Personal Protection Equipment (PPE)

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Starting Points

Work hygiene strategy

When working with any hazardous substance, the starting point must be that personal exposure complies with the ALARA principle, where ALARA stands for *As Low As Reasonably Achievable*.

The approach to bring ALARA into practice is known as the work hygiene strategy and contains the following considerations:

- Can the substance be avoided by choosing a different process with less hazardous effects?
- Can the substance be replaced by a less hazardous alternative?
- Can the activities with the substance be limited as much as possible?
- Can the activities with the substance be separated from the environment as far as possible (e.g. glove box, fume cupboard, etc.)?
- Can the location of the activity be separated from the environment as far as possible (e.g. in a controlled area or by avoiding unnecessary presence in the lab for administrative tasks)?
- If the above criteria cannot or not sufficiently be satisfied, the correct personal protection equipment must be provided.

Considerations for choosing the right PPE

Personal protective equipment must meet a number of conditions. The equipment must:

- offer protection without itself causing new risks;
- be usable in the prevailing circumstances of the workplace;
- be easy for the employer to work in, and should fit him properly (based on the size of the wearer);
- have a CE mark. The presence of a CE mark is mandatory and testifies for the product to meet the requirements of the applicable EC directive;
- be supported by clear instructions before use.

Personal and free

In principle, personal protective equipment should always be worn and used by the same person. Your employer will provide it free of charge.

Duties of employees regarding the use of protective equipment

Employees must follow the instructions given by their employer. If your employer obliges you to wear personal protective equipment, such as a lab coat, gloves and safety glasses, you must do so. If you repeatedly refuse to follow the instructions by your employer, disciplinary actions may be taken.

Lab coats

A good covering lab coat provides adequate protection against splattering solutions and in the event of fire is easy to remove. From a hygienic point of view it also prevents cross contamination via clothing. Therefor a lab coat should stay in the lab environment where it belongs and is not supposed to be worn outside that proximity.

In most laboratories there are lab coats available for general use and visitors. If you plan to do a lot of laboratory work, you may want to obtain your own lab coat from the central store.

Laboratory coat

Lab coats should be washed regularly. The secretary's office of your department can provide you with the further details about the washing service.

It is not permitted to wear lab coats that are manufactured from 100 % synthetic materials (e.g. Nylon). These are highly flammable and the melted material can stick to the skin. They can also become statically charged.

Protective eyewear

Safety glasses have to be equipped with permanently attached side shields to provide more adequate eye protection against chemical splashes or possible flying around debris such as glass splinters from accidents with equipment or experimental set ups.

Laser safety glasses are a special kind of safety glasses working merely as wavelength filters. It should therefore be noted that the appropriate glasses are used according with the applied laser wavelength.

Under some circumstances the use of goggles is instructed. Goggles completely enclose the eye area and are therefore the most effective PPE against the risk for possible eye damaging. This can be of concern for high intensity exposures with for instance a lot of dust or strong scattering optical radiation. The disadvantage of goggles is that they are much more uncomfortable to wear and that they can suffer from moisture condensation limiting the eye sight.

Safety glasses

Laser safety glasses

Safety goggles

Protective gloves

Gloves can be worn as a protection against biological and chemical agents. Despite the obvious ease that gloves can be put on, the wearing of a certain type of gloves should be a well-considered choice that otherwise can lead to very high personal health risks.

Every disposable glove only provides short term protection against chemical exposure due to the permeation properties that all glove materials suffer from. The ease of permeation depends on the combination between:

- The chemical properties of the handled compound
- The type of glove material
- The thickness of the glove material

Good practices for the use of gloves

- Disposable gloves should never be considered as a tool for deliberate contact with chemicals but only as a mean of protection that delays exposure from an accidental contact. Only heavy duty non-disposable gloves can be used for unavoidable contact with chemicals.

