



Factory siting, layout and building design

Introduction

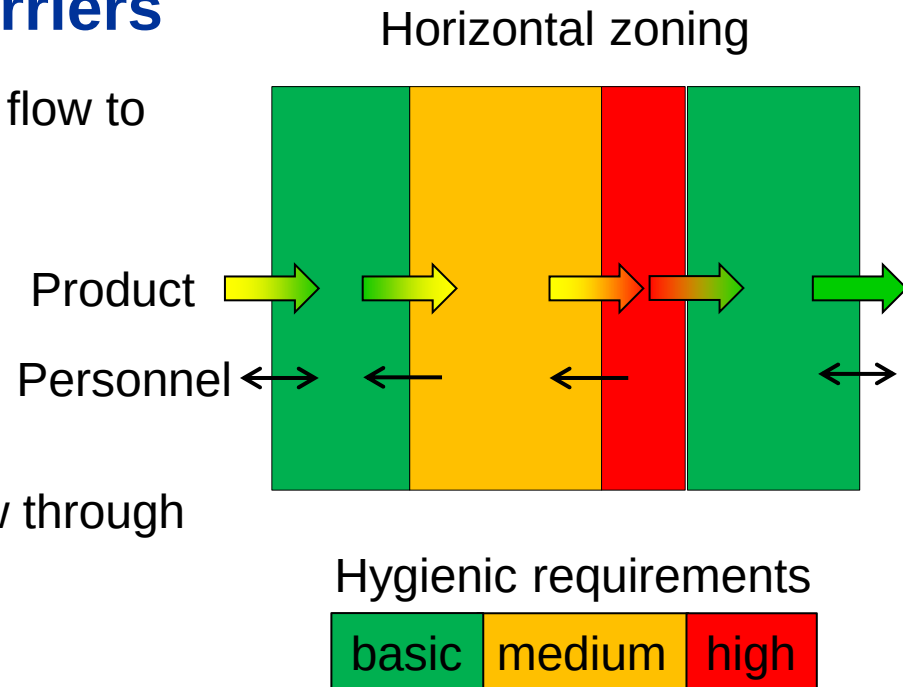
Protect your product comprehensively!

- Even a hygienically designed machine is no guarantee for a safe production without an effective barrier to the environment
- A good building layout and master concept, also called master plan, for the design of a food processing facility is necessary to avoid:
 - Attraction, entry and nesting of pests
 - Accumulation of water, soil and dust
 - Microbiological and allergenic contaminations
- Building layout should facilitate cleaning and disinfection activities

Introduction

System of effective barriers

- Prohibit all unnecessary mass flow to product by barriers:
 - Solid barriers
 - Directed-air-flow barriers
- Organize necessary mass flow through controlled transfer zones:
 - For personnel
 - For material / traffic
 - Zoning philosophy = “Boxes within boxes”



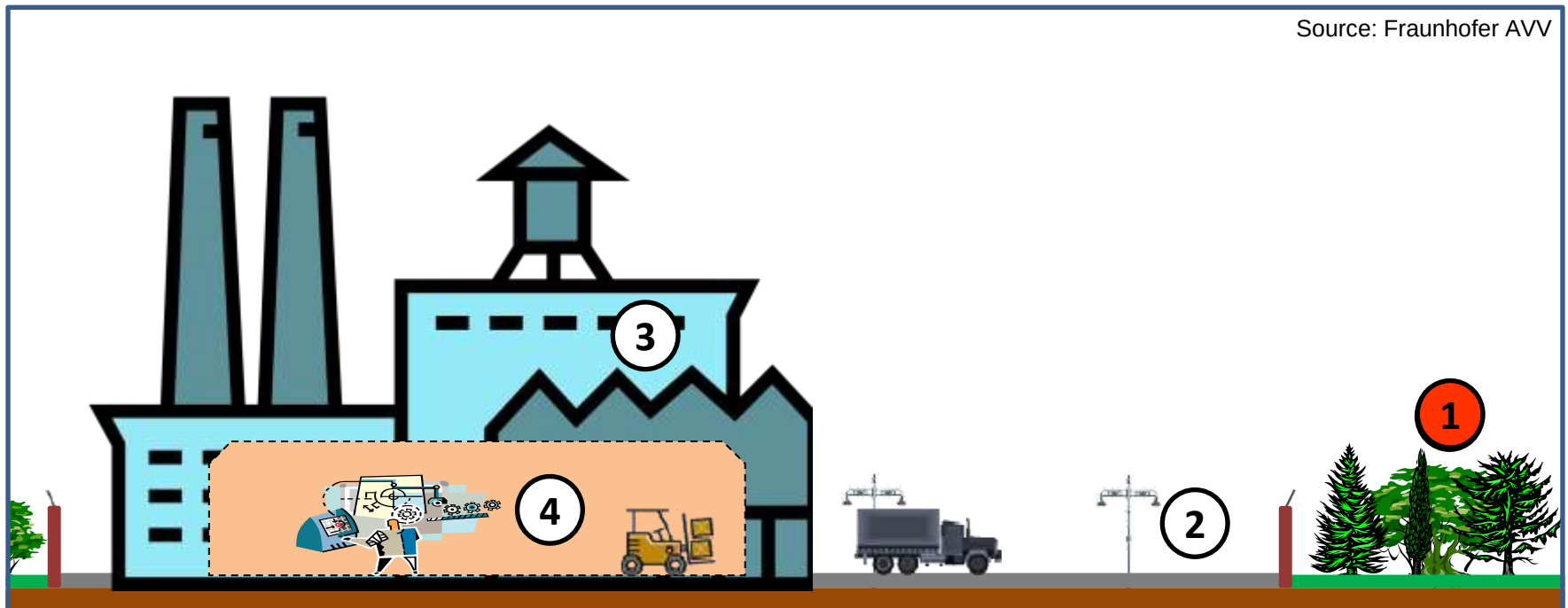
Zones for factory planning

1 Environment

2 Factory site

3 Building envelope

4 Production areas



Regulations

Excavations



Light pollution



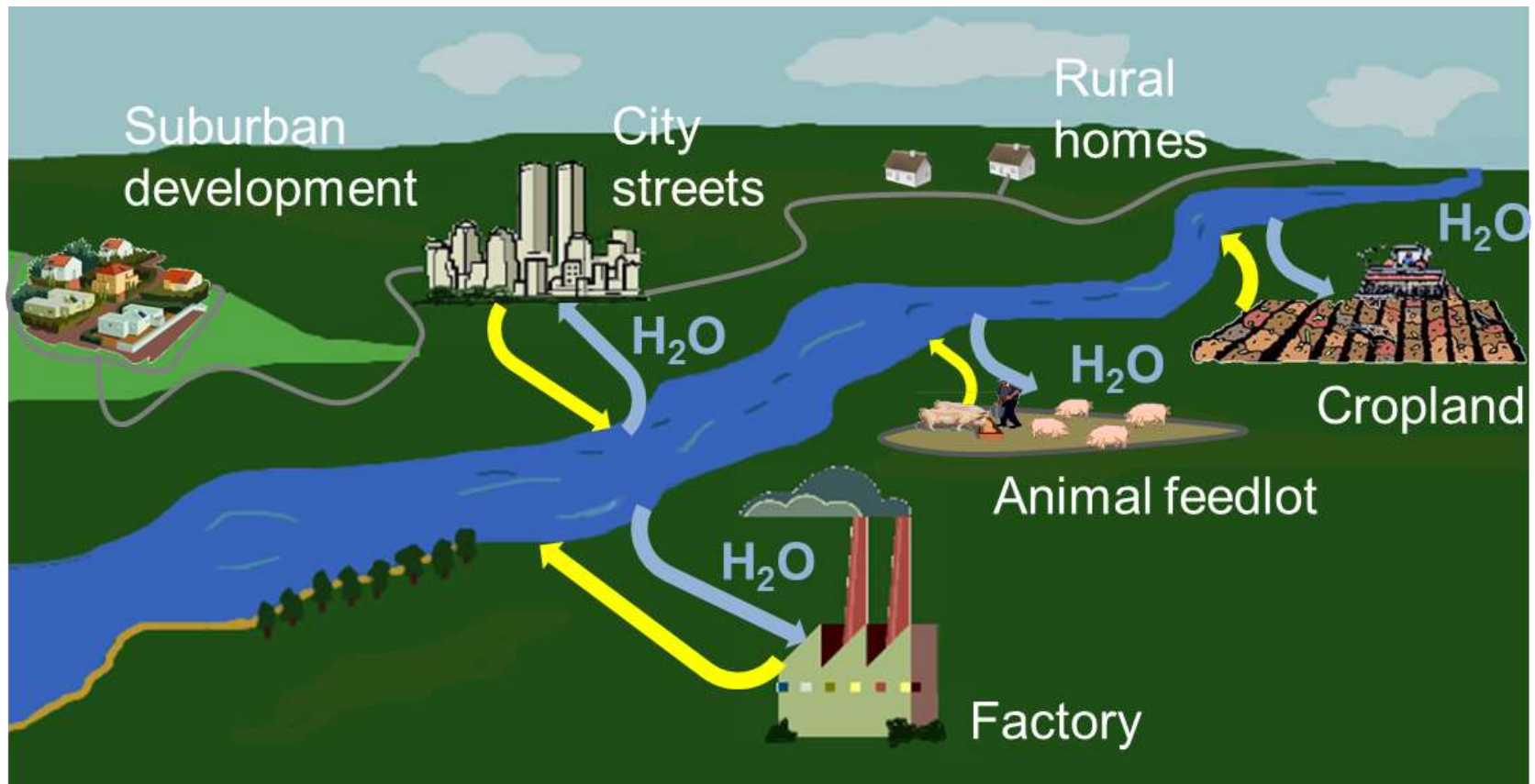
Regrettably the noise is not on the picture



Polluted soil?

