HSE for master students in physics laboratories 2019

- Builds on HMS0003 – The NV faculty's course for master students

- Subjects that may be important for work in physics labs:
  - General HSE information
  - Electrical hazards
  - Chemicals, substance index
  - Gas
  - Waste disposal
  - Fume hoods
  - Personal protective equipment
  - Radiation protection
  - Risk assessment

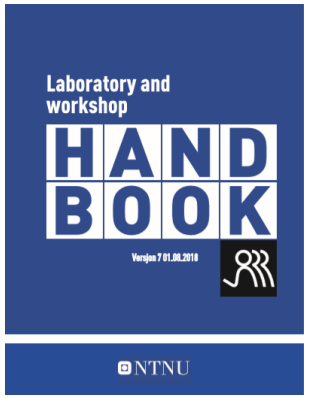
- In addition there are practical trainings given locally in the labs

HSE roles and responsibilities at IFY

	*Erik Wahlstrøm* - Head of department	Responsible leader
	*Oddbjørn Grandum* - HSE coordinator	HSE in general, gas supply, radiation protection, fire protection, fume hoods, and more.
	*Kristin Grendstad* - Senior engineer biophysics	Purchasing chemicals, substance index, exposure index. Disposal of hazardous waste.
	Supervisors and lab engineers	HSE in the labs - operation, training, supervision, etc.

Links to HSE information on Innsida

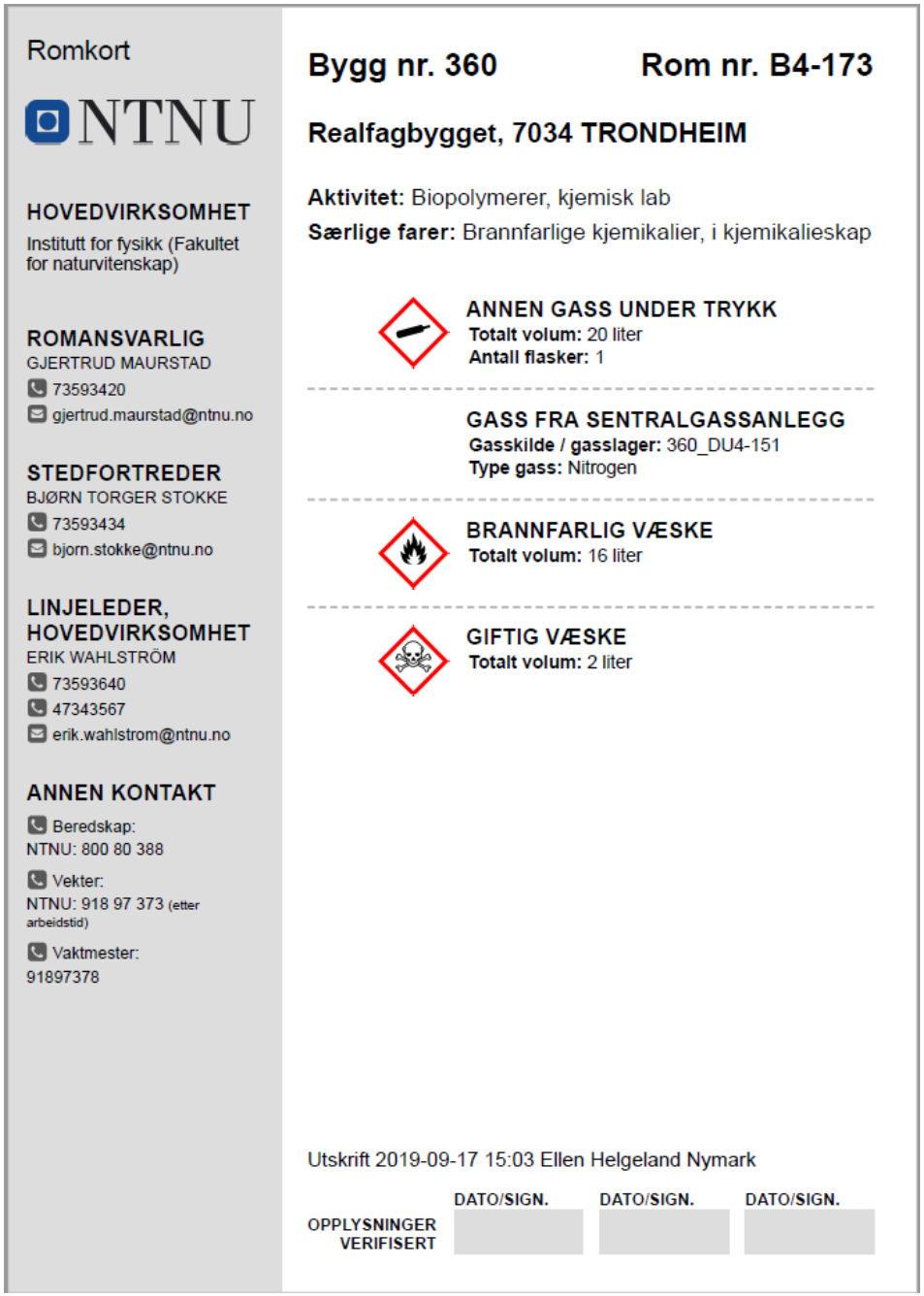
- HSE for employees at NTNU – for NTNU in general
- HSE for students at NTNU – specifically for students
- HSE at NV – local to the NV faculty (in Norwegian)
- HSE at IFY – local to IFY (in Norwegian)
- Laboratory and workshop handbook (pdf)



Important documentation for laboratories

Room card	Outside every lab entrance - Content and hazards in the room, important for the fire department
Apparatus card	At apparatus - Conditions around the operation, emergency stop procedures, etc.
Operation instructions	Instructions for performance of work tasks or use of apparatus
Risk assessments	Documentation of hazards - At the time being, doe “manually” (Excel), should be available for all involved
Safety data sheet	Safety information about hazardous chemicals/substances - Should be available in the lab (paper copies, soon digital on tablet)
Substance index	Digital archive of hazardous substances, including safety data sheets - Read access for all who need it

Room card



Romkort

NTNU

HOVEDVIRKSOMHET
Institutt for fysikk (Fakultet for naturvitenskap)

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erik.wahlstrom@ntnu.no

ANNEN KONTAKT
Beredskap:
NTNU: 800 80 388
Vekter:
NTNU: 918 97 373 (etter arbeidstid)
Vaktmester:
91897378

Bygg nr. 360 **Rom nr. B4-173**

Realfagbygget, 7034 TRONDHEIM

Aktivitet: Biopolymerer, kjemisk lab
Særlige farer: Brannfarlige kjemikalier, i kjemikalieskap

ANNEN GASS UNDER TRYKK
Totalt volum: 20 liter
Antall flasker: 1

GASS FRA SENTRALGASSANLEGG
Gasskilde / gasslager: 360_DU4-151
Type gass: Nitrogen

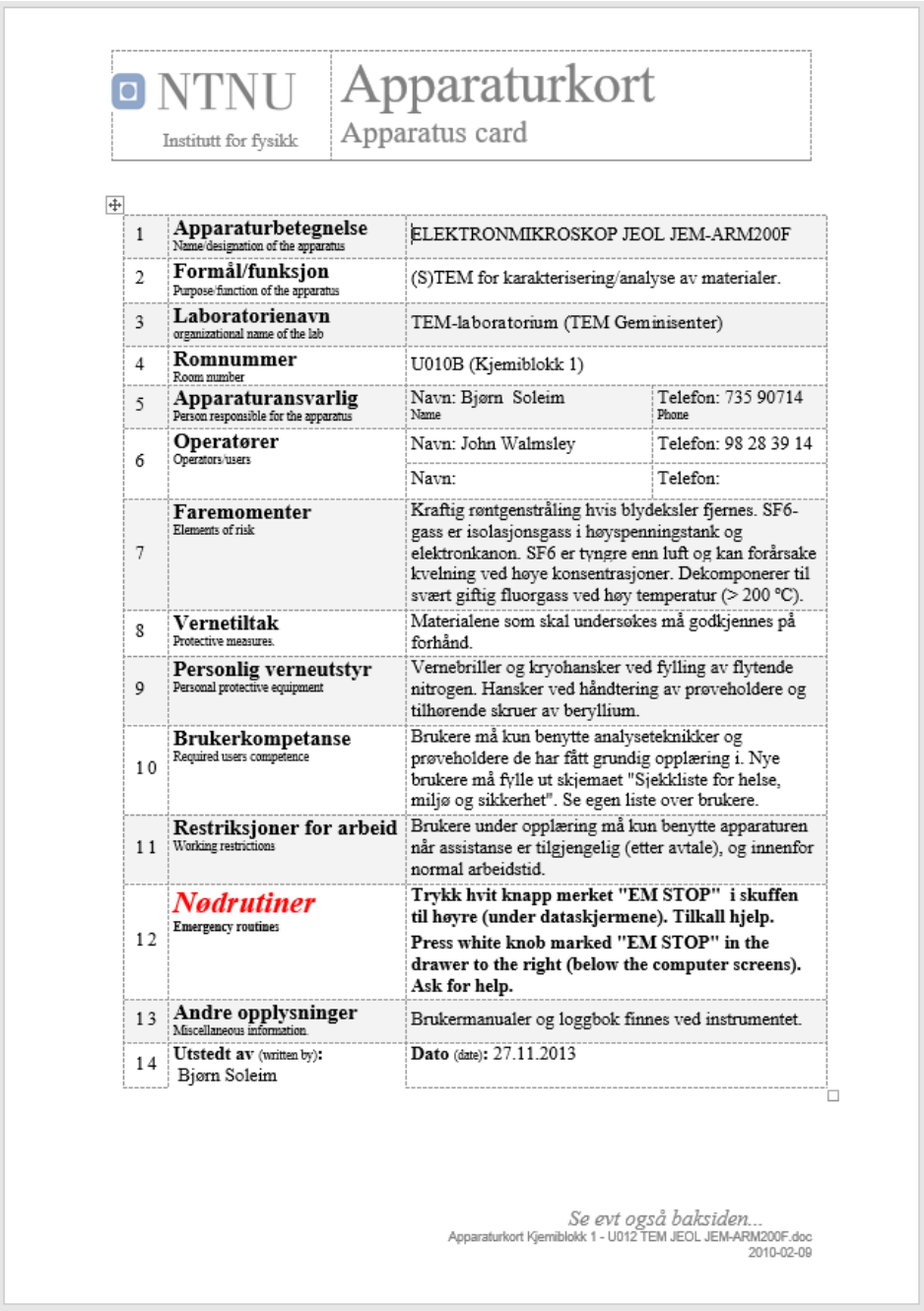
BRANNFARLIG VÆSKE
Totalt volum: 16 liter

