# 4. Hygienic design of open systems

Product should not come into contact with contaminated surfaces. Especially in open processing, the design of the production environment should be hygienic to avoid recontamination of the product.

## *4.1. Condensation*

Condensations can lead to product contamination when water droplets enter the product in an open process area:

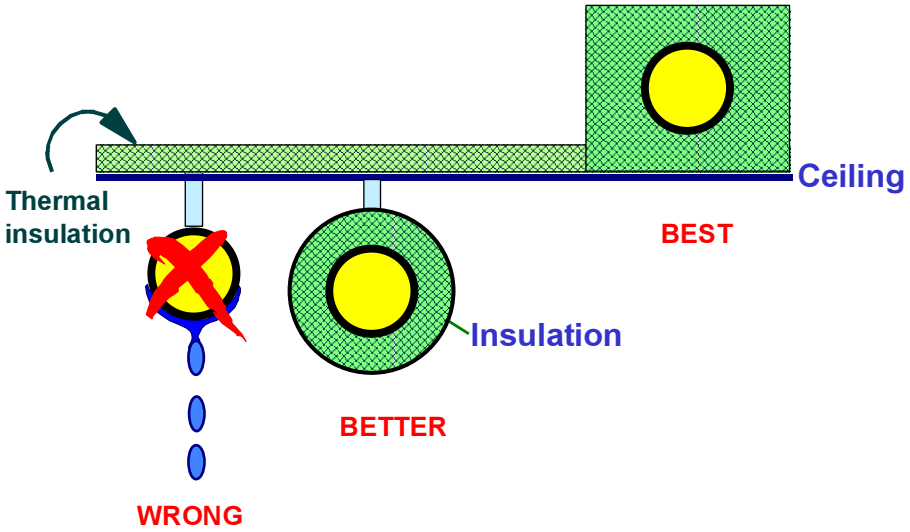



**Figure 4.1 Three ways to install a pipeline for cold materials.**

Pipelines transporting cold liquid should be insulated or integrated in the ceiling to prevent water droplets entering product in a line below.

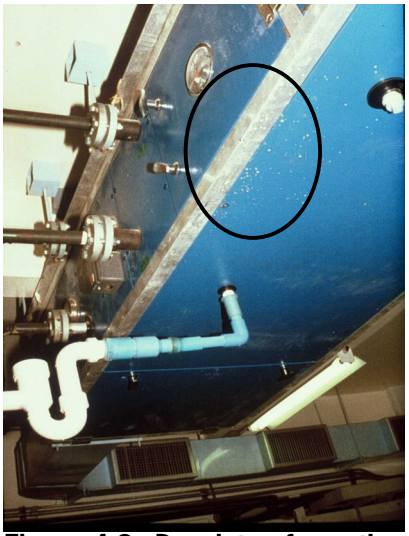


**Figure 4.2 Droplet formation on air handling unit.**

## *4.2. Covers*

### 4.2.1. Tank lids

Covers should prevent dripping of condensate or soil residues in the product. When the lid and its hinge are not designed correctly, dust, condensation etc. accumulating on the cover will fall into the tank when the cover is lifted (left).

