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  
3 Building envelope

2 Factory site  
4 Production areas

Source: Fraunhofer AVV
Regulations

- Light pollution
- Excavations
- Polluted soil?

Regrettably the noise is not on the picture.
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
- Distance to trees and bushes (climbing support)

Prevent entry of climbing, jumping and burrowing creatures
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

- Distance to buildings:
  - ≥ 10 m
  - ≥ 1 m
  - ≥ 15 cm

- Grit size:
  - ≤ 2.5 cm

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

Horizontal surface
Lamp shade
Lamp post

Inclined, rounded surface

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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

Source: Fraunhofer AVV
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 < 1mm x 1 mm
Building envelope

Placement of air supply systems

- Prevention of cross-contaminations
Building envelope

Roof

- Pest-tight, water proof
- Sloped (≥ 3°) 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 ≥ 45°)
- No windows next to product area
- As few as possible entrances
Zones for factory planning

4 | Production rooms

Source: Fraunhofer AVV
Main Flows

Layout

- Personnel flow
- Waste and Residues flow
- Product flow
- Others: packaging, traffic
- Services: gases, utility, water, air
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

Source: O. Rondouin, Exaris
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

<table>
<thead>
<tr>
<th>Zone</th>
<th>Hygienic requirements</th>
<th>Purpose of the area</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Basic</td>
<td>No handling of open and processed product</td>
</tr>
<tr>
<td>M</td>
<td>Medium</td>
<td>e.g. closed processing, protects zone H</td>
</tr>
<tr>
<td>H</td>
<td>High</td>
<td>e.g. open processing, clean room</td>
</tr>
</tbody>
</table>
Hand washing facilities
Step-over
Final product processing & primary packaging
(high care & pressurised)
Secondary packaging and palletizing
Finished product store

Movement of production staff
Movement of raw materials and product

Source: Curiel, Unilever

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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 ≥ 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 breaktroughs
- 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

Walk-on composite ceiling with services above

Production

Typical walk-on ceiling

Source: Curiel, Unilever
Production rooms

Electrical installations

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

Source: Barnickel, LVFZ Kempten

EHEDG GL: 26
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 desinfection 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