GIFTIG VÆSKE
Totalt volum: 2 liter

Utskrift 2019-09-17 15:03 Ellen Helgeland Nymark

	DATO/SIGN.	DATO/SIGN.	DATO/SIGN.
OPPLYSNINGER VERIFISERT			

Apparatus card



NTNU
Institutt for fysikk

Apparaturkort
Apparatus card

1	**Apparaturbetegnelse** Name/designation of the apparatus	ELEKTRONMIKROSKOP JEOL JEM-ARM200F	
2	**Formål/funksjon** Purpose/function of the apparatus	(S)TEM for karakterisering/analyse av materialer.	
3	**Laboratorienavn** organizational name of the lab	TEM-laboratorium (TEM Gemini senter)	
4	**Romnummer** Room number	U010B (Kjemiblokk 1)	
5	**Apparatursansvarlig** Person responsible for the apparatus	Navn: Bjørn Soleim Name	Telefon: 735 90714 Phone
6	**Operatører** Operators/users	Navn: John Walmsley	Telefon: 98 28 39 14
		Navn:	Telefon:
7	**Faremomenter** Elements of risk	Kraftig røntgenstråling hvis blydeksler fjernes. SF6-gass er isolasjonsgass i høyspenningstank og elektronkanon. SF6 er tyngre enn luft og kan forårsake kvelning ved høye konsentrasjoner. Dekomponerer til svært giftig fluorgass ved høy temperatur (> 200 °C).	
8	**Vernetiltak** Protective measures.	Materialene som skal undersøkes må godkjennes på forhånd.	
9	**Personlig verneutstyr** Personal protective equipment	Vernebriller og kryohansker ved fylling av flytende nitrogen. Hansker ved håndtering av prøveholdere og tilhørende skruer av beryllium.	
10	**Brukerkompetanse** Required users competence	Brukere må kun benytte analyseteknikker og prøveholdere de har fått grundig opplæring i. Nye brukere må fylle ut skjemaet "Sjekkliste for helse, miljø og sikkerhet". Se egen liste over brukere.	
11	**Restriksjoner for arbeid** Working restrictions	Brukere under opplæring må kun benytte apparaturen når assistanse er tilgjengelig (etter avtale), og innenfor normal arbeidstid.	
12	***Nødrutiner*** Emergency routines	**Trykk hvit knapp merket "EM STOP" i skuffen til høyre (under dataskjermene). Tilkall hjelp.** **Press white knob marked "EM STOP" in the drawer to the right (below the computer screens). Ask for help.**	
13	**Andre opplysninger** Miscellaneous information.	Brukermanualer og loggbok finnes ved instrumentet.	
14	**Utstedt av** (written by): Bjørn Soleim	**Dato** (date): 27.11.2013	

Se evt også baksiden...

Apparaturkort Kjemiblokk 1 - U012 TEM JEOL JEM-ARM200F.doc
2010-02-09

Operation instructions

DRIFTSINSTRUKS | **Fakultet for naturvitenskap og teknologi**

MASKIN/APPARATUR/INSTRUMENT:	JEOL transmisjonselektronmikroskop
Fabrikat/serienr:	JEM-2100 sn.EM1743001050105 **Lokalisering:** K1-U010B
Original manual finnes hvor?	Ved instrumentet

Loggbok med kvittering for opplæring og vedlikehold av utstyret:
Liste over godkjente brukere samt loggbøker for bruk og vedlikehold finnes ved instrumentet

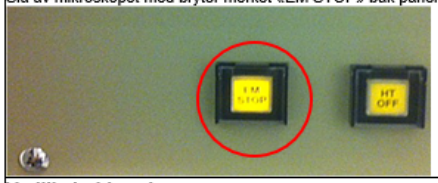
Risikovurdering:

Gjennomført risikovurdering, dato:	
Arkivert:	

Påbudt personlig verneutstyr:		**Faremomenter:**	
Øyevern ved fylling av LiN	X	Brann	
Hansker ved fylling av LiN	X	Kjemikalier/gasser	
Hørselvern		Strøm/høy spenning	
Bekledning		Temperatur/trykk	
Åndedrettsvern		Kutt/klemfare	
Skjerming		Roterende utstyr	
Annet		Farlig avfall	
Ingen		Utenom arbeidstid	
		Annet	
		Ingen	X

Bruksanvisning (Fyll inn, eller henvis til vedlegg)
Se vedlegg, "JEM-2100 (130821) Short user guide" (finnes også ved instrumentet). Bruksanvinsning for teknikker som STEM, EDS og GIF finnes ved instrumentet.

Nødprosedyre (Handlemåte ved nødstopp, bilde av nødbryter og lignende)
Slå av mikroskopet med bryter merket «EM STOP» bak panel nede til venstre på mikroskopet:



Vedlikeholdsrutiner

Hyppighet:	Ved behov
Serviceavtaler:	JEOL Skandinavia
Kontaktpersoner:	Bjørn Soleim (Kontaktperson JEOL: Heimir Magnusson)
Vedlikehold beskrives i eget vedlegg:	

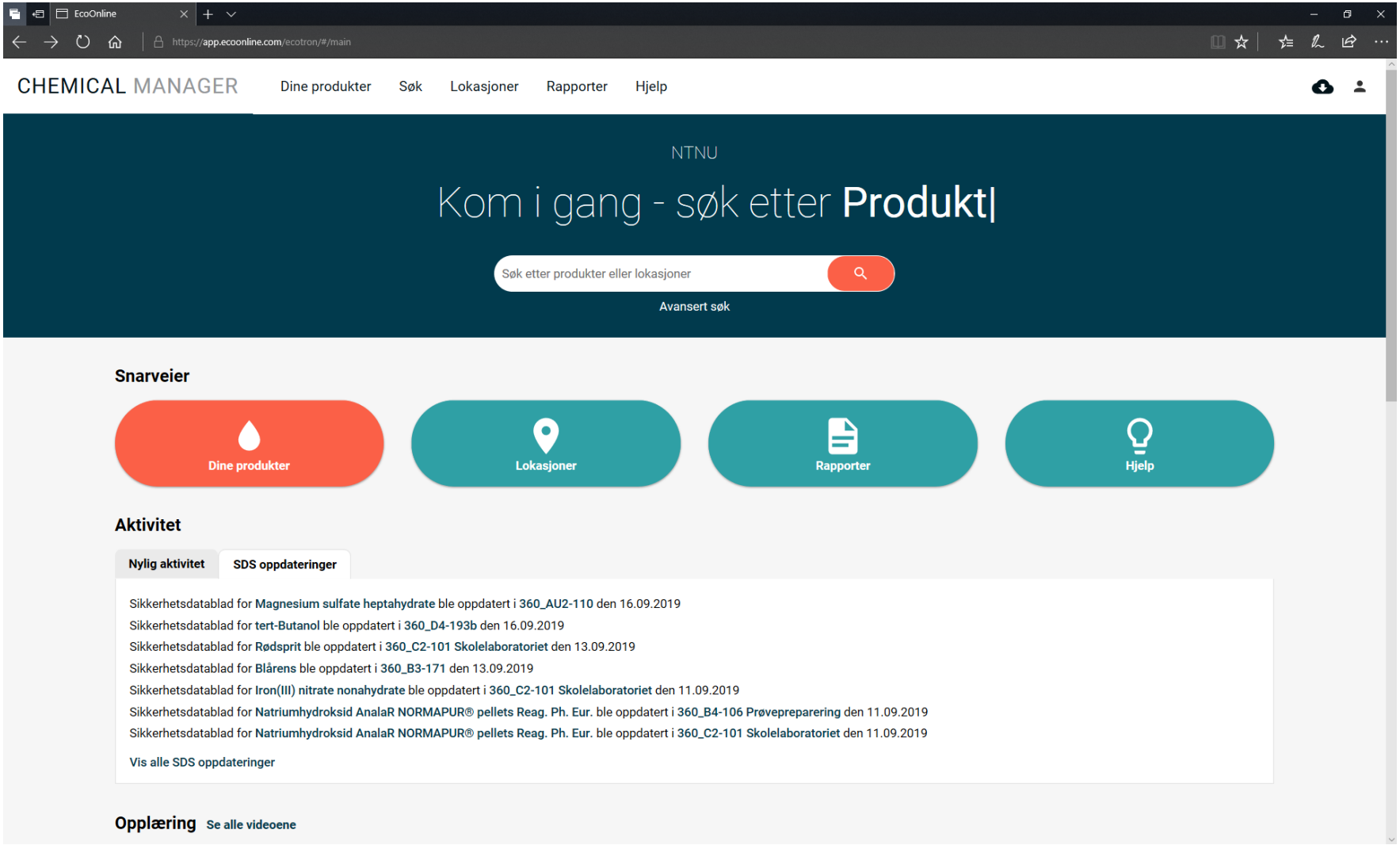
Utstyrsansvarlig:			
Navn:	Bjørn Soleim	Navn:	Ragnhild Sæterli
Telefon:	73590714	Telefon:	73593143
Mobil:	99109180	Mobil:	98666799
Signatur		Signatur	

Kontrollert og oppdatert:

Dato:		Dato:		Dato:	
Dato:		Dato:		Dato:	

M:\Driftsinstrukser\Driftsinstruks B4-106 - TemPol.doc

Substance index



Clarifications before starting work in the lab

- **Lab routines**
  - Local routines, operation instructions, special conditions?
- **Health conditions**
  - Allergies, pregnancy/breast feeding, disabilities, etc
  - Need for medical examination? Registration in exposure index?
- **Knowledge**
  - Required courses? Literature? Background?
- **Training**
  - Introduction and training given by engineers and supervisor
- **Risk assessment**
  - All lab work should be risk assessed

Working alone in the lab?

