, depending on the nature of the substance and the thickness and the material of the glove. In most situations, use of thin disposable gloves is sufficient. They are easier to use than thicker, more durable gloves. They are available in three sizes; always choose the right size and prevent damaging them with long nails or rings. The penetration rate for disposable gloves is low for many substances, in the order of a few minutes. Only use them for short periods, remove them after contamination and dispose of them correctly with the solid waste. The use of more durable gloves is preferably limited to long-term or regular work with specific chemicals. There are also special gloves available to protect the hands against high or low temperatures. Regular and long-term wearing of gloves can aggravate eczema

disorders. Latex (natural rubber or neoprene) gloves that can be worn under plastic or rubber gloves are recommended.
Bear the penetration time of the substances you are working with in mind when choosing the material of your gloves. The Chemiekaarten (section 'prevention') gives advice about the most effective materials. Disposable gloves of neoprene or PVA (polyvinylalcohol) offer reasonable protection against a large number of organic substances. The protection offered by natural rubber gloves, or those of polyethene, is less but often sufficient. PVC is in many cases not a good choice. Natural rubber, neoprene and PVC offer reasonable protection against watery solutions and diluted acids; PVA is not suitable for this nor for a number of polar solvents.
Table 9.6 gives the probable penetration times for a number of common chemicals through the materials listed.

Table 9.6: Penetration times (relative) for a number of substances in four materials

Penetration time in minutes:

SUBSTANCE/MATERIAL	NATURAL RUBBER (0.4 MM)	NEOPRENE (0.4 MM)	PVC (0.2 MM)	PVA (0.3 MM)
Acetone	1 – 10	1 – 10	< 1	1 – 10
Aniline	> 10	> 10	1 – 10	> 10
n-Butanol	1 – 10	> 10	1 – 10	> 10
Chloroform	< 1	1 – 10	< 1	> 10
Dichloromethane	< 1	< 1	< 1	> 10
Dimethyl formamide	> 10	> 10	< 1	1 – 10
Dimethyl sulphoxide	> 10	> 10	> 10	< 1
Dioxane	1 – 10	> 10	< 1	> 10
Ethanol	1 – 10	> 10	1 – 10	< 1
Phenol	> 10	> 10	> 10	1 – 10
n-Hexane	< 1	> 10	> 10	> 10
Methanol	1 – 10	> 10	1 – 10	1 – 10
Methyl ethyl ketone	1 – 10	1 – 10	< 1	1 – 10
Methyl iodide	< 1	< 1	< 1	< 1
Pyridine	< 1	> 10	< 1	1 – 10
Toluene	< 1	1 – 10	< 1	1 – 10
Tetrachloroethane	< 1	< 1	< 1	> 10
Water	> 10	> 10	> 10	< 1

Occasionally: special protective devices

Occasionally you may need special protective devices, such as face shields, hearing protectors or respiratory protection. Such protective devices are only used when, after careful assessment, prevention of or protection from the risk **at source** is not reasonably possible (see 'Strategy').

In most instances, lab ventilation and hoods, or if necessary a glove box, provide sufficient limitation of exposure to hazardous gases and vapours. When working with very hazardous substances in the form of finely ground powders, for example when grinding or sieving, respiratory protection should be considered. The wearing of safety shoes and safety helmets also falls into the category of occasional situations in laboratories.

10. TRANSPORT HAZARDS

10.1. Transportation of chemicals and chemical waste

It is permitted to transport solvents through corridors and in stairwells and lifts on condition that this occurs in closed glass flasks of between 1 and 3 litre capacity and use is made of a carrying basket or bucket. Larger amounts may only be transported in metal or synthetic vessels or in safety cans. It is forbidden to transport any chemical through the building in an open flask. For information about the collection dates for Chemical Waste, see the Store's Internet site:
http://www.fwn.rug.nl/magazijn/afval/

10.2. Transport of cryogenic substances

The transport of inert gases cooled to a fluid is permitted in the building on condition that:
- use is made of glass Dewar vessels of up to 5 litres or of metal Dewar or expansion vessels.
- lifts are not used to transport people and cryogenic fluids at the same time. It is forbidden to use lifts intended for people. There is a lift with external controls for transporting cryogenic fluids in building 18.
- it is **forbidden** to transport reactive gases cooled to a fluid in open vessels. These gases must be condensed at the work station.