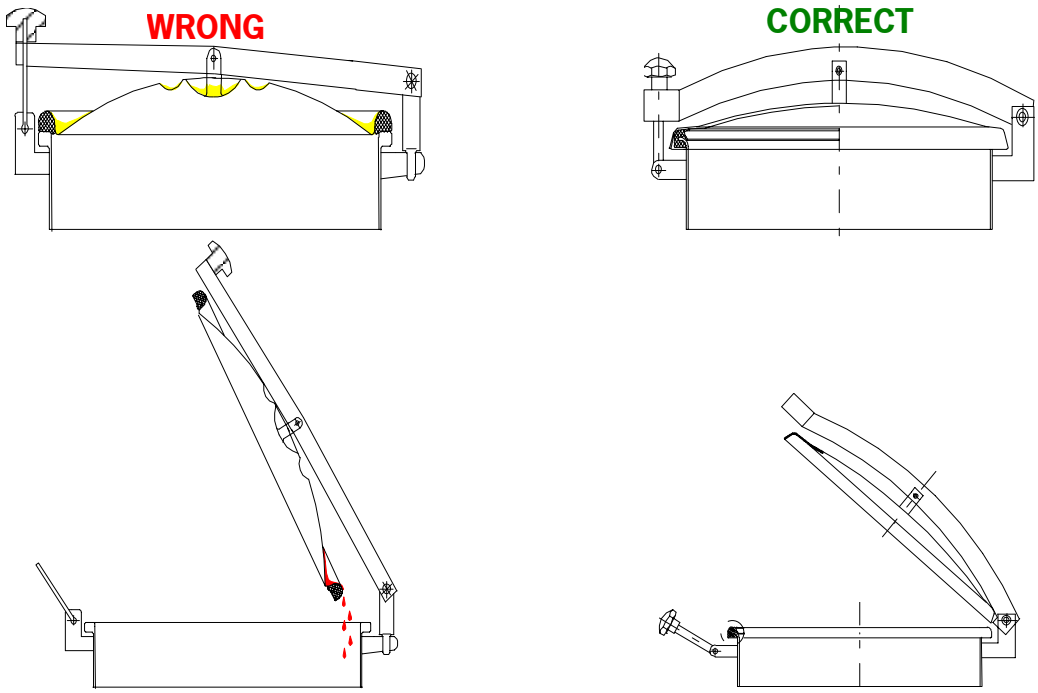



**Figure 4.3 wrong (left) and correct (right) design of lid and hinge .**

### 4.2.2. Covering process lines

When there is a risk of materials entering the product or packaging material, process lines must be covered.

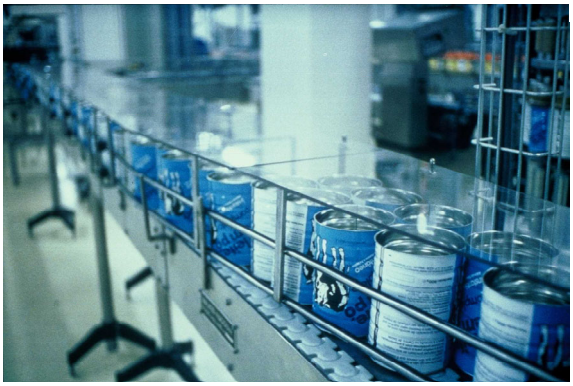


**Figure 4.4 Left: Chocolate melting. The lack of a top cover poses a risk of entrance of particles/microorganisms. Right: Lines with open products or packaging should be covered like this to prevent entrance of contaminants in the cans and subsequently in the product**

### *4.3. Rims*

The design of top rims of product containing equipment like containers and boxes must avoid ledges where product can accumulate and which are difficult to clean (doc. 13, EHEDG).