- Risk assessment determines whether it is acceptable to work alone.
  - Danger of acute injury demanding help quickly from others?
  - Are there others within “shouting distance” that may help?
  - The supervisor should give the permission to work alone.

- Working alone alarm (jobbe alene-alarm):
  - Only some places at IFY
  - Only consequence reduction

A few things to remember in the lab

- Never eat or drink in the lab

- Never taste the chemicals
- Never use your mouth for any work tasks

- Remove gloves and wash your hands before leaving the lab

- Log your activity thoroughly

- No practical jokes in the lab

Emergency planning at IFY, NV and NTNU

- *Emergency planning*: Being prepared and being able to act correctly in an acute, stressful emergency
- **Everybody** can get a role in an emergency – as one involved or first to arrive
  - Be able to give first aid, handle a fire, shut down apparatus, etc.
  - Notify according to notification procedures
  - Contribute with local knowledge about the activity at an emergency scene, etc.
- On Innsida:

  Emergency (Norwegian and English)

  Emergency planning at NTNU (Norwegian and English)

  Emergency planning at the NV faculty (Norwegian)

Some relevant warning signs at IFY


Gas flask


Flammable substance


Oxidizing substance


Electrical hazard


Toxic


Biological hazard


Hot surface


Cold


Laser


Magnetic field


Non-ionizing radiation


Ionizing radiation

Dangers of electricity

- Current through the heart region is especially dangerous
- **10 mA** can paralyze muscle control
- **50 mA** can give atrial fibrillation/cardiac arrest
- High voltages (> 1 kV) can also create an electric arc.

Effects of an electric shock

- Acute injuries:
  - Atrial fibrillation, cardiac arrest
  - Respiratory failure
  - Electrical burns, superficial and/or internal
  - Injuries may also appear after a delay (several days)

- Long term effects:
  - Physical nerve damage, paralysis
  - Muscular/skeletal damage
  - Mental problems (post traumatic stress)

Avoid electric current through your body

- Avoid the possibility of current passing through your upper body (hand to hand or hand to foot).
- Do not grab something that is potentially conducting, use the back of your hand to touch it (if necessary).
- *Fuses* (e.g. 16 A) protect equipment, not people.
- *Residual-current devices (RCDs)* (approx. 30 mA) are intended for protection of people in the event of a fault that may lead current from phase to ground through a person.

Electrical equipment

- Do not use electrical equipment that is in poor condition.
  - Report the defect so it can be repaired.
- Wires and plugs must also be in order.
  - Insulation on wires, and strain relief and encapsulation on plugs and sockets must be intact.
- Limit the use of extension leads.
  - Do not use extension leads with equipment that draw a lot of current (e.g. ovens)
  - Avoid creating tripwires and dust collectors with the extension leads.
- If you get «shocked» by equipment, immediately stop using it.
- The electrical system in the building (TN) is somewhat different from the normal (IT).
  - Can be of consequence for equipment in some cases…

Chemicals and hazardous substances

- **Acquisition of chemicals**

  The ordering must go through the orderer (“fagbestiller”) of chemicals.

  Before you order:

  Safety data sheet (SDS) must be read.

  Substitution must be considered (for hazardous substances).

  Before you use the chemical:

  Risk assessment of the use must be performed.

Substance index at NTNU

- Legally required index of *hazardous* substances*:*
  - Important technical/chemical data
  - Where the substances are located
  - Safety data sheets, or information sheets
  - Risk assessment of inherent properties
  - Other important information

- *EcoOnline* software with modules:
  - ***Chemical Manager* – substance index**
  - *EcoExposure* – exposure index
  - *Eco Local Publisher* – create information sheets

Chemical Manager

Link to the substance index on Innsida, where you can log in

https://innsida.ntnu.no/wiki/-/wiki/English/Safety+data+sheets

SDS Benzen

Regulations of chemicals

Norway follows the rules for EU

- **REACH:** EU's legislation regulating chemicals
- **GHS:** Global (UN) system for classification and labelling of chemicals
- **CLP**: EU's directive implementing *GHS*

Safety data sheet

1	**Identification**	Product identifier, recommended use and restrictions on use, supplier contact information, emergency phone number
2	**Hazard Identification**	Classification (hazard class and category), label elements (including hazard pictogram, signal word, hazard statement and precautionary statements) and other hazards (e.g. thermal hazards).
3	**Composition / Ingredients Information**	For a hazardous product that is a substance: the chemical name, synonyms, CAS No. and the chemical name of impurities, stabilizing solvents and stabilizing additives where classified and that contribute to the classification of the product. For a hazardous product that is a mixture: for ingredients that present a health hazard, the chemical name, synonyms, CAS No. and concentration. Note: Confidential Business Information Rules may apply.
4	**First Aid Measures**	First-aid measures by route of exposure as well as most important symptoms/effects.
5	**Fire Fighting Measures**	Suitable (and unsuitable) extinguishing media, specific hazards, special equipment and precautions for fire fighters.
6	**Accidental Release Measures**	Protective equipment, emergency procedures, methods and materials for containment and clean up.
7	**Handling and Storage**	Precautions for safe handling, conditions for storage, including any incompatibilities.
8	**Exposure Controls / Personal Protection**	Exposure limits, engineering controls, personal protective equipment.
9	**Physical and Chemical Properties**	Appearance, odour, odour threshold, pH, melting/freezing point, boiling point and range, flash point, upper and lower flammable or explosive limits.
10	**Stability and Reactivity**	Reactivity, chemical stability, possible hazardous reactions, conditions to avoid, incompatible materials, hazardous decomposition products.
11	**Toxicological Information**	Description of various toxic effects by route of entry, including effects of acute or chronic exposure, carcinogenicity, reproductive effects, respiratory sensitization.
12	**Ecological Information**	Aquatic and terrestrial toxicity (if available), persistence and degradability, bioaccumulative potential, mobility in soil
13	**Disposal Considerations**	Safe handling and methods of disposal, including contaminated packaging.
14	**Transport Information**	UN number and proper shipping name, hazard classes, packing group.
15	**Regulatory Information**	Safety, health and environmental regulations specific to the product.
16	**Other Information**	Other information, including date of the latest revision of the SDS.

← Primary hazards

← Spillage on skin? Inhalation?

← Extinguishing media?

← Measures at spillage

← Handling. What should be avoided?

← Necessary protective equipment?

← Highly reactive? Explosive?

← Important for disposal

← Hazard symbols, H and P statements

Hazard classification of substances

Type of hazard	Hazard class and category
Physical hazards	Example: Flammable liquids (category 1, 2, 3)
Health hazards	Example: Carcinogenicity (category 1 A-B, 2)
Environmental hazards	Example: Hazardous to the aquatic environment (acute category 1, chronic category 1-4)

GHS hazard symbols

***Signal words* indicating relative severity:**
Danger (*Fare)****, Warning (****Advarsel)***

H and P statements

- Hazard statements (**H**):

Code	Type of hazard	Example **H** statements
H200 –	Physical hazard	H226 – Flammable liquid and vapour
H300 –	Health hazard	H350 – May cause cancer
H400 –	Environmental hazard	H400 – Very toxic to aquatic life

- Precautionary statements (**P**):

Code	Type of measure	Example **P** statements
P100 –	General	P103 – Read label before use
P200 –	Prevention	P232 – Protect from moisture
P300 –	Response	P313 – Get medical advice/attention
P400 –	Storage	P402 – Store in a dry place
P500 –	Disposal	P501 – Dispose of contents/container ...

Exposure index

Index of employees who are exposed to:

- Carcinogenic and mutagenic chemicals
  - H340 – May cause genetic defects
  - H350 – May cause cancer
  - H350i – May cause cancer by inhalation
- Lead and lead compounds
- Biological factors
  - Infection risk group 3 & 4
- Dust containing asbestos fibres
- Hazardous substances in rock work
- Ionising radiation

First aid measures

Fire fighting measures

Emergency planning for chemical spillage

- Personal safety is most important;
  - Safe to clean up yourself?