10.3. Transport of gas cylinders

You must use the special transport trolleys. When storing gas cylinders, it is important to secure the transport trolleys against falling over with the help of a brace or chain.
We differentiate two types of cylinder. The size of the cylinder determines the way that the cylinder is transported:

- **small cylinders, so-called 'lecture bottles'**
- **cylinders whose contents are greater than 0.5 litre**

Cylinders smaller than 10 litres may be transported using an ordinary trolley.
Cylinders larger than 10 litres may only be transported using a cylinder trolley.
The main tap must be closed during transportation. The pressure reducer must be removed and the protective cap must be in place.

10.4. Transport of radioactive substances

All work with radioactive substances, including transportation, is forbidden without special permission. Always contact F. van der Horst, ext. 4831 or 95380.

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**,
(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**, 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**.

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**.
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**, 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_2SO_4, HNO_3, H_3PO_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_4OH, 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_2O_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**.

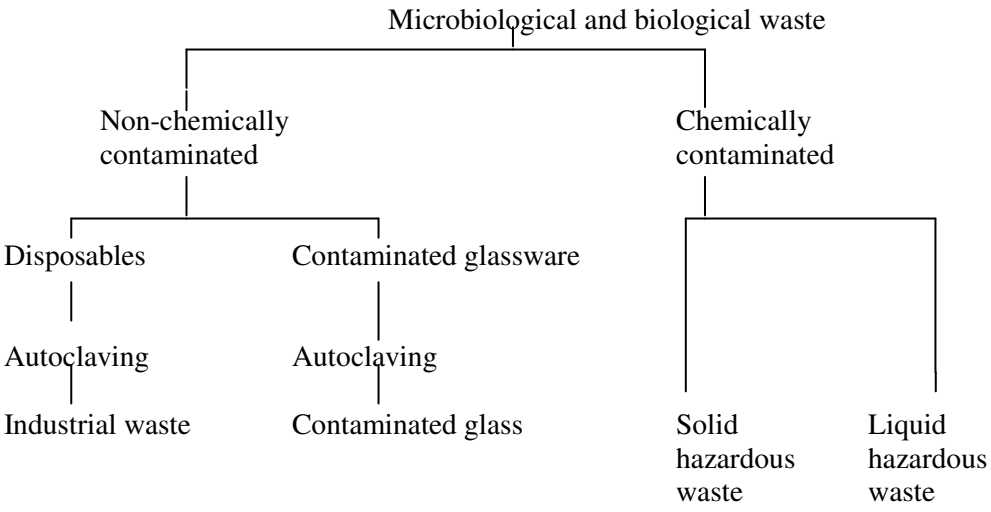
The Chemistry-Physics complex intends to introduce an automated system for managing chemicals. This is the result of provisions in the Working Conditions Act regarding the localization and stock management of toxic substances. The system will 'log out' empty chemicals packaging from the Store using the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



Non-chemically contaminated waste is microbiological or biological waste that contains no chemicals from categories 1 to 8 of the EURAL (Table 11.1). Chemically contaminated waste must be treated as hazardous waste and sorted into liquid and solid hazardous waste (see above). Injection needles go into the injection needle box, packaging materials and disposables go into the covered container after having been emptied, liquid waste goes into the correct category waste jerry can.

Non-chemically contaminated disposables (petri dishes, pipette points, cups, gloves, etc.) are autoclaved: thermal decontamination at at least 120 ºC and 1.5 bar overpressure for at least 20 minutes. Autoclaved waste is offered for disposal to the dump after collection in a container specially for this type of waste. Autoclaved waste must be clearly identified as such on its packaging when offered for disposal. The waste should be packed in plastic bags sealed with autoclave tape stating that it is autoclaved waste, the date and its origin. The person offering it must provide a statement that the autoclaved waste does not constitute a hazard to public health.

Non-chemically contaminated glassware must also be autoclaved and removed for recycling. If you have any questions, contact the Chemicals Store, ext. 4103, **b.t.f.bosma@rug.nl** or the VMT coordinator, **A.M.W.H. Thunnissen**, ext. 4380.

Cadavers and bedding waste

All animal products not suitable for human consumption, such as cadavers, organs and blood products which are no longer required for research, are removed in a Medibin and sent to the disposal company Van Gansewinkel, ext. 0512-858584.
This waste can be deposited at the waste depot on Tuesdays (twice a month – see list of dates) (5116-0002), between 9 a.m. and 12 noon at Nijenborgh 4 and should be reported to B. Bosma (ext. 4103).
Until its removal the Medibin is kept at -20˚C in a freezer in the climate room of the animal laboratory. The date of the next removal and the total weight of the Medibin is registered on the ingoing/outgoing list.
Additional animal products necessary for research must be stored in the -20˚C freezer at the animal laboratory and/or in the -80˚C freezer in laboratory 5116-0030.
Needles must be disposed of in a special container. Bedding waste must be disposed of as regular waste. It should be put into a big blue bag and thrown into the regular waste container.
Medibins and containers for needles can be picked up at the chemical store.