Regulations

Thermal pollution



Environment

Climatic conditions

- Tropic / maritime / continental
- Fluctuation of temperature
- Rain, humidity
- Barometric pressure
- Main wind direction and strength
- Risk of extreme weather / environmental disaster
- Types of pest
- Avoid flooding sensitive sites
- Avoid fire sensitive areas



Environment

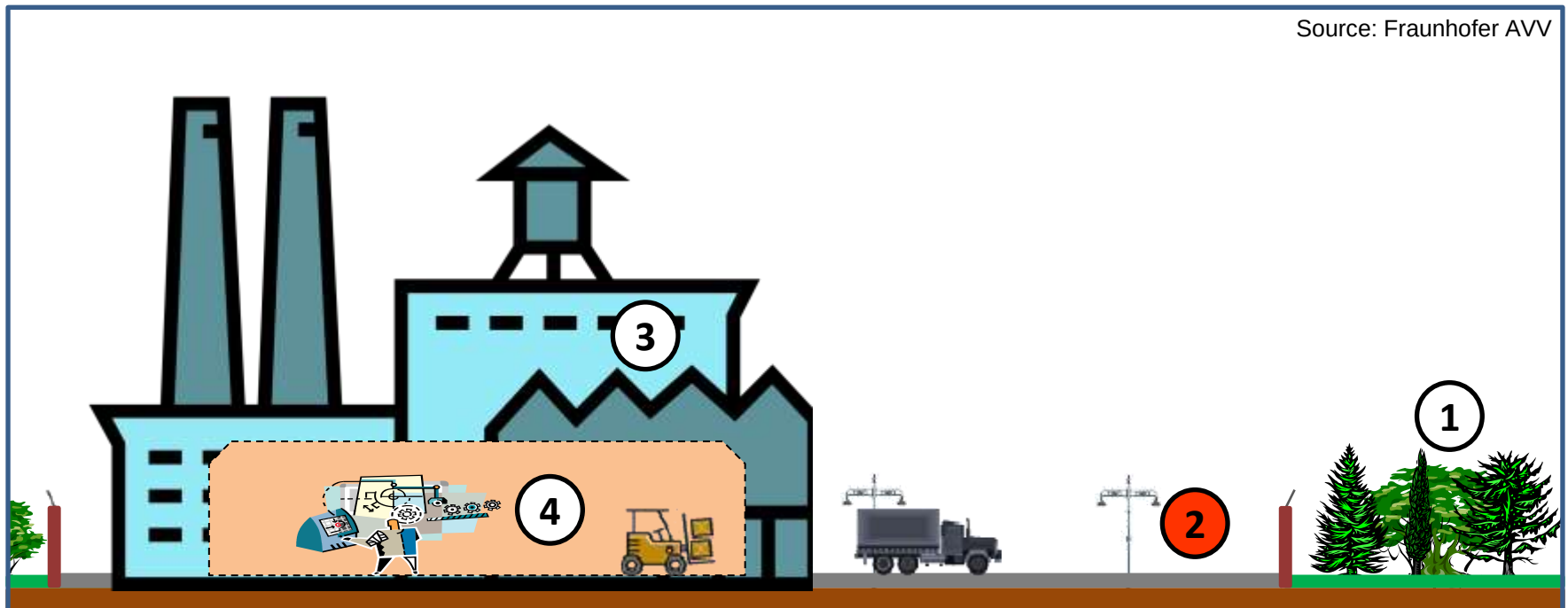
Immediate environment

- Legal requirements
- Landscape
 - Local flora and fauna
 - Higher humidity close to water
 - Breeding place for insects and pests
- Economic use
 - Infrastructure
 - Local emissions
 - Quality of groundwater
 - Adequate distance to agriculturally used areas



Zones for factory planning

2 Factory site



Source: Fraunhofer AVV

Factory site

Ground and facilities

- Checking of soil quality and soil support capability
 - Precluding chemical or biological contamination
 - Cracking due to sagging foundations → hygienic risks
- Prevention of hiding places for animals
- Covered waste collection unit

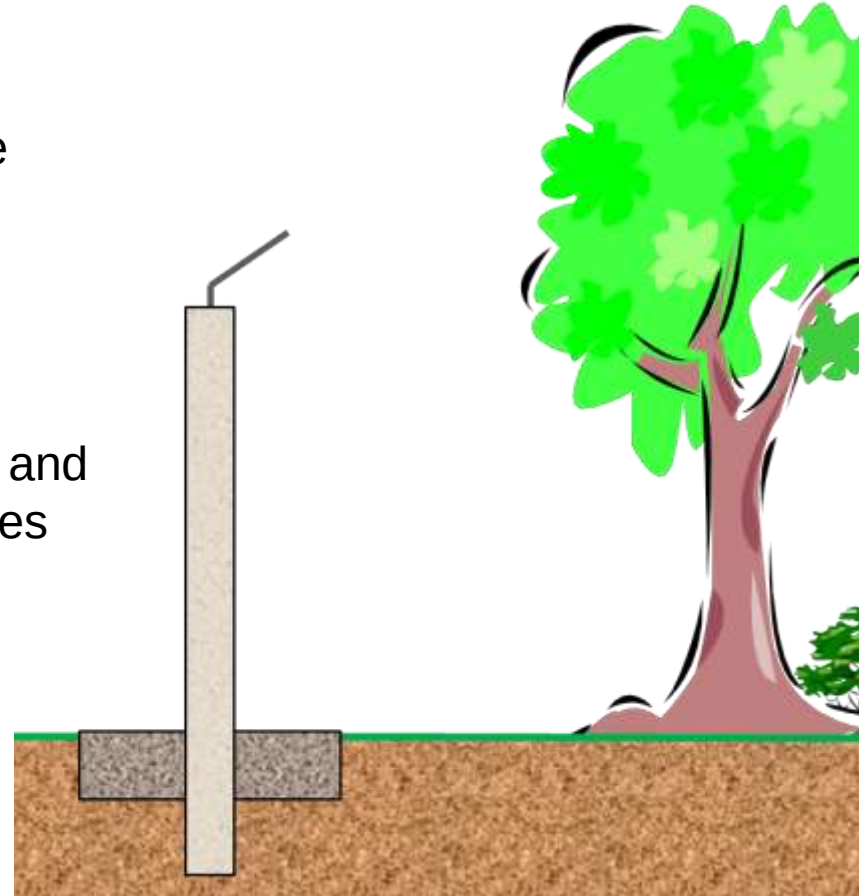
Factory site

Perimeter fence

- Uninterrupted with a managed entrance
- Unplanted strip inside and outside (e.g. coarse gravel)
- High enough
 - Deep enough
 - Smooth enough

}

Prevent entry of climbing, jumping and burrowing creatures
- Distance to trees and bushes (climbing support)



Factory site

Protect your product against potential acts of sabotage, vandalism or terrorism

- Outside perimeter : physical security system against people and vehicles
 - Access control post
 - Fences (sufficient height) and barriers
 - Turnstile
 - Plots against vehicles used as a ram
 - Cameras
- Inside perimeter
 - Alarm
 - Cameras
 - Doors, windows...resistant against intrusion
 - Electronic Badge for opening doors



Factory site

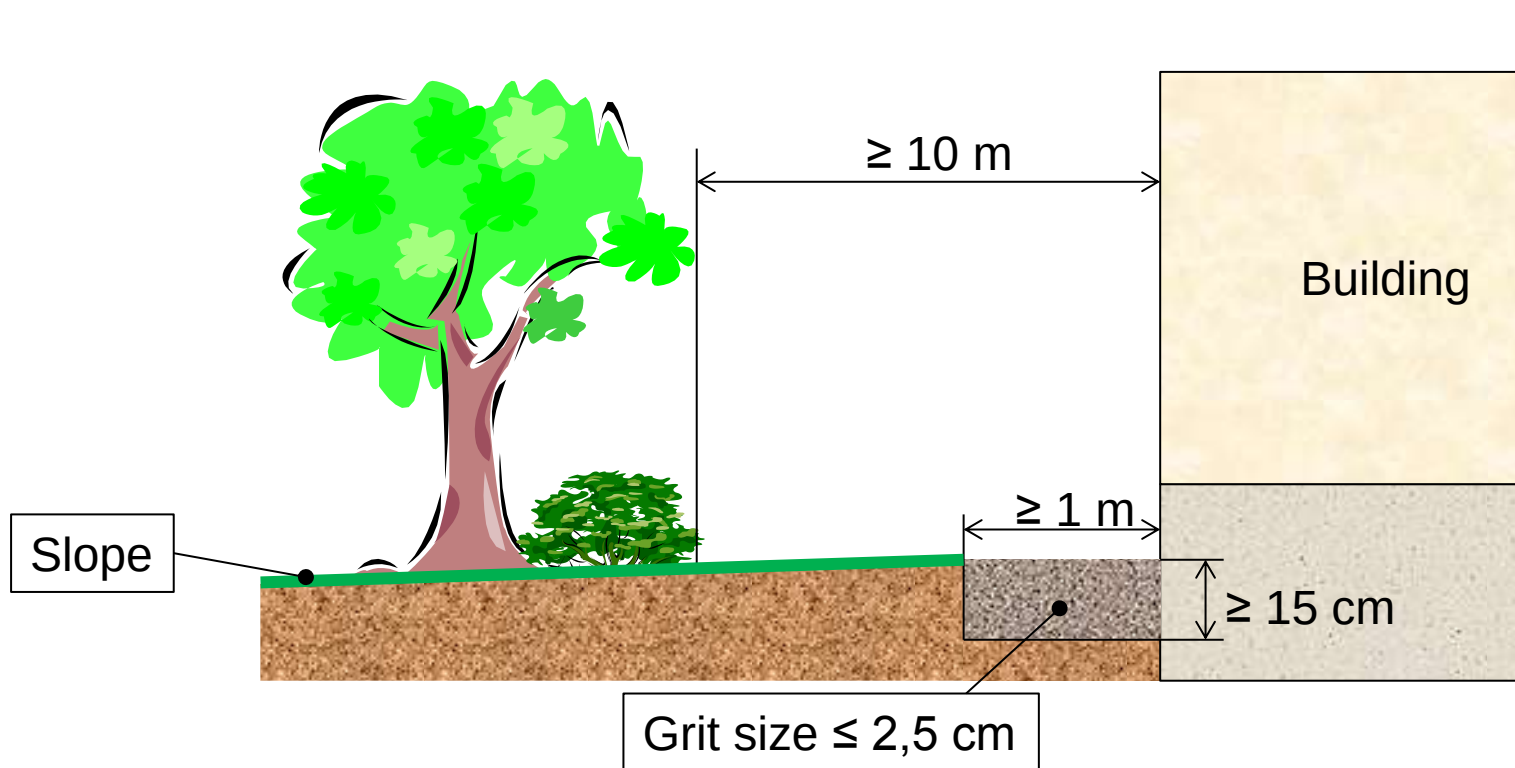
Protect your product against potential acts of sabotage, vandalism or terrorism

- Protect raw materials and finished products
 - Access control for going to storage area or equipment (silo, water tank...)
 - Security (padlock on supply pipe...)
 - Install security equipment on process lines
 - Restricted area : closed trap, door, grid, cover
 - Remove hazard : foreign bodies detectors, magnets...)
 - Monitoring : alarm...