  OR
  - Evacuate, alert and leave it to the fire department?
- Quick warning to others affected
- Materials for handling chemical spillage can be found in the lab
  - Protective equipment, absorbents

Storage of chemicals

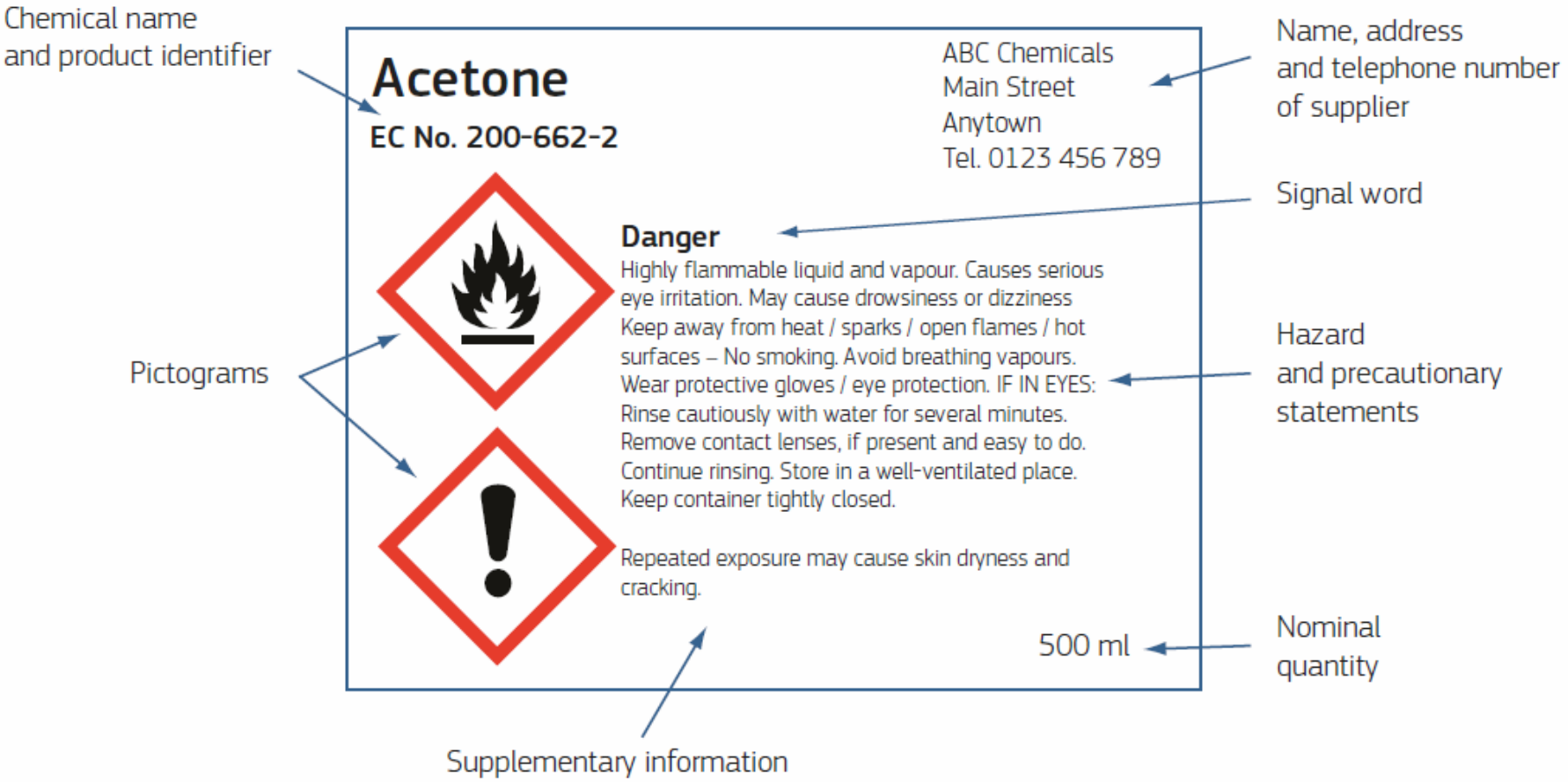
- Chemical cabinets connected to ventilation
- Lower cabinets of the fume hoods
- Fire resistant cabinets for substantial amounts of flammable or oxidizing substances
- Locked cabinets for very toxic substances
- It is important with compatibility, and separation, for:
  - Acids <-> bases
  - Toxic
  - Flammable
  - Oxidizing
  - “Particularly reactive”

IFY chemical storage

- Shared chemical storage for IFY in C4-100
- Access control, training required
- Work stations for weighing, sample preparation

Personal protective equipment

Labelling of chemical containers

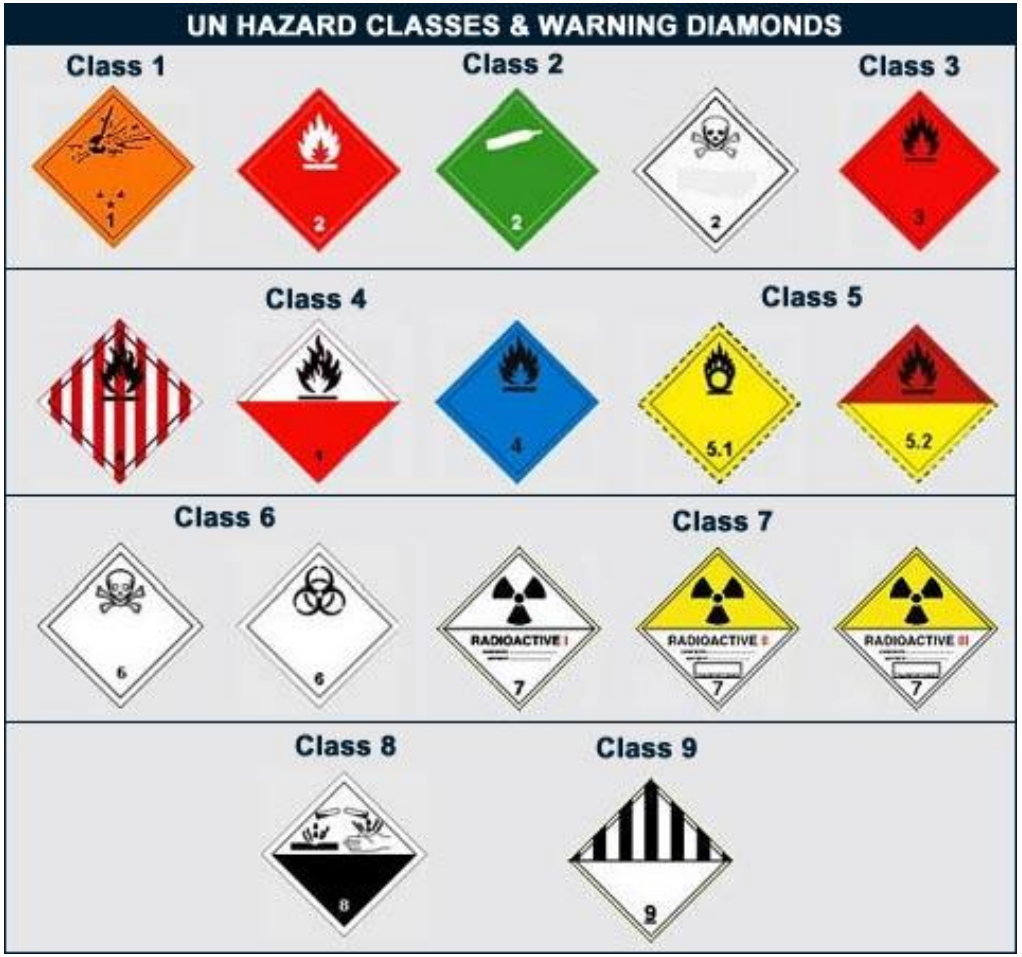


Labelling of your own chemicals

- Non-original containers and self-made substances, in the lab and in storage, must also be labelled:
  - Name of the chemical, and potentially formula
  - Concentration
  - Date
  - Name of owner
  - Possibly hazard statements (GHS)
- Also completely harmless substances, like water, must be labelled!

ADR – hazard symbols for transport on roads

- Labels that will appear on containers …



Formation of peroxides

- **Peroxides:** Reactive oxygen compounds which may initiate violent reactions
- Risk factors for formation in different chemicals:
  1. Access to oxygen (air in the container)
  2. Concentration (evaporation, distillation)
  3. Polymerization
- Especially relevant for many ethers
  - At IFY, among others, *Tetrahydrofuran (THF)*

Peroxide forming chemicals

- Avoid:
  - Light, access to air
  - Long term storage, max 1 year
  - Heat, shock/friction
  - Addition of contaminants
- Cool storage
- Small containers, limited storage
- Labelling with date of receipt, use
- If there are signs of contamination (precipitate, crystals, or similar):
  - Do NOT open the bottle; label it and notify

Transportation of chemicals

- Use special transportation containers or a trolley with a frame for safe transport of chemicals

- Evaluate risks: What might happen if a bottle breaks…?