The persons responsible are:

- Christa Reitzema, e-mail: **reitzema@biomade.nl**, ext. 4109 en 4161 and
- Jarmila Smisterova. e-mail: **smisterova@biomade.nl**, ext. 4109.

Industrial waste

The Department of Environmental Protection in Central Services is responsible for the separation and removal of industrial waste. A number of substreams are collected separately for recycling. The remaining waste is disposed of via the compression container to the dump. Those items suitable for recycling or 'useful' processing include:

- paper
- clean glass
- metal (incl. furniture, equipment)
- clean plastic
- wood (incl. pallets)
- vegetable, fruit and garden waste

The Chemistry-Physics complex has facilities for the separate collection of paper (in the offices and next to the photocopiers) and glass ('clean' glassware in the laboratories). In consultation with the cleaning service, waste metal can be transported daily to a special container. It goes without saying that the metal must be free of chemicals, radioactivity or oil. Large quantities of clean plastic or metal can be disposed of separately after consultation with Central Services; contact Site Management for this (ext. 4827), email: **m.j.koekoek@rug.nl.**

Some substreams of waste created by work in the laboratories may be disposed of as Industrial Waste. However, it should be collected in separate sacks or containers and supplied with a label stating contents, origin and date. Prevent mixing with 'domestic' industrial waste. These substreams are:

- Some EURAL exceptions: 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 in the industrial waste.
- autoclaved microbiological and biological waste that is not chemically contaminated
- clean glassware

Waste prevention

Too much laboratory waste is money thrown away. Every year the Chemistry-Physics complex disposes of between 40 and 45 tons of hazardous waste, more than half of which is liquid waste. The costs vary according to the type of waste, but on average it costs at least EUR 1 per kilo. For some solvents, that is the same as their cost price. Despite these rising costs, the annual waste production in the complex is not decreasing. It is obviously not easy to realize waste prevention in the laboratories. However, there are a few starting points.

The first starting point is 'critical purchasing' of chemicals. A large package may seem cheaper, but if certain chemicals are only occasionally used, the chances are high that the major part of them will end up in the rubbish at a high cost. Tailor-made purchasing then becomes interesting, and at the same time prevents the creation of superfluous stock. Internal reuse is also among the possibilities.

'Critical use' of chemicals is a second point for attention. The scale of many experiments can or should be smaller. After all, chemical analyses or physical determinations need less and less specimen material. Experiments and analyses can be prepared using computer simulations.

'Critical use' can also be applied to glassware and disposables (pipette tips, cover glasses, petri dishes, etc.). The use of disposables in laboratories has increased sharply over the past few years, partly due to the automating of much laboratory work. One way to prevent waste, for example, is to use positive displacement pipettes (with a capillary) instead of disposable pipette points. Washable, preferably glass specimen bottles, cuvettes and the like are alternatives to disposable equipment.

If you have any questions or ideas, please contact the university Health, Safety and Environment Service, ext. 4575 or 8010, **d.jager@rug.nl.**

11.2. Emissions into water

Standards and regulations

Waste substances from laboratories are 'hazardous waste' in a legal sense and may not be discharged. The permit issued within the framework of the Surface Waters Contamination Act (Wvo) sets out standards for the maximum concentrations of a number of substances and substance groups in waste water (Table 11.2.A). In order to monitor this, the waste water in the central waste pipe (which connects to the main sewer) is regularly sampled and analysed by an external analysis bureau. Exceeding these standards can lead to fines and measures imposed by the relevant government body; for the University of Groningen chemical laboratories that is the district water board Waterschap Noorderzijlvest.
Substances on the so-called 'black list' may not be discharged at all, regardless of their concentration (Table 11.2.B).

In practice, a zero discharge policy is very difficult to achieve when dealing with extremely weak solutions of acids or bases. Some discharges are 'tolerated', as long as they are very low concentrations and small amounts (50-100 ml).

- diluted watery solutions (< 0.1 mol/l) of acids, bases, buffers and EDTA may be washed down the drain with water.
- watery solutions of alcohols with a concentration less than 15% v/v may be discharged, as long as practicable processing is possible. Be aware of additions that may damage the environment.
- because of the risk of explosion, acetone and ethyl acetate may only be discharged at a concentration of less than 5% v/v.