Factory site

Distance to buildings



Source: Fraunhofer AVV (acc. to Hauser 2008)

Factory site

Areas for roads, walking and parking

- Stable and cleanable materials
- Minimise or eliminate joints (e.g. use concrete, Tarmac or similar materials)
- Periodic maintenance (remove pests, plants and close gaps)



Factory site

External light sources

- On poles or standards (not at buildings)
- Lamp design: Avoid possibility of accumulation, perching on lamps
- Avoid high-UV amenity lighting



Factory site

Sufficient draining of the premises

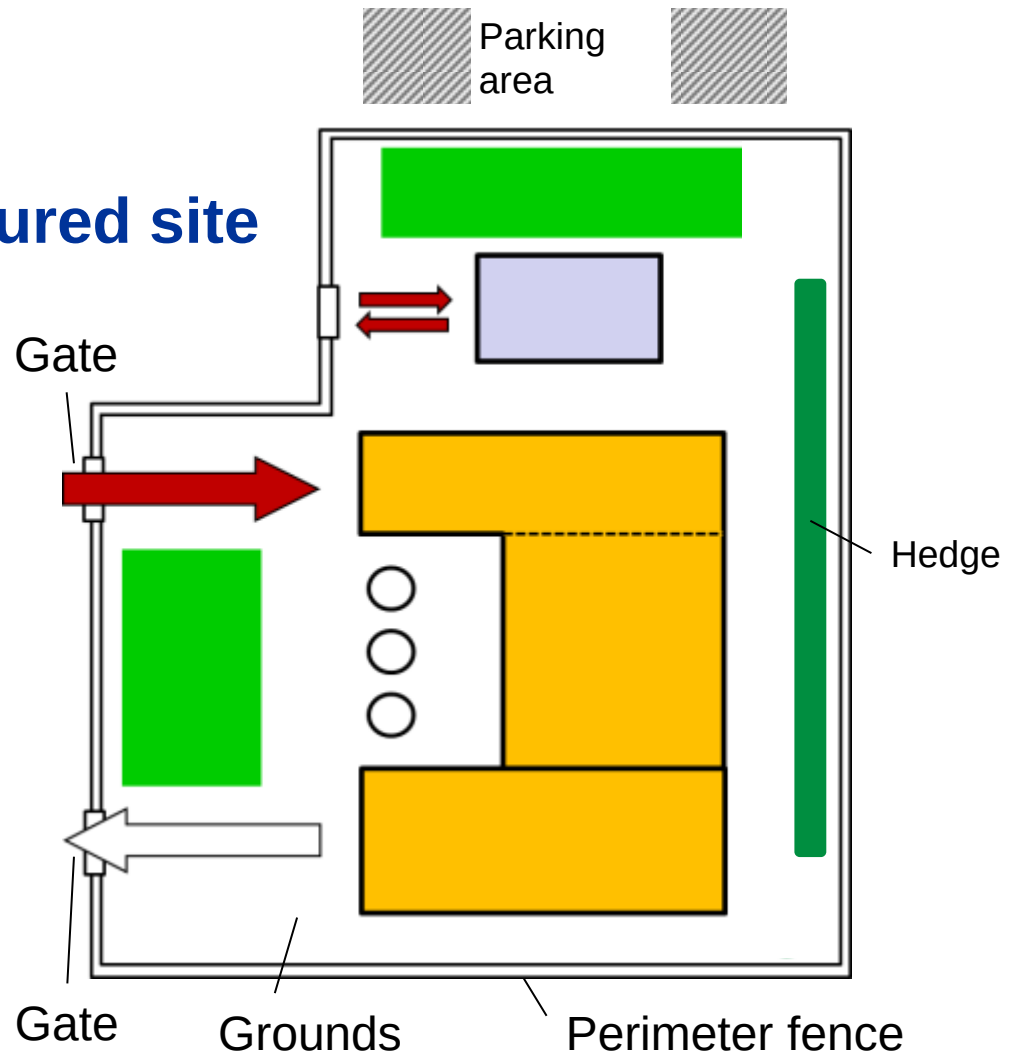
- As possible: plane surfaces
- Inclined away from buildings
- Qualified surface drainage system
- At every local minimum on the site there must be a drain

→ Fast removal of water out of the premises

Factory site

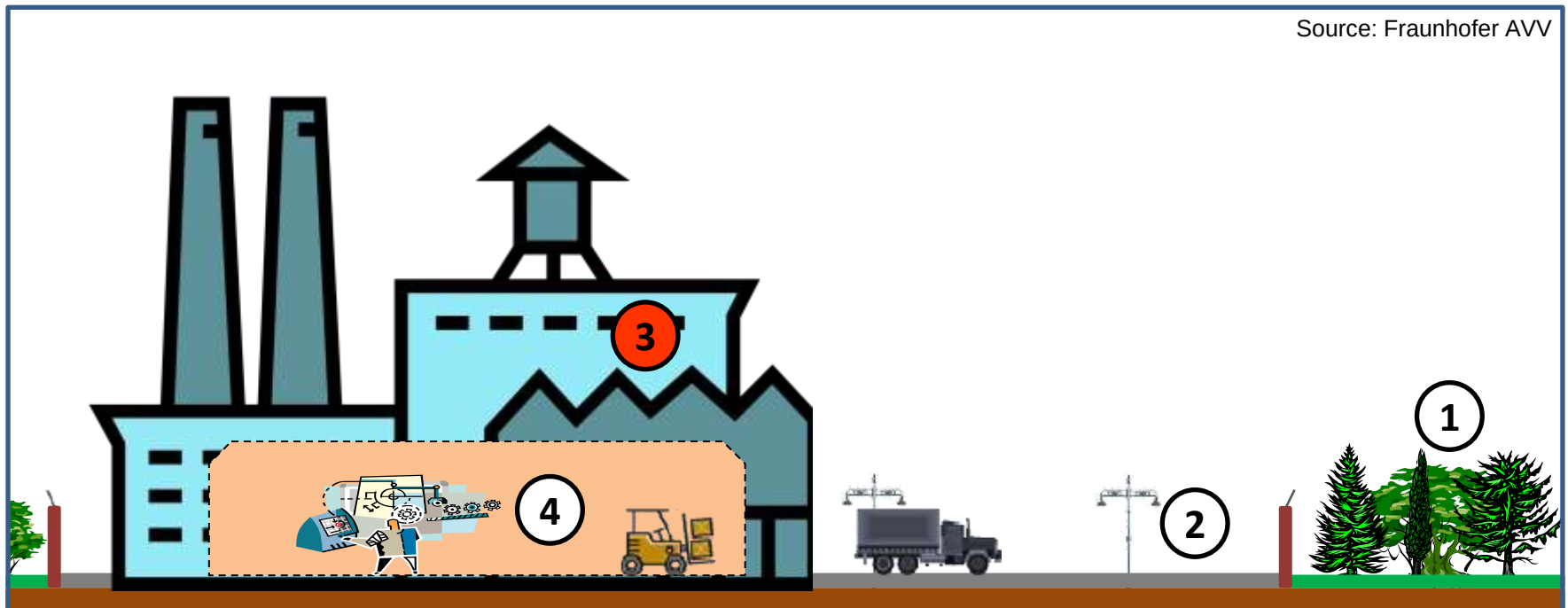
Simple model of a structured site

- Location and arrangement of buildings have to be accurately projected
- Routes for employees, products, production equipment, products, disposal...
- Barrier to environment
- prevent possibility of contamination from laboratories inside the factory



Zones for factory planning

3 Building envelope



Building envelope

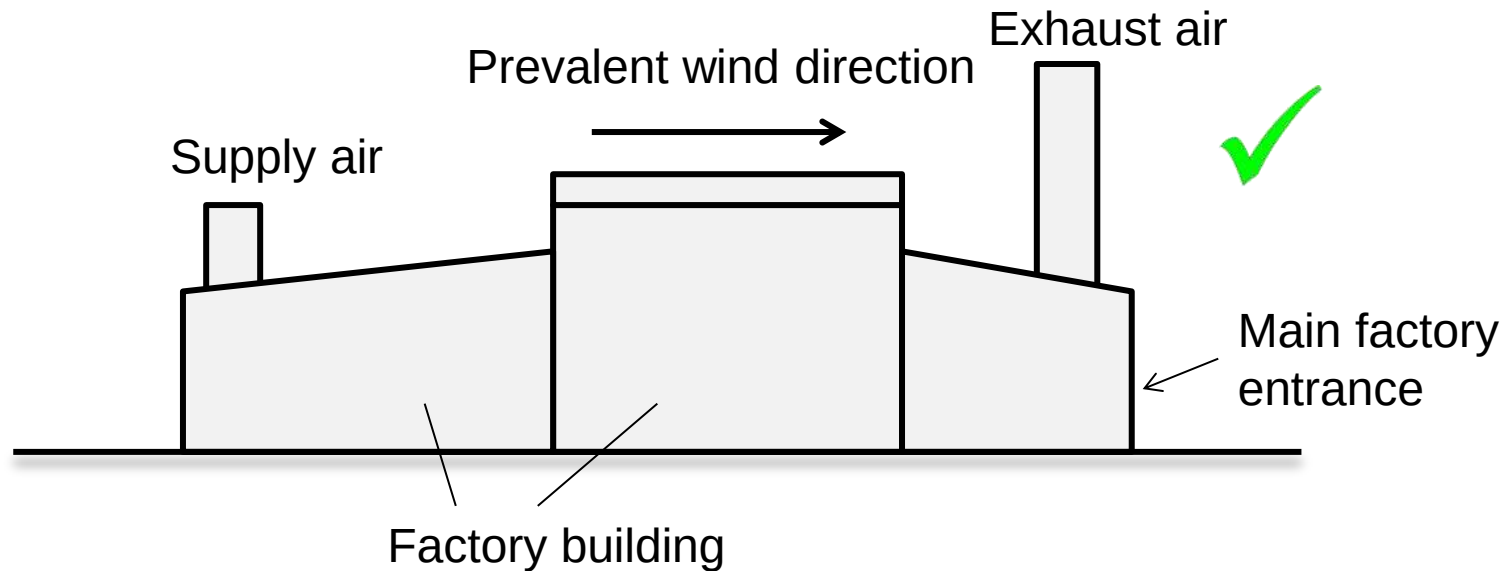
Protection against animals, pests and microbial contamination

- Prevention of hiding places for animals
- Building envelope impenetrable to living invaders
- Self closing openings/ doors/ windows/ apertures (protected by fine screens if open) / Pest-tight openings
- No light sources above entrances
- Avoid stairs for personnel next to loading bays
- All opening screened with stainless steel mesh $< 1\text{mm} \times 1\text{ mm}$