Chemicals - more information

NTNU's guidelines:

Chemicals and gases

Disposal of chemical waste

Peroxide forming chemicals (Univ. Bergen)

NTNU's HSE movie (20 min):

(in Norwegian)

Sikkerhet på laboratoriet

Gas use at IFY

Pressurized gas cylinders

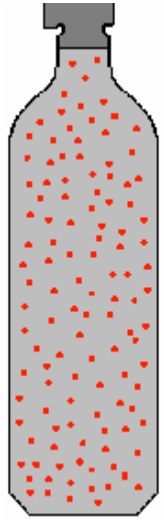
Gas outlets from central gas supply

Liquid nitrogen and helium

(Pressurized air)

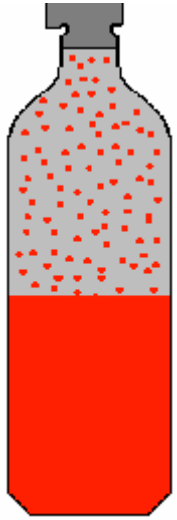
Gas in different phases

Compressed



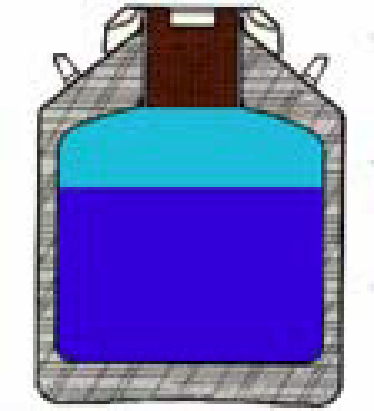
Examples:
N_2, Ar, O_2

Compressed and liquified



Examples:
CO_2, Propane

Cryogenic liquid



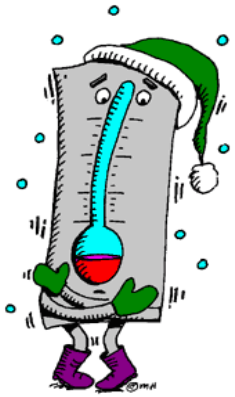
Examples:
Liquid N_2, He

«Dry ice»
(Solid CO_2)

Hazards with gas use

High pressure

Suffocation



Frostbite

Fire and explosion

Poisoning

Oxygen-enrichment

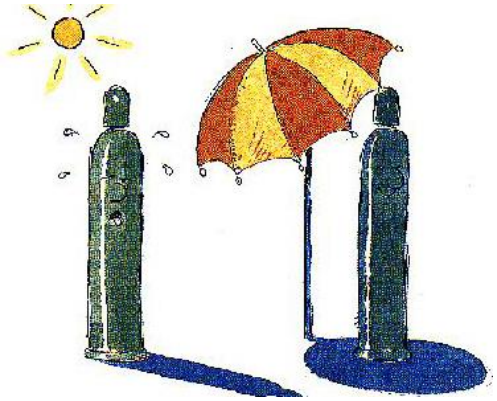
Physical protection of gas cylinders

Compressed gases typically have a cylinder pressure of 200 bar.

Pressurized gas

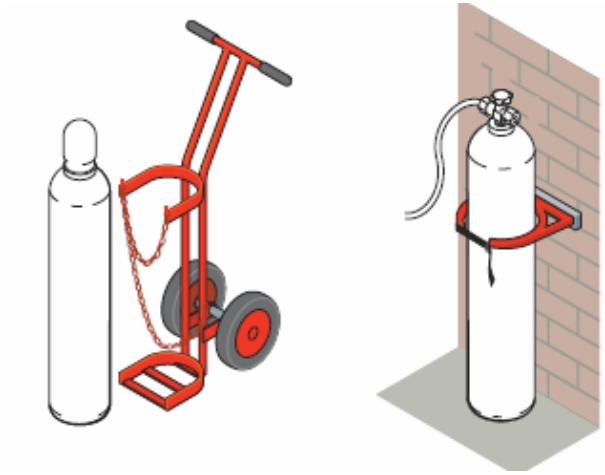
Gas cylinders must not be exposed to temperatures above 45 °C

- Risk of explosion



Gas cylinders must be secured against accidents that may damage the valve

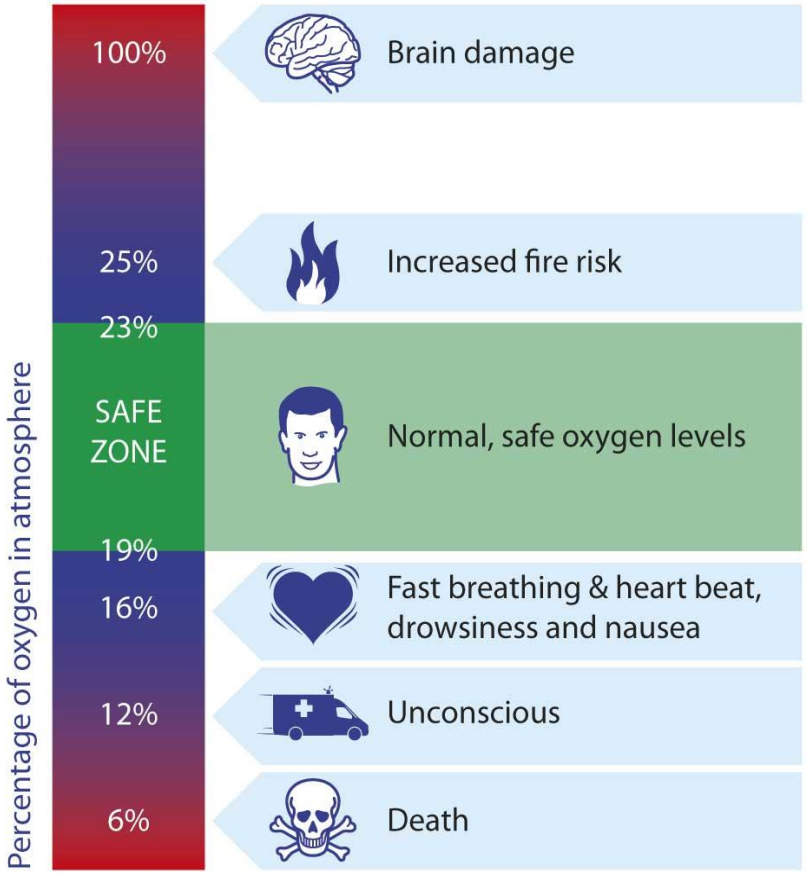
- The cylinder becomes a deadly rocket if the valve is broken off



Oxygen content in the air

- Organic materials (including clothes, hair) become combustible when oxygen-enriched.
- Fat, oils, etc, must never be used in conjunction with O_2.

- Danger of O_2 shortage with all use of gas, also liquid N_2 and dry ice (CO_2).
- Suffocation caused by lack of O_2 can happen without warning.



Liquid nitrogen (-196 °C)

- Can cause serious frostbite instantly.
- Use cryogenic protection equipment during handling
  - Gloves, face shield, impervious clothes and suitable footwear
- Many materials become brittle in extreme cold
- Confinement in a closed container will give rise to quick build-up of pressure and an explosion
- Displacement of oxygen and danger of suffocation

Toxic gases

- Different types of toxic effects:
  - Affects the oxygen uptake, examples: CO_2, CO
  - Irritating to the organism, examples: NH_3, Cl_2, NOx
  - Affects the central nervous system, example: organic solvents
- Relevant protective measures:
  - Filtered gas masks
  - Fresh air masks/supply
  - Personal gas detector/alarm
  - Fixed gas alarm which alerts security
- NB! CO especially dangerous to foetuses

Combustible gases

- ***Flammable*** *gases*
  - Examples: propane, hydrogen
- Conditions for ignition
  - Suitable concentration of gas
  - Sufficient ignition energy
- Should be stored separately from oxidizing gases and flammable materials, and ignition sources

- ***Oxidizing*** gases can enhance existing fires
  - Examples: oxygen, laughing gas (N_2O)

Gases – further information

- Interactive e-course
- Basic training for all who are going to handle gases.

Waste disposal

Guidelines:

- About waste at NTNU in general
- Disposal of chemical waste
- Disposal of infectious waste

Combustible waste

- Paper, cloths with residue of solvents, oil, etc, which can cause self-ignition:
  - First possibly aired in a fume hood
  - Put in red container - *Brannfarlig avfall*
- Leftovers of combustible fluid *in the chemical container* is treated as chemical waste
- Explosive substances must NOT be disposed of in the same manner as other chemicals…

Chemical waste

- <u>Contaminated lab waste:</u>
  In container for chemical waste

- <u>Leftovers of chemicals:</u>
  - Stored in a labelled container, preferably the original
  - Disposal by agreement

Infectious waste (biological)

- Biological waste:
  - Tissue samples, pathological waste
  - Objects contaminated with biological material, cytostatic, antibiotics

- In yellow plastic container

- Needles and such should be put directly in a special, small, yellow container
- Do not try to replace the needle cap (danger of needlestick)

Glass waste

- Cleaned and dried glass waste:
  In special containers in the lab

- Contaminated glass waste:
  As other contaminated lab waste

- Stinging/cutting objects are put in special boxes in the lab

Fume hood

Standard fume hood in Realfagbygget

Markings for hatch height and max opening

Control panel on fume hood

Flashing red light + sound alarm:
Too low airflow. Lower the hatch.

Green light: Airflow OK

Flashing blue light + red light: Hatch opening is over maximum. Lower the hatch.

Gives maximum airflow. Red diode indicates active. Reset by pressing button again.

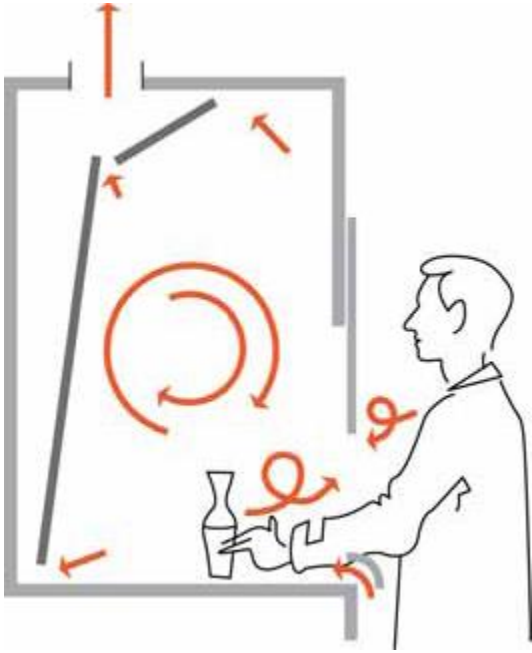
Button is disabled.
The airflow cannot be switched off.

Reset/Mute: Silence the alarm for a period.
Alarm silenced for 5 minutes.

Button is disabled.