Table 11.2.A – Maximum percentages in a random sample according to the Wvo permit for the University of Groningen chemical laboratories

PARAMETER		STANDARD	
Hg	Mercury	**F O R B I D D E N !**	
Metal	Cadmium, chromium, copper, lead, zinc	3000	µg/l (aggregate)
Aromat	Benzene, toluene, ethyl benzene, xylenes, naphthalenes	100	µg/l (aggregate)
EOX	Extractable organic halogen compounds	100	µg/l (expressed as chlorine)
VOX	Volatile organic halogen compounds	100	µg/l/l (expressed as chlorine)

Table 11.2.B

RELEVANT SUBSTANCE GROUPS ON THE 'BLACK LIST' Discharges and emissions must be prevented with the 'best' existing technologies		
	WATER	**AIR**
METALS AND METAL COMPOUNDS		
Arsenic, cadmium, mercury	X	X
Chromium, lead		X
Organo tin compounds	X	
CHLORINATED HYDROCARBONS		
Dichloroethane, vinyl chloride	X	X
Chloromethanes, chloroethanes, chloroethenes (other)	X	
Chlorobenzenes, chlorotoluenes, chlorophenols	X	
Chloronitro and chloroamino compounds (aromatic)	X	
Chloronaphthalenes, chlorobiphenyls, chloroterphenyls	X	
Chlorinated pesticides	X	
AROMATIC HYDROCARBONS		
Benzene	X	X
Ethyl and isopropylbenzene, toluene, xylenes	X	
Biphenyl	X	
Polycyclic aromatics	X	
Mineral oil	X	
ORGANIC NITROGEN COMPOUNDS		
Acrylonitrile, hydrazine		X
Benzidine, diethyl amine and dimethyl amine	X	
ORGANOPHOSPHATES:		
Various pesticides	X	

Specific practice: chlorinated solvents

Experience has shown that the University of Groningen chemical laboratories are able to comply with most of the standards that the Wvo places on the quality of waste water (Table 11.2.A). Sadly there is one exception – volatile organic halogen compounds, particularly dichloromethane and chloroform. The standard for these substances is exceeded more often than the permit issuer can turn a blind eye to. The excesses are usually short 'peaks' resulting from careless use of these solvents. Clearly, people are not sufficiently aware that a small discharge is more than enough to exceed the standard and that chlorinated solvents, particularly dichloromethane, are reasonably soluble in water (dichloromethane 20 g/l, chloroform 8 g/l). Possible causes of discharges are:

- use of the waterjet pump
- disposal of the water phases of extractions and reactions media
- careless washing up.

In consultation with Waterschap Noorderzijlvest, we have drawn up rules for the use of chlorinated solvents. If these rules are obeyed, the laboratories can conform to the standard without any problem. If the problems remain and the threatened fines imposed, we shall have to strongly discourage the use of chlorinated solvents.

Rules for the use of chlorinated solvents

1. It is forbidden to use waterjet pumps when working with chlorinated solvents.
2. It is forbidden to use chlorinated solvents as extractors, unless it can be shown that no alternative extractor can be used. Ethyl acetate is often a suitable alternative.
3. It is forbidden to use chlorinated solvents as a reactions medium, unless it can be shown that no alternative reactions medium can be used.
4. No chlorinated solvents may be used during student practicals.
5. The aqueous fractions of extractions and reactions media that have been in contact with chlorinated solvents may not be washed down the drain. They must be disposed of as hazardous waste or extracted with an organic solvent (not chlorinated), after which the extract must be disposed of as hazardous waste.
6. Glassware that has been in contact with chlorinated solvents must be rinsed with acetone or alcohol during cleaning; the rinse liquid must be disposed of as hazardous waste.

11.3. Emissions into the air

Standards and regulations

Emissions of gases and vapours into the outside air mainly occurs through the ventilation channels of the hoods. The size of the emission is difficult to determine using chemical analyses – each hood has a separate channel, there is a wide diversity of volatile substances and the emissions are discontinuous. The air transported away is not cleaned.
Thus there are no strict numerical standards set out in the environmental permit (Environmental Protection Act). The premise of the permit is 'good housekeeping', which means that the formation and dissemination of damaging and irritating vapours, gases and particles is opposed by taking measures 'at source', at the work station. This applies in particular to substances on the 'black list' (Table 11.2.B) and to organic solvents in general. When the latter escape into the environment they contribute to the formation of photochemical smog.

