Foreword

Safe and healthy working at FOM. It is something we can and must do! As an employer, FOM has to ensure it is possible. But you are also responsible, together with your line manager. In its working conditions legislation, the government has laid down rules for health, safety and well-being in the workplace. Such rules are necessary, yet far more important still is how FOM as an employer and you as an employee apply them in practice. And that is what this book is about.

Safe and healthy working is the responsibility of each and every individual. I therefore advise you to read this booklet carefully and to keep it to hand in your place of work. If you have any further questions, do not hesitate to consult your line manager or your local Health and Safety Officer. If situations arise that could affect your health and safety, please inform your line manager. Only by working together we can make and keep our workplaces safe and healthy.

This printed health and safety manual, which was completely revised by FOM’s Health and Safety Advisory Committee in 2015, only provides a snapshot. Health and safety issues are changing all the time, so the latest updates are published on the FOM website: www.fom.nl. Please make sure that you consult this on a regular basis.

Dr Christa Hooijer
Interim Director, FOM
Introduction

A healthy, safe and pleasant workplace

A safe and healthy working environment at FOM is not an option, it is a necessity. We as your employer have to provide it, but you also have responsibilities. This shared obligation to ensure health, safety and well-being at work is laid down in the Working Conditions Act (Arbowet).

Until the early 1980s, the Dutch government applied the principle that the best way to enforce workplace safety was by imposing rigid rules. Since then, however, new ideas have gained the upper hand. The government has taken a step back, defining only the basic principles of health and safety and leaving it up to the so-called "social partners" – the organizations representing employers and employees – to agree the details between themselves. This means that creating good, safe working conditions is much more of a customized, workplace-specific process than it used to be.

Not that the government has withdrawn completely. Through the Labour Inspectorate (Inspectie SZW), it continues to check that everyone is playing by the rules. As and when necessary, this body is empowered to take corrective action. It is good that there are laws in place to guarantee health and safety at work, but what is far more important is how these issues are addressed in practice. There has to be a true health and safety culture in the workplace.

This booklet is part of our effort to promote that culture at FOM. Everyone should read chapters 1-4. The rest provides information and tips about a wide range of issues, some general and others more specific. Take from this the material which is important to you.

You are responsible

Good working conditions are not a luxury! Everyone at FOM is responsible for ensuring that our Health and Safety Policy is properly applied in their own working environment. It is your health, safety and well-being which are at stake, and those of your colleagues.

The Working Conditions Act is founded upon the idea that managers and employees should work in unison to create a safe, healthy workplace. This confers both obligations and rights upon everyone.

The employer

The employer must have a sound Health and Safety Policy. This should clearly define everyone’s tasks in this respect, should ensure that the employer provides as healthy and safe a workplace as possible and should reserve sufficient time and resources for proper
implementation of the policy. The law also requires the employer to safeguard workers’ psychosocial well-being – that is, to protect them from sexual harassment, aggression, violence and so on.

**The employee**
As an employee, you have both rights and obligations. You have the right to:
- information and training about the risks associated with your work
- information about safety precautions and protective equipment
- information about how to use protective equipment properly (if the nature of your work requires this)
- discuss working conditions (for example, at regular team meetings)
- a regular medical examination, support and advice (from a specialist Health and Safety Service, for example) if your work involves health risks
- visit the company doctor if you suspect that your work has made you unwell
- complain about unsafe or unhealthy work situations; and,
- stop working in the event of imminent danger.

You are obliged to:
- work safely and ensure that you do not endanger your own health or that of others
- comply with safety procedures
- use safety devices, precautions and equipment correctly, and not interfere with them
- wear personal protective equipment if required to do so
- accept training and information; and,
- immediately report any unsafe or unhealthy situation to your supervisor.

**Information and instructions**
Good preparation is half the battle. Make sure you obtain the information you need and are up to date on essential matters. For example:
- the names and contact details of the Health and Safety Officers at your location
- emergency telephone numbers (first aid and fire)
- what to do in the event of an emergency
- alarm signals and how to respond to them
- evacuation routes and emergency exits; and,
- the specific safety regulations which apply in your own workplace.

Upon joining FOM, every employee receives information and instructions about the specific safety regulations applicable in their workplace. If you do not, then ask for them! Always acquaint yourself with possible risks from nearby departments, as well.

**Pregnancy and planning a baby**
Some types of work may pose an increased risk to pregnant women and/or their unborn children. To identify these at the earliest possible stage, FOM has a “Checklist for prospective, expectant, new and breastfeeding mothers” – ask your line manager or Health and Safety Officer for a copy. And make an appointment with your line manager as soon as you can, to discuss any necessary changes to your duties. This is your legal right, so use it!

**Psychosocial well-being**
The employer is obliged to take action to ensure that psychosocial issues do not affect the health and safety of its employees. For example, it must:
- provide work that is sufficiently challenging to promote your personal development
- limit the amount of monotonous work
- facilitate easy and effective communication with managers and colleagues
- prevent excessive stress or pressure caused by your work, your working conditions or the organization; and,
- protect you from sexual and other forms of harassment, aggression, violence and bullying.

**Risk assessment**
One of the main provisions of the Working Conditions Act is that every organization employing more than 25 people must conduct workplace risk assessments (Risico-inventarisatie en –evaluatie, RI&E). These determine if and how their working conditions pose a danger to employees’ health, safety and well-being. They also consider the extent of potential dangers and whether or not anything can be done to overcome them. Risk assessment is an ongoing process: a constant search for ways to improve working conditions, taking into account the latest scientific insights and available professional services.

The Plan of Action (Plan van aanpak) is an integral part of the risk assessment, containing specific objectives to be achieved and risk-reducing measures to be implemented within a specified period of time. Its progress is discussed regularly with the Works Council. The employer is required to make a copy of the risk assessment available to the Works Council and to give all employees the chance to familiarize themselves with it.
**Expert support**

The Working Conditions Act draws a distinction between active participation in promoting health and safety by every member of staff and specialist tasks. All employees are required to take as much responsibility as they can for preventive duties, but certain tasks have to be carried out by a qualified expert. Many organizations contract these out to external advisers, but at FOM we employ our own qualified health and safety specialists as far as possible.

**Depending upon where you work, the following expert support may be available.**

- a dedicated Health and Safety Officer or Service, either internal or external. They can answer any questions you may have about health and safety at work
- direct colleagues who have been assigned specific responsibility for workplace safety, and received special training. For example, Lab Safety Officers and Safety Supervisors
- a Company Doctor. You can consult them with personal work-related health problems, such as help during sick leave, as well as for regular medical check-ups and so on. You can obtain their details from your line manager, personnel manager or Health and Safety Officer. Note that the company doctor can only advise you on occupational health matters; they are not a substitute for your own GP.

If you are not sure who to contact or how to find them, e-mail safety@fom.nl and we will do our best to help you.

**From theory to practice**

This booklet is just a guide. By now you are broadly aware of the basics of the Working Conditions Act. Its underlying principles are co-operation and shared responsibility, and at FOM we implement our own Health and Safety Policy in the same spirit. For more information, see www.fom.nl/safety

Please now read those sections of the booklet dealing with matters relevant to you and your workplace.

Finally, consider this. Knowing the facts is important, of course, but with health and safety it is even more important to have the right frame of mind. To think safe and to act safe. If you adopt this mentality when reading this booklet and putting its advice into practice, then you really will make your workplace much safer.

And if you think your work could be made safer, healthier and more enjoyable, please let us know!
Chapter 1

General safety regulations

1. Always use your common sense at work. Take all reasonable precautions to guarantee your own safety and that of others.

2. The supervisor ensures that everyone in their group works in a safe manner and that new employees are made aware of any possible dangers related to their work.

3. Work safely and make sure you are familiar with the regulations in force in your workplace, including those governing overtime.

4. Observe the safety procedures applicable in the workplace, and use the required personal protective equipment. These are usually indicated by signs at the entrance.

5. If you see a dangerous situation or a breach of the safety rules, act immediately to rectify it! Report situations or activities that cannot be improved there and then to your line manager, supervisor or Health and Safety Officer, without delay.

6. Do not perform high-risk tasks alone. This is prohibited unless unavoidable. Arrange to have a colleague present, either by prior agreement or by the way the workplace is organized, so that help is available immediately in the event of an emergency.

7. Ensure that experimental equipment and systems are safe by design, including fail safe and fire safe, and do not pose a danger to the user or anyone else. For more details, consult the FOM guidelines “Proactive approach for Safety and Environment for new scientific projects”.

8. Do not bypass safety devices or shortcut procedures. This is strictly forbidden.

9. At the end of the working day, make sure that the equipment you are responsible for has been made absolutely safe. Only leave equipment unsupervised if the relevant emergency procedures are displayed clearly. These must include information about the location of the main switch(es) or lock(s) and the equipment owner. Find out about what arrangements are in place in your workplace.

10. Switch off all electrical equipment when not in use.
Every FOM site has an emergency response team. In the event of an emergency, its members will issue instructions which must be followed. Familiarize yourself with the alarms, evacuation routes and the emergency exits in your workplace. Report all accidents and near misses, so that their causes can be analysed and lessons learnt.

Introduction
An accident, fire or other disaster can have a huge impact upon all those affected by it. To prevent such incidents, as well as to reduce the risks they pose and to learn from them, every FOM site has an emergency response team.

Always think about your own safety and that of your colleagues. To request help, call the emergency number or alert the emergency response team.

Fire
Fire occurs when flames are able to sustain themselves. If kept under control, this need not present an immediate danger. But the alarm should be raised whenever a fire occurs unexpectedly or is out of control.

In the event of fire
- always raise the alarm FIRST
- follow the instructions displayed prominently throughout the building. Read the instructions carefully on a regular basis – you will not have time to do so when a fire breaks out!
- evacuate everyone in the vicinity of the blaze
- when trying to extinguish a small fire, always put your own safety and that of your colleagues first. Use the nearest extinguisher to tackle the blaze: that is most likely to be the correct type for it. Only the emergency response team is allowed to use the fire hoses
- leave the building when instructed to do so by the emergency response team. Follow the marked evacuation route (green signs) to the nearest emergency exit.

Extinguishers
There are several different types of extinguisher, for different types of fire. Make sure you are using the right one for the fire you are tackling. Using the wrong type can be highly dangerous! If you are in any doubt, leave it to a trained member of the emergency response team.
The most common forms of firefighting equipment in a research environment are…
• extinguishers (carbon dioxide, powder or AFFF)
• fire hoses
• fire blankets.
A fire blanket can be used to put out burning clothes or a small fire by smothering the flames.

Fire prevention
Prevention aims to ensure that people stay safe and healthy by not being exposed to danger in the first place. It also means pre-empting risk and acting as soon as the first signs of a problem appear.

How to prevent fires
• work in such a way that the risk of fire is kept to a minimum, including when conducting experiments
• when working with flammable or explosive substances, keep to the absolute minimum necessary amount. If possible, use gas detection
• when working with flammable substances, welding equipment or burners, always keep a suitable fire extinguisher within easy reach
• do not store combustible packaging material (polystyrene foam, cardboard, etc.) in rooms and corridors
• report hazardous situations to your line manager, supervisor or Health and Safety Officer, without delay
• use all protective safeguards provided.

Occupational accident
An occupational accident is a work-related incident that results in a person suffering injury and/or requiring time off work or, in the worst case, in death.

If you are involved in an occupational accident or a "near miss":
• report the incident to your line manager, supervisor and/or Health and Safety Officer. Each institute or laboratory has a different procedure for this. In consultation with you, all necessary measures will be taken to remove the cause, to prevent any recurrence and to reduce associated risks
• your Health and Safety Officer draws up a report for the accident registers of your own institute and FOM as a whole
• your team leader notifies FOM through your personnel officer
• in the case of a serious incident involving hospital admission, a chance of permanent physical or mental injury or death, your Health and Safety Officer immediately notifies the Labour Inspectorate (Inspectie SZW) by telephone, e-mail or fax. The scene of the accident is cordoned off and secured for investigation.
Chapter 3

Screen work

Working with screens has become an integral part of our lives. But it can lead to a variety of health problems, with repetitive strain injury (RSI) being the best-known. If you do not act in time, occasional symptoms may develop into chronic medical conditions.