Use of fume hood

- Fume hood in use? Air flow OK (can check with piece of paper)?
- Keep the hatch as far down as possible, and never higher than the maximum working opening.
- Raise the hatch slowly, so that the air flow can be adjusted.
- As little equipment, containers, etc, as possible in the fume hood during work.
- Work far in and in the centre of the fume hood.
- Work using slow motions.
- Never put your head in the fume hood.
- Close windows and doors close to the fume hood.
- Avoid traffic around the fume hood.
- Clean and tidy the fume hood after use.
- **Always close the fume hood after use.**



Point suctions

For less hazardous substances

Mobile filter station

A fan pulls contaminated air through a filter

Glove bag

Glove box

Can control the atmosphere; negative/excess pressure, gas content.

Sterile and safety benches

- **Sterile bench («LAF bench»)**: Filtered air (free of particles, sterile) is blown over the work surface to protect the sample. Does not protect the operator.
- **Safety bench, class II:** Sterile filtered air circulates in the bench. Both operator and sample are protected.

Safety bench

LAF bench

Fume hood – further information

Guidelines for fume hoods at NTNU

Personal protective equipment

The Working Environment Act (Arbeidsmiljøloven) §2-3:

- If no *other* measures are sufficient, personal protective equipment should be used.
- An employee is obliged to wear protective equipment if the employer requires it.
  - Protective equipment should be CE marked and certified according to relevant norm

CE - EU's declaration of conformity
NS - **N**orsk **S**tandard (Norwegian Standard)
EN - **E**uropean **N**orm
ISO - **I**nternational **S**tandards **O**rganization

Protective eyewear

- Different types of eye/face protection
- Contact lenses are <u>not</u> recommended in chemical labs
- “Ordinary” glasses are not accepted as protective eyewear

Protective eyewear instructions at the NV faculty. (Link in Norwegian)

Protective eyewear should be used:

- When it is stated in the chemicals' safety data sheets
- When it is stated in apparatus card or operation instructions
- With risk of splashing, work with liquid nitrogen, pressure, chip breaking work, danger of explosion, work in cutting machines, use of a saw, etc.
- In rooms and areas with the mandatory signs («eye protection lab»)

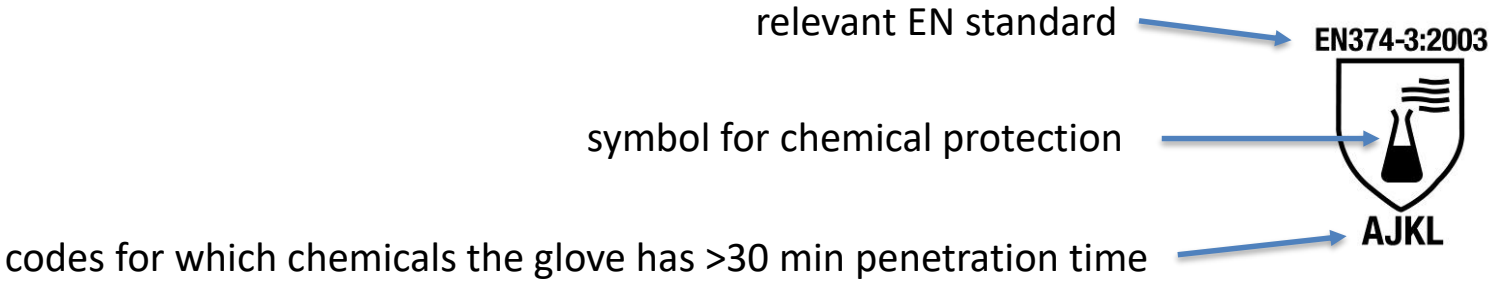
Hearing protection

- The right kind for different purposes
  - Danger of acute hearing damage, “shot noise”?
  - Long term, annoying noise?
  - Should be practical and comfortable in use

Gloves

- Many variants and ranges of application
- Three categories of protection level
  - Cat. 1: low risk – e.g. “washing-up gloves”
  - Cat. 2: moderate risk – e.g. “work gloves”
  - Cat. 3: high risk – e.g. gloves for strong chemicals
- Gloves in cat. 2 and 3 must be **EN** certified for the use

- Example of labelling of glove for chemical use:



Gloves – mechanical protection

- Mechanical wear
  - “regular work gloves”

- Prick and cut protection
  - Kevlar fabric, chainmail, etc

- ESD – against electrostatic discharge

Gloves – chemical and biological protection

- The selection of chemical resistant gloves is determined by type of chemicals and penetration time
- The suppliers have references/tables
- The safety data sheet for the chemical states the correct type of glove
- Disposable or reusable gloves?
- Complete immersion in the chemical or just a few drops of spillage now and then?

- Biological protection

Chemical resistant gloves - examples

- Disposable gloves – Nitrile
  - Most commonly used glove in the lab

- Good chemical protection – «4H»
  - Protects well against many hazardous substances
  - Fragile foil, often used with outer glove

- “Thick” gloves – robust
  - Butyl rubber

Gloves – thermal protection

- Heat protection

- Cold protection, cryogenic gloves
  - for liquid nitrogen

Clothes and footwear in the lab

- With chemical use:
  - Lab coat, preferably cotton
  - Complete covering of legs
  - Shoes of impervious material, optionally chemical shoe covers

- For mechanical protection:
  - Safety shoes with toe cap

- With extra demand for cleanliness:
  - Shoe covers or special lab shoes

Respiratory protective equipment

- **Used if no other measures are good enough**
  - **See the risk assessment**

- **What should you be protected against?**
  - Particles; dust, smoke, aerosols
  - Gases/fumes
  - Biological factors; bacteria, viruses, fungi

- **What level of protection is required?**
  - How dangerous is the substance?
  - What is an acceptable leakage, through the filter or with a leaky mask?

Respiratory protective equipment – filtering types

Disposable dust mask

Half-mask

Motor-assisted full face mask

Full face mask

Respiratory protective equipment – filters

- Dust filters:
  - P1: only against the coarsest dust
  - P2: against coarse/medium coarse dust, often used
  - P3: against fine dust, aerosols, droplet infection. Quickly becomes difficult to breath through
- Gas filters:
  - Letter and colour codes for different gases, E.g.: «A – brown» for organic fumes with boiling point > 65 degrees
- Combination filters:
  - Both dust and gas filtering in the same filter unit

Fresh air breathing apparatus

- Fresh air supplier must be used if
  - The oxygen content may fall **below 19.5 %**
  - The contamination's content and amount is unknown
- Fresh air can be supplied from your own portable bottle, or a central supply from a larger container, a different room, etc.

Regulator for fresh air supply – is connected to a source of clean air

Masks

- *Protection factors:*
  - How many times cleaner does the air become with a mask?
- The mask must fit well to the face
  - Beard, hair, etc. may reduce the protection significantly
- Health conditions can affect mask use:
  - Allergy to materials in the mask, glasses/lenses, respiratory afflictions, and more

Special protective equipment

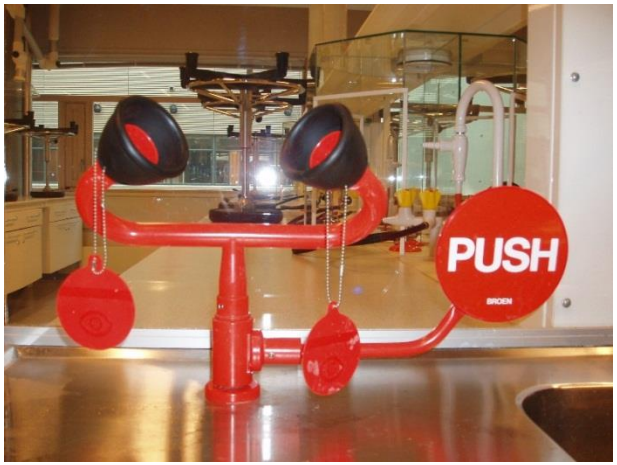
- Laser safety glasses – specially tailored to each laser
- Lead coats – for work with radioactive sources
- Cryogenic protective equipment – for liquid nitrogen
  - Safety glasses/face shield, cryogenic coat, impervious footwear, cryogenic gloves

- Physical protection – fall protection, helmet, etc.

Eye wash stations

- Box with eye wash bottles
  - *Ph Neutral* for neutralisation of acids/bases (small bottle)
  - Sterile salt water eye wash (large bottle)