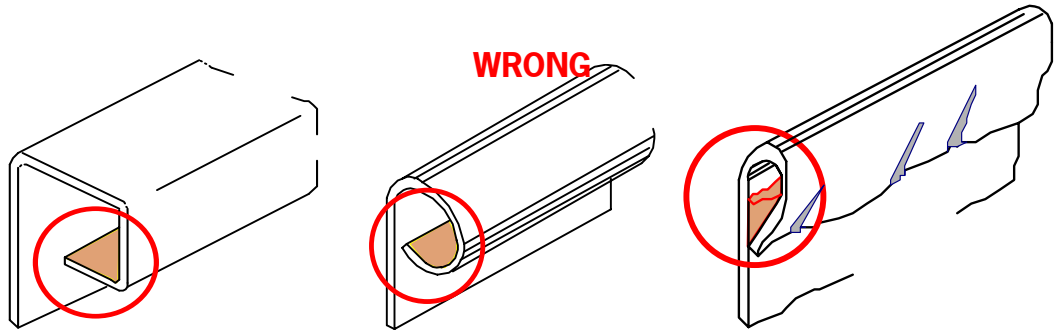



**Figure 4.5 common mistakes in dsign of top rims of product containing equipment .**

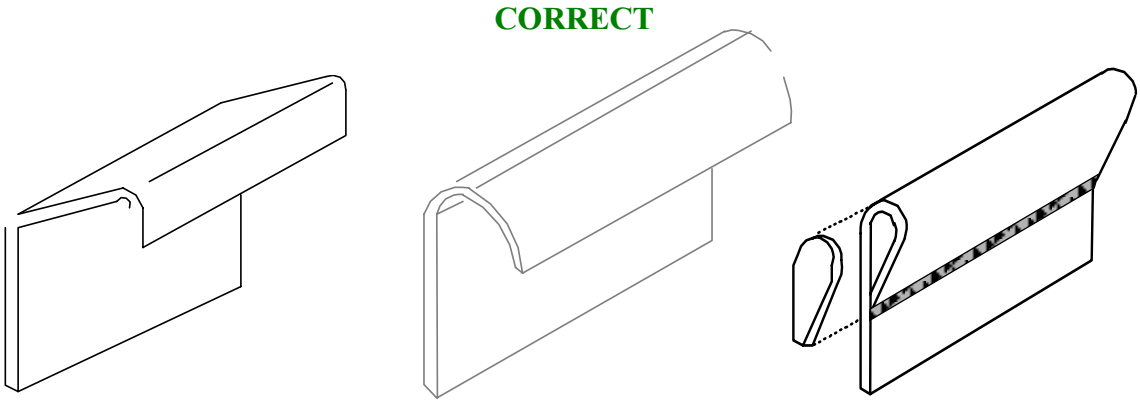



**Figure 4.6 Correct open (2 pictures on left) and closed rim (right picture).**

Open top rim designs must be rounded and sloped for drainage. If the top rim is welded to the wall, the well must be flush and polished to provide a smooth surface. In this case the rim most be totally closed (Figure 4.6).

### *4.4. Conveyor belts*

Embedded reinforcements as well as fabric backing materials inside conveyor belts must be covered to avoid contact with the product:

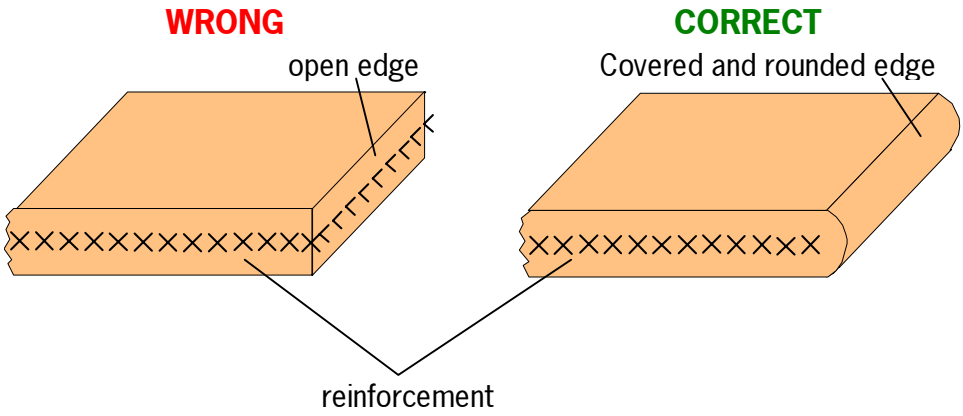



**Figure 4.7 Open edges of belts cause hazards by crevices or penetration of liquids (left). Reinforcement materials must be covered at edges (right).**

Design of a conveyor belt should be such that no accumulation of product residues or micro-organisms can occur. Gears and motors of belt drives must also be covered to avoid any contamination of the product (doc. 13 EHEDG).

### *4.5. Staircases*

Staircases should be easily cleanable and not pose the risk of personnel contaminating the product (right). Materials used for staircases should be able to resist cleaning agents and product residues.

**Figure 4.8 Open staircase (detail) with corrosion formation**

**Figure 4.9 Open staircase where people can contaminate the product.**

Good design:

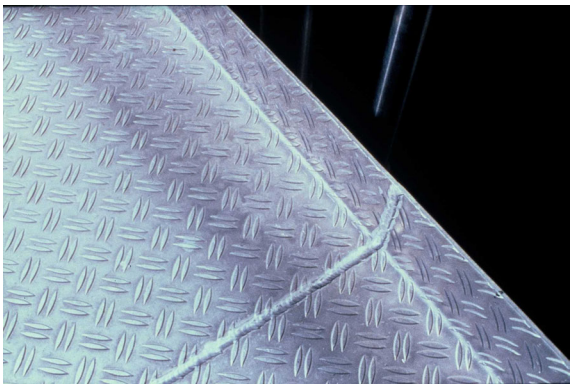


**Figure 4.10 Materials used for staircases used must be easily cleanable but not slippery. Edge prevents transfer of soil towards product.**