Specific practice: organic solvents

More than 80% of the mass of the chemicals used annually in the laboratories are organic solvents. Part of this 'vanishes' into the air. According to a balance study of the purchase and disposal of solvents, this is a significant proportion – about 25% of the used volume.
Most of the emissions are attributable to a limited number of practices. These practices are suitable for measures in the fields of facilities and 'good housekeeping'.

Table 11.3: Sources of emissions and the effect of measures (% of the total solvent emission, indicative)

PRACTICE	EMISSION	MEASURE (RESULT)	REDUCTION
Cleaning glassware	25%	Centralized cleaning (90%)	23%
Environmental tanks (open/funnel)	22%	Flap on funnel (95%)	21%
Vacuum film evaporator	28%	Replacement/adaptation (58 %) Provisions/manual (25%)	16% 7%
Polymer precipitation	3%	Closed system (85%)	3%
Total	78%		70%

Tips for reducing solvent emissions:

- Keep bottles of solvents closed as much as possible. Cover beakers and other glassware containing solvents as much as possible.
- Keep the waste containers closed as much as possible. Use the lid or a sealable funnel.
- Dispose of the waste containers in time and prevent unnecessary storage in the hood.
- Keep the laboratory tables and the hood tidy. Do not let wet tissues, filters, etc. lie around. Never leave superfluous chemicals lying around.
- Wash up regularly and carefully. Use the centralized cleaning facilities as much as possible.

Use a vacuum pump with the rotary film evaporator, **the use of a waterjet pump is forbidden**. This also prevents chemical discharges and the use of drinking water.
Always check the correct temperature setting and do not press 'start' too soon.
Use a second cooling system after the vacuum.

Be particularly careful when using and choosing your solvents. Choosing a less volatile solvent can prevent emissions and exposure.

11.4. Using energy and water

Gas and electricity

Laboratories are among the large-volume users of gas and electricity by university buildings. The Chemistry and Physics complex is responsible for more than 30% of the total University of Groningen consumption of these two energy sources. The costs are staggering, over EURO 1.2 million per year, of which about EURO 1 million is for electricity alone (FB-VGI, Energy Annual Reports). There is great potential for savings here. The University has set out in a covenant that it is going to strive for significant energy savings in the coming years – 8% by 2010 (as compared with 1996, in GJ). The aims for new construction projects are even more ambitious.
A significant part of the energy use is determined by the construction of the building and the centralized facilities – heating, cooling and ventilation. There is little that an individual laboratory user can contribute to energy saving here, besides turning off the radiator and putting on a sweater. The Nijenborgh 4 complex dates from before the energy crisis of the 1970s and was certainly not built with energy conservation in mind. New construction work and renovation can realize great gains with careful selection and design of ventilation systems, hoods, heating, light, façade materials and the like.
This does not mean that a daily user of the lab can do nothing to reduce the power bills. One of the largest items in electricity use is lighting. Energy-saving bulbs, reflective fittings and time switches at places that are used extensively are highly recommended when replacing lighting. One other obvious thing – if a room is not in use, turn the light off. The same applies to computers, monitors and all types of equipment, both small and large. It's a bad habit to leave a PC on overnight. Heating equipment (ovens, insulating sheaths, etc.) should be paid special attention because of their high power levels. We do not recommend the use of electric heaters in the offices.

Water

The Nijenborgh 4 complex has managed to significantly reduce its water use in the past few years, from about 100,000 m^3 to about 31,000 m^3 in 2008. This was essential – the water use was comparable with that of a small urban district. With the rising costs for the purchase and disposal of water (2008: EURO 2,50/m^3), our investments in water-saving measures soon paid for themselves.
Among the heavy items for water use are the cooling of large pieces of equipment, the use of waterjet pumps and the cooling of reactions and distillations. 'Domestic use' was probably about 10%.
There is a closed cooling system for cooling large pieces of equipment. The savings in the past few years have mainly been achieved by revising this system. Various large-volume users who had changed to individual cooling using drinking water could be reattached to the system. So, if you have

any problems with the centralized cooling system, please let the in-house services department know and do not resort to the tap.
We estimate that the cooling of reactions and distillations takes about 200 litres of water per hour per setup. Water coolers are also an option – here the water circulates. The golden rule here too is don't let the tap run unnecessarily or too hard.

11.5. Use of paper

This does not apply specifically to the laboratories but it is an inescapable fact – the University uses mountains of paper. The University disposes of some 400 tons of paper waste per year (about 40% of the total waste production) and that amount has not significantly reduced since the advent of PCs and e-mail. It can all be reduced.