Risks

Screen work can result in many physical problems. These are usually referred to collectively as repetitive strain injury (RSI) or complaints of the arms, neck and shoulders (CANS). RSI is an umbrella term for complaints affecting the hands, wrists, elbows, shoulders or neck, resulting from bad posture, repetitive movement or even a lack of movement (static posture).

RSI usually arises when a person frequently repeats a certain "unnatural" movement over a long period of time, often in combination with pressure of work and stress. The most common cause is spending extended sessions at a computer, with the arm, neck and shoulder muscles permanently tensed.

Possible causes

Factors which can encourage the development of RSI

Tasks
- pressure of work.
- type of tasks performed.

Workstation
- monitor, keyboard and mouse
- chair, desk and accessories
- workstation arrangement and organization.

Personal circumstances.

RSI seems to appear mainly after relatively short bursts of high-pressure activity rather than long periods of work under less pressure. Stress and pressure of work are important factors in its development, more so than the ergonomic quality of the workplace.

Working situation
- posture
- working methods.

Work environment
- amount of light
- indoor climate.
How to prevent complaints
Ensuring that your work is varied and avoiding pressure “peaks” are crucial to the prevention of physical complaints.
• try to stay relaxed at work, both mentally and physically
• avoid using the computer continuously for long periods – at home as well as at work!
  Take short screen breaks and move around
• do not skip these screen breaks, even when you are under pressure
• stand up regularly and walk around. If you need something from the printer, the storeroom or the coffee machine, fetch it yourself!
• ask for expert advice about specific software and seek help if you experience software problems

Workplace test
Everyone who works with a computer should undergo a workplace test conducted by a preventive health expert – preferably as soon as they join FOM, not once complaints have already arisen. This test checks:
• that your chair, desk and screen are adjusted correctly for you
• that your working environment is suitable (daylight and artificial light, reflections, sunshades)
• whether you need any desktop accessories (document holder, ergonomic keyboard or a special mouse)
• your posture and whether you need any aids to improve it (armrest, footrest).

If you operate a laptop or notebook at your workstation for more than two hours a day, it is better to place it on a stand and use a separate screen, keyboard and mouse.

The ideal computer workstation
Not everyone is the same height or has the same physical proportions. So configuring a workstation is a very personal matter. But there are some basic rules of thumb:
• the furniture should be suitable for computer work, and adjusted to the user’s size and physique. Properly adjust the monitor, too
• there should be sufficient room all around the workstation, with no obstacles on or under the desk
• always sit directly facing the screen
• your eyes should be between 50 and 70 centimetres from the screen
• there should be little light contrast between the monitor and the surrounding area
• no daylight or indoor lighting should reflect onto the screen.

Your posture
A good posture eases the burden on your body. During screen work:
• your back should be upright and the vertebrae in a straight vertical line
• your head should be aligned with your back and not have the tendency to lean forward
• your knees should be at an angle of at least 90°, as should your elbows
• you should keep your fingers relaxed while typing (the keyboard only requires a light touch)
• your wrists should be relaxed and your hands should not be at an angle to the arms (fold away the feet under the keyboard and do not use a wrist support)
• change your position regularly.

Your eyesight
If you suffer headaches, blurred vision or other eyesight problems during screen work, computer glasses may help. These have a longer focal length than reading glasses (50-70 cm). Moreover, reading glasses or multifocals can strain the neck. If you need computer glasses, FOM will cover all or part of the cost.

Contact
If you have any questions about RSI or workstation ergonomics, contact the preventive health experts or the Health and Safety Officer. If you think you have symptoms of RSI, contact the company doctor. The Central Personnel Department (cpd@fom.nl) can direct you to the doctor for your location.

FURTHER READING
• www.fom.nl/safety
• www.wvoi.nl -- arbocatalogus --> Occupational Health and Safety Catalogue for Research Institutes
• www.arbokennisnet.nl --> kennisdossiers --> RSI en Beeldschermwerk
• Arbo Informatieblad 2 - Werken met beeldschermen, Sdu Uitgevers
When carrying out scientific research, new experimental setups are often assembled in to test hypotheses. These sometimes use only off-the-shelf equipment bearing the CE safety mark, but often devices have to be modified or built from scratch by the researchers or the instrument workshop. In these cases the personnel concerned are considered the equipment’s manufacturer and the research group is responsible for its safety.

**Experimental setups**

It is very difficult to define an experimental setup or assembly exactly. In general, however, they can be divided into two categories.

1. those with some associated risks, which can be reduced to an acceptable level by taking standard health and safety precautions such as observing normal lab and hygiene rules. This applies, for example, to setups involving small quantities of hazardous substances and using simple tools and machinery.

2. new setups and those with associated risks which cannot be reduced to an acceptable level by taking standard health and safety precautions. These can only be used after additional safeguards have been put in place. Examples include setups involving moving or cutting parts, potential exposure to significant quantities of hazardous substances, lasers, highly toxic substances, very hot components, high noise levels and high pressure.

Because of their experimental nature, these setups are also likely to be changed over time. This further complicates compliance with all the statutory safety requirements.

**Risk assessment**

Under the Working Conditions Act, experimental setups must undergo a risk assessment before use. This applies equally whether they have been constructed in-house, bought off the shelf or taken over from other researchers. In all of these cases:

- the risks must be assessed in a systematic manner
- where necessary, additional health and safety precautions must be put in place; and,
- any residual risks must be deemed acceptable.

By considering health, safety and licensing requirements from an early stage, risks can be tackled at source and applications expedited. For this reason, an initial risk assessment is conducted during the planning phase and measures are taken immediately to mitigate those identified. In this way, many safety issues are tackled before the project proper begins.
Aspects to consider in this respect range from environmental regulations to the rules for working with genetically modified organisms (GMOs) and restrictions under the Nuclear Energy Act (Kernenergien wet).

Aim
By considering health, safety and the environment from the planning stage of a project onwards, we ensure that:
- delays associated with statutory obligations, such as licence applications, are minimized
- workplace health and safety are enhanced and the risk of accidents reduced
- the associated costs can be included in the budget from the outset
- fewer unforeseen health and safety costs are incurred and operational reliability increases.

Tips
- a dedicated person responsible for health and safety is appointed for each project. This is often, but not necessarily, the project leader. The appointment is made by the institute’s director, or by the management team on his or her behalf
- the Health and Safety Officer is informed of each project as soon as it is initiated. He or she advises and supports the designated person responsible for health and safety
- highly toxic, explosive or reactive substances must be kept in specially designated areas
- consider any risks that might arise in unforeseen circumstances, such as interruptions to the power, water or ventilation supply
- if necessary, notify security and the emergency response team of any preventive or responsive measures adopted
- check that the facilities in the intended research location are suitable for the proposed setup. Consider such factors as emergency arrangements, storage of hazardous substances, explosion-proof electrical systems, adequate ventilation and access by unauthorized persons.

By assessing the potential risks associated with an experimental setup in a systematic and multidisciplinary fashion, the great majority can be tackled at an early stage in the project. And by doing this consistently with every new setup, we as an organization gain more and more expertise in risk assessment each time we conduct one.

The FOM institutes have a procedure in place for assessing the potential risks of new scientific projects. At many university research groups, too, it is standard practice to evaluate experimental work in advance and to discuss the findings with the Health and Safety Officer.

Further Reading
- www.fom.nl/safety
- Proactive approach for Safety and Environment for new scientific projects, Health and Safety Advisory Committee of the FOM Foundation 2012
- Checklist voor technische proefopstellingen en/of projecten, Good Practice 6, Arbo catalogus Nederlandse Universiteiten (VSNU)
Chapter 5
Working with machinery

By machinery we here mean all powered equipment, tools and other devices used when conducting research. These are subject to strict safety rules. Safely designed machinery is a good start, but it is also essential to use it safely. Working with machinery is allowed only if you have the required expertise. Otherwise, either leave it to someone else or obtain proper instruction.

Introduction
There are numerous safety risks associated with the use of powered machinery.

- electrocution from contact with live elements
- physical injury (cuts, pinching, crushing) from contact with moving parts
- hearing loss
- burns, fire and explosion due to overheating and sparking.

To use machinery safely, it is important to observe a number of basic precautions:

- shield moving parts which could cause physical injury
- make sure the device has an emergency stop button – this is compulsory
- make sure the device cannot switch itself on again after an interruption to the power supply
- never remove, bypass or tamper with safety measures.

New machinery must comply with European safety requirements (under the EU Machinery Directive) and bear the CE mark. The manufacturer or importer is responsible for this. Machinery you construct or modify yourself must meet exactly the same safety requirements, although CE marking is not needed if the device is solely for your own use. For all machinery, a Dutch-language instruction manual and a technical construction file must be available.

Clothing
To be safe, dress safely. That means:

- wear close-fitting clothes
- do not work wearing loose items of clothing (such as a wide jumper, open jacket or loose belt)
- wear appropriate closed footwear in areas where machinery is located (no trainers or sandals) Safety shoes are obtainable from your supervisor or Health and Safety Officer.
Safety regulations
Most machine work takes place in laboratories and the instrument workshop. Naturally, each type of machinery poses its own risks, as do related tasks like welding and spraying. These can include exposure to contaminated air (welding fumes, cutting fluid, exhaust gases), light and heat radiation or noise, as well as physical dangers (lifting, standing for lengthy periods).

When working with machinery, a number of basic rules apply:
• leave maintenance of machinery and equipment to authorized and qualified personnel
• never carry out maintenance on moving parts
• when replacing belts or gearwheels, or during repairs, switch off the machine in such a way that there is no possibility it can be switched on again unexpectedly
• shield moving parts (axles, belts, gearwheels, etc.)
• properly shield grinder wheels, with a gap of at least 3 mm between the support and the wheel
• when grinding small items, never use gloves or a cleaning cloth
• keep the area around the machinery clean and free of obstacles
• use clamps when drilling
• use a swarf hook to remove metal splinters.
• always use a brush to clean machinery, never a pneumatic gun. Compressed air can blow metal splinters into people’s eyes, or further into the bearings you are trying to remove them from! Moreover, they are so loud they can damage your hearing
• only operate machinery as described in the instruction manual, and always use the prescribed personal protective equipment
• immediately report any defects or breakdowns to your supervisor, even if you are able to fix them yourself.

Personal protection
• always wear close-fitting clothes and safety glasses
• protect long hair from moving parts: wear a hairnet or ponytail
• do not wear jewellery (rings, bracelets or necklaces) – it can become caught in the machinery
• always wear safety glasses in areas where machinery is situated
• when using a grinder, wear safety glasses even if it is fitted with an eye shield
• wear hearing protectors whenever there are excessive or damaging levels of noise.

FURTHER READING
• www.fom.nl/safety
• www.arbokennisnet.nl --> kennisdossiers --> machineveiligheid
• Arbo Informatieblad 11 - Machineveiligheid: afschermingen en beveiligingen, Sdu Uitgevers
• Arbo Informatieblad SB - Machineveiligheid bij aanschaf en ingebruikname van nieuwe en gebruikt machines, Sdu Uitgevers
Chapter 6
Hoisting, lifting and internal transport

This chapter summarizes the safety rules and guidelines for moving heavy loads, both horizontally and vertically. Strict regulations apply to the safety, maintenance, testing and inspection of hoisting and lifting equipment. Users must be suitably trained and must receive prior authorization from their supervisor.

Introduction
Hoisting and lifting equipment is used to move loads vertically. To do so is to defy gravity, so there is always a risk that the load will fall unexpectedly. Such falls may be caused by...

- defective equipment
- incorrect use of the equipment
- overloading
- breakage of the load
- an unstable or shifting load
- an unstable supporting floor or gantry
- weather conditions.

To prevent incidents caused by these factors, various statutory requirements for hoisting and lifting have been imposed based upon past experiences.