## *4.6. Fork lifts*

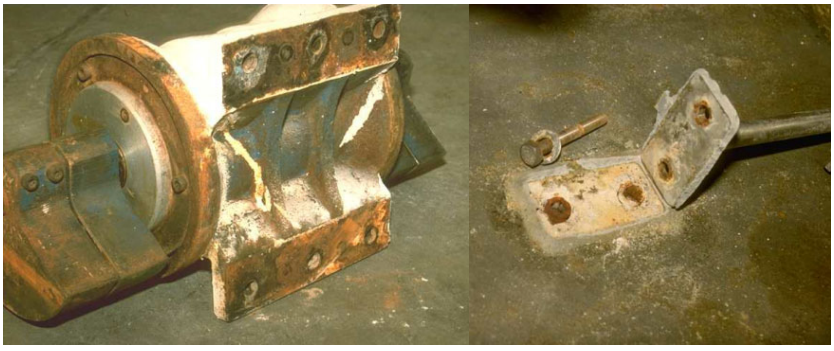
All equipment used in a factory must be smooth,easily cleanable and not cause accumulation of micro-organisms and subsequent contamination of the product.

**Figure 4.11 Wheels of fork lift may accumulate product residues.**

## *4.7. Installation of equipment*

### 4.7.1. Processing equipment

Process lines should be built and installed in such that equipment is easily accessible and cleanable so that no soil can build up at inaccessible places.



When equipment is attached to the floor, product residues can reach the underside of equipment through cracks and crevices and cause accumulation of soil and micro-organisms.

**Figure 4.12 Collection of dirt and corrosion under equipment supports.**

When support structures of equipment are attached to the floor or walls either a minimum clearance of 30 cm for cleaning a inspection must be applied or the equipment must be properly sealed against the mounting surface. Gaps, cracks and crevices where micro-organisms or insects can survive after cleaning must be avoided (doc. 13, EHEDG).

**Figure 4.13 Left: underside of process line difficult to clean. Right: effect of balance being attached to the floor.**

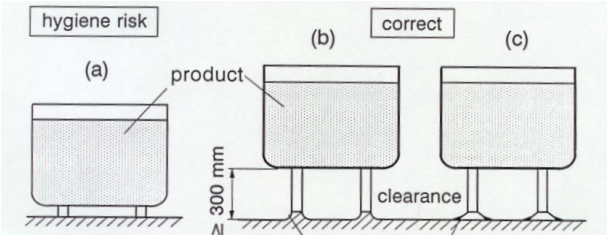



**Figure 4.14 Installation of equipment on floors. Left: hygiene risk because of small clearance and feet without radius and sealing. Right: correct situation. Equipment placed high enough to allow cleaning and placed on rounded pedestals or sealed to the floor.**

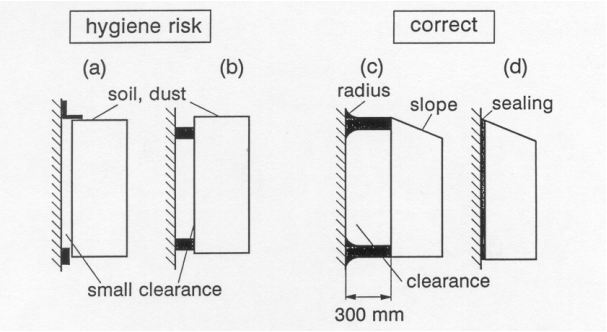



**Figure 4.15 Installation of equipment on walls. Equipment should either be sealed to walls, or sufficient clearance should be provided for cleaning.**

Horizontal surface should be avoided to prevent dust accumulation. Clearances should be large enough to allow for easy cleaning (Figure 4.14 and Figure 4.15).

Equipment must not be mounted beneath tanks or vessels so that maintenance and cleaning is possible.

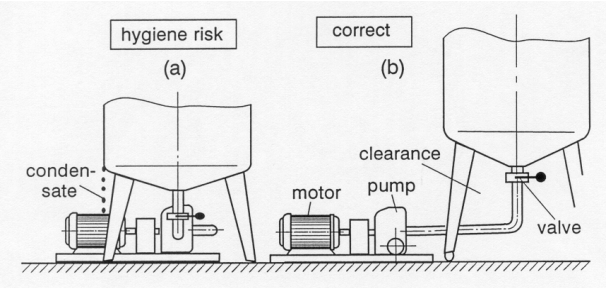



**Figure 4.16 Installation of equipment: correct and incorrect methods.**

Below some illustrations of the principles outlined above:

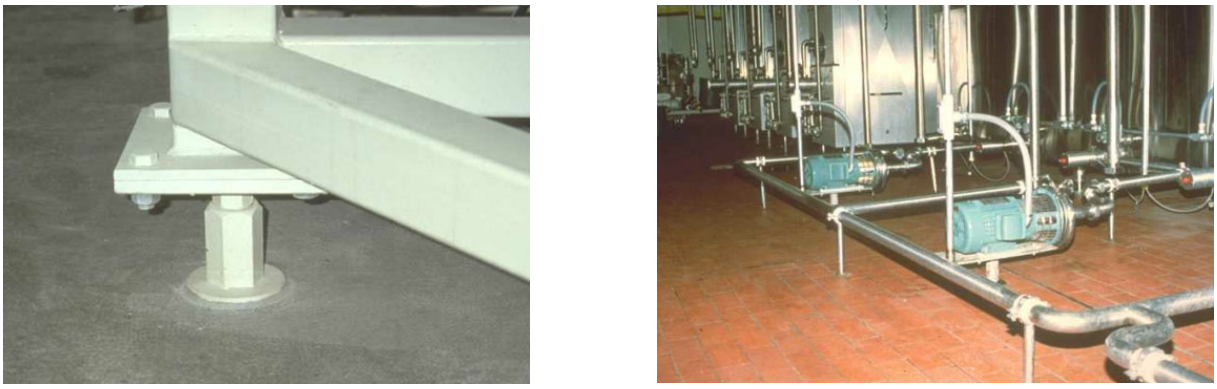


**Figure 4.17 Equipment with large enough clearance for cleaning.**

Instead of clearance, equipment can also be sealed to the floor:

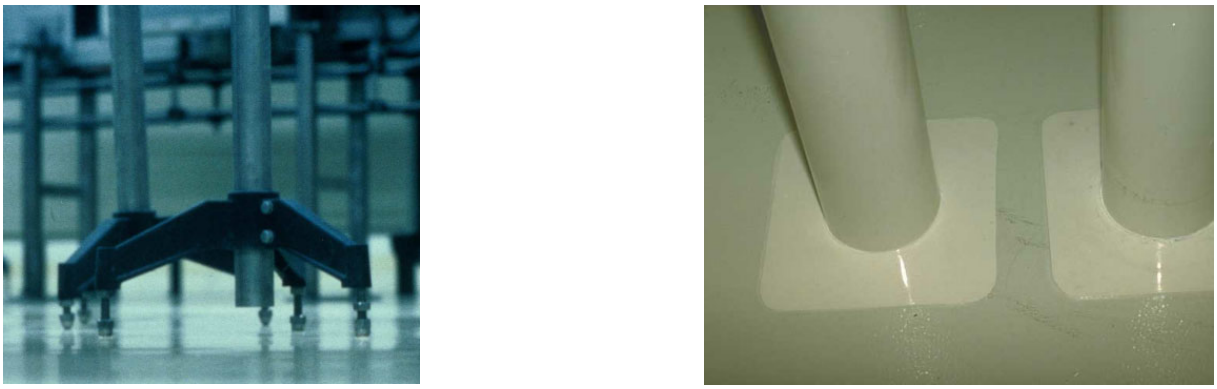


**Figure 4.18 Sealing of equipment to floor.**

### 4.7.2. Cable trays and pipelines

Cable trays, pipelines, and transfers of these through walls or floors can collect dirt and can facilitate spreading of pests or contaminants in processing areas. Therefore, a lot of attention has to be paid to sealing and cleanability.

When no sealing is applied open spaces exist when pipelines are transferred through the wall or the floor.

Open spaces in the floor cause airflows (pay attention to the coat) and may allow entrance of contaminants or pests in processing areas.

**Figure 4.19 Openings for cables and pipes may be a source of contaminants and pests.**

When cable trays are hanging from the ceiling they should be open on the underside to prevent dust formation and to enhance the possibilities for cleaning:

**Figure 4.20 Open and closed cable trays.**

Even when the cables are completely closed on all sides, dust formation can build up through cracks and crevices. When the covering is removed, dust formation and cob webs become visible (Figure 4.19, right). Cables should therefore be stored in a way that they are easily accessible, cleanabe and no dust formation can occur.