- use both sides of the paper in your notebook
- reuse waste paper for jotting
- use recycled paper
- use e-mail rather than paper post
- be critical of your use of the photocopier
- if possible, make reduced copies and/or double-sided copies
- if there are no facilities for this, ask for them – it's dogged that does it!
- collect paper waste separately.

APPENDICES

APPENDIX 1

EXTRAORDINARY HAZARDS (R and S PHRASES)

When applicable, these R and S codes are printed on the label attached to the substance or liquid.

R PHRASES (HAZARD INDICATION)

R 1 Explosive when dry
R 2 Risk of explosion by shock, friction, fire or other source of ignition
R 3 Extreme risk of explosion by shock, friction, fire or other source of ignition
R 4 Forms very sensitive explosive metallic compounds
R 5 Heating may cause an explosion
R 6 Explosive with or without contact with air
R 7 May cause fire
R 8 Contact with combustible material may cause fire
R 9 Explosive when mixed with combustible material
R10 Flammable
R11 Highly flammable
R12 Extremely flammable
R13 Extremely flammable liquefied gas
R14 Reacts violently with water
R15 Contact with water liberates extremely flammable gases
R16 Explosive when mixed with oxidizing material
R17 Spontaneously flammable in air
R18 In use, may form flammable/explosive vapour-air mixture
R19 May form explosive peroxides
R20 Harmful by inhalation
R21 Harmful in contact with skin
R22 Harmful if swallowed
R23 Toxic by inhalation
R24 Toxic in contact with skin
R25 Toxic if swallowed
R26 Very toxic by inhalation
R27 Very toxic in contact with skin
R28 Very toxic if swallowed
R29 Contact with water liberates toxic gases
R30 Can become highly flammable in use
R31 Contact with acids liberates toxic gas
R32 Contact with acids liberates very toxic gas
R33 Danger of cumulative effects
R34 Causes burns
R35 Causes severe burns
R36 Irritating to eyes
R37 Irritating to respiratory system
R38 Irritating to skin
R39 Danger of very serious irreversible effects
R40 Possible risk of irreversible effects
R42 May cause sensitization by inhalation
R43 May cause sensitization by skin contact
R44 Risk of explosion if heated under confinement

R45 May cause cancer
R46 May cause heritable genetic damage
R47 May cause birth defects
R48 Danger of serious damage to health by prolonged exposure

COMBINED R PHRASES

R14/15	Reacts violently with water liberating highly flammable gases
R15/29	Contact with water liberates toxic, highly flammable gas
R20/21	Harmful by inhalation and in contact with skin
R21/22	Harmful in contact with skin and if swallowed
R20/22	Harmful by inhalation and if swallowed
R20/21/22	Harmful by inhalation, in contact with skin and if swallowed
R23/24	Toxic by inhalation and in contact with skin
R24/25	Toxic in contact with skin and if swallowed
R23/25	Toxic by inhalation and if swallowed
R23/24/25	Toxic by inhalation, in contact with skin and if swallowed
R26/27	Very toxic by inhalation and in contact with skin
R27/28	Very toxic in contact with skin and if swallowed
R26/28	Very toxic by inhalation and if swallowed
R26/27/28	Very toxic by inhalation, in contact with skin and if swallowed
R36/37	Irritating to eyes and respiratory system
R37/38	Irritating to respiratory system and skin
R36/38	Irritating to eyes and skin
R36/37/38	Irritating to eyes, respiratory system and skin
R42/43	May cause sensitization by inhalation or in contact with skin

S PHRASES (SAFETY MEASURES DESIGNATION)

S 1	Keep locked up
S 2	Keep out of reach of children
S 3	Keep in a cool place
S 4	Keep away from living quarters
S 5	Keep contents under ... (appropriate liquid to be specified by the manufacturer)
S 6	Keep under ... (inert gas to be specified by the manufacturer)
S 7	Keep container tightly closed
S 8	Keep container dry
S 9	Keep container in a well-ventilated place
S12	Do not keep the container sealed
S13	Keep away from food, drink and animal foodstuffs
S14	Keep away from ... (incompatible materials to be indicated by the manufacturer)
S15	Keep away from heat
S16	Keep away from sources of ignition – do not smoke
S17	Keep away from combustible material
S18	Handle and open container with care
S20	When using do not eat or drink
S21	When using do not smoke
S22	Do not breathe dust
S23	Do not breathe gas/smoke/vapour/aerosol*
S24	Avoid contact with skin
S25	Avoid contact with eyes
S26	In case of contact with eyes, rinse immediately with plenty of water and seek medical advice