Bystanders
Bystanders and passers-by in areas where hoisting and lifting work is under way are also at risk. To stay safe:

- heed safety notices and do not enter cordoned-off areas
- never pass underneath a suspended object
- follow all instructions given by authorized personnel
- for more information about lifting and hoisting, contact your Health and Safety Officer.
**Hoisting**
The key to safe hoisting is choosing the right equipment. Before starting the job, assess the risks involved and take appropriate precautions to minimize them. This assessment should also determine which equipment to use. During the job itself, the following rules apply:
- always observe the procedures in place at the hoisting site
- always note the maximum loads of the equipment and all accessories
- only use equipment and accessories for their intended purpose
- consider your own safety: Always use the prescribed personal protective equipment, such as helmets, shoes and gloves
- consider the safety of others: Cordon off the area and place safety notices
- safeguard open hatches. Cordon them off and place safety notices before opening them
- if the task cannot be carried out by following the standard procedure, compile an alternative which ensures everybody’s safety
- any equipment made in-house must be tested and approved before use
- before starting work, make absolutely sure that all equipment is in proper working order: Report any defects or doubts to your supervisor
- ensure that accessories like sling belts, trestles, clamps, chains and shackles are replaced regularly
- all hoisting equipment must be inspected regularly. Use only approved items.

**Lifting**
Observe the following rules for safe lifting.
- use only suitable equipment in good working order (pallet trucks, forklifts, scissor lifts, mobile hoisting gins)
- all lifting equipment must be maintained and inspected regularly.

**Internal transport**
Observe the following rules for the safe internal transport of large loads.
- use only suitable, approved equipment in good working order
- if using a forklift, the operator must hold a forklift licence
- stack materials for transport safely, making sure that no parts are projecting
- tailor your speed to the circumstances and the weight of your load
- never use a pallet truck to carry people.

**Inspection and maintenance**
Like all machinery, hoisting, lifting and internal transport equipment must be safe to use. Regular inspections are carried out to confirm this.
- before using any equipment, check that it is safe
- some equipment must be inspected regularly by a qualified expert
- the inspection checks that the equipment can reasonably be expected to remain safe until the next inspection is due
- when using such equipment, check when it was last inspected and for how long the approval is valid. Equipment not subject to a regular inspection and maintenance regime cannot always be guaranteed to be safe.

**FURTHER READING**
- www.fom.nl/safety
- www.arbokennisnet.nl --> kennisdossiers --> werkleuk:<br>transportmiddelen
- Arbo Informatieblad 17 - Hijs- en hefmiddelen, Sdu Uitgevers
Work at height is any working activity more than 2.5 metres above the ground. The greatest risk it poses is falling. This can be reduced by using protective barriers (fencing, railings) and well-maintained, approved equipment (scaffolding, ladders, fall arrest systems).

**Introduction**
The scale of an experiment, or the need to reach certain equipment or areas, sometimes necessitates work at height. The associated risks can be reduced or eliminated by using the correct equipment and making sound working agreements.

**General rules**
- before use, check all equipment for defects
- make sure the equipment is regularly maintained and inspected by experts
- make sure the equipment is placed on a stable, even surface
- if any equipment is placed in front of a door, make sure that it cannot be used
- take care when working in the vicinity of live electrical systems. Keep the equipment at least two metres away from them
- wear safe footwear, preferably with treaded soles
- if there is any risk of banging your head, wear a safety helmet
- when working in very high locations that are difficult to make safe, wear a safety belt.

**Stepladders**
- make sure that stepladders are fully opened
- do not use the top step if you are unable to hold onto anything
- stepladders with a platform must be fitted with a support bracket measuring at least 60 centimetres.
The principle risks of scaffolding work are:

- falls, especially through the hatch or when ascending or descending
- collapse due to overloading
- toppling on uneven or unstable ground or due to inadequate ground and wall anchoring.

**Work on flat roofs**

No edge protection is required if work being carried out on flat roofs is more than four metres from the edge and both the working area and its access routes are clearly marked. Otherwise, protective measures must be put in place. These may consist of:

- a permanent fence or railing
- a temporary fence
- the use of safety lines and belts.

If a flat roof is accessed by ladder, make sure that this is secured at the top with safety brackets to prevent it toppling or falling.

**Ladders**

A ladder is not a place of work, it is just a means to reach a high point. If the job is lengthy or complicated, use a hydraulic lift instead.

- a ladder should only be used up to 10 metres from the ground
- ladders should be placed at an angle of approximately 70° to the ground. (To test this, stand upright with your toes against the base of the ladder. You should just be able to hold the ladder with outstretched arms.)
- prevent the ladder from sliding (safety brackets) or use one with intact ladder shoes
- lean ladders against a firm, sturdy surface
- do not lean too far to one side. Work only as far as you can reach comfortably
- use a ladder of the correct height. It should extend at least one metre beyond the point at which you are working
- tie the adjustment rope of an extension ladder to one of the rungs. The overlap between the two sections should be at least two rungs
- never climb beyond the second hinge of a three-part combination ladder being used as a stepladder.

**Scaffolding**

Scaffolding is a system of interconnected steel pipes or frames, which may only be assembled by qualified persons. Preassembled tower scaffolds, with or without wheels, are also widely used. When using either type, make sure that it is stable and that the ground underneath is solid and even. If wheels are fitted, lock or lift them. Be aware of potential dangers in the vicinity (doors, passers-by) and use the stabilization aids provided. Ascend and descend the scaffolding on the inside, through the hatch in the working platform.
Electricity is an indispensable part of our lives. No organization or company can do without it—all have electrical installations and systems, machinery or equipment. Electricity is generally a safe form of energy, but there are risks—almost all of which can be eliminated by taking proper precautions. For this reason, there are strict rules governing the design of all electrical systems and work on them. We divide these systems into electrical installations, meaning everything from the main fuse to the power socket, and electrical equipment: all systems and machinery powered through the socket.

**Risks**
Working with electricity entails a number of risks, especially:
- Injury or death by electrocution
- Arcing and fire caused by short circuits
- Fire due to overloading

**Electrical installations**
Electrical installations and appliances must comply with Dutch standards (NEN 1010 for the construction of low-voltage installations; NEN-EN 50110-3140 for the use of both high and low-voltage installations and appliances). Electrical work on installations and equipment must be carried out by qualified personnel. In a safe installation, it is not physically possible to touch live parts.

**Tests**
Electrical equipment means any workplace appliance or device fitted with a plug and so connectable to an electrical installation. All such equipment must bear the CE safety mark, indicating that it complies with the low-voltage guidelines, or—if produced before 1995, when the mark was made compulsory—comply with relevant regulations under the Commodities Act (Warenwet).

Electrical devices are dangerous if metal parts become live as a result of a defect. For that reason, equipment should undergo regular safety inspections. Ask your Health and Safety Officer how frequently these are required. The inspection procedures are described in standard NEN 3140. Experimental equipment must also comply with NEN 3140. Power tools need to be checked regularly, too. The next inspection date should be given on the device itself.
Disconnection
Maintenance, repair and other work on live installations and equipment is strictly prohibited.
• low voltage (batteries etc.): detach the cable linked to the chassis
• mains voltage (230 V): cut off the power using the main switch, by pulling out the plug or by removing and retaining the fuses. Always leave a note, with your name on it, warning that the device must not be reconnected to the power supply
• high voltage (alternating current: >1000 V effective between two phases or >600V between one phase and earth; direct current: >1500V between two poles or >900 V between one pole and earth): cut off the power supply in the same way as with mains voltage devices, but remember that this does not guarantee that there are no live parts. For example, some capacitors can retain their charge for weeks. For this reason, electrical parts should be made safe with a reliable earthing rod. Make a clearly visible earth connection and, if necessary, keep capacitors shorted.

FURTHER READING
• www.fom.nl/safety
• www.wvoi.nl ---> Occupational Health and Safety Catalogue for Research Institutes ---> electricity
• www.arbokennisnet.nl ---> kennisdossiers ---> elektrische veiligheid
• Arbo Informatieblad 54 - Elektrische veiligheid, Sdu Uitgevers
Hazardous substances are chemicals and other materials which pose a risk to human health and safety. These substances can be identified from the warning symbols on their labels. Some present an immediate danger (fire, explosion, asphyxiation, etc.), whilst others have a medium to long-term effect (irritants, carcinogens, reprotoxins, mutagens, etc.). To work safely with any hazardous substance, it is important to be aware of its specific dangers. For advice, ask your supervisor, line manager, Health and Safety Officer or another expert.

Introduction
By their very nature, hazardous substances pose a threat to human health and safety or the environment. They can include:
• chemicals and other materials used in laboratory or production work
• products generated during work processes, sometimes unintentionally – for example, diesel fumes, wood dust, sealant fumes, welding fumes and toner particles and ozone from laser printers.

Hazardous substances come in many forms: gases, vapours, mists, smoke, dust clouds, liquids and solids. Whether a person is actually exposed to any of these is irrelevant to its definition as “hazardous”.

The characteristics of a substance are described in its “hazard classification” under the European classification, labelling and packaging (CLP) regulations, which in turn are derived from the EU Regulations on the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH). The official hazard classification combines one or more warning symbols, in red diamonds, with the standard hazard statements applicable to the substance in question.

By using these symbols and statements, the manufacturer clearly communicates the dangers of its products. From the standardized information on the label, it is easy to determine what regulations – if any – apply to a given substance.
Safety regulations

Many universities require you to compile a safety report before starting work with hazardous substances.

• if chemistry is not your field, ask an expert (Health and Safety Officer, Lab Safety Officer) for information and advice before you start working with chemicals. They should be able to tell you:
  • the characteristics of the substances you will be using
  • the correct working method and where you should work (e.g. fume cupboard)
  • what safety precautions to take and what personal protective equipment to use
  • how to dispose of waste products and how to deal with spills
  • how to treat injuries caused by the chemicals (first aid)

• before you start work, read the relevant material safety data sheets so that you know how to stay safe and what to do in the event of an emergency. Now that the REACH regulations are in effect, many of these sheets include an extensive description of how to work safely with the substance in question, and under what conditions

• check whether there are any special procedures for the substances you will be working with, which may require additional safety precautions. Such procedures apply for highly toxic substances like hydrogen cyanide, highly flammable ones like ethanol and highly corrosive ones like hydrofluoric acid, as well as for nanomaterials

• despite all your care and precautions, something could still go wrong. Make sure you know where to find eyewash, an emergency shower, a fire blanket, a suitable fire extinguisher and so on in the event of an emergency

• the risks associated with hazardous substances must be addressed as set out in the mandatory Occupational Health and Safety Strategy (Arbeidshygiënische Strategie). This requires you to consider the following aspects in the following order:
  1. can I modify the source?
  2. can I shield the source?
  3. can I work in a special environment?
  4. can I use shielding in that environment?
  5. what personal protective equipment can I use?

In other words, do not automatically think of personal protective equipment first!

• wear closed shoes, long trousers and a lab coat in the laboratory. Wear safety glasses when working with strong acids or when dangerous reactions are to be expected. The same applies if someone nearby is carrying out a “dangerous” experiment

• do not work alone. Find a colleague who knows exactly what to do in the event of an accident and ask them to stay close by, but at a safe distance

• work in a clean and orderly manner

• if possible, work with hazardous substances in a fume cupboard. Ideally, you should not sit down. Ensure that your face is always in front of the sliding window. This reduces the risk of accidents and injury caused by spattering, and also significantly cuts the chance of breathing in toxic vapours.

Material Safety Data Sheets

In the Netherlands, suppliers of hazardous substances are required to provide a material safety data sheet (Veiligheidsinformatieblad, VIB). This is an unambiguous means of communicating the product’s dangers to the recipient, so that appropriate measures can be taken to protect people and the environment. The VIB must meet certain statutory requirements, such as providing information about the nature of the damage the substance can cause, relevant first-aid actions, recommended personal protective equipment, permitted maximum concentrations and any compulsory controls.

Exposure

Some substances can damage human health if they enter the body through inhalation, skin contact or ingestion. Of these means of exposure, inhalation is the most common. However, more and more of the substances now used can trigger an allergic reaction if only a small quantity touches the skin. Enzymes and isocyanates, for example.

To determine whether the atmospheric concentration of a substance in the workplace may be harmful, this is checked against the defined occupational exposure limits (OELs) for gases, vapours, mists and dust. There are two types of OEL in the Netherlands.

• statutory OELs, set by the government and legally enforceable

• discretionary OELs, set by the employer if no statutory limit has been determined.