The same applies for lights or other items hanging on the ceiling:

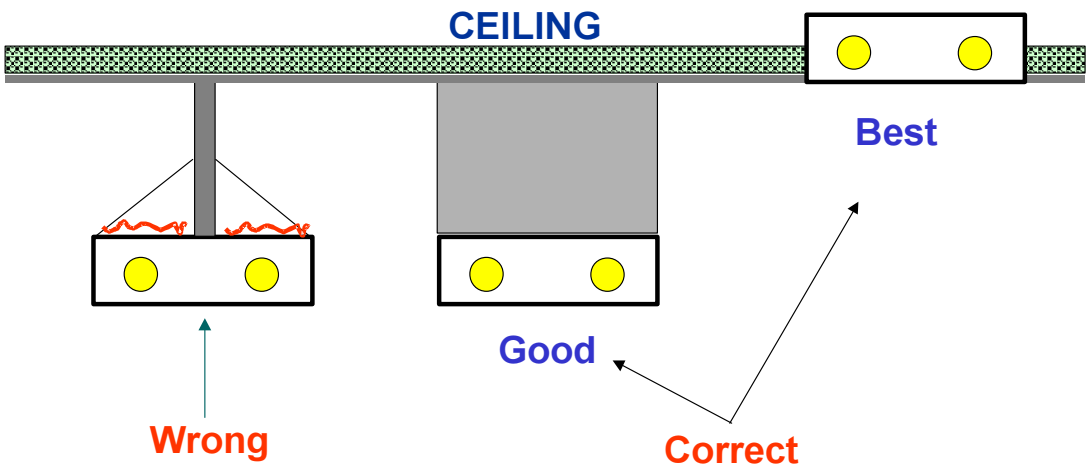



**Figure 4.21 Mounting of lights on ceiling .**

## *4.8. Air*

Growth of microorganisms in the factory environment should be prevented. To prevent the growth of moulds, the humidity should be below 50%. This can be achieved using ventilation or air conditioning systems. Depending on local conditions (for instance: is the facility located downwind of a waste water treatment plant?), product requirements and preservation methods used, it may be necessary to decontaminate air. This can be done by incineration (heating to 350 °C), but is in most cases obtained using air filters. Installation of filter cartridges must be done carefully to prevent leaks between cartridge and housing (Lelieveld, 2000).

Filters should be checked regularly to prevent blockages and thus insufficient filtration of air.

**Figure 4.22 Left: bad location of intake opening of ventilation system. Right: air inlet not kept clean.**

Air inlets should also be checked and cleaned regularly. Preferably they should be located in such places that entrance of contamination is prevented (Figure 4.22).

Good design of air filtration system:

For critical applications two filter assemblies in series may be used (Lelieveld, 2000). Even then, maintenance of the filters is important to prevent malfunctioning of the air filtration system.

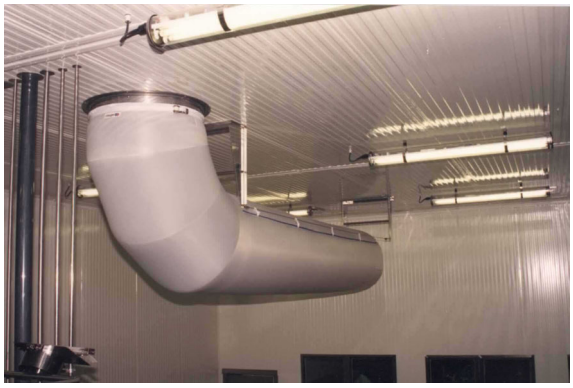


**Figure 4.23 Air travels through a flexible airsock that can be removed and cleaned easily.**

## *4.9. Personnel*

### 4.9.1. Shoes

Use of a disinfecting bath to decontaminate shoes before entering a production area is usually not efficient to remove all soil and bacteria from the shoe surface. Thus it is better to use shoe covers to prevent transfer of bacteria from one area to another via contact with dirty shoes. Shoe covers, however, can be damaged…

Therefore, the best solution to prevent contamination of factory floors (and eventually contamination of the product) is to change shoes before entering a high-care area. To enforce this, a shoe-changing room should be provided with a high bench in the middle. The (company-provided) shoes may only be worn inside the factory, the normal shoes may only be worn outside. The bench prevents accidental wear of the wrong footwear in the wrong area.