Building envelope

Placement of air supply systems

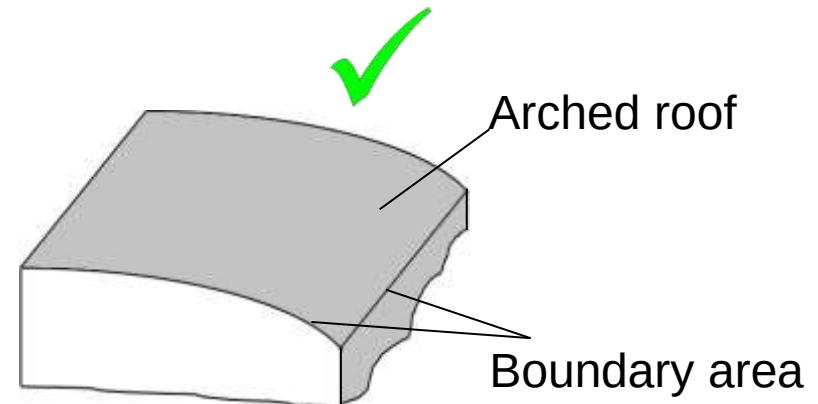
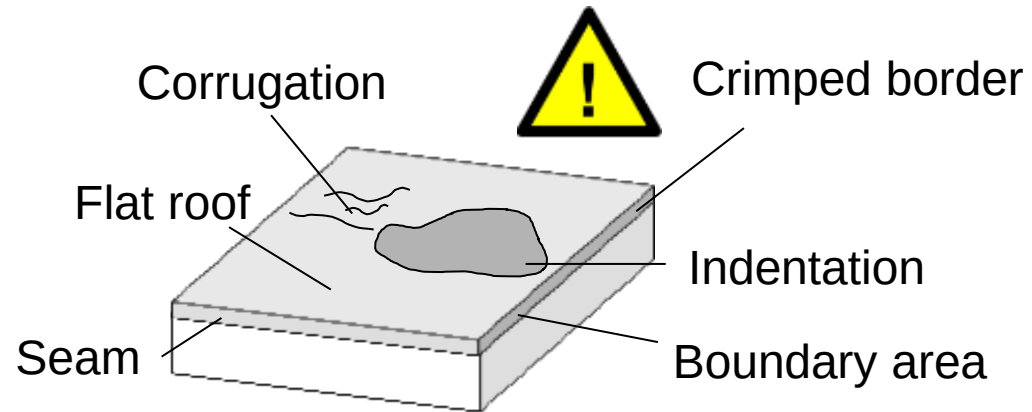
- Prevention of cross-contaminations



Building envelope

Roof

- Pest-tight, water proof
- Sloped ($\geq 3^\circ$) and self draining
- As possible: Consist of a single membrane
- Avoid internal roof drains
- No Ventilation devices that discharge food particles onto the roof (Birds and pests attracted!)
- Spaces between roof and upper side of suspended ceilings should be accessible

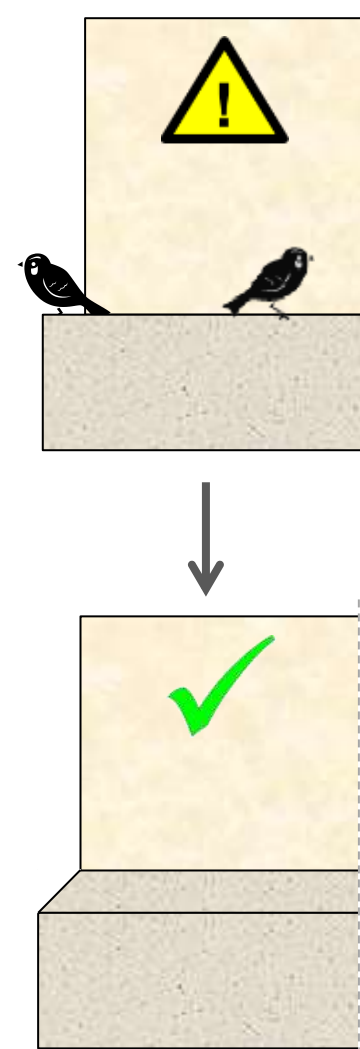
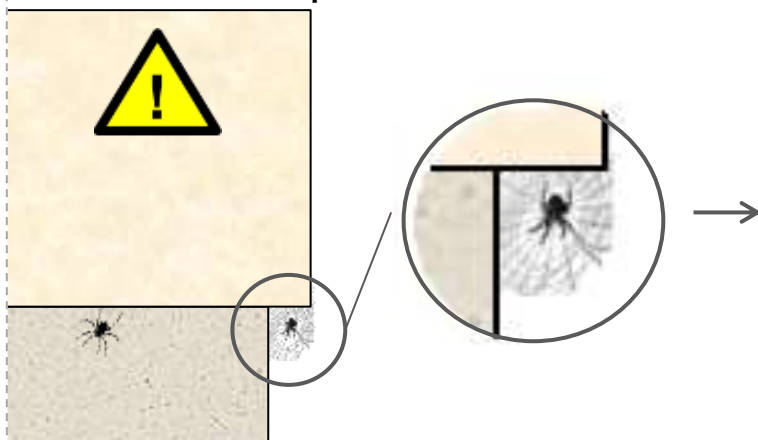


Source: Fraunhofer AVV (acc. to Hauser 2008)

Building envelope

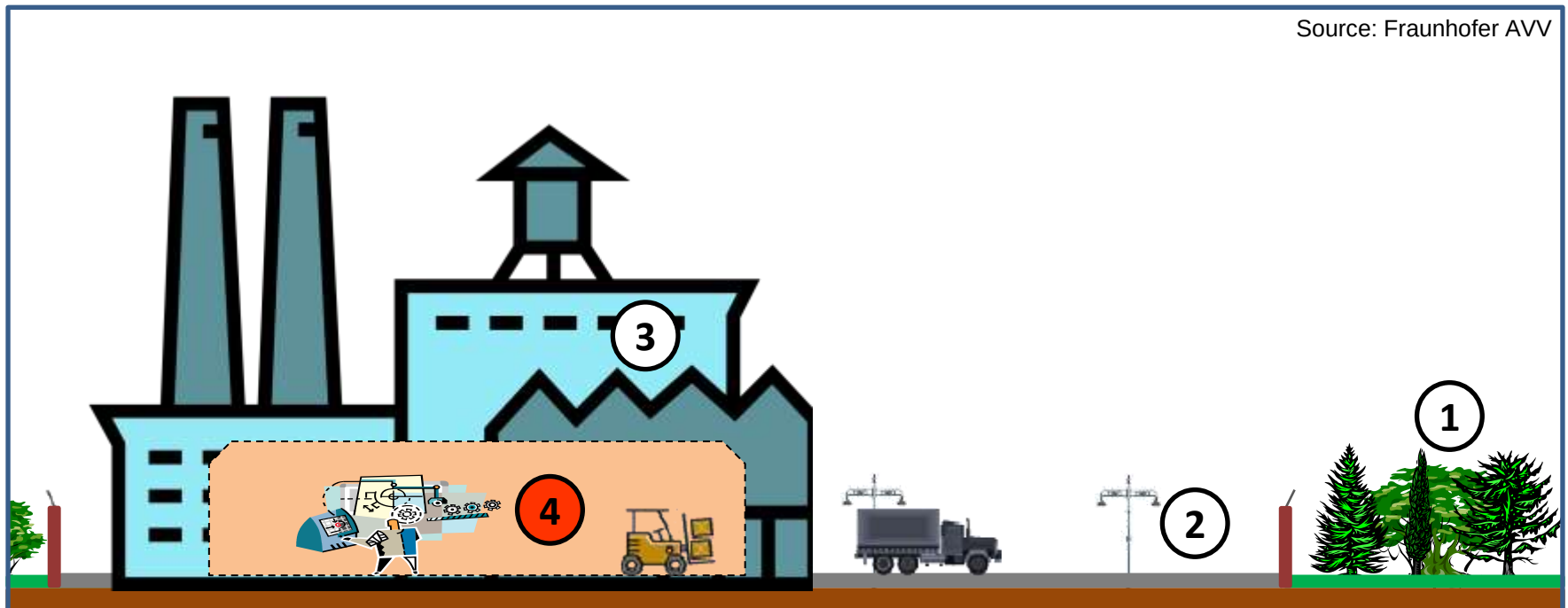
Wall exteriors

- Smooth surfaces
- All gaps sealed
- No horizontal surfaces (gradients $\geq 45^\circ$)
- No windows next to product area
- As few as possible entrances



Zones for factory planning

4 | Production rooms



Main Flows

Layout

Others: packaging,
traffic

Services:
gases, utility
water, air

Personnel flow

Waste and
Residues flow

Product flow



Product flow

- Segregation of zones with different hygienic standards
- Routes as short and straight as possible,
- Minimise product traffic
- Product flowing from basic to high hygiene
- Prevent cross contamination between product and
 - Raw material
 - Secondary packaging material
 - Residues
 - Cleaning chemicals / non-food chemicals
- Allergens



Personnel flow (process areas)

Traffic should be reduced to a minimum

- Group areas with same or similar purpose in the same area (e.g. cold stores)
- Make unique areas for residues treatment, for weighing and sorting ...
- Wash-rooms available close to the working areas (adequately segregated from production, packing and storage areas)
- Segregated routes for visitors and others