- Gloves should only be worn during an activity that there's chance for skin contact with a chemical or biological agent and never longer than necessary.
- When gloves become contaminated change them as soon as possible.
- Wearing of gloves outside the risk area is an irresponsible action. It increases the chance for any possible contaminants to permeate into the glove (and eventual the skin) and be transferred to others by cross contamination.
- Gloves should always be disposed after use. Re-use of gloves is dangerous and absolutely unnecessary.

Glove materials

Common available glove materials are: Latex, Nitrile (Nitrile-butadiene rubber, NBR), Polyvinyl chloride (PVC), Neoprene® (Polychloroprene), Butyl, Polyvinyl alcohol (PVA) and Viton® (Fluororubber). The first four of these types can be obtained in as well disposable as non-disposable variants. Disposable gloves are comfortable to wear and do not too much compromise the wearer's sense of touch.

The chemical resistance of latex is below par compared to other glove materials that nowadays are available. Besides that, employees who often wear latex gloves are at risk for developing latex allergies. Nitrile, PVC and Neoprene offer better chemical resistance Nevertheless has the use of each of these types to be considered carefully depending on the chemical to handle.

Butyl, PVA and Viton gloves are only obtainable in non-disposable variants. This means that after cleaning and some recovery time for the gloves it is allowed to re-use them. Butyl gloves are affordable and offer good protection against several solvents. For those chemicals that Butyl is not suitable, PVA shows good qualities that are complementary to Butyl and, although more expensive than Butyl, still affordable. Viton gloves are very expensive and despite their excellent protection against a variety of chemicals, also Viton does have its Achilles heel.

Chemical resistance properties of different glove materials

The following table can be used as a quick guide for selecting the right kind of glove material.

Code letter	Chemical	Category	Latex	Nitrile	PVC	Neoprene	Butyl	PVA	Viton
A	Methanol	Primary alcohol	<1	1-2	2	3	6	<1	6
B	Acetone	Ketone	<1	<1	<1	2	6	<1	<1
C	Acetonitrile	Nitrile compound	<1	<1	1-2	2-3	6	5	<1
D	Dichloromethane	Chlorinated paraffin	<1	<1	<1	<1	1	6	3
E	Carbon disulphide	Sulphur containing organic compound	<1	<1	<1	<1	1-2	6	6
F	Toluene	Aromatic hydrocarbon	<1	1-2	1-2	<1	<1	6	6
G	Diethylamine	Amine	<1	1-2	3	<1	1-2	1	3
H	Tetrahydrofuran	Heterocyclic and ethereal compound	<1	<1	<1	<1	1-2	4	<1
I	Ethyl acetate	Ester	<1	1-2	<1	1-2	4	6	<1
J	n-Heptane	Saturated hydrocarbon	<1	6	1-2	3	<1	6	6
K	Sodium hydroxide 40%	Inorganic base	6	6	6	6	6	<1	6
L	Sulphuric acid 96%	Inorganic mineral acid	<1	3	2	3	6	<1	6

Source: Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (IFA)

In the table above each glove is ranked by breakthrough times (level 0 to 6) for a certain chemical group:

Protection Index	Measured breakthrough time	Protection Index	Measured breakthrough time
class 1	> 10 minutes	class 4	> 120 minutes
class 2	> 30 minutes	class 5	> 240 minutes
class 3	> 60 minutes	class 6	> 480 minutes

The test chemicals were slected to represent the widest possible range of chemical classes. For this purpose, the most basic molecular substance of a homologous series of organic compounds was selected.

Since the diffusion rate decreases with increasing molecular size, it can be anticipated that when chemical protective gloves are used against higher representatives of the homologous series, protective action is equal or probably even better. It is however essential to study the manufacturer's product information for a definite answer about the glove's protection against the agent of interest and for what duration.

Classification of protective gloves

Personal protective equipment (PPE), including protective gloves, is classified broadly in Categories I, II and III in accordance with the PPE Directive, 89/686/EEC. All chemical protective gloves are assigned to Category III.