The Social and Economic Council of the Netherlands (Sociaal Economische Raad, SER) maintains a database of OELs, which are also known as workplace exposure limits (WELs), threshold limit values (TLVs) and derived no-effect levels (DNELs).

Pregnancy and planning a baby

Some types of work with chemicals may pose an increased risk to pregnant women and/or their unborn children. To identify these at the earliest possible stage, FOM has a “Checklist for prospective, expectant, new and breastfeeding mothers” – ask your line manager or Health and Safety Officer for a copy. And make an appointment with your line manager as soon as you can, to discuss any necessary changes to your duties.
Labelling
Chemical substances and products must be labelled by their manufacturer or supplier, following the rules set out in REACH. The Working Conditions Act also requires the labelling of substances produced in-house. The label should include:
- the official name of the substance, its dangerous components and their concentrations
- the relevant official warning symbols, risk descriptions and hazard statements ("H statements")
- the date of production or preparation
- the name of the person producing or preparing it.

Storage
Most accidents involving hazardous substances occur in untidy workplaces with old chemicals and empty packaging. Always tidy up your workplace and store hazardous substances in a suitable and safe place, in accordance with statutory rules (PGS 15). In many cases, the local environmental licence includes storage requirements. In general, a number of basic rules apply:
- the fume cupboard is not to be used for storage; that would prevent it from working properly
- chemicals should be kept in special ventilated and fire-resistant cupboards (as per EN-14470-1). After use, return them to where they came from. Flammable and toxic substances must be stored in fire-resistant safety cabinets
- there are so-called "irreconcilable combinations" of chemicals. These are substances which must never come into contact with one another because that would trigger a reaction creating heat or pressure. Even in storage, keep them well apart. Examples include acids and bases, flammable substances and oxidizing ones
- proper labelling is obligatory for all packages containing chemicals
- chemical waste must be disposed of separately. For details, see the hazardous waste disposal guide for your location.

Flammable substances
- ideally, work in the fume cupboard. If this is not possible, ensure that there is sufficient ventilation to keep the concentration of vapours low. This renders them harmless and reduces the risk of fire and explosion. The concentration should not exceed the lower explosive limit (LEL)
- in the event of a spill, act immediately – especially if a substance has splashed onto your clothes
- no more than one day’s supply of flammable substances is allowed in areas where experiments are carried out
- do not leave solvents lying about after working hours. Instead, lock them in a fire-resistant and ventilated cabinet
- squeeze bottles containing flammable liquids such as acetone can easily cause fires as a result of static electricity or syphoning when heated. Limit their use (and that of their contents) as much as possible.

MEER WETEN?
- www.fom.nl/safety
- www.ser.nl --> OEL Database
- www.arbokennisnet.nl --> kennisdossiers --> gevaarlijke stoffen
- ChemIDplus --> group of databases covering chemicals, occupational safety and health, poisoning and risk assessment
- Arbo Informatieblad 31 - Gezondheidsrisico’s van gevaarlijke stoffen, Sdu Uitgevers
- Arbo Informatieblad 55 - Werken met allergenen, Sdu Uitgevers
- Arbo Informatieblad 6 - Werken met kankerverwekkende stoffen, Sdu Uitgevers
- Chemiekaartenboek, Sdu Uitgevers
- Directive 99/92/EC ATEX 137: Workplace Directive on minimum requirements for improving the health and safety protection of workers potentially at risk from explosive atmospheres
- www.publicatiereeksgevaarlijkestoffen.nl --> PGS-15
Workplace exposure to hazardous substances can be harmful to health. Because of the serious damage they cause, one category requiring particular attention is carcinogens, mutagens and reprotoxins (CMRs). In many cases, their effects only become apparent much later.

Carcinogens and mutagens
Carcinogens are substances that cause or promote cancer. Mutagens bring about changes to our DNA which, if they affect reproductive cells, can be passed on to future generations. Both types are identified using specific hazard statements on their labels and/or in their material safety data sheets (see table).

<table>
<thead>
<tr>
<th>MUTAGEN</th>
<th>CARCINOGEN</th>
<th>REPROTOXIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>H340</td>
<td>H350</td>
<td>H360</td>
</tr>
<tr>
<td>H341</td>
<td>H351</td>
<td>H361</td>
</tr>
</tbody>
</table>

Exposure limits
Carcinogens can be divided into those with an occupational exposure limit (OEL) of zero and those with a higher OEL. The former, known as genotoxins, work by damaging the genes and so therefore have no safe exposure threshold. The latter, non-genotoxins, are more harmful the greater the level of exposure and so it is possible to define an OEL.

Mixtures and preparations
A mixture or preparation is deemed carcinogenic if the percentage by mass of a carcinogenic component is equal to or greater than the concentration level for that component, as listed in Annex 1 of the EU Dangerous Substances Directive (67/548/EEC). If the substance concerned is not on that list, then the limit is set at 0.1 per cent by mass. Bear this in mind when making and labelling your own mixtures or preparations.
Risk assessment
Employers are required to conduct a risk assessment to determine what dangerous substances their personnel might be exposed to in the workplace. This also has to assess the risk of exposure and describe what preventive measures have been taken. In addition, when carcinogens or mutagens are present it must state:
• why the use of a carcinogen or a carcinogenic process is strictly necessary, and why a safer substitute would not be technically feasible
• how much of the carcinogen or mutagen is usually manufactured or used per year, and how much is usually held in storage
• what type of work is usually carried out with the carcinogen or mutagen
• the route by which employees might be exposed
• what preventive measures have been taken to prevent or minimize exposure
• what personal protective equipment is used during activities in which employees might be exposed
• how employees are usually or might be at risk of exposure.

Reprotoxins
Reprotoxins are substances which harm the reproductive system, affecting both fertility (male and female) and unborn children. Certain chemicals can also endanger babies through breast milk.

Dyes
The dyes used as lasing media in dye lasers are almost all known or thought to be carcinogenic. The same applies to the dyes used in histology and other biological research – to stain sections, for example. When working with these substances, wear the correct gloves (see the relevant International Chemical Safety Card or MSDS) and perform tasks like weighing and preparing solutions in a fume cupboard.

Asbestos
Many buildings dating from before 1980 almost certainly contain asbestos, which used to be a common insulation and fireproofing material. It is particularly likely to be found in service areas, doors, shafts and the like. And it may also be present as insulation or a sealant (asbestos cord) in some laboratory equipment – old drying ovens, for instance. In most cases, objects, items and areas known to contain asbestos carry a warning sticker: “Voorzichtig – bevat asbest”/“Caution – contains asbestos”. If they suffer any damage or defects, always notify your Health and Safety Officer immediately.
Official list of CMRs
Twice a year, the Ministry of Social Affairs and Employment publishes an updated list of substances and processes classified in the Netherlands as carcinogenic, mutagenic and reprotoxic.

REACH: substances of very high concern (SVHC)
The enactment of the REACH regulations in 2007 brought with it more systematic consideration of the registration, evaluation and authorization of hazardous substances entering the European market. With the new rules, the EU has ensured that companies now have to gather more information about the dangers of their products and pass this on to the end user. At the same time, REACH shifts responsibility for providing such information from government to the private sector. This means that it is left up to manufacturers and importers to determine how substances covered by the regulations may be used.

Known CMRs are included on the list of “substances of very high concern” (SVHC). This means that their use is subject to very tight restrictions, and prospective users must apply to the European Chemicals Agency (ECHA) for authorization.

TIPS
• check the ECHA website to see if a substance is listed as an SVHC
• look for less harmful alternatives
• if no alternative is available, compile a chemical safety report (CSR) and request authorization.

FURTHER READING
• www.arbokennisnet.nl --> gevaarlijke stoffen --> CMR stoffen
• Arbo Informatieblad 6 - Werken met kankerverwekkende stoffen en processen, Sdu Uitgevers
• List of carcinogenic, mutagenic substances, Ministry of Social Affairs and Employment
• www.echa.europa.eu --> ‘Candidate List of Substances of Very High Concern’
Practically every research institute in the Netherlands now works with engineered (man-made) nanomaterials. These may have quite different hazard characteristics from the same chemical compound at the micro-scale. When new nanomaterials are developed, researchers are the first to be exposed to any dangers they pose. This means that particular care must be taken when working with these materials.

Introduction
Nanotechnology can be described as the design, production, manipulation and application of structures at nano-scale, with at least one dimension measuring less than 100 nanometres. The results are called nanomaterials.

The European Commission uses a slightly broader definition, describing a nanomaterial as "a natural, incidental or manufactured material containing particles, in an unbound state or as an aggregate or an agglomerate", and which meets one of the following criteria:

- for 50 per cent or more of the particles in the number size distribution, one or more external dimensions is in the size range 1-100 nm
- the specific surface area by volume of the material is greater than 60 m²/cm³ (this only applies to particles larger than 1nm).

Classification
Nanomaterials can be classified by form, as shown in the diagram below.
Risk assessment

Nanomaterials need to be included in the risk assessment of hazardous substances, examining the nature, extent and duration of possible exposure. Essentially, there is no difference between exposure to nanomaterials and exposure to other chemical substances. But particular attention does need to be paid to nano-specific safety aspects. For example, the measure of exposure used to estimate risk may be different from that used for other substances.

Whilst there remain many uncertainties about the potential dangers of nanomaterials, there are now indicators to possible ways of estimating the harm they might cause. One widely used and generally accepted classification considers the following factors, here listed from high risk to low:

• fibrous, rigid, insoluble forms
• insoluble particles with a parent material classified as a carcinogenic, mutagenic or reprotoxic (CMR) substance
• non-fibrous insoluble particles, with a parent material not possessing CMR properties
• soluble particles.

Pyrophoricity

As well as posing health risks, nanomaterials in powder form tend to be pyrophorous, or combust spontaneously. This is due to their high surface area to mass ratio, which causes reactivity. Before working with larger quantities of dry powder, it is therefore recommended that you familiarize yourself with the pyrophorous properties of the nanomaterial.

Exposure

Exposure to nanomaterials can occur via the respiratory tract, the digestive tract and the skin. In addition, they are often injected directly into the bloodstream for medical applications (imaging, diagnosis or therapy). Particles can also be released into the body as implants wear. Because of their size, these materials are able to pass through natural barriers in the body which block larger (micro-scale) substances. For comparison a red blood cell has a diameter of approximately 5,000nm. They thus enter the bloodstream and are transported to the organs. They can even transit the blood-brain barrier. Animal studies of carbon and gold nanomaterials have shown that they can also reach the brain through the nose and olfactory nerve. Their size thus creates new exposure routes.

It is assumed that the following factors affect the toxicity of nanomaterials:

• a very extensive surface area per unit of mass
• aggregation or agglomeration
• the number of particles per unit of mass
• morphology (fibrous, spherical, crystalline)
• particle size (distribution).

The main workplace exposure routes are thought to be inhalation and skin contact.

FURTHER READING

• www.fom.nl/safety
Working with gases and handling gas cylinders are very much a part of any research environment. But a potential dangerous one. If handled incorrectly, cylinders can shoot off like a rocket or explode. The gases themselves are generally hazardous, too: flammable, harmful, corrosive and/or toxic. Great care is therefore required. Special ordering procedures, workplace discipline and good management are the key to proper safety.

Introduction
Because of their frequent and widespread use, gases have a special place in research. They are held in gas cylinders, pressurized metal canisters or flasks fitted with a regulator valve, at pressures of approximately 250 bar and in volumes ranging from 0.1 to 150 litres. These cylinders may contain permanent gases like nitrogen, methane and oxygen, liquefied gases like ammonia or gases dissolved in a solution, like acetylene.

In general terms, gases can be divided into five categories according to their intrinsic properties.
1. inert
2. flammable
3. oxidizing
4. toxic
5. corrosive.

All gas cylinders are potentially dangerous. Not just because of the hazards posed by the gas itself, but also due to the pressure they are under. So gases should always be handled with care.