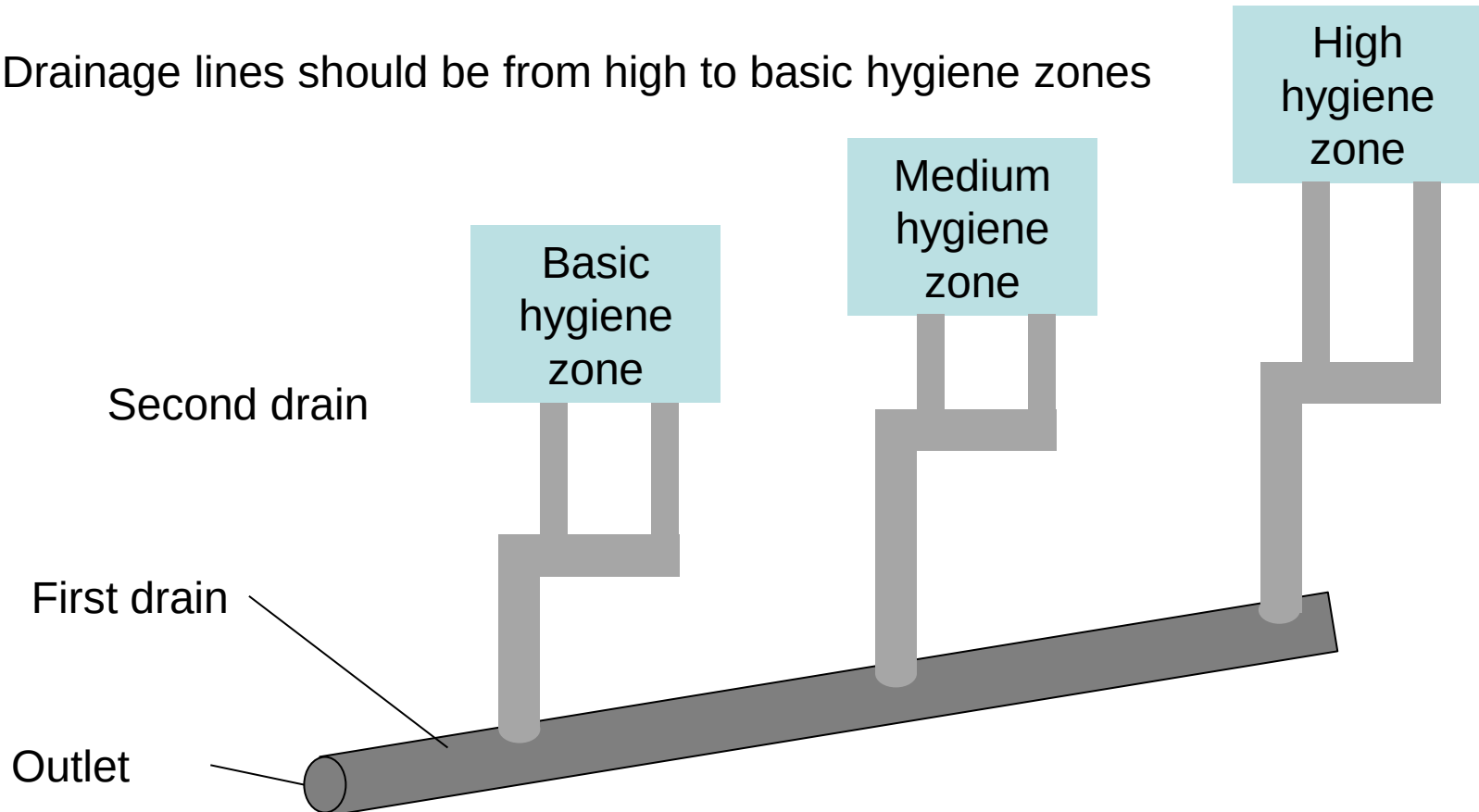
Residues and by-products flow

- Residues / liquid wastes / by-products should be captured at source and then taken directly to closed containment or drainage
- Make safe provision for waste-container traffic and temporary storage

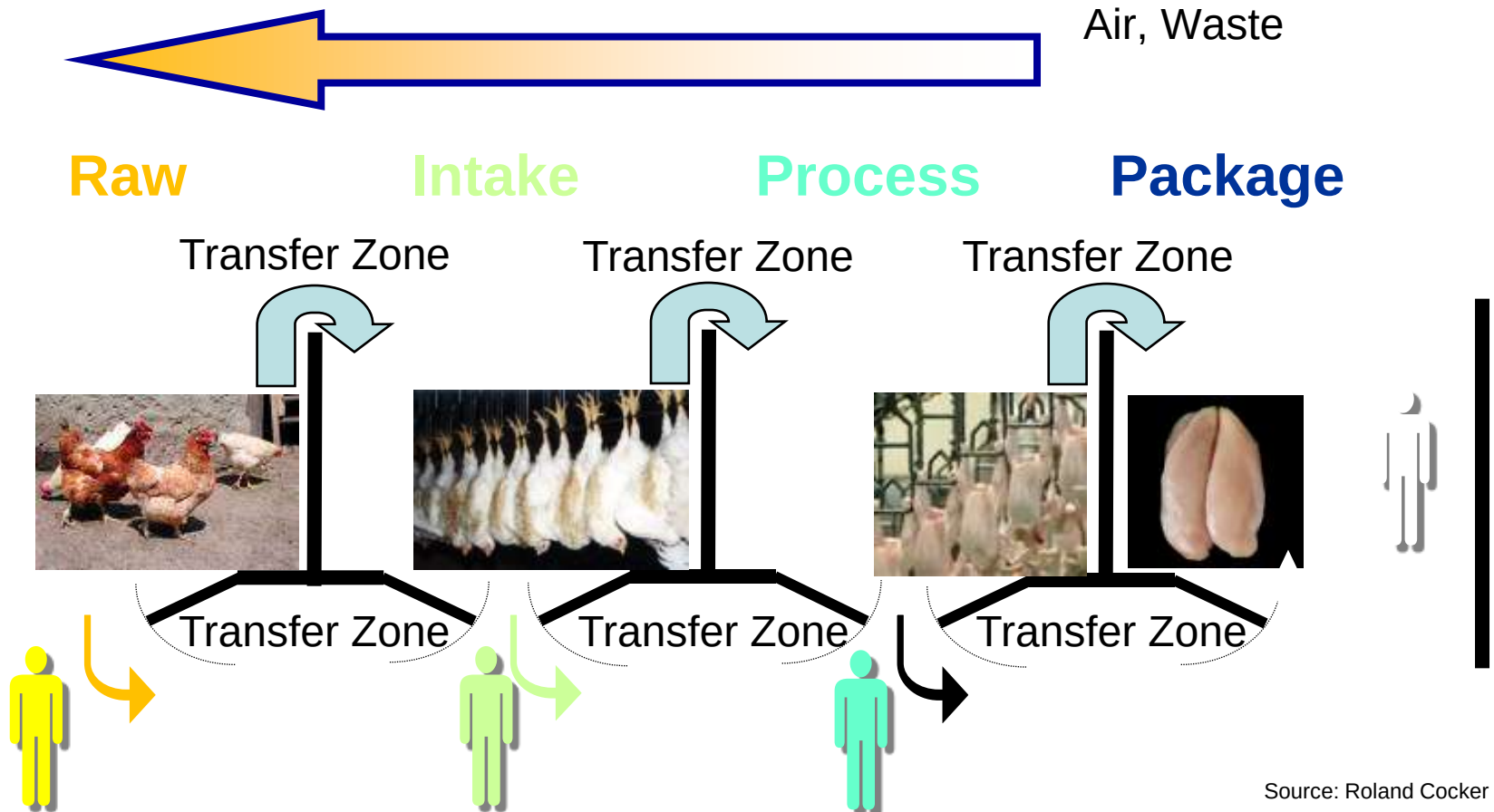


Residues and by-products flow

- Drainage lines should be from high to basic hygiene zones



Contra-flow of Air, Waste & People vs. Product



Source: Roland Cocker

Zoning

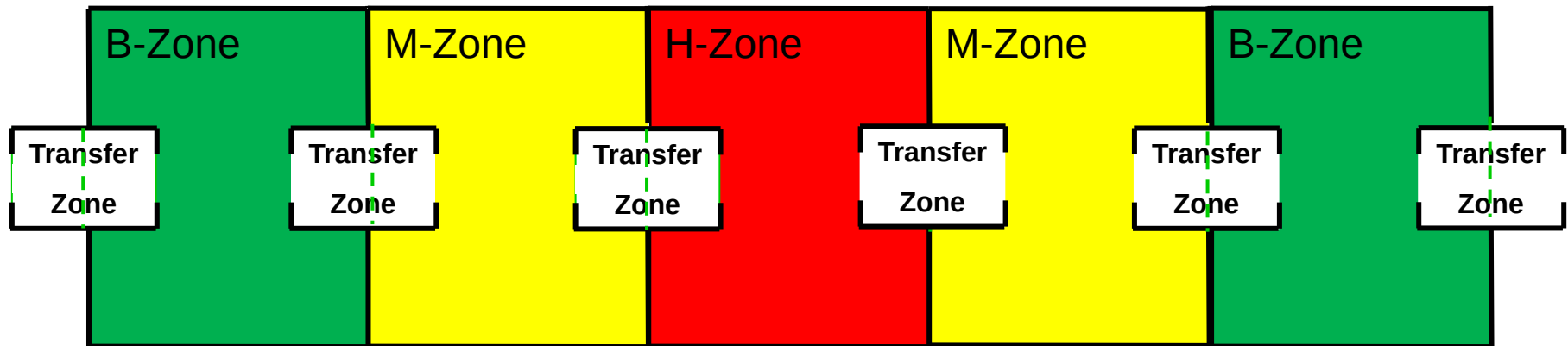
Zoning may involve

- Equipment, tools and other working devices of restricted use within designated areas (e.g. Color code)