S27	Take off all contaminated clothing immediately
S28	After contact with skin, wash immediately with plenty of …….(to be specified by manufacturer)
S29	Do not empty into drains
S30	Never add water to this product
S33	Take precautionary measures against static discharges
S34	Avoid shock and friction
S35	This material and its container must be disposed of in a safe way
S36	Wear suitable protective clothing
S37	Wear suitable gloves
S38	In case of insufficient ventilation, wear suitable respiratory equipment
S39	Wear eye/face protection
S40	To clean the floor and all objects contaminated by this material, use ... (to be specified by the manufacturer)
S41	In case of fire and/or explosion, do not breathe fumes
S42	During fumigation/spraying, wear suitable respiratory equipment
S43	In case of fire use ……. (fire-fighting equipment to be specified by the manufacturer.) Should water increase the risks, add: Never use water
S44	If you feel unwell, seek medical advice (show the label where possible)
S45	In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible)
S46	If swallowed, seek medical advice immediately and show this container or label
S47	Keep at temperature not exceeding ... C° (to be specified by the manufacturer)
S48	Keep wetted with ... (appropriate material to be specified by the manufacturer)
S49	Keep only in the original container
S50	Do not mix with … (to be specified by the manufacturer)
S51	Use only in well-ventilated areas
S52	Not recommended for interior use on large surface areas
S53	Avoid exposure - obtain special instructions before use

COMBINED S PHRASES

S1/2	Keep locked up and out of reach of children
S3/9	Keep in a cool, well-ventilated place
S3/7/9	Keep container tightly closed in a cool, well-ventilated place
S7/9	Keep container tightly closed in a well-ventilated place
S7/8	Keep container tightly closed and dry
S20/21	When using do not eat, drink or smoke
S24/25	Avoid contact with skin and eyes
S36/37	Wear suitable protective clothing and gloves
S36/39	Wear suitable protective clothing and eye/face protection
S37/39	Wear suitable gloves and eye/face protection
S36/37/39	Wear suitable protective clothing, gloves and eye/face protection
S3/14	Keep in a cool place away from ... (incompatible materials to be indicated by the manufacturer)
S3/9/14	Keep in a cool, well-ventilated place away from ... (incompatible materials to be indicated by the manufacturer)

S3/9/49	Keep only in the original container in a cool, well-ventilated place
S3/9/14/49	Keep only in the original container in a cool, well-ventilated place away from ... (incompatible materials to be indicated by the manufacturer)
S47/49	Keep only in the original container at temperature not exceeding ... C° (to be specified by the manufacturer)

APPENDIX 2

HAZARDOUS REACTIONS WITH COMBINATIONS OF VARIOUS SUBSTANCES

ACETIC ACID	- Chromic acid
	- Nitric acid
	- Alcohols
	- Phenols
	- Perchloric acid
	- Peroxides
	- Permanganates
	- Ammonia
	- Chloroacetic acid
ACETONE	- Concentrated $HNO_3 + H_2SO_4$
	- HNO_3 + acetic acid
	- Hypobromite
	- Chloroform
	- Hydrogen peroxide
ACETYLENE = ETHYNE	- Chlorine
	- Bromine
	- Copper
	- Fluorine
	- Silver
	- Mercury
	- Iodine
	- Cu and Hg salts
	- Ag salts in NH_3
ACTIVE CARBON	- Hypochlorite
	- Oxidants
	- Ammonium nitrate
	- Chlorine monoxide
ALKALINE SOLUTION ALUMINIUM POWDER	- Zinc
	- Water
	- Chlorinated hydrocarbons
	CO_2 fire extinguisher
	- Halogens
	- Hydrogen cyanide
	- Carbon monoxide
AMMONIA	- Mercury
	- Chlorine
	- Hypochlorite
	- Iodine
	- Bromine
	- Anhydrous hydrogen fluoride
AMMONIUM NITRATE	- Acids
	- Metal powders
	- Flammable liquids
	- Chlorates
	- Nitrites
	- Sulphur
	- Organic compounds in powder form
	- Nitrates
	- Sulphides