Storage
Most gases are purchased centrally, due to the compulsory registration of the cylinders, stock management needs and the monitoring of approval dates. Personnel working with gas cylinders should be properly trained and instructed. When storing cylinders, bear in mind the following tips.
• when not in use, cylinders should be stored in the specially designed gas depot outside the building
• when in use, cylinders should be kept either in the gas depot or in recognizable fire-resistant cylinder cabinets
• make sure cylinders cannot fall over: secure them with a chain, strap or bracket
• upon delivery, an expert should check the cylinders’ contents, embossed formulation stamp, approval date and condition (damage)
• gases which may react with one another must be stored separately
• always remove the regulator valve
**TIPS**

- when moving cylinders, always use a gas cylinder trolley and make sure they are firmly attached to it
- only move cylinders fitted with a protective cap
- make sure that lecture bottles are fitted with a tight-fitting screw top or stopper
- never lift or hoist a gas cylinder by its protective cap. This is designed only to protect the vulnerable valve and could fly off. If a cylinder does have to be hoisted, first place it inside a container
- never throw, knock or roll gas cylinders. A fall, impact or gyration could cause the valve to break or leak, especially at low temperatures. This particularly applies to cold gas cylinders, due to the increased brittleness of the metal
- transporting gas cylinders in cars is prohibited.

**Connections**

Ideally, gas cylinders should be configured for use outside the research area. If this is not possible for any reason, use a sufficiently ventilated gas cylinder cabinet with gastight outlets. In some laboratories, gas cylinders may only be connected and disconnected by authorized personnel. Check whether this applies at your workplace.

**TIPS**

- owned gas cylinders must be inspected and approved regularly. The last and/or next date of inspection is embossed on the cylinder itself, and can often also be found on a sticker
- rented cylinders must be returned to the supplier before their next inspection is due. Failure to do so can incur substantial additional costs
- reach agreements with suppliers about delivery times, the return of empty cylinders and so on
- all fittings (valves, pipes, tubing) must be inspected regularly (preferably annually) to check that they are in proper working order.

**Transport**

Gas cylinders may only be transported by an expert or another suitably qualified person. Ask about local procedures.

- cylinders should be fitted with a good protective cap to prevent damage to the main regulator valve
- keep different gases apart from one another
- store empty cylinders separately from full ones, or at least label them “Leeg”/“Empty”. Treat them with the same care as full cylinders
- it is recommended that toxic and corrosive gases only be purchased in smaller flasks (so-called “lecture bottles”), since even minor leaks can have disastrous results.

**Tests**

The Environmental Protection Act (Wet Milieubeheer) prohibits the stocking and use of “expired” gas cylinders. When ordering gases, you should therefore be sure that all the contents will be used before the cylinder’s next inspection is due. This is easily achieved by establishing a central registration system recording what cylinders are in use and where they are.
For added safety, cylinders containing flammable gases have left-handed screw threads. Left-handed nuts and couplings can be recognized by the notches at their corners.

### Connecting the Regulator Valve

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Attach the cylinder to a bracket or chain</td>
</tr>
<tr>
<td>2</td>
<td>Remove the protective cap, if necessary</td>
</tr>
<tr>
<td>3</td>
<td>Attach the regulator valve. Make sure that it is the correct type and check that the sealing ring is undamaged</td>
</tr>
<tr>
<td>4</td>
<td>Before opening the cylinder, close all valves (regulator and/or needle valve)</td>
</tr>
<tr>
<td>5</td>
<td>Open the cylinder slowly, to protect the diaphragm</td>
</tr>
<tr>
<td>6</td>
<td>Now open the other valve(s)</td>
</tr>
</tbody>
</table>

### Disconnecting the Regulator Valve

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Close the cylinder’s main connection</td>
</tr>
<tr>
<td>2</td>
<td>Close the regulator valve</td>
</tr>
<tr>
<td>3</td>
<td>Release the pressure from the pipes (open the needle valve and then close it again)</td>
</tr>
<tr>
<td>4</td>
<td>Remove the regulator (and/or needle) valve. WARNING: do not allow corrosive, flammable or toxic gases to escape into work areas</td>
</tr>
<tr>
<td>5</td>
<td>Put the protective cap back on the cylinder</td>
</tr>
<tr>
<td>6</td>
<td>Remove the cylinder</td>
</tr>
</tbody>
</table>

### General Safety Rules

- Filling gas cylinders yourself is prohibited.
- Before working with a gas, familiarize yourself with the information on its material safety data sheet so that you know how to work safely and what to do in the event of an emergency.
- Make sure you know the contents of any gas cylinder you handle. The embossed information near the top of the cylinder is definitive, not the colour of the cylinder or the direction of the screw thread.
- Never allow gas cylinders to be heated, under any circumstances whatsoever. If, exceptionally, a cylinder is used briefly outside a special cabinet, never attach it to a radiator or any similar object and always shield it from direct sunlight. The maximum safe cylinder temperature is 50°C.
- Prevent internal contamination of the cylinder by:
  - Using a check (non-return) valve if necessary.
  - Always leaving a small amount of residual pressure in the cylinder.
  - Always closing the valve after use.
- If you do believe a cylinder to be contaminated, inform the person responsible for gases or the supplier.

### Toxic and Flammable Gases

Before using a toxic or flammable gas, consult your Health and Safety Officer, Lab Safety Officer, lab supervisor or another expert.

- Different procedures for ordering and working with toxic or flammable gases apply at each laboratory. Approval is required from the person responsible for gases.
- When taking safety precautions, always assume the most dangerous situation. For example, a serious leak caused by a ruptured main pipe and where the master valve can no longer be closed.
- Areas in which toxic or flammable gases are being used must be well ventilated. Toxic fumes should flow directly outside, via an extractor system or a fume cupboard. Inspect extractor and ventilation systems on a regular basis.
- Consider installing a gas-leak detection system. This is required wherever there is a risk that the occupational exposure level (OEL) or lowest explosive limit (LEL) might be exceeded. Check with your Health and Safety Officer. Install detectors not only in working areas, but also in gas cylinder cabinets. Place detectors of heavy gases in a low position in the room and those for light gases high up.
- Some gases are not particularly dangerous in themselves, but can produce highly toxic substances if exposed to fire, naked flames or heat. Examples include the insulating gas SF6 and the cooling agent Freon.

### Self-Mixed Gases

If you need to mix a gas yourself, first obtain permission from the person in charge of safety.

- Follow the procedure for mixing gases.
- Keep the gas pressure in the cylinder as low as possible.
- Always use a new cylinder, never a used one.
- Label the cylinder, even if it has only been in use for a short time.
- Never make any alterations to the information embossed on the cylinder. Ask the person in charge for the proper instructions.

### Further Reading

- www.fom.nl/safety
- Gas supplier
Widely used in experiments, cryogenic liquids are ones kept at extremely low temperatures. Often liquefied gases, they are mostly used as cooling agents. The best known is liquid nitrogen, with a temperature of -196 °C. Liquid helium, oxygen and carbon dioxide are also used extensively in laboratories.

Risks
Working with cryogenic liquids (liquid nitrogen, oxygen or – coldest of all – helium) means working with very low temperatures, where safety is hugely important. Various dangers need to be considered.

First and foremost, any contact with a substance this cold can cause serious freezing-related injuries.

Another hazard is oxygen displacement when the liquids evaporate. Very small amounts of liquid produce huge quantities of gas. Be especially cautious when using cryogenic liquids in small or poorly ventilated spaces. Because of this effect, gas detectors are often required to monitor oxygen levels. If these fall below a safe threshold, an audible and/or visible alarm is triggered.

Pressure
In sealed containers, cryogenic substances can develop very high pressures. This means that barrels, canisters and pipes holding them must always be able to "breathe" safely into the outside air through an unblockable opening, or be fitted with a reliable, unblockable pressure relief valve. Sealed Dewar flasks containing them must have dual underpressure safeguards. Check regularly that these devices have not frozen up.

Fire and explosion
With a lower explosive limit (LEL) of just 4 per cent, the danger posed by liquid hydrogen speaks for itself. Liquid air and, especially, liquid oxygen are fierce oxidisers which turn the porous flammable substances they are easily absorbed by into highly explosive materials! (In its gaseous state, for example, oxygen attaches easily to all kinds of fabrics.) So always keep liquid air and oxygen well away from flammable substances and, along with liquid hydrogen, well away from sources of ignition. Avoid atmospheric exposure of liquid nitrogen, to prevent oxygen condensing. Always make sure that there is sufficient ventilation and extraction, and check regularly that these systems are working properly.
Precautions
Take the following precautions when working with cryogenic liquids.
• skin contact causes burn-like injuries. Wear closed shoes, safety glasses (preferably a face mask) and, if necessary, special gloves when pouring cryogenic liquids
• cryogenic liquids are kept and transported in double-walled, vacuum canisters, preferably of metal or glass, with a loose lid. These are known as Dewar flasks
• the vapour from cryogenic liquids can displace the oxygen from the air in poorly ventilated rooms. This may cause suffocation
• dewars being transported in lifts should not be accompanied by people. Note that the rules for the use of lifts vary from one location to another
• when tapping cryogenic liquid, and whenever there is a large amount of evaporation, ensure that there is sufficient ventilation
• when tapping, ensure that you do not damage the Dewar flask. This could cause the liquid inside to boil, which would present an immediate and serious danger
• when liquid air evaporates, liquid oxygen remains. This is a strong oxidizing agent, which could cause a fire or explosion. When mixing oxygen with oil or fat, there is a risk of spontaneous combustion
• pouring liquid gases from glass Dewar flasks is not recommended. The rim of the flask is welded and contact with the extremely cold liquid could create enough stress for the seam to fail and the flask to implode. Instead, always use a syphon or a specially made transfer device
• only seal a Dewar flask with its own lid, as this contains special openings to allow the constant release of gas. Note that these lids can become brittle in contact with cryogenic liquids, and so break easily
• shroud glass Dewar flasks in a protective covering (mesh, metal, cloth, tape)
• before filling a flask, cool it slowly using small quantities of liquid coolant
• do not cool glasses of activated charcoal or other easily inflammable organic materials in Dewar flasks containing liquid oxygen. Use liquid nitrogen instead
• do not use liquid oxygen or liquid air to cool flammable gases or liquids to very low temperatures, because of the danger of explosion. Again, use liquid nitrogen instead. When using liquid nitrogen in open air, be aware that liquid oxygen will also form within a short time
• after use, either empty open flasks or seal them to prevent high concentrations of oxygen forming by condensation of air
• ideally, sealed Dewar flasks containing cryogenic liquids should have dual underpressure safeguards. These require regular inspection
• at -196°C, the temperature of liquid nitrogen, argon is a solid and so has a very low vapour pressure. Solid argon can thus survive for relatively long periods in a vacuum, and may later cause an unexpected increase in pressure.

Personal protection
Contact with cryogenic liquids or inadequately insulated containers, pipes or tubes containing cryogenic liquids can cause serious freezing-related injuries, similar to burns. So always use the prescribed personal protective equipment.
• a face mask or safety goggles with side protectors, to guard against splashes
• loose-fitting thermal insulating gloves, which can be removed quickly should they be splashed with cryogenic liquid
• a loose-fitting lab coat, which can be removed quickly.

Accidents
When working with gases and with hazardous substances posing particular risks, specific first-aid precautions may be required. Make sure that you are aware of these, and that the necessary items are actually on hand. If an accident with a cryogenic liquid does occur, bear in mind the following points.
• treat cryogenic “burns” in the same way as ordinary burns: rinse the wound immediately under a cold tap
• avoid inhaling cold gases over long periods; they can damage the lungs. In the event of excessive exposure, or if you are in any doubt, consult a doctor
• if a person working with cryogens feels dizzy or faints, move them immediately to a well-ventilated area
• the vapour produced when liquid helium is exposed to the air is actually condensed contamination. It consists mainly of air and water vapour rather than helium gas, which is invisible.

Further Reading
• www.publicatieeksgevaarlijkestoffen.nl --> PGS-9
• www.arbokennisnet.nl --> Arbokennisdossier --> verstikkingsgevaar in besloten ruimten
• Arbo Informatieblad 18 - Laboratoria. Sdu Uitgeverij
Vacuum equipment is used in many projects. A vacuum is a void containing no matter and exerting virtually no pressure. Vacuum systems are designed to resist pressure from the outside (underpressure) rather than the inside (overpressure).