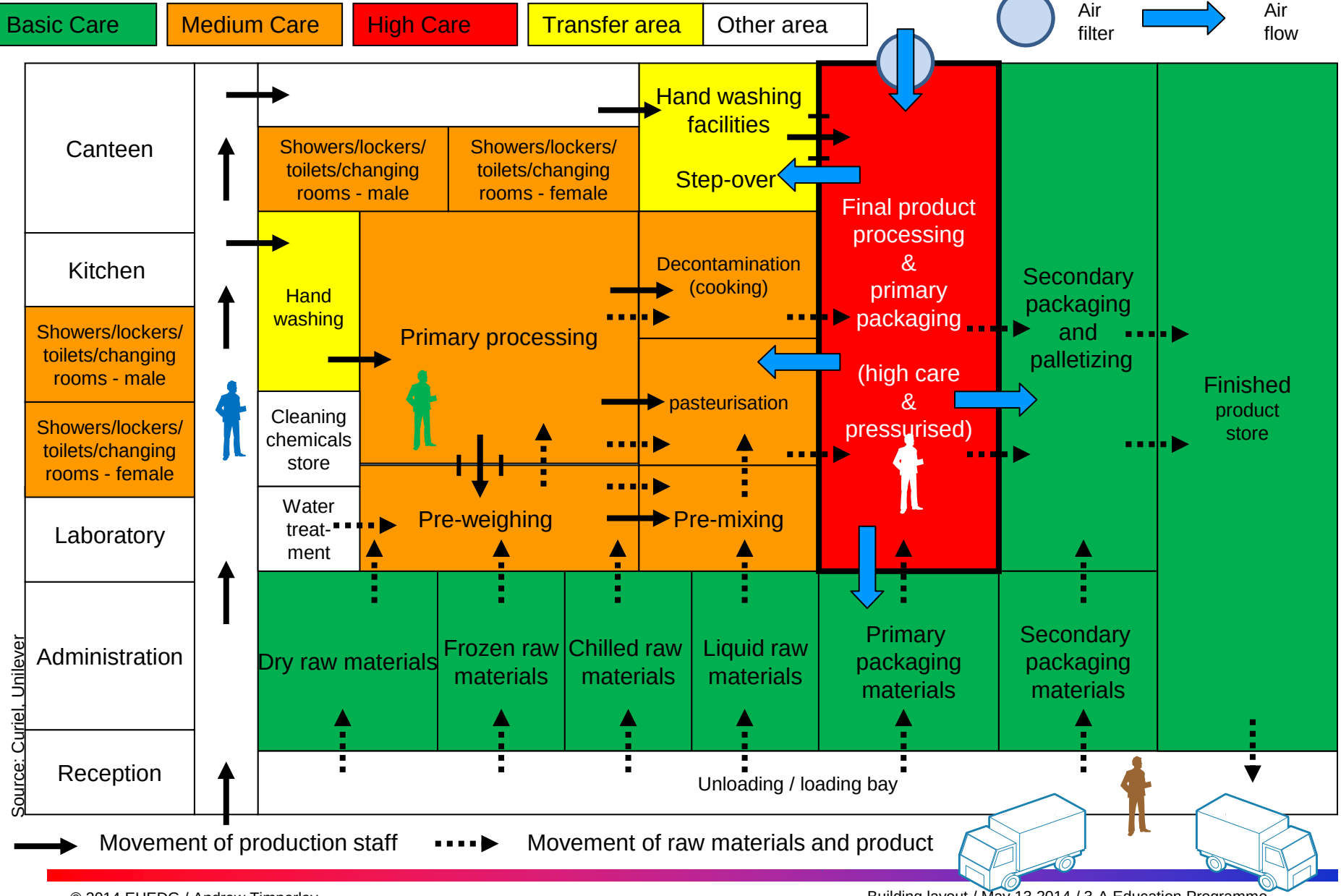


- Make provision for local storage as appropriate
- Internal hygiene policy: requirements of each area (clothing, hands cleaning and disinfection for accessing certain areas, etc.)

Generic Layout of Hygiene Zones



Zone	Hygienic requirements	Purpose of the area
B	Basic	No handling of open and processed product
M	Medium	e.g. closed processing, protects zone H
H	High	e.g. open processing, clean room

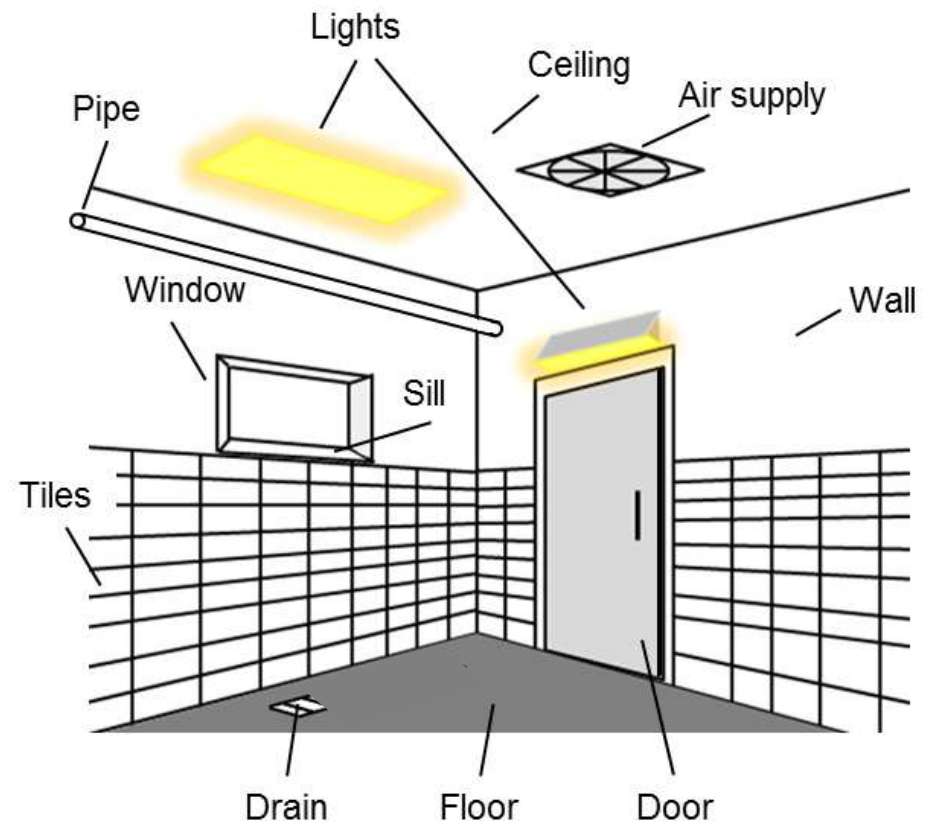


Source: Curiel, Unilever

Production rooms

Overview production room surfaces

- 3 main classes of walls / surfaces
 - Floors
 - Vertical walls
 - Ceilings
- Openings
 - Windows, doors, stairways
- Installations
 - Light sources, pipes, wires, air boards, (HD-plants)



Source: Fraunhofer AVV (acc. to Hauser 2008)

Production rooms

Floors: Hygienic design criteria

- impermeable
- resistant to expected loads, chemicals
- without cracks;
- with cleanable joints (material + dimensions);
- self draining or dry floor operation
- easy to clean
- the subfloor must be strong enough for the installation

Production rooms

Floors: Design

- Flooring tiles
 - Epoxy grouting, joint sealing
(water, heat and chemical resistant)
 - Vibratory setting
 - Prevent cracking
 - Good wet grip
- Or seamless type
(epoxy resin grouting screed/concrete)
- the floor must be in accordance with local regulation about people safety



Source: Hermanek, ACO Industries k.s.

Production rooms

Floors: Drainage

- To avoid stagnant water:
 - Inclined floor (slope $\geq 2\%$)
 - Covered discharge gutters
 - Central drainage channel, lateral drainage channel, central drainage points
 - Hygienic designed sink trap
- For cleanability:
 - Floor finish
 - Connection to vertical walls (wall socket design)



Production rooms

Floors: Drainage

- Damaged drain surrounding is a good breeding ground for potentially pathogenic microorganisms



Source: Barnickel, LVFZ Kempten

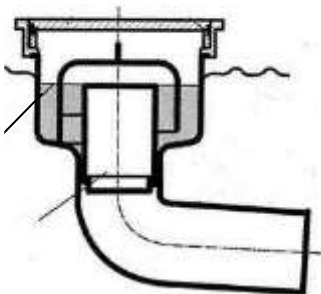
Production rooms

Floors: Drainage

- Covered gutters / drains
- Sink trap removable for cleaning
- prefer drain with round geometry
- Spacing of drain must be adequate for the expected discharge rate during processing and cleaning

Water level

Plug-in odour trap

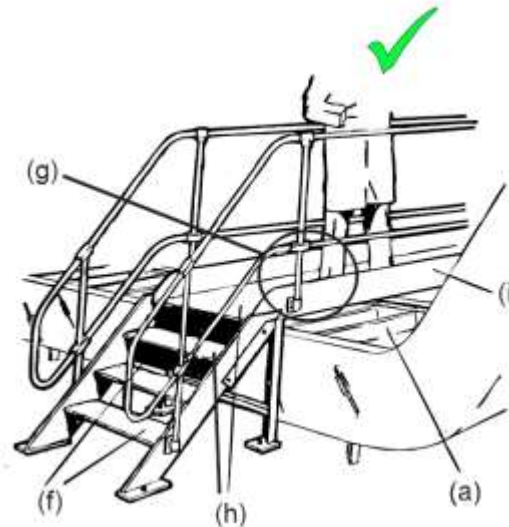
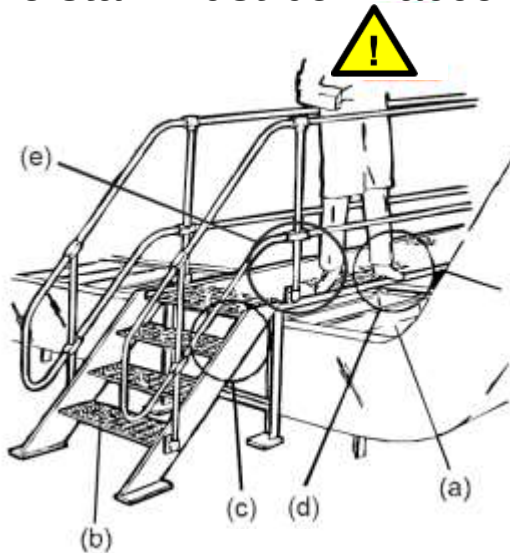


Source: Hermanek, ACO Industries k.s.

Production rooms

Floors: Walkways

- Avoid walkways over exposed product stream/lines
- Covering the product line OR walkways in hygienic design
- the stair must be in accordance with local regulation about people safety