ANILINE	- Nitric acid
	- Hydrogen peroxide
	- Ozone
	- Peroxides
BENZENE	- Sulphuric acid
	- Permanganates
BORON	- Acetylene
	- Ammonia
	- Benzene
	- Butadines
	- Butane
	- Carbides
	- Methane
	- Hydrogen
	- Turpentine
BROMINE	- Ammonia
	- Ethyne
	- Butadines
	- Butane
	- Methane
	- Propane
	- Hydrogen
	- Carbides
	- Turpentine
	- Benzene
	- Metal powder
	- Hydrocarbons
CALCIUM CARBIDE	- Water
	- Silver nitrate
	- Peroxides
CARBON	- See active carbon
CARBON DISULPHIDE	- Ether
	- Potassium chloride
	- Nitric acid
	- Manganese chloride
CHARCOAL	- See active carbon
CHLORATES	- Ammonia salts
	- Acids
	- Metal powders
	- Sulphur
	- Organic substances in powder form
	- Cyanides
	- Silver sulphide
CHLORINE	- See Bromine
CHLORINE OXIDE	- Ammonia
	- Methane
	- Phosphine
	- Hydrogen sulphide
	- Mercury
	- Organic substances
	- Sugar
	- Phosphides
CHLOROACETIC ACID	- Bismuth (alloys)
	- Acetic anhydride
	- Organic compounds
CHLOROFORM	- Acetone

	- Potassium
	- Sodium
CHROMIC ACID	- Acetic acid
	- Naphthalene
	- Camphor
	- Glycerol
	- Turpentine
	- Alcohol
	- Pyridine
	- Flammable liquids
COPPER	- Ethyne
	- Hydrogen peroxide
	- Chlorates
	- Bromates
	- Iodates
CUMENE HYDROPER- ACIDS	- Organic and anorganic acids
	- Flammable liquids
CYANIDES	- Acids
ETHANOL	- Manganites
	- Oxidizing acids
ETHYNE	- See Acetylene
FLUORIDE	- EVERYTHING
GLACIAL ACETIC ACID	- See acetic acid
GLYCEROL	- Manganese carbonate
HALAMID	- Sodium sulphate
	-
HALOGEN HYDROCARBONS	- Aluminium powder
	- Alkali metals
	- Magnesium
HYDROCARBONS	- Halogens
	- Chromic acid
	- Barium oxide
	- Sodium peroxide
HYDROGEN FLUORIDE	- Ammonia (gas or anhydrous solutions)
	- Phosphorus pentoxide
HYDROGEN PEROXIDE	- Various metals
	- Flammable liquids
IODINE	- Ethyne
	- Ammonia
	- Hydrogen
	- Phosphorus
MAGNESIUM POWDER	- See Aluminium powder
MERCURY	- Ethyne
	- Oxalic acid
	- Ammonia
	- Fulminic acid
	- Fulminates
NITRIC ACID	- Acetic acid
	- Aniline
	- Alcohols
	- Thiophene
	- Chromic acid
	- Hydrogen cyanide
	- Hydrogen sulphide
	- Flammable liquids

	- Flammable vapours
	- Nitrobenzene
	- Sulphates
	- Thiosulphate
	- Acetone
	- Metal powders
	- Hydrogen peroxide
	- Hydrogen sulphide
NITROBENZENE	- Nitric acid
ORGANIC SOLVENTS	- See flammable liquids
OXALIC ACID	- Mercury
	- Silver
	- Chlorates
	- Hypochlorates
PERCHLORATES	- Acids
	- Sulphides
	- Sulphites
PERCHLORIC ACID	- Acetic anhydride
	- Bismuth (alloys)
	- Alcohols
	- Paper
	- Wood
	- Charcoal
	- Ether
	- Organic substances
PERMANGANATES	- Glycerol
	- Benzaldehyde
	- Ethylene glycol
	- Sulphuric acid
	- Metal powders
PEROXIDES	- Ethanol
	- Methanol
	- Glacial acetic acid
	- Acetic anhydride
	- Benzaldehyde
	- Carbon disulphide
	- Glycerol
	- Ethylene glycol
	- Ethyl acetate
	- Methyl acetate
	- Furfural
	- Aniline
PHOSPHORUS (white/yellow)	- Air
	- Oxygen
	- Hydroxides
	- Ammonium nitrate
	- Potassium permanganate
	- Sulphur
	- Silver nitrate
PICRINIC ACID	- Heavy metals
	- Salts
POTASSIUM	- Bromine
	- Chlorine
	- Iodine
	- Hydrogen cyanide
	- Carbon monoxide

	- Carbon dioxide - Water - Halogen hydrocarbons - Carbon disulphide - Hydrochloric acid - Sulphuric acid - Hydrogen fluoride - Maleic anhydride - Ethyne - Silver halogenides
POTASSIUM SULPHIDE **SILVER (metal)**	- Diazo compounds - Acetylene - Oxalic acid - Tartaric acid - Fulminate - Ammonia compounds
SULPHURIC ACID	- Chlorates - Perchlorates - Permanganates - Carbides - Fulminates - Picrates - Metal powders

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I N D E X