Risks
The greatest risk of working with underpressure is implosion, when the vacuum chamber suddenly collapses in on itself. This is particularly dangerous when using glass equipment or apparatus, as the implosion can generate shock waves with an explosive effect. These easily shatter glass, and can send splinters flying in all directions. Another risk comes from insufficiently airtight equipment, allowing air or other gases to seep in. Not only does this compromise the process, it can also result in dangerous reactions with contents of the chamber. Finally, vacuum pumps can generate disruptive or even dangerous amounts of noise.

Safety precautions
When working with vacuum equipment and apparatus, certain precautions need to be taken. Bear in mind the following points:

- check with the manufacturer or supplier that the equipment has been tested for the use you intend to put it to
- test the strength and airtightness of each individual piece of equipment
- vacuum systems at risk of implosion must be properly protected from noise and splintering
- large windows (four inches or more) must be double-glazed
- safeguard the equipment against overpressure
- ensure that the pressure in the system can be monitored at all times
- glass Dewar flasks must be shrouded in a protective covering
- regularly maintain and check all precautions
- place glass vacuum apparatus in a fume cupboard or behind protective shielding
- take precautions to prevent the flowback of liquids and gases
Hazardous substances
If hazardous substances are subjected to a vacuum, bear in mind the following points.
• insufficient suction in the extraction tubes can cause explosive or toxic mixtures to collect in them
• make sure that all used gases, vapours and particles are disposed of responsibly (neutralization, dilution to below lower explosive limit)
• use vacuum pumps with a purge function, to prevent hazardous substances collecting inside
• if using an oil diffusion pump, check that the oil is resistant to the hazardous substances you are working with
• if and when a pump is overhauled, state what hazardous substances it has been used with so that the engineers can protect themselves against any residues
• if possible, use an oil-free diaphragm pump fitted with an aftercondenser
• dispose of old oil and rinsing fluid as chemical waste.

Further reading
• Handboek ‘Kwaliteits-, Arbo- en Milieuzorg in het laboratorium’ Hoofdstuk 3.2 Veiligheid bij werkzaamheden onder verhoogde en verlaagde druk
• H. Kramers-Pals en I. van het Leven. Veiligheid in het laboratorium. Uitgeverij Syntax Media
Particle and electromagnetic radiation above a certain level of energy is called ionizing radiation. Although we cannot see, hear, smell, taste or feel it, ionizing radiation is harmful and so subject to strict rules.

Introduction
Ionizing radiation is emitted by natural radiation sources, but can also be generated artificially. It is produced when atoms with unstable nuclei change spontaneously and is harmful when absorbed by our bodies. The greater the dose, the more damage is caused and the harder it becomes for the body to repair it. Exposure is expressed in millisieverts (mSv) per unit of time.

Risks
High doses of ionizing radiation, in excess of the prescribed radiological limits, can cause “early” symptoms of radiation sickness such as redness and swelling of the skin, hair loss, gastric complaints (nausea, vomiting, diarrhoea), damage to the small intestine and degeneration of bone marrow. The long-term effects – primarily cancer – may take many years to appear, or even be passed on to the next generation.

Nuclear Energy Act
The Nuclear Energy Act (Kernergiewet, KEW) regulates all work involving radioactive materials or equipment that emits ionizing radiation. It requires the licensing of organizations using such materials or equipment. Safeguards to protect workers are set out in the Radiation Protection Order (Besluit stralingsbescherming), a statutory order issued under the KEW.
The Radiation Protection Order requires the appointment of a qualified Radiation Safety Officer to oversee all work involving ionizing radiation, and defines their duties. They include:
- conducting acceptance tests upon receipt of new radioactive sources and equipment
- issuing permission to use sources and equipment
- keeping the KEW file up to date
- registering, safeguarding and managing sources
- monitoring radiation levels
- informing and training colleagues
- the acquisition and disposal of radioactive sources

The Radiation Safety Officer may appoint expert assistants at individual locations to support them in their duties, but despite this remains solely responsible for authorizing any work involving radiation and must always be actively involved in monitoring such work.

Exposure limitation policy is based upon three key principles.

**Justification**
The benefit or purpose of the operation must outweigh the negative effects on people, animals, plants and goods.

**Optimization**
The exposure or contamination of persons must be kept to an absolute minimum; this is known as the ALARA principle: “as low as reasonably achievable”.

**Limitation**
Dosage limits are established and must be observed, to protect employees and the general population from risk.

**Sources**
There are two types of radioactive source.

- **Enclosed sources**
  These sources are fixed or enclosed in a container so that it is almost impossible for the radioactive material to spread. Examples are calibration sources for contamination monitors and caesium sources for therapeutic purposes.

- **Open sources**
  Open sources are radioactive materials that have not been confined to a container. There is thus a much greater risk of radiation spreading from them. Open sources are mostly used in research and in nuclear medicine. Specific requirements regarding the working area apply when they are used in laboratories.

**Dosage**
The natural dose of background radiation in the Netherlands is about 2 millisieverts (mSv) per year. The Nuclear Energy Act states that employees and the general population may receive an additional dose of up to 1 mSv per year, although an exception applies to radiological or exposed workers. Anyone working with sources or equipment that emits ionizing radiation and who runs the risk of being exposed to more than 1 mSv per year is regarded as a radiological worker.

**Precautions**
To minimize the risks from ionizing radiation, it is important to take the following precautions.
- keep the amount of radioactivity used as low as possible
- keep exposure to a minimum (and/or work as fast as possible)
- keep as far away from the source as possible
- use protective equipment, such as a lead shield when working with gamma emitters or a perspex shield for beta emitters
- wear gloves when working with open sources. Never let the glove touch objects that should not be contaminated
- use the prescribed personal protective equipment, such as a lead apron and gloves.
Safety Regulations and Tips

Accidents
As long as everyone observes the safety rules, working with radioactivity is quite safe. But despite all precautions, things can still occasionally go wrong for some reason or another. The greatest danger posed by such incidents is the spread of radioactive contamination, and with it the risk to health and the environment. Decontamination requires specialist know-how and is always done from the edge of the affected area towards its centre. That is, from the area of least radioactivity to the area of most. In the event of an accident, always inform the Radiation Safety Officer immediately and discuss how best to deal with the problem.

Waste
The disposal of radioactive materials is subject to strict rules. The Radiation Safety Officer arranges their transfer to the government-designated storage and disposal organization, COVRA.

X-rays
X-rays are a form of radiation produced when electrons or ions collide with matter. It is important to remember that, when the intensity of the beam is constant, the delivered dose rises rapidly as the energy level increases. Experiments with the potential to generate levels of radiation beyond permitted limits must be licensed!

To work safely with X-rays, bear in mind the following points:
• if the level of radiation exceeds the permitted limit, the Radiation Safety Officer must be informed immediately and must take measurements straight away
• only qualified experts may take X-ray measurements; the information from the various radiation monitors needs to be properly interpreted!
• make sure the equipment is properly shielded
• if necessary, use a radiation monitor and warning labels and lamps
• make sure the equipment is serviced in accordance with the prescribed procedure
• if in doubt, have the Radiation Safety Officer take measurements
• if dosages are high, wear a lead apron and other personal protective equipment.

FURTHER READING
• www.fom.nl/safety
• Radiation Safety Officer FOM-Nikhef
• Radiation Safety Officer FOM-Institute DIFFER
• www.arbokennisnet.nl --> kennisdossiers --> straling
• Arbo Informatieblad 27 - Ioniserende straling, Sdu Uitgevers
• Praktische stralingshygiëne, G. Brouwer (2008)
• F. Weissman en J. Welleweerd, Stralingsfysica (1996)
• A.J.J. Bos et al., Inleiding in de Stralingshygiëne (2e druk, 2007)
• H. Kramers-Pals en I. van het Leven, Veiligheid in het laboratorium, Uitgeverij Syntax Media
Non-ionizing radiation is the collective name for electromagnetic, electrostatic and magnetic fields with frequencies of 0-300 GHz. This form of radiation does not penetrate deep into human tissue, but the heating it causes at the point of exposure can cause permanent damage to the skin or eyes. Such exposure should thus be kept to a minimum.

Introduction
In a standard laboratory environment, there are numerous sources of non-ionizing radiation. These can include welding equipment, lasers, induction ovens, ultraviolet sensors for DNA detection, ultraviolet lighting devices, microwave sources and the fields surrounding cryogenic or other magnets and MRI scanners. Because the behaviour of an electromagnetic field depends upon its frequency, for practical purposes we can divide the non-ionizing part of the spectrum into two parts. Up to 300 GHz we refer to electromagnetic fields, and beyond that to optical radiation (infrared, visible and ultraviolet light).

This chapter covers various sources of non-ionizing radiation, in each case describing its principal risks and the precautions to take against it.

Electromagnetic radiation
The presence of an electromagnetic field is easy to detect. However, its measurement requires special equipment and interpretative expertise.

Precautions
Make sure the equipment has been properly constructed and is well-maintained. The following additional precautions are listed in order of importance:
- consider alternative techniques
- shield the source: enclose it, and also shield reflections (source protection takes priority over personal protection)
- keep as far away from the source as possible (>1 metre)
- reduce individual exposure time through, for example, staff rotation
- use personal protective equipment.
Electrostatic and extremely low frequency (ELF) fields (0-300 Hz)

Electrostatic fields are generally natural. For example, the earth’s magnetic field and those caused by friction. Others are formed in the immediate vicinity of high-voltage power lines and current carriers and by industrial electrolysis processes, MRI equipment and superconducting and conventional magnets (magnetostatic fields).

Exposure

Electrostatic fields pose no known health risk. The greatest danger is suffering an electrical shock on touching a statically charged object. The exposure limit is based upon the chance of discharge and observability.

Magnetostatic fields cause minor electrical potential differences in blood vessels, but have no known lasting detrimental effects. The exposure limit is based upon the current induced in the body as a result of movements in the magnetic field. Low-frequency alternating magnetic fields generate currents in the human body as powerful as those it produces itself, and so can directly activate muscles and nerves.

Short-term risks

- artificial body parts and implants, including pacemakers and ferromagnetic implants, may be affected (exposure limit 0.5 mT)
- magnetic strips on bank and credit cards may be wiped (at levels greater than 1 mT)
- at flux densities greater than 3 mT, metal objects may be attracted to the magnetic field
- one possible acute effect is seeing flashes of light, so-called phosphenes, caused by direct stimulation of the retina by the electric field generated inside the head. Phosphenes themselves are not considered dangerous, but shock reactions to them could pose a risk.

Long-term risks

Much research has been and is being conducted in this field. The general conclusion is that there is very little or no relationship between ELF and health.

Precautions

- display warning signs: “NO ACCESS for persons with pacemakers or ferromagnetic implants”
- use stainless-steel tools and non-magnetic fire extinguishers
- keep larger metal objects away from magnetic fields.

Low frequency (LF) fields (300 Hz-10 MHz)

Up to 100 kHz, only the induced current density and the internal electric field strength are relevant. Beyond this level, the specific absorbed energy is also important. The whole body absorbs energy, but not to the same extent everywhere.

Radio frequency (RF) and microwave fields (10 MHz-300 GHz)

Sources of RF and microwave radiation include high-frequency generators (gyrotrons, klystrons, etc.), microwave ovens, industrial RF heaters, radio and television transmitters and radar systems. These can be divided into strong and weak sources. Base stations for mobile telephony are weak sources, for example, whereas mobile telephones themselves are strong ones.

Risks

Direct exposure to electromagnetic fields in this frequency range heats human tissues because they absorb the energy and convert into warmth. This effect is most dangerous for the brain, eyes, genitalia, stomach, liver and kidneys. The depth of penetration is frequency-dependent. In parts of the body prone to resonances, the damage can be exacerbated.

Precautions

The two most effective methods to reduce exposure are good source design and good source shielding. Absorbent clothing is not always effective. At high-risk locations, the local expert should take measurements to check that exposure limits are not being exceeded. If levels are too high, the affected area should be cordoned off and marked.

Visible and infrared (IR) light (0.4-1000 µm)

Infrared radiation is released at high temperatures – during welding, forging and glass-blowing work, for example, and by heat lamps and plasma sources.