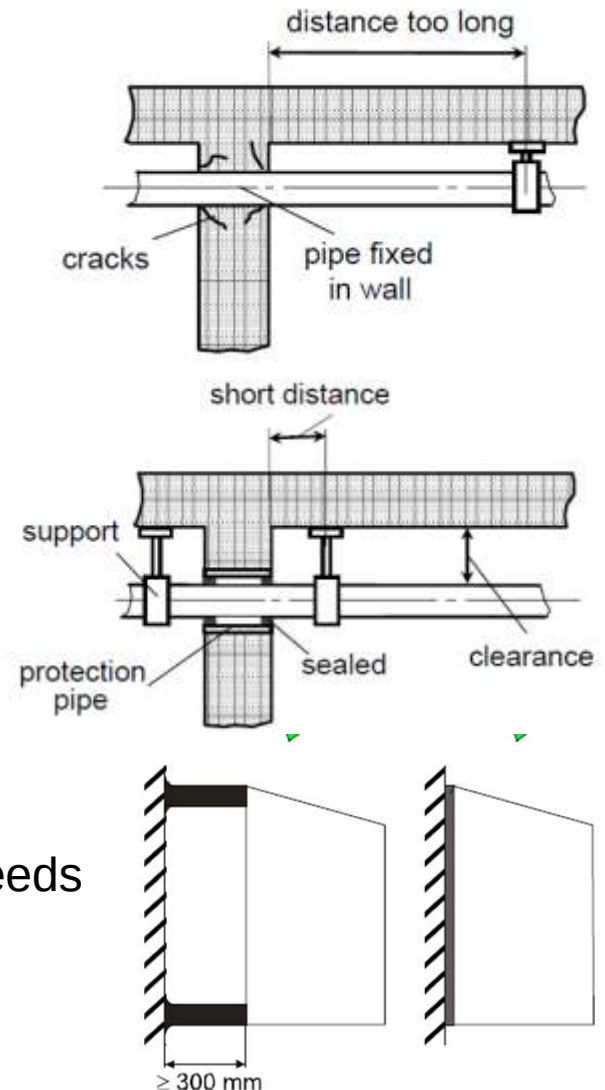
Source: EHEDG GL Doc. 11

Source: EHEDG GL Doc. 26

Production rooms

Vertical walls

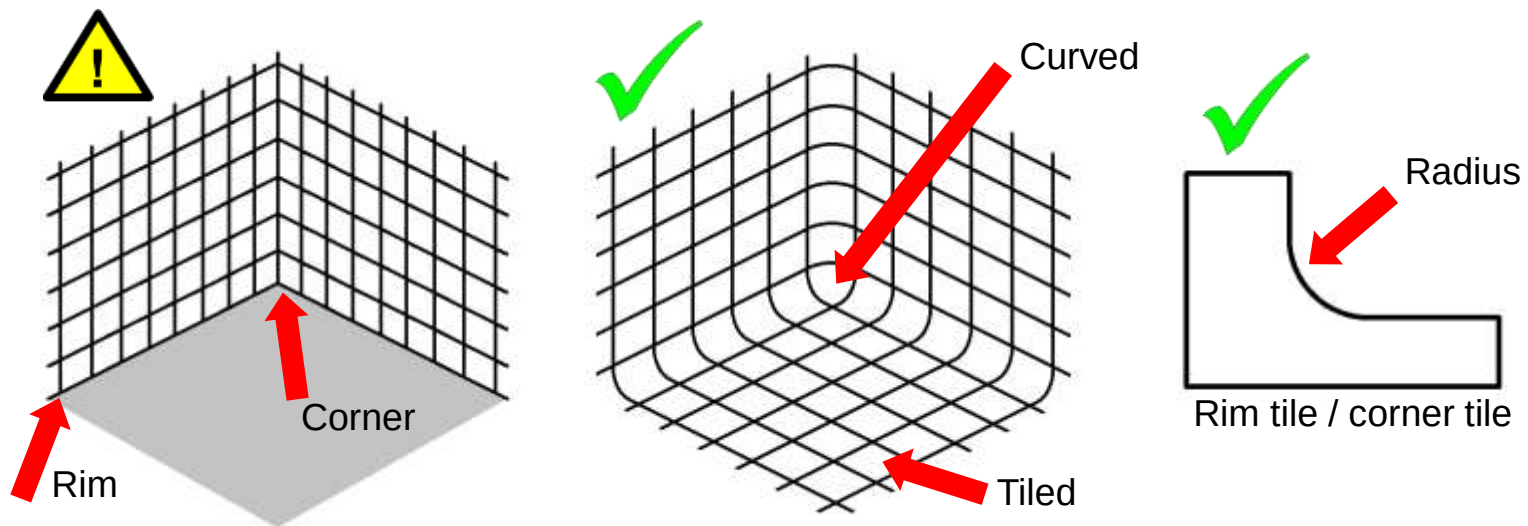
- Material (hard, flat, smooth, washable)
- Covers / cladding (wall tiles, plates, panels)
- No ledges / no protrusions
- Wall socket design for easy cleanability
- Openings: windows, doors, stairways
- Sealed openings for services through the wall (pipes, ...)
- Installations: equipment placed near the wall needs enough distance to the wall → accessible for cleaning (e.g. electrical cabinets, boards)



Production rooms

Vertical walls: Design

- Edge protection strips (metal or plastic)
- Impact protection at lower part of the wall
- Wall socket: rounded tiles with a suggested minimum radius of 75mm



Source: Fraunhofer AVV (acc. to Hauser 2008)

Production rooms

Vertical walls: Protection



Source: R. Soro, Ainia

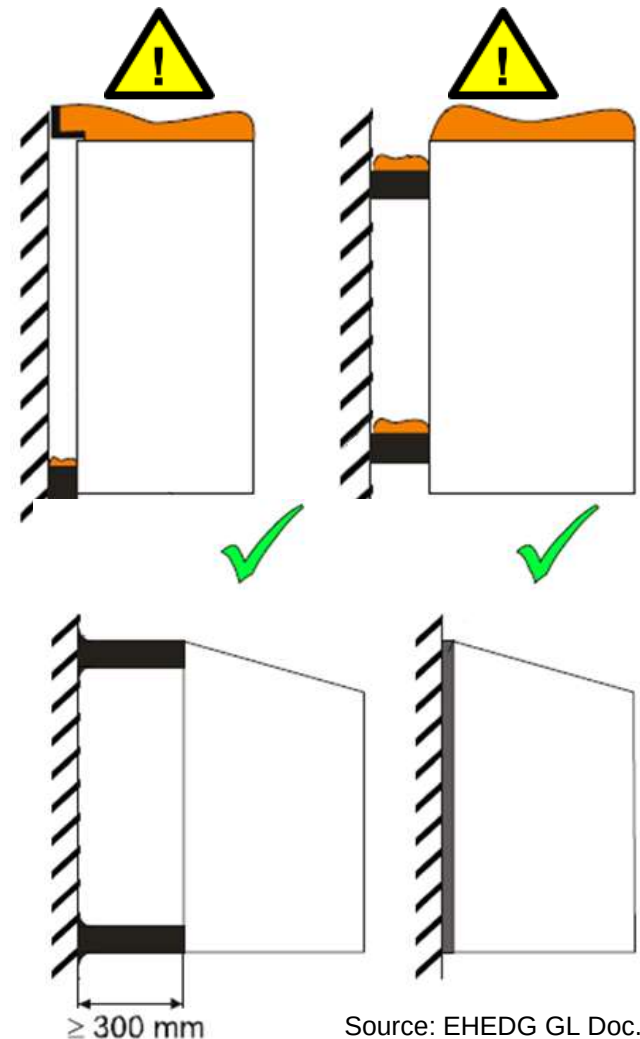
Production rooms

Vertical walls: Openings

- e.g. windows / doors / wall breakthroughs
- Eliminate if not needed!
- Impermeable to pests (e.g. screened permanently closed)

Vertical walls: Installations

- e.g. electrical cabinet
- No horizontal surfaces
- Sealed to the wall or enough space for easy cleaning accessibility

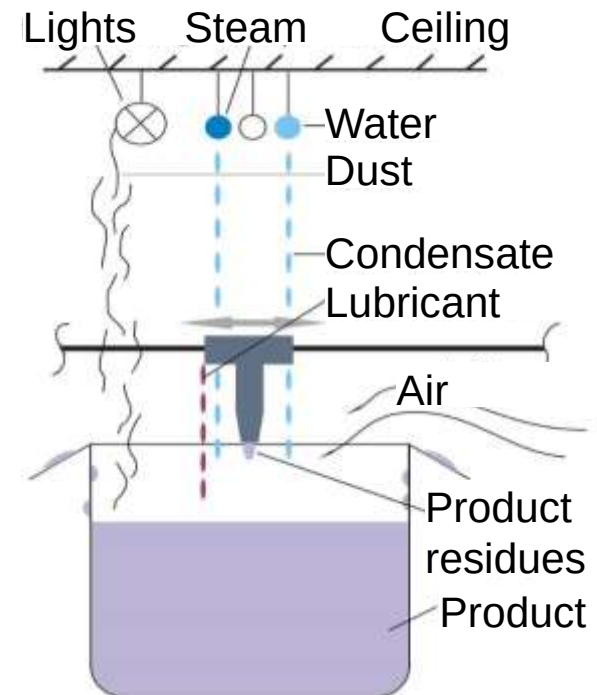


Source: EHEDG GL Doc. 13

Production rooms

Ceilings

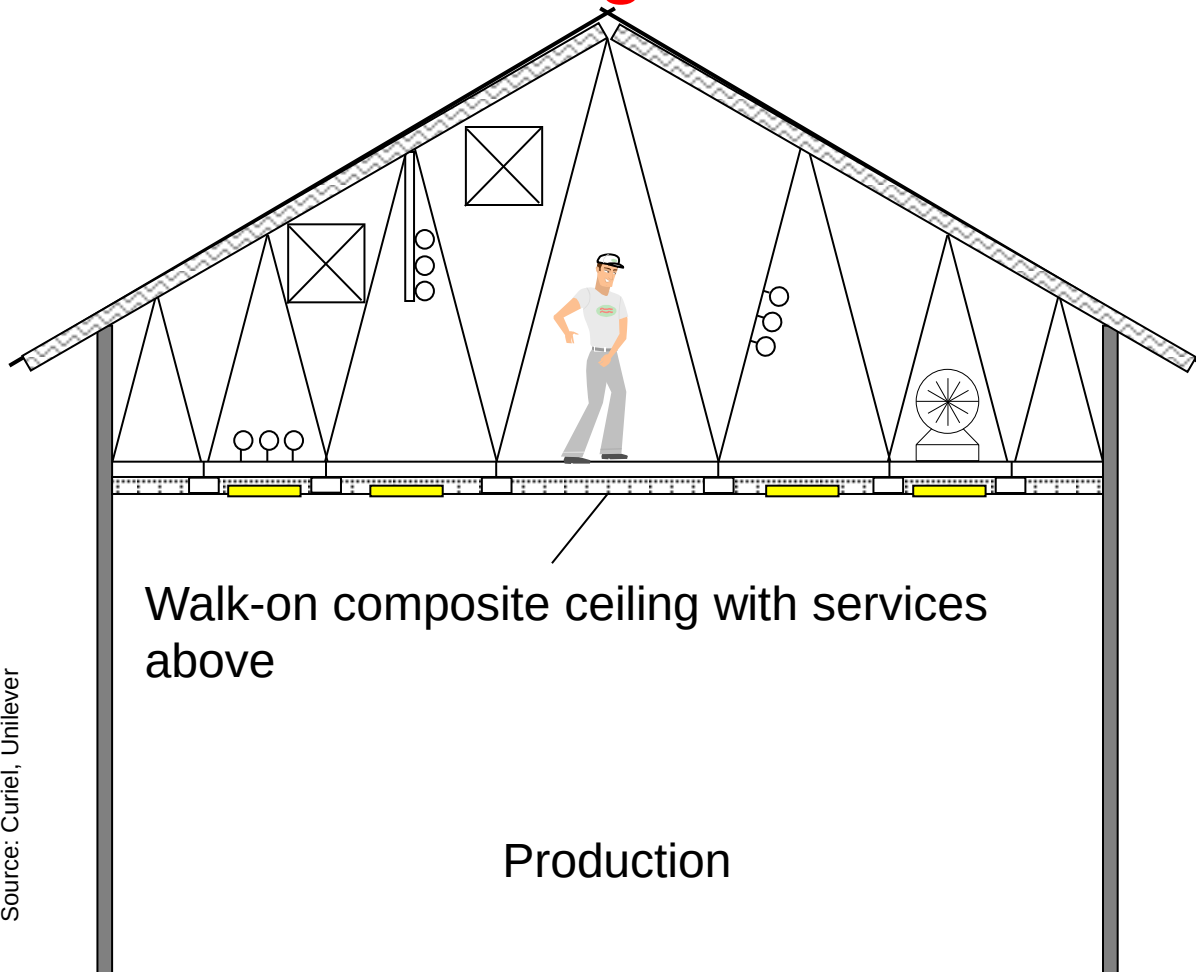
- Suspended ceiling not sealed from the room only acceptable in areas with basic or medium hygienic requirements
- Covers, cladding (glazed tiling, plates)
- Openings: stairways, elevators, conveyor belt
→ Sealing systems required!
- Installations: pipes, wires, light sources, air ventilation
→ Falling contaminants