- Eye wash stations
  - Different types



Emergency shower for the whole body

Protective measures – examples of measuring devices

Gas alarm for personal use

UV radiation

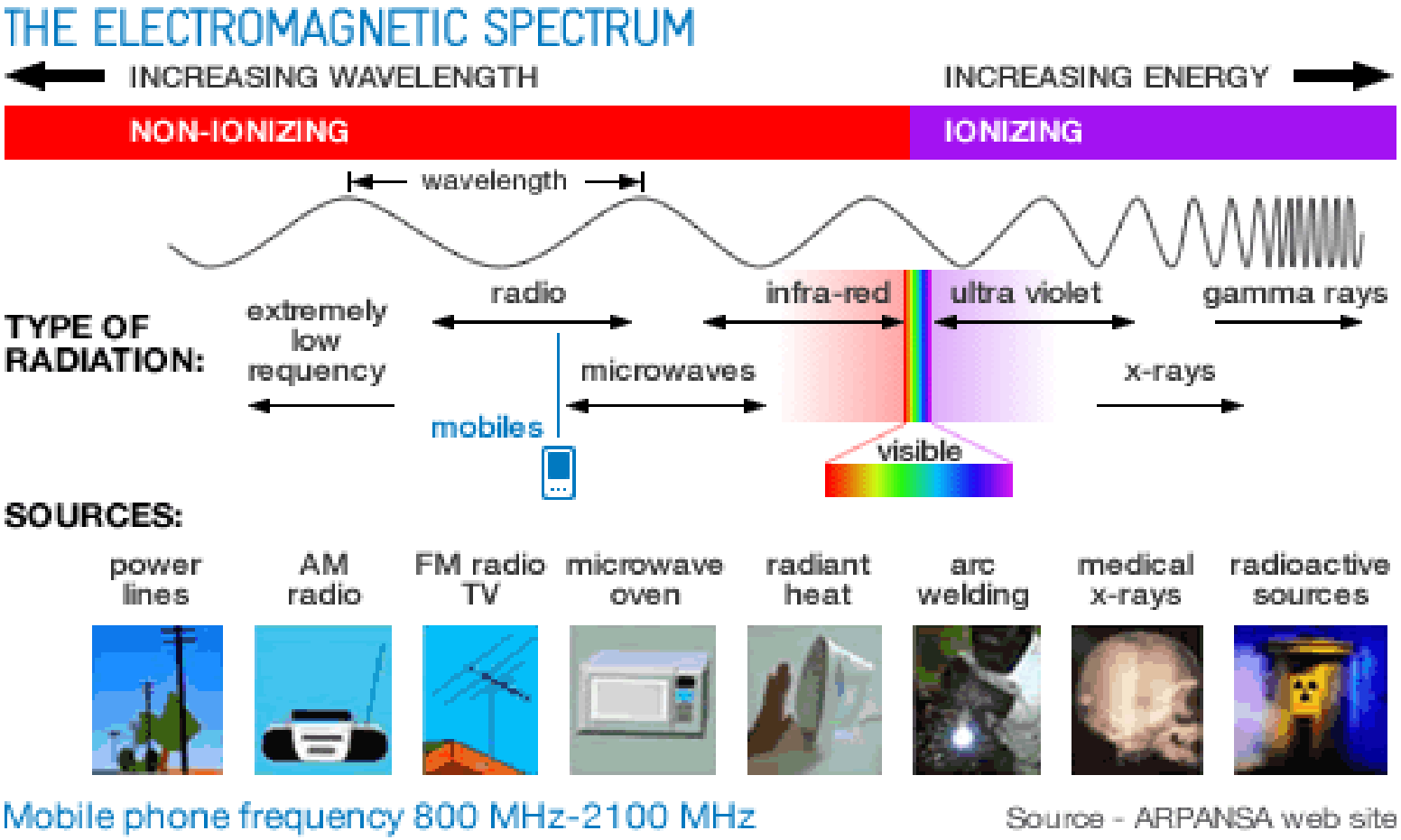
Air flow (in fume hoods)

Gas alarm in lab

Ionizing radiation

Acoustic noise

Radiation sources and radiation protection

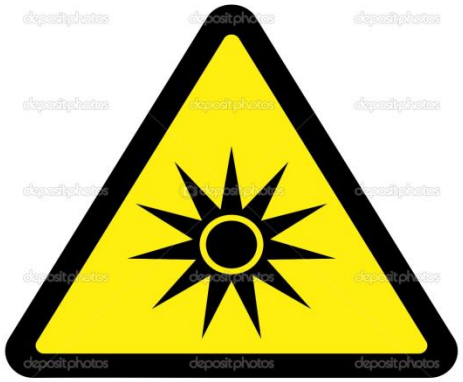


Warning signs for radiation

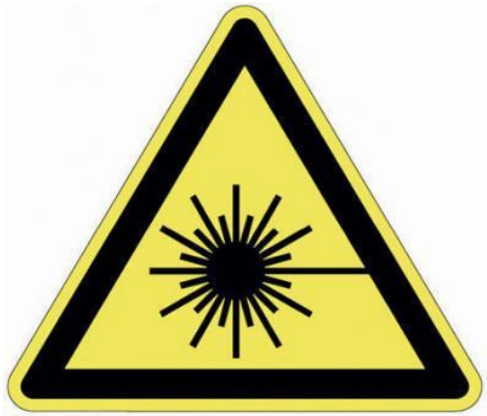
Ionizing radiation

Non-ionizing radiation

Strong magnetic fields



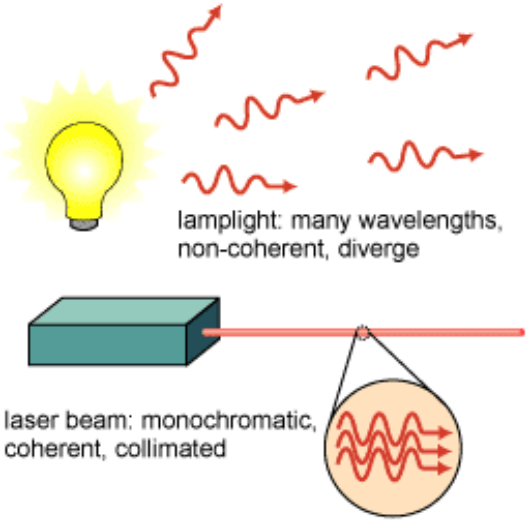
Optical radiation
(seldom used)



Laser radiation

Lasers

- Highly concentrated beam
- Potentially dangerous to the eyes
- Cannot “see” from the beam how dangerous it can be
- Lasers should be classified and labelled
- An international standard (EN 60825)



Laser classification

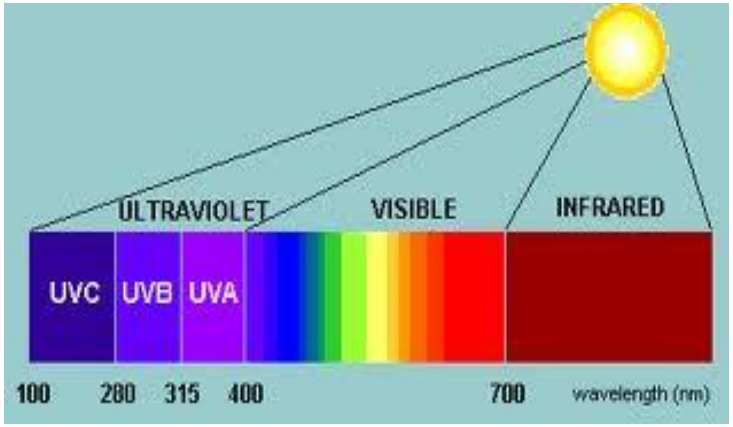
Laser class	Risk	Use
1 (1M)	Always safe	Free use, encapsulated strong lasers (CD players, etc)
2 (2M)	Safe as long as you don't stare into the beam over a longer period	Free use; laser pointers, laser levels
3R	Safe for short glimpses, reduced safety margin	Use in controlled conditions in the lab
3B	A direct beam is always dangerous to the eyes, diffuse reflections are considered safe	Only use under restrictions in adapted lab. Training required
4	Always dangerous to the eyes, including short glimpses of diffuse reflections. Can also be fire hazardous. Can cause skin damage.	Only use under strict restrictions in adapted lab. Training required

Laser pointers

- Lasers that are used in “the public sphere”; in lectures, and more
- Maximum allowed effect **1 mW (clas 2)**
- Be aware of many illegally sold laser pointers on the market
- Green colour gives greater visibility than red for the same radiation effect

Ultraviolet radiation (UV)

- UVA (315-400 nm)
  - Tan
- UVB (280-315 nm)
  - Tan and sun burn
- UVC (100-280 nm)
  - Skin and eye damage; “sun” burn, snow-blindness
  - Lacks in the sun radiation on earth
  - Only used technically



UVC sources

- A typical source consists of a fluorescent tube without fluorescent coating
  - Emission at 254 nm from Hg-gas discharge
- Typical use:
  - Sterilization (air, water, surfaces)
  - Polymerization, curing
- Require safety measures
  - Eye and skin protection
  - Controlled use

Other strong light sources

- New technology has given us some very strong light sources which may easily damage the eyesight.
- Should be used with care, eye protection might be required

Examples:

Light-emitting diodes (LED)

Laser-driven light sources (LDLS)

X-ray

- “Structure” x-ray: concentrated beam towards a material sample
- Even short exposure might cause bad wounds
- The x-ray machines at IFY are encapsulated
- Own laboratories and routines
- Training in the lab