Risks

IR radiation is most damaging to the skin (burns) and eyes (blinding). The eyes are most vulnerable to light with a wavelength of 400-500 nm, the so-called “blue light hazard”. Within the infrared spectrum, there are several known risk areas. IR-A penetrates the skin and deep into the eye, where it can cause thermal damage (retinal injury and cataracts). IR-B and IR-C are absorbed by the cornea and so are less dangerous, but long-term exposure can damage the cornea itself.
Veiligheidsregels
- shield the source
- use personal protective equipment specially designed for this danger (clothing and eye protection)

Ultraviolet (UV) light (100-400 nm)
Ultraviolet radiation is transmitted by hot light sources such as the sun, incandescent lamps, halogen lamps, UV lamps, sunbeds, welding arcs and gas-discharge lamps (such as mercury lamps).

Risks
Excessive exposure primarily endangers the skin and eyes. Acute effects are burns (erythema) and inflammation of the cornea (arc eye). Long-term effects are skin cancer, swelling of the skin, premature ageing of the skin and cloudy vision (cataracts).

Precautions
Exposure to UV light in the workplace should be prevented:
- shield permanent or temporary UV-generating setups. Aluminium sheets and most types of plastic, including perspex, provide sufficient protection. But test the material’s effectiveness before use
- if shielding is not possible, use the appropriate personal protective equipment (glasses, clothing, sun creams, etc.)
- when welding, regulations require the use of protective gloves and clothing
- make sure the experimental area is not accessible by unauthorized personnel. Display warning signs or stickers.

Legislation
The EU Electromagnetic Fields Directive (2013/35/EU) entered force in 2013 and must be implemented in national law by all member states no later than 1 July 2016. It draws a distinction between “exposure limit values” (ELVs) and “action levels” (ALs). The former are in fact the statutory occupational exposure limits, based directly upon proven health effects and biological data. The directive defines different ELVs for static magnetic fields and alternating electromagnetic fields.

The EU Artificial Optical Radiation Directive (2006/25/EC) was published in 2006 and in the Netherlands is now implemented through the Working Conditions Decree (Arbeidsomstandighedenbesluit).

FURTHER READING
- www.fom.nl/safety
- www.nvs-straling.nl
- Arbo Informatieblad 60 - Kunstmatige Optische Straling, Sdu Uitgevers
- Arbeid en Gezondheid, handboek over het beheersen van gezondheidsrisico’s op het werk, Vakmedianet
- Arbo Informatieblad 39 - Elektromagnetische velden, Sdu Uitgevers
- Europese Richtlijnen 2013/35/EU: workplace directive on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields)
Working with lasers carries potential risks. A laser beam shone into the eye can cause blindness or partial blindness. A beam on the skin can produce serious hypodermic burn injuries that do not heal easily. Good safety precautions can reduce the risks. Safe working with lasers is quite possible, but requires instruction, workplace discipline and good management. Laser safety always begins with ensuring that people who have nothing to do with the task in hand are not exposed to the beams or their reflections.

Introduction
Encasing a laser beam (as in DVD players) can completely eliminate the dangers. This is not usually an option in a laboratory setting, however, as the laser light is often an integral part of the experiment and must traverse a network of mirrors and other optical elements that routinely need adjustment. Depending upon the type of laser used, this creates risks.

Risk classification
Lasers are divided into risk categories, ranging from Class 1 (harmless to the eyes) to Class 4 (where even the reflection of the laser beam can cause serious damage to the eye). The table below describes each category in more detail. Given that nearly all the lasers used in FOM laboratories are Class 4, the rest of this chapter discusses the risks and precautions associated with that category.

<table>
<thead>
<tr>
<th>CLASS</th>
<th>SAFETY LEVEL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Safe</td>
<td>Safe under reasonably foreseeable conditions of operation. Wavelength in the visible or non-visible spectrum.</td>
</tr>
<tr>
<td>1M</td>
<td>Caution</td>
<td>Safe in normal use, but not when viewed with optical aids such as a diverging lens within 10 cm of the laser aperture. Wavelength in the range 300-4000 nm.</td>
</tr>
<tr>
<td>1C</td>
<td>Safe</td>
<td>Safe in normal use</td>
</tr>
<tr>
<td>2</td>
<td>Safe</td>
<td>Low-power (&lt; 1 mW) visible lasers, which are safe because the eye is protected by aversion responses, including blinking reflex and head movement, within 0.25 second. Looking into the beam for longer than this would cause eye injury. Wavelength in the range 400-700 nm.</td>
</tr>
<tr>
<td>2M</td>
<td>Caution</td>
<td>As Class 2, but not safe when viewed with optical aids (see 1M).</td>
</tr>
<tr>
<td>3R</td>
<td>Potentially hazardous</td>
<td>Direct viewing of beam is potentially hazardous.</td>
</tr>
<tr>
<td>3B</td>
<td>Hazardous</td>
<td>Direct viewing of beam is not safe to the eye. Wavelength in both the visible and non-visible spectrum.</td>
</tr>
<tr>
<td>4</td>
<td>Very hazardous</td>
<td>Always harmful to the eye and skin. Viewing a direct, reflected or diffusely reflected beam causes immediate injury.</td>
</tr>
</tbody>
</table>
Precautions

General
Most lasers in research laboratories are in Class 4, the most dangerous category. Direct, reflected and even diffused beams can cause serious injury. Take the following precautions.
• project laser beams horizontally, well below eye level
• where possible, screen beams with matt, non-reflective material. This should be as close as possible to the beam
• do not wear anything that might reflect the beam, like a watch, rings or a metal belt buckle
• avoid using any reflective objects or equipment at beam level
• if possible, use only non-reflective (matt and/or black) accessories, optics holders and so on
• make sure there are enough beam dumps to block any reflections
• a visual warning on the outer housing of a laser device indicates when it contains or is emitting a beam. When this warning is lit, nobody may enter the room without the permission of the experiment leader. Anybody who does enter must wear laser safety glasses
• a laser must never be activated by an unauthorized person. To prevent this, use locks or a specific sequence of actions which cannot be replicated accidentally
• every laser must have an emergency cutout switch or, if this is really not possible, a main switch within easy reach. Instructions on how to switch off the laser should be displayed clearly on the door of the laser laboratory
• reduce the intensity of the beam during alignment, by either reducing the power or using diaphragms and filters
• wear laser safety glasses whenever possible. Bear in mind, however, that these generally only offer protection across a limited range of wavelengths. Ask the Laser Safety Officer for more information. Glasses are no substitute for any of the above precautions!
• avoid the beam contacting the skin
• if possible, use fluorescent cards or IR sensor cards. These can often be purchased in combination with laser safety glasses
• when using a high-power IR beam for extended periods, wear hand and wrist protection
• never look directly into a laser beam, even when wearing safety glasses. This applies to all beams, including those generated by HeNe lasers. To trace a beam, use a piece of paper or card.
**Technical**
- Laser apparatus located in a freely accessible area must always be screened off so that bystanders can NEVER be hit by a laser beam or its reflection. This applies even when the equipment is being serviced.
- Laser apparatus which cannot be properly screened off must be located in a separate, enclosed and blacked out room: the laser laboratory.
- All reflections of the beam must be captured by hoods, screens, shields or beam dumps.
- Laser beams emitting beyond the optical table must be shielded (inside a tube, for example).
- Lasers must never be directed upwards without first shielding them. During vertical translation, screening above the beam is mandatory.
- The “Lasers on” signs must light up as soon as the laser is switched on. When they are lit, nobody may enter the room without the permission of the experiment leader. Anybody who does enter must wear laser safety glasses.
- Optical tables are usually made of metal and so must be earthed.

**Managerial**
Everyone working with a laser must be trained in the use of that specific device, and in particular in its dangers and the relevant safety precautions. Completion of this training is recorded in writing.
- New or heavily modified laser experiments cannot begin until the Laser Safety Officer or a qualified laser technician has conducted a risk assessment and all necessary safety precautions are in place.
- Outside normal working hours, lasers may only be used by or under the supervision of expert laser operators, under the responsibility and with the permission of the group or team leader.

**Precautions for laser chemicals and gases**
- Gloves and safety glasses must be worn when working with laser dyes.
- Many laser dyes and their solvents are toxic and possibly carcinogenic. Whether in powder form or ready to use, dyes must be kept in a ventilated safety cupboard.
- Be very careful when using and mixing dyes and their solvents. Mixing is allowed only at a special ventilated “dye station”. Make sure no powder is blown around, as it could be inhaled. Clear up any spills immediately.
- Put any dye and residues that are no longer going to be used in the dye waste container straight away. Dispose of them as chemical waste.
- Ideally, glass vessels used for dissolving and storing dyes should not be used for any other purpose. Always clean them thoroughly.
- Always ensure that weighing apparatus and mixing equipment do not come into direct contact with the dye.
- All utensils used to weigh and mix dyes, such as spatulas and spoons, should first be laid out on paper or tissues. This prevents contamination of the surrounding area.
- Most of the gases used in excimer lasers are toxic. Make sure the cylinders are kept in a safe, ventilated and fire-resistant cabinet. If a window in the apparatus itself breaks, the gases can escape into the laboratory. So take appropriate precautions.

**FURTHER READING**
- [www.fom.nl/safety](http://www.fom.nl/safety)
- Arbo Informatieblad 18 - Laboratoria (hoofdstuk 6), Sdu Uitgevers
- Arbo Informatieblad 60 - Kunstmatige Optische Straling (hoofdstuk 4), Sdu Uitgevers
- Laser safety regulations FOM-Institute AMOLF
- Laser safety regulations FOM-Institute DIFFER
- Laser safety regulations FOM-Nikhef
Personal protective equipment

Personal protection is about more than simply reaching for the nearest protective equipment. First, try to eliminate the risks present in any situation. Only once all reasonable technical and managerial steps have been taken to minimize exposure should personal protective equipment (PPE) come into play. The employer is required by law to provide this. For advice on what items to use, how to use them and how to look after them, ask your Health and Safety Officer. Always report broken or defective PPE.

Introduction
All work entails some risk, but work on brand-new products and applications more than most. Sometimes these risks are minor, sometimes much greater. But they can be managed by taking the appropriate preventive measures. These are set out in the mandatory Occupational Health and Safety Strategy (Arbeidshygiënische Strategie), which requires that risks be tackled as close to the source as possible.

In other words, PPE should be your last resort! In this chapter we describe various common types of PPE and their uses.

Protective clothing
Wear protective clothing when ordinary workwear is not enough to ward off external dangers. Examples include lab coats, safety glasses, safety shoes, welding aprons, safety helmets (hard hats) and fall arresters. Check especially that the material is suited to protect against the hazard you face.
Head protection
Wear head protection when you are at risk of being hit by falling objects or moving parts, or could bang your head. There are several types.

- **Safety helmets**
  Usually worn on building sites, in places where work is going on at different heights and during hoisting activities.

- **Hairnets**
  Worn by people with long hair working with or close to machinery with exposed moving parts, such as drills and motorized couplings.

- **Hygienic face masks**
  Worn in locations subject to special hygiene restrictions, such as clean rooms.

A safety helmet must be replaced if it is ever hit by a falling object or damaged in any other way. Moreover, all helmets are marked with an "expiry date". With most plastic models, this is three to five years from the date of production. If your helmet "expires", ask your supervisor or Health and Safety Officer for a new one.

Eye protection
Eye protection is designed to safeguard the eye from physical hazards (chemicals, optical radiation) or mechanical ones (splinters) whilst not obstructing your view of the work in hand. Again, there are several types.

- **Safety glasses and goggles**
  These are fitted with hardened glass, designed specially to protect against small objects and particles (chemicals, wood or metal splinters).

- **Laser safety glasses**
  These generally only offer protection across a limited range of wavelengths.

- **Welding masks and goggles**
  These protect against the heat and light generated by welding, which can cause blindness, arc eye (photokeratitis) and cataracts.

- **Visors**
  Protecting the entire face, not just the eyes, visors or face shields are worn with a headband or attached to a safety helmet. Their use is recommended when the whole face is at risk, as when grinding, milling or working with aggressive liquids or cryogenic gases.