Source: Fraunhofer AVV



Walk-on Ceilings



Typical walk-on ceiling



Production rooms

Electrical installations

- Bundles of electric cables are difficult to clean
- Time intensive cleaning behind the grid



EHEDG GL: 26

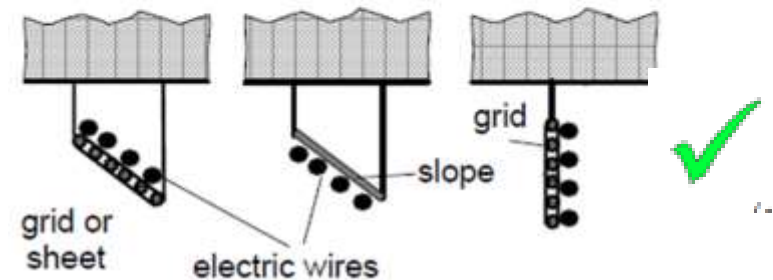
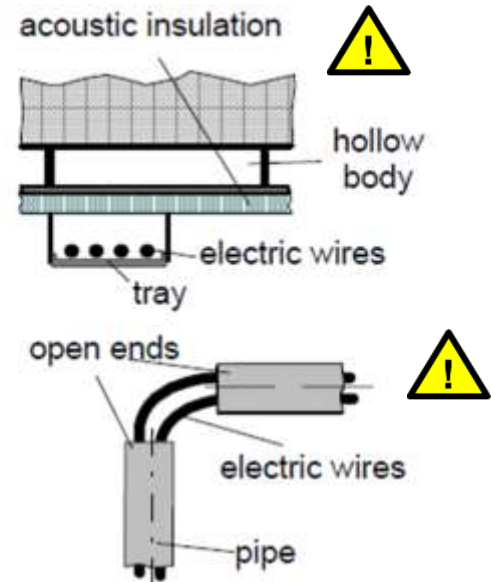


Source: Barnickel, LVFZ Kempten

Production rooms

Ceilings: Electrical installations

- Not acceptable
 - Open pipes for fixing
 - Horizontal surfaces
 - Clusters of electric wires
- Hygienic design
 - minimise cableing in process areas
 - Closed pipes with sealed outlet
 - Inclined stainless steel grid
 - Distanced parallel electric wires

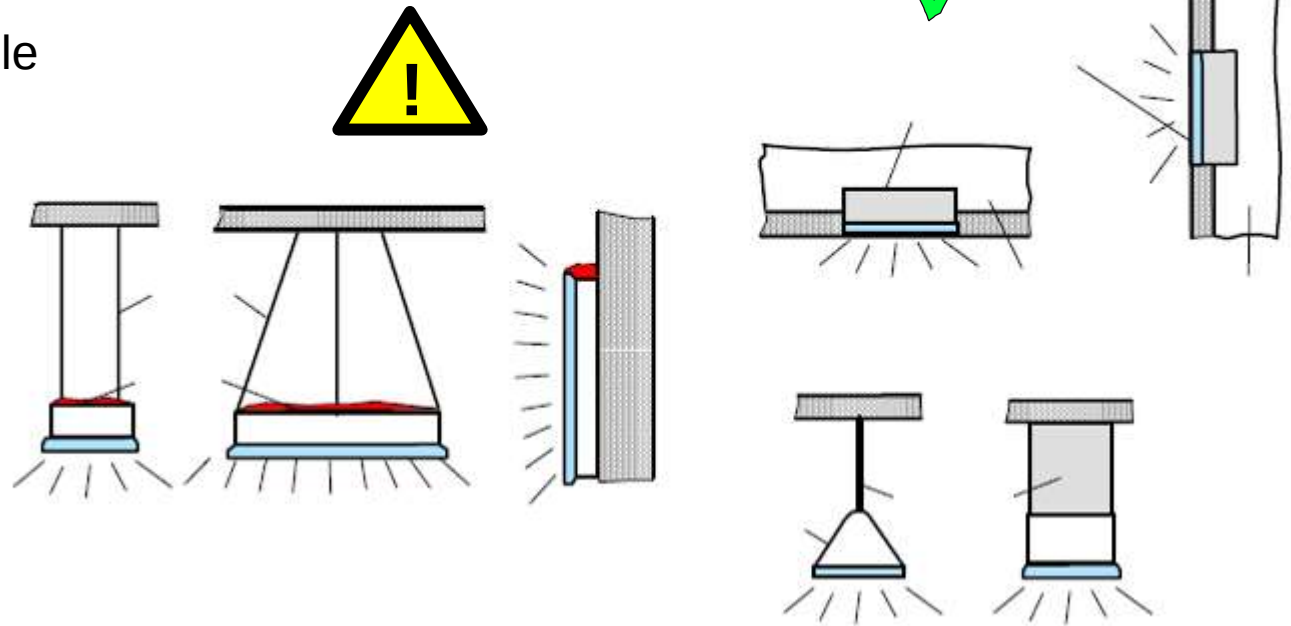


Source: EHEDG GL Doc. 26

Production rooms

Ceilings: Installation of light sources

- Avoid soil deposition and glass fragments
- Integrate in walls/ceilings
- Relocate if possible
- Seal up



Source: EHEDG GL Doc. 26

Production rooms

Installations

- Horizontal areas more than 3 m height are rarely cleaned
- Make provision for high level cleaning



Source: Barnickel, LVFZ Kempten

Production rooms

Ventilation

- Adequate ventilation should be provided to prevent condensation or excessive dust.
- Natural ventilation should be avoided
- Best option: controlled combination of supply and extraction systems
- Air flow must go from high hygiene to basic hygiene zones
- The system must ensure the number of air changes recommended depending on the hygienic requirements of the area.

Production rooms

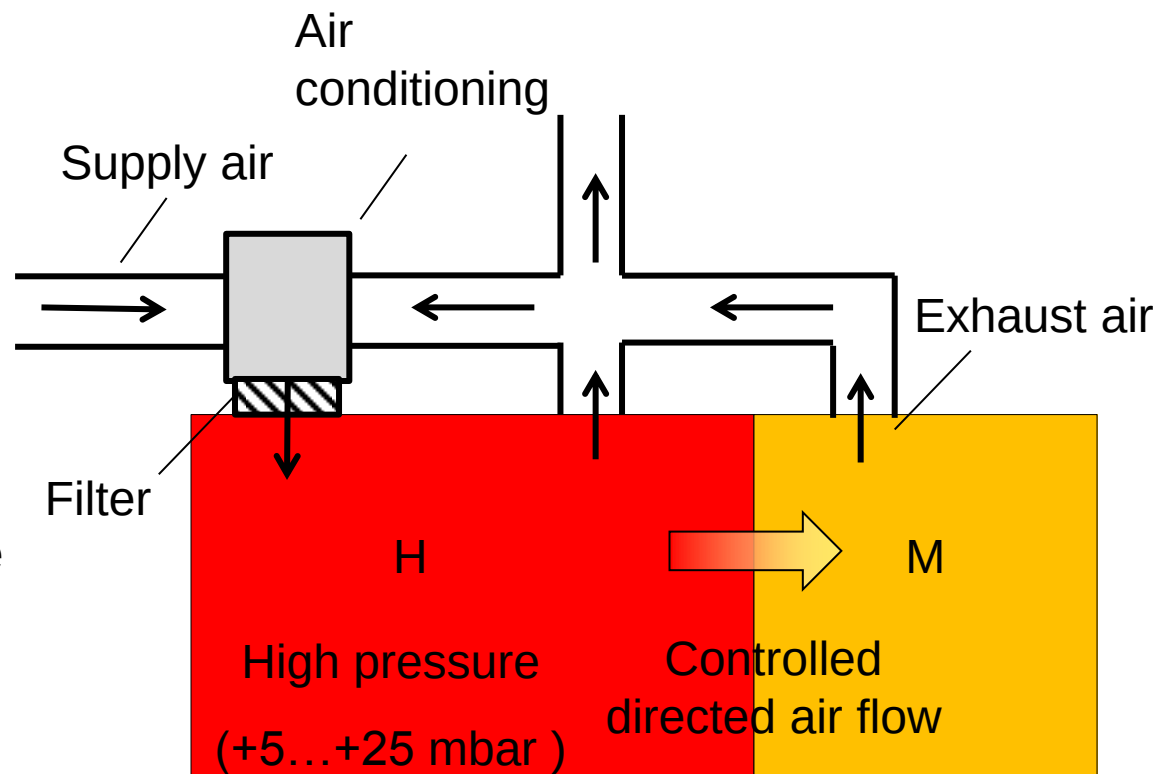
Ventilation

- Air must be filtered
- A moderate over pressure (25 pascal) is recommended in production areas to prevent contaminants from entering.
- Air should be kept as dry as possible to avoid microorganism growth
- Ventilation for a clean and free of contaminants air will be achieved through the combination of filtration, temperature and humidity control and pressure gradient.

Production rooms

Controlled directed air circulation (one way)

- Air supply system
- Decontamination of air
- Prevent the transfer of air-transported particles into the H-Zone



Source: Fraunhofer AVV (acc. to Hauser 2008)

Production rooms

Locks

- Lock systems are part of the air supply
- Allow transfer of product and persons through barriers
- Decontamination of materials/products or persons if required



Source: K. Lorenzen

Production rooms

Movement of personnel / traffic

- Controlled movement / access control
- Protective clothing
- Routine hygiene trained personnel
- Well organized infrastructure, so that personnel can keep / follow hygienic rules
 - e.g. switch for washing basin handled with knee or by motion sensors
 - Doors opened by motion sensors
 - Changing rooms and ergonomically designed disinfection equipment
 - Effective locks

Summary

Hygienic design rules for building layout

- Remote from farms, dumps, effluents, airborne particle sources
- No entry / no encouragement for vectors
- Zoning philosophy: multiple barriers = „boxes within boxes“
- Control all mass flows (necessary and unwanted)
- Export potential hazards from the high care zone
- Select qualified raw materials
- Stop accumulation of moisture / water
- Minimize / eliminate horizontal surfaces