Exposure of 5-10 seconds
Appearance of wound after 25 days

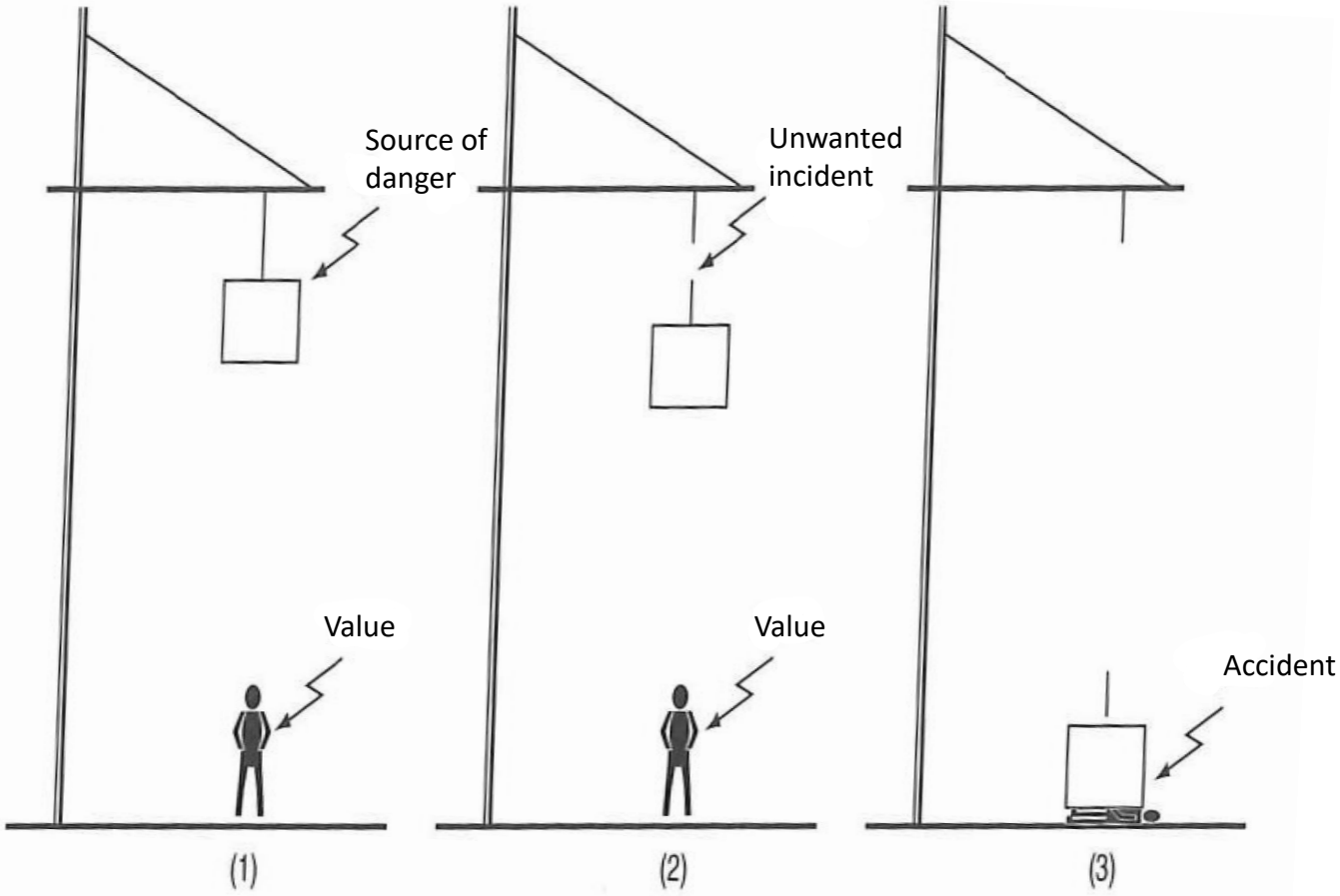
Electron microscope

- Uses electrons instead of light for depiction/magnification
- Can involve really high voltages
- Enclosed systems, safe to use

Risk assessment

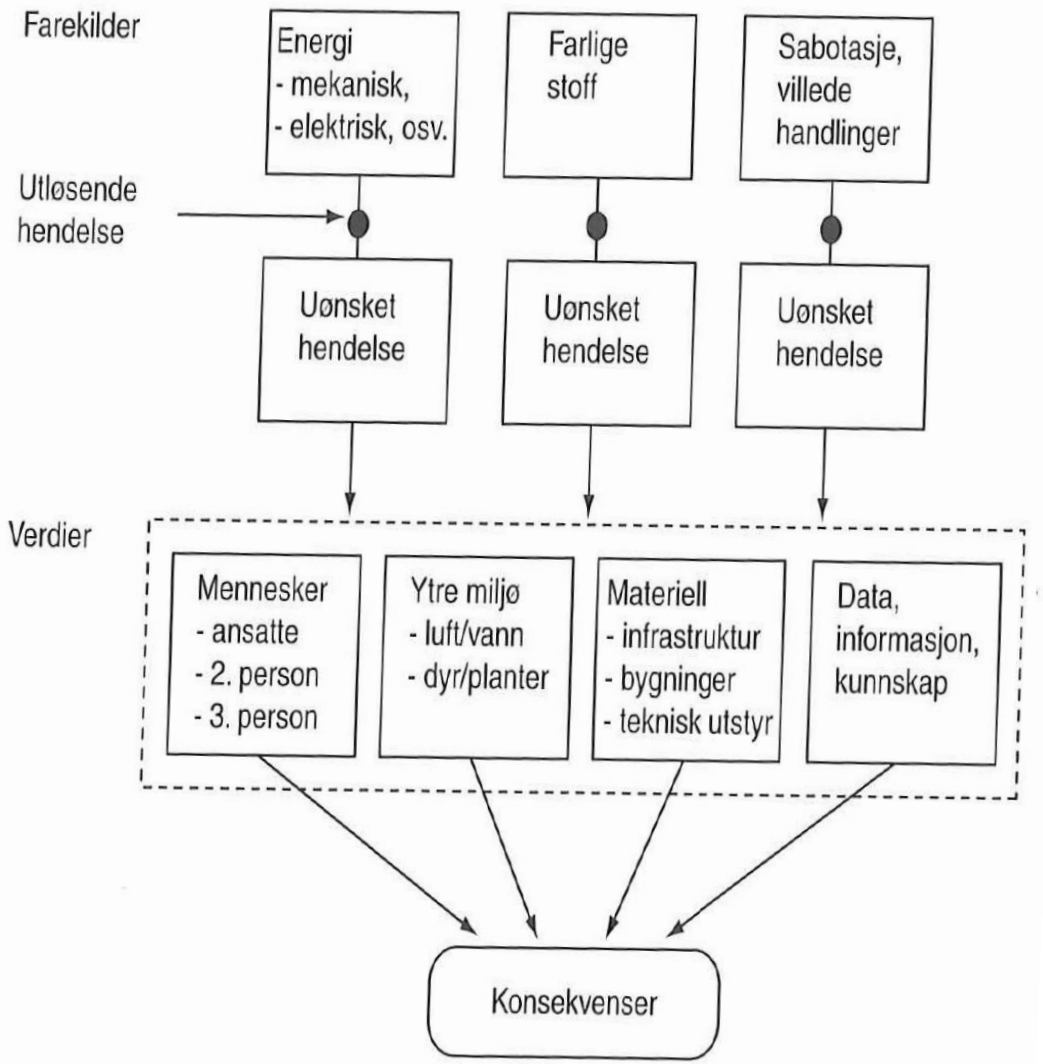
- *Hindsight in advance*

- **What should be evaluated (*source of danger*)?**
- **What might go wrong (*unwanted incident*)?**
- **What is *the probability*?**
- **What could *the consequences* be?**
- **What has been done so far (*existing measures*)?**
- **Is the risk considered acceptable (*acceptance criteria*)?**
- **What more could be done (*new measures/safety barriers*)?**



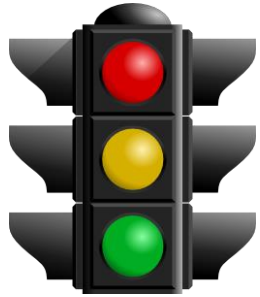
Figur 3.1. Farekilde, uønsket hendelse og ulykke.

Source of danger, unwanted incident and accident



Figur 2.5. Illustrasjon av trusler, verdier og konsekvenser i risikoanalyser.

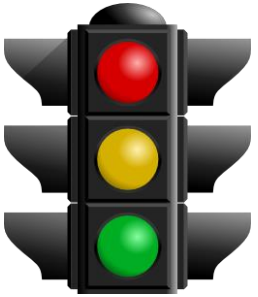
Risk assessment – process



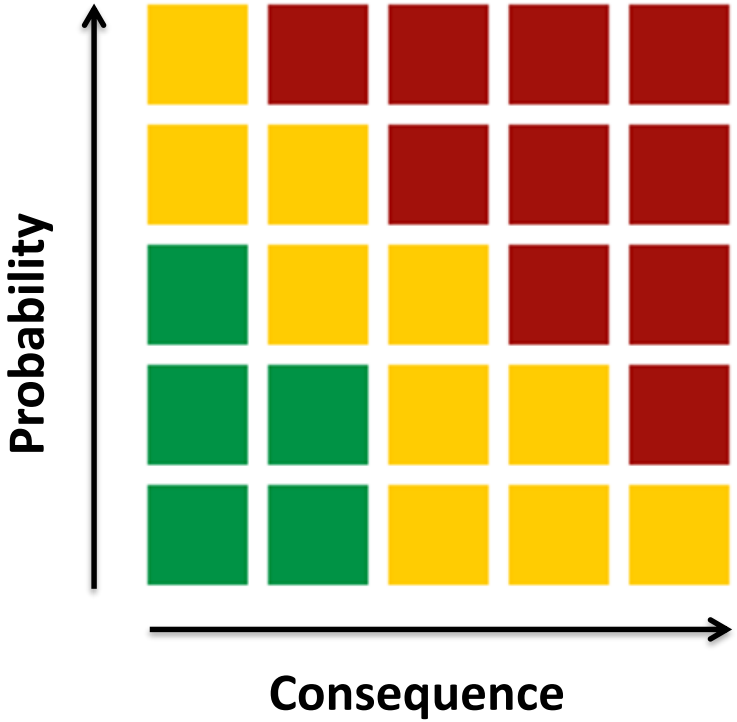
- Is done for all risky activities,
  in collaboration with supervisor, lab engineers, and others:
  - Inspection/demonstration
  - Gather information
  - Brainstorming
  - Describe risks
  - Prepare measures
  - Evaluate the end result – acceptable?

Innsida: https://innsida.ntnu.no/wiki/-/wiki/English/Risk+assessments

Acceptance criteria – risk matrix



Consequence x *Probability* = *Risk value*



The colours state degrees of risk:

- **Red**: Unacceptable risk. Measures must be carried out.
- **Yellow**: Evaluation area. Measures must be considered.
- **Green**: Acceptable risk. Measures may still be considered.

Safe work analysis (SJA)

- Checklist for smaller work, variations of previously risk assessed processes, etc.
- Two variations of the form – ordinary and for chemical use (in Norwegian)
- A more thorough risk assessment should be the basis for an SJA form

Risk assessment - documentation

- The RiskManager software is recommended not used because of instability
- Temporary solution: Excel template

Good luck with the lab work ...