Hearing protection
Extended exposure to noise at or in excess of 80 dB(A) can permanently and incurably damage the hearing. If you are in any doubt as to the level of noise in your workplace, ask your Health and Safety Officer to take measurements.

Hearing protection is recommended at noise levels above 80 dB(A), and compulsory from 85 dB(A) upwards. The employer is required to provide this. Each additional 3 dB(A) halves the safe daily exposure time.

**Safe daily exposure times**

<table>
<thead>
<tr>
<th>NOISE LEVEL IN DB(A)</th>
<th>SAFE DAILY EXPOSURE TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>8 hours</td>
</tr>
<tr>
<td>83</td>
<td>4 hours</td>
</tr>
<tr>
<td>86</td>
<td>2 hour</td>
</tr>
<tr>
<td>89</td>
<td>1 hour</td>
</tr>
<tr>
<td>92</td>
<td>30 minutes</td>
</tr>
<tr>
<td>95</td>
<td>15 minutes</td>
</tr>
<tr>
<td>98</td>
<td>7.5 minutes</td>
</tr>
<tr>
<td>101</td>
<td>aprox 4 minutes</td>
</tr>
</tbody>
</table>

The best type of hearing protection to use depends upon the required protection factor (to reduce the noise reaching the ear to 80 dB(A) or less). If you work in a very noisy environment, otoplastics are recommended. These are sophisticated made-to-measure earplugs. The table below compares the effectiveness of different forms of protection when used both correctly and incorrectly.

**HEARING PROTECTION DEVICE**

<table>
<thead>
<tr>
<th>NOISE REDUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>earplugs, ill-fitting</td>
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<td>otoplastics, ill-fitting</td>
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<td>disposable foam earplugs, incorrectly inserted</td>
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<td>ear defenders, incorrectly worn</td>
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Safety Regulations and Tips

Foundation for Fundamental Research on Matter

Foot protection

Safety shoes or boots are issued to protect the feet from injury caused by, say, heavy or sharp falling objects and splintered chemicals. Depending upon the situations, the following footwear may be required.

• **Welder’s shoes or boots**
  These protect welders against burns, cuts and sparks.

• **Fur-lined safety shoes**
  These are used when very low temperatures are likely.

• **Chemical-resistant safety shoes**
  When working with or in the vicinity of hazardous chemicals, it is advisable to have suitable footwear. Various specially designed shoes are available.

• **Electric static dissipating shoes**
  These so-called ESD shoes are used mainly in workplaces where sensitive equipment needs to be protected against static discharges.

Safety belts and harnesses

Work at height (above 2.5 metres) in places where no safety barriers, fencing, railings or scaffolding have been erected requires the use of fall prevention and arrest equipment.

• **Safety harnesses**
  Use when there is a danger of falling from a height of 2.5 metres or more.

• **Fall arresters**
  Use to interrupt falls when working with a safety harness and vertical line.

• **Fork-lift safety belt**
  By law, must be worn by fork-lift drivers.

Respiratory protection

Respiratory protective equipment (RPE) is used:

• to prevent the inhalation of hazardous substances (gases, vapours, dust); and,
• to maintain a supply of oxygen to the lungs when the air is deprived of it.

The nominal effectiveness of a respirator is often indicated using the filter performance rating P1, P2 or P3. P1 filters provide the lowest level of protection, against relatively benign substances, P3 filters the highest. Which kind you use will depend upon the type and degree of contamination you need to block out.

Actual effectiveness depends upon how much material is captured and for how long the device is in use, so change the filter regularly.

The most common types of RPE are

• **Particulate filter respirators**
  These protect against particulate matter (dust particles, etc.) in the air, but NOT against gases and vapours.

• **Gas filter respirators**
  These provide protection against gases and vapours, capturing them by means of adsorption. Different substances require different filter membranes; these are coded, both by colour and alphanumerically.

• **Combination filter respirators**
  These combine a gas and a dust filter.

• **Powered air-purifying respirators**
  These can be worn separately or in combination with a safety helmet or welding mask. A belt-mounted motor pumps air through purifying filters and into the hood, which is pressurized so that contaminants cannot reach the wearer.

Hand and arm protection

Various types of gloves are available to protect the hands from sharp or rough materials, corrosive or aggressive liquids, burns and the absorption of hazardous substances.

The use of gloves in a chemical laboratory requires particular care, as not all types are suitable for handling every chemical. Before starting work, check the material safety data sheet for the best sort to use. The larger suppliers also provide quick reference aids. Disposable gloves must never be reused.

FURTHER READING

- [www.arbokennisnet.nl](http://www.arbokennisnet.nl) --&gt; kennisdossiers --&gt; beheersmaatregelen/PBM
- Arbo Informatieblad 49 - Beleid persoonlijke beschermingsmiddelen, Sdu Uitgevers
- Kluwer’s pbm-gids, Kluwer
Scientific research affects the environment by consuming energy, water and raw materials as well as through its inevitable waste flows. FOM considers it very important to minimize the environmental impact of research work, so it is the duty of us all to act responsibly in this area – at work and outside it.

Introduction
In addition to complying with the health and safety requirements described in the previous chapters, it is also important to observe the rules put in place to minimize the impact of our work on the environment. Responsibility for this lies not just with the experimental researchers in our laboratories, but with all FOM personnel. In many cases local environmental protection and waste disposal rules apply to offices as well as laboratories. These are often enshrined in an environmental licence. Find out what regulations affect you.

Environmental licences
Work with the potential to damage the environment usually requires official permission, frequently in the form of an environmental licence. This imposes emissions limits on an organization or site, for example, and sets out what precautions must be taken to prevent nature and wildlife coming to harm. The licensing regime requires a proactive approach on the part of the organization concerned. The use of genetically modified organisms (GMOs) and radioactive substances also requires licences. For more information, consult your Health and Safety Officer, Radiation Safety Officer or Biological Safety Officer.

Below we discuss some of the general measures you can take in certain key areas to keep the environmental impact of your work to a minimum.

Chemicals
Many chemicals are as potentially dangerous to the environment as they are to human health and safety. A substantial proportion of those used in the laboratory could have disastrous effects if released untreated into the atmosphere, ground or sewers.
Handling chemicals in an environmentally-aware manner means considering the following factors.

**General prevention**
- before buying hazardous chemicals, check whether less harmful alternatives are available
- check if the substance you require is already in stock at FOM
- buy no more than you think you will use, and use no more than is strictly necessary for your experiment
- consult your local waste disposal guide for details of how to separate and arrange the collection of used chemicals.

**Release prevention**
- never leave waste containers open. If necessary, close them temporarily using a funnel with a glass stopper or ball in it
- resell bottles, flasks, etc., after use
- never allow solutions to evaporate into the air. Instead, make sure that any vapours are condensed and captured
- never pour chemicals or chemical waste down the sink.

**Tips**
- use energy, water and raw materials sparingly
- buy environmentally-friendly items whenever possible. These often have some form of sustainability certification, or comply with the government’s sustainable procurement criteria
- monitor waste flows
- use cars as little as possible for commuting. There are plenty of alternatives: public transport, cycling, car sharing, etc.
- switch off equipment when not in use
- make sure that radiators can emit all their heat efficiently
- use coolants sparingly: ice, dry ice and liquid nitrogen also represent a form of energy
- switch off the lights when you are the last person to leave a room
- always print documents on both sides of the paper
- be alert to energy consumption, heat loss, atmospheric emissions of hazardous substances, noise production, the use of non-sustainable materials and so on

**Waste collection**
Waste generated by FOM is separated according to type and collected by specialist processing contractors. Use the facilities provided locally to deposit your waste. Typically, this should be separated into the following types.
- paper, plastic, glass and metals
- construction and bulk waste
- electrical equipment
- hazardous household waste (HHW), such as toner/printer cartridges, batteries and fluorescent tubes
- chemical waste, including GMO waste
- radioactive substances

**FURTHER READING**
- www.stoffen-info.nl --> informatie over REACH en GHS
- www.publicatiererksgevaarlijkestoffen.nl --> PGG-15
- www.pianoo.nl --> thema’s --> duurzaam inkopen
- www.smk.nl (Stichting Milieukeur)
FOM Health and Safety Policy

FOM considers it very important to look after the health, safety and welfare of its employees. For us, that is a moral duty as well as a legal one. Our policy in this respect is enshrined in a range of documents compiled and maintained by the Health and Safety Advisory Committee of the FOM Foundation.

Policy objectives
FOM’s Health and Safety Policy has a number of defined objectives.
• to maintain the highest possible standards of safety and health protection for all employees, guests, trainees and visitors
• to maintain these standards proactively and to enforce them before any job begins, whilst at the same time ensuring that they facilitate effective research
• to keep the organization and all the installations, equipment, machinery and goods in and around its premises as safe and healthy as possible
• to maximize psychosocial well-being at work.

Responsibilities
Ultimate responsibility for health and safety rests with the Director of the FOM Foundation. She delegates some of this responsibility to the directors of the individual institutes, and they in turn entrust specific aspects of it to departmental managers through so-called “missives”. In many cases, individual employees (Health and Safety Officers, designated responsible persons, members of the emergency response team, etc.) are charged with implementing specific aspects of health and safety policy on the workfloor.

Co-operation
The Working Conditions Act requires employers and employees to work together in the field of health and safety. In the research sector, which includes FOM, their co-operative efforts have produced such tools as the Occupational Health and Safety Catalogue for Research Institutes.

The employer is required to adopt a policy which keeps the workplace as safe and healthy as possible. The employee is required to comply with this policy, to take part in activities promoting it and to report unsafe situations. This is why everyone joining FOM receives information about health and safety here.
Consultations
The Director of the FOM Foundation takes advice on health and safety matters from the Central Health and Safety Officer and the Health and Safety Advisory Committee. That is made up of the Central Health and Safety Officer and the Health and Safety Officer of each institute, and is chaired by the Head of the Central Personnel Department.

The FOM Foundation has both a central Works Council and local equivalents. The foundation’s Director meets regularly with the central council to discuss health and safety matters, and reports annually to it on progress in the implementation of health and safety policy.

Workplace requirements
As their employer, the FOM Foundation is responsible for the health and safety of all its personnel, including those working at other locations such as universities. All workplaces used by FOM employees must meet the following minimum requirements.
1. there is a designated Health and Safety Officer or equivalent at the location
2. an in-house emergency response team is present at the location and is able to act effectively in the event of an emergency
3. upon secondment to the workplace, the FOM employee receives full and adequate information about the risks associated with their work. This must include instruction on emergency response procedures, such as raising the alarm, basic firefighting, evacuation and escape routes
4. the location is designed in such a way that all working activities can be carried out safely
5. information is on hand explaining how to report dangerous situations and other health and safety issues, and from whom advice on safe working can be sought.

Should an employee feel that these requirements are not being met, they should report this to the Central Health and Safety Officer or their personnel officer at FOM. We will then contact the organization responsible on their behalf.

High-risk work
High-risk work may only be performed by personnel with the necessary professional know-how and skills. Such work includes tasks involving electricity, gas cylinders, radiation, hazardous substances, lasers, hoisting equipment and work at height.

In many cases, special training and courses are available locally to ensure that specific duties are performed safely. Do not hesitate to enquire about these opportunities!
FOM Foundation
www.fom.nl/safety
DIFFER intranet
FOM-Nikhef intranet
AMOLF intranet

Organizations with FOM working groups
Occupational Health and Safety Catalogue for Research Institutes, Association of Dutch Research Institutes: www.wvoi.nl

External sources
www.arbokennisnet.nl
www.arboportaal.nl

Books
• Veiligheid en milieu in laboratoria
• Praktische stralingshygiëne
• Arbeid en gezondheid 2014
• Praktijkgids Arbeidsveiligheid 2015
  Walter Zwaard et al. Vakmedianet.

QUICK LINKS
Current health and safety information: www.fom.nl/arbo
Personal contact: safety@fom.nl
Report absent due to illness: ziekmeling@fom.nl
Central Personnel Department: cpd@fom.nl

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In compiling this publication, the authors have made use of existing FOM texts as well as drawing upon websites, folders and brochures from universities and suppliers, reports from the Universities Joint Organization for Occupational Health, Safety and the Environment (IAVM), health and safety information sheets, specialist literature and practical experiences.

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