Marking of protective gloves

Chemical resistant protective gloves are clearly marked by the Erlenmeyer flask pictogram and provide protection for at least 30 minutes against at least three of the twelve test chemicals (Class 2). A code letter beneath the Erlenmeyer flask pictogram indicates the chemicals against which the glove has been tested.

Low chemical resistant protective gloves are identified by a test beaker pictogram. They provide splash protection, i.e. they are watertight and serve as protection against certain chemicals.

Information for the marking of chemical protective gloves

<table>
<tr>
<td>EN 374-3
  </td>
<td>A chemical protective glove marked with a test-beaker pictogram is airtight and waterproof. The gloves are tested for their waterproofing and airtightness in the course of the approval process (refer to the illustrations, left). Should the manufacturer's information also state a chemical against which the glove offers resistance, it may be used for a limited time for protection against this particular chemical.</td>
</tr>
<tr>
<td>EN 374-3
 
A J L</td>
<td>The code letters of the chemicals against which the glove provides protection constitute part of the marking. The test standard must be stated, and the "test beaker" and "Erlenmeyer flask" pictograms must not both be used on the same product. The code letters and the corresponding test chemicals and their substance classes are indicated in the table.</td>
</tr>
<tr>
<td>EN 374-2
  </td>
<td>At present, it is assumed that protective gloves which resist complete permeation during the test provide effective protection against bacteria and fungi spores. This assumption does not hold true for protection against viruses, since these are substantially smaller. A glove is considered resistant to microorganisms when it satisfies at least Class 2 in the penetration test to Annex A of DIN EN 374-2 (Acceptable Quality Level – AQL < 1.5).</td>
</tr>
<tr>
<td>EN 388
 
2 1 2 0</td>
<td>Protection against mechanical risks is indicated by this pictogram. The four digit code represents the level of protection against four categories of mechanical actions.

Example:
<table>
<tr><th>Test method</th><th>Performance level</th></tr>
<tr><td>Resistance to abrasion</td><td>2</td></tr>
<tr><td>Resistance to cutting</td><td>1</td></tr>
<tr><td>Resistance to tearing</td><td>2</td></tr>
</table>
</td>
</tr>
</table>

	Resistance to puncturing 0 Chemical protective gloves are not subject to minimum requirements concerning the mechanical protection that they offer. In the context of certification in accordance with the PPE Directive, these tests are however performed, and the results stated in the manufacturer's information and beneath the pictogram.
	The "open book" pictogram indicates that important data must be consulted in the manufacturer's information, for example concerning the resistance to individual chemicals or formulations.
CE 0121	The CE mark documents that the glove complies with the general requirements of the PPE Directive. **This is mandatory; the product does not otherwise constitute protective equipment.** **1234** (four-digit code, e.g. 0121) Code number of the test body responsible for regular quality surveillance of the glove model. Always appears adjacent to the CE mark (e.g. **CE 0121** for the IFA, the body notified under the number 0121 in accordance with the PPE Directive).

Respiratory protective equipment (RPE)

A respirator (face mask) offers protection against inhalation and ingestion of harmful particles (solid and liquid) in the local atmosphere. By covering nose and mouth airborne particles are removed from the inhaled air by: mechanical filtering, absorption, replacement of the atmosphere, or a combination of all three.

There are five types of respirators:

- disposable,
- half mask,
- full face,
- powered air respirators and
- airline fed respirators.

Disposable mask

Half mask

Full face respirator

Some have removable filter cartridges which can be replaced with different types for removing different substances.

Disposable masks and half masks cover the mouth and nose. Disposable masks are usually made of the filtering material but some incorporate a one way valve designed to make breathing out easier. It also helps prevent misting of prescription or safety glasses which may be worn in conjunction with the mask.

Filtering Face Pieces (FFP's)

A FFP (Filtering Face Piece), also called "filtering half mask" or "filtering face piece", are entirely or substantially constructed of filtering material. The level of protection complies with a rating that is defined by the EN149 in the following classes:

Class	Filter penetration limit (at 95 L/min air flow)	Inward leakage
FFP1	Filters at least 80% of airborne particles	<22%
FFP2	Filters at least 94% of airborne particles	<8%
FFP3	Filters at least 99% of airborne particles	<2%

Face masks, powered and airline fed respirators

Half masks will be made of a non-filtering material and have a cartridge fitted which may or may not be replaceable. Full face respirators differ from half face in that they cover the eyes as well. They look like a visor but fit close around the entire face.

Powered air respirators and airline fed respirators take the form of a hood or a helmet. A powered respirator has a means of cleaning the atmosphere. An airline fed respirator is fed with breathable air from an external source and requires an umbilical to do so.

P ratings

Face masks and powered air respirators are equipped with detachable filter units enabling replacements or the exchange for other types of filters. Filter units specifically designed for the removal of particulates are defined by the EN 143 into the following classes:

Class	Filter penetration limit (at 95 L/min air flow)
P1	Filters at least 80% of airborne particles
P2	Filters at least 94% of airborne particles
P3	Filters at least 99.95% of airborne particles

FFp's and P-filters do not meet the requirements to protect against vapours and fumes. For this purpose filter cartridges have to be applied.

Chemical cartridge respirators

Chemical cartridge respirators use a cartridge to remove gases, volatile organic compounds (VOCs), and other vapours from breathing air by adsorption, absorption, or chemisorption. A typical organic vapour respirator cartridge is a metal or plastic case containing from 25 to 40 grams of sorption media such as activated charcoal or certain resins. The service life of the cartridge varies based, among other variables, on the carbon weight and molecular weight of the vapour and the cartridge media, the concentration of vapour in the atmosphere, the relative humidity of the atmosphere, and the breathing rate of the respirator wearer. When filter cartridges become saturated or particulate accumulation within them begins to restrict air flow, they must be changed.

Chemical filter cartridge denominations and colour codes

A filter cartridge is classified by a colour code that is corresponding to a combination of letters representing the specificity for one or more chemical groups as follows:

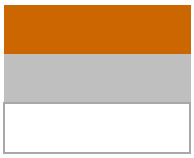
Colour codes	Denominations	Description
Brown	AX[1)]	Gases and vapours of organic compounds with boiling point ≤ 65 °C
Brown	A	Gases and vapours of organic compounds with boiling point > 65 °C
Grey	B	Inorganic gases and vapours, e.g. chlorine, hydrogen sulphide, hydrogen cyanide
Yellow	E	Sulphur dioxide, hydrogen chloride
Green	K	Ammonia and organic Ammonia derivates
Black	CO[2)]	Carbon monoxide
Red	Hg[3)]	Mercury vapour

Blue	NO[4)]	Nitrous gases including nitrogen monoxide
Gold	Reactor[5)]	Radioactive iodine including radioactive methyl iodide
White	P	Particles

1) AX filters may only be used as supplied from factory. Reuse and use against gas compounds is absolutely impermissible.
2) CO filters for one time use only. Must be disposed after use. Special guidelines according to local regulations apply.
3) Hg Filters can only be used for a maximum of 50 hours according to EN 14387.
4) NO filters for one time use only. Must be disposed after use.
5) Reactor filters: special guidelines according to local regulations apply.

Example of chemical cartridge coding

A2B2-P3



A filter with the above mentioned colour code is suitable for the following contaminants:

A2
gases and vapours of organic compounds with a boiling point beyond 65 °C up to concentrations covered by filter class 2 and
B2
inorganic gases and vapours, e.g. chlorine, hydrogen sulphide, hydrogen cyanide, up to concentrations covered by filter class 2 and
P3
particles up to concentrations covered by filter class 3.

Picture of a chemical filter cartridge