**Figure 4.24 Cabinet with shoes. Employess must enter high care areas of the factory with these factory-provided shoes.**

**Figure 4.25 Bench in the middle of the shoe changing room. Shoes are changed here.**

### 4.9.2. Clothes

Personnel should be clean and tidy. For high care areas special clothing is advised that is used in these areas only, to prevent cross contamination. Human activity can promote the transfer of skin particles in the air that may end up in the product. It is then better to use specific fibre material with smaller pore size so that skin particles are trapped and can not be released to the surroundings:

**Figure 4.26 Employees dressed in special clothing.**

For delicate products, the use of caps and mouth covers can prevent entrance of hairs or other particles into the product.

Furthermore, people should wash their hands before entering the production facility and be free from any possible hazard that could spread bacteria or foreign bodies into the product, i.e. no insecure jewellery to be worn, no coins or other small items to be carried loose in protective clothing pockets (no outside pockets) and no handling of money in the production area.

**Figure 4.27 Caps should be worn to prevent hairs falling in the product.**

These regulations account for everyone entering the production area including cleaners, engineers, management and visitors.

### *4.10. Pests*

Entrance of rodents, birds, insects etc. in the factory should be prevented since this causes unhygienic situations. Therefore, when designing doors and windows care must be taken that animals can not enter (see chapter 2.3). Furthermore, inspection of doors, windows and also the roof and surroundings for traces of animals should be carried out on a regular basis.

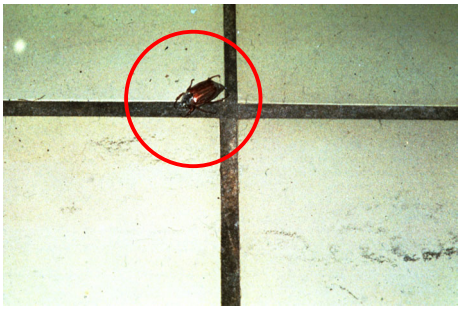


**Figure 4.28 Beetles don't belong in a factory.**

Signs of insects, rodents or birds entering the factory can be found when inspections are carried out regularly. Look for trails, droppings, or traces of feeding activity.

**Figure 4.29 These traces found in dust are most likely caused by the tail of a mouse.**

The production environment should be made as inattractive for animals as possible. The outer walls of factories for instance should not have ridges or other protrusions that allow settling of birds (Lelieveld, 2000):

### *4.11. Zoning/layout*

The production plant must be built in such a way that finished product cannot come into contact with raw materials. Therefore, the flow of material must be from raw materials to the separate finished product exit. Also, people should not move from raw

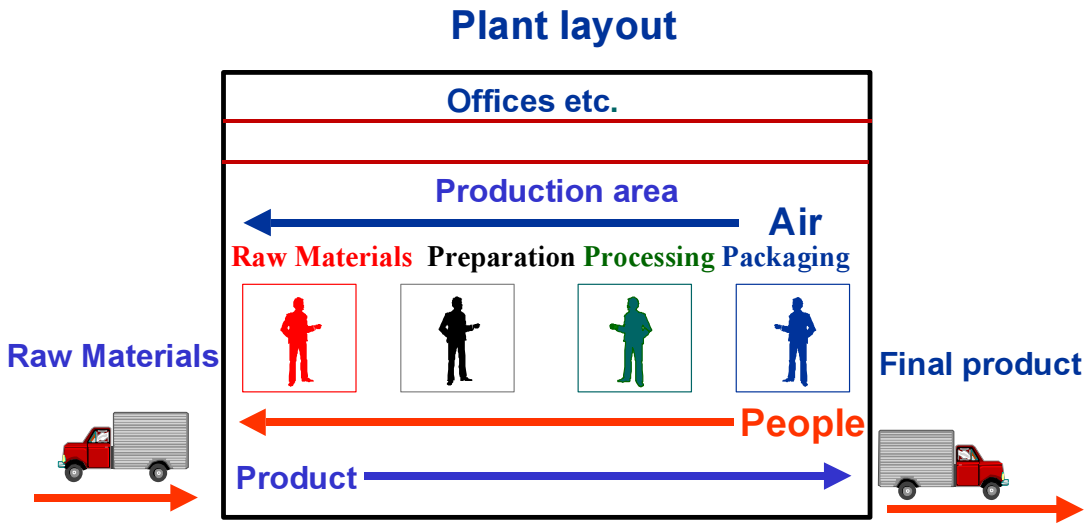



**Figure 4.30 Basic zoning scheme for a factory .**

materials to the finished product area. The same accounts for airflows: air should flow from clean areas towards the raw material side of the factory (Figure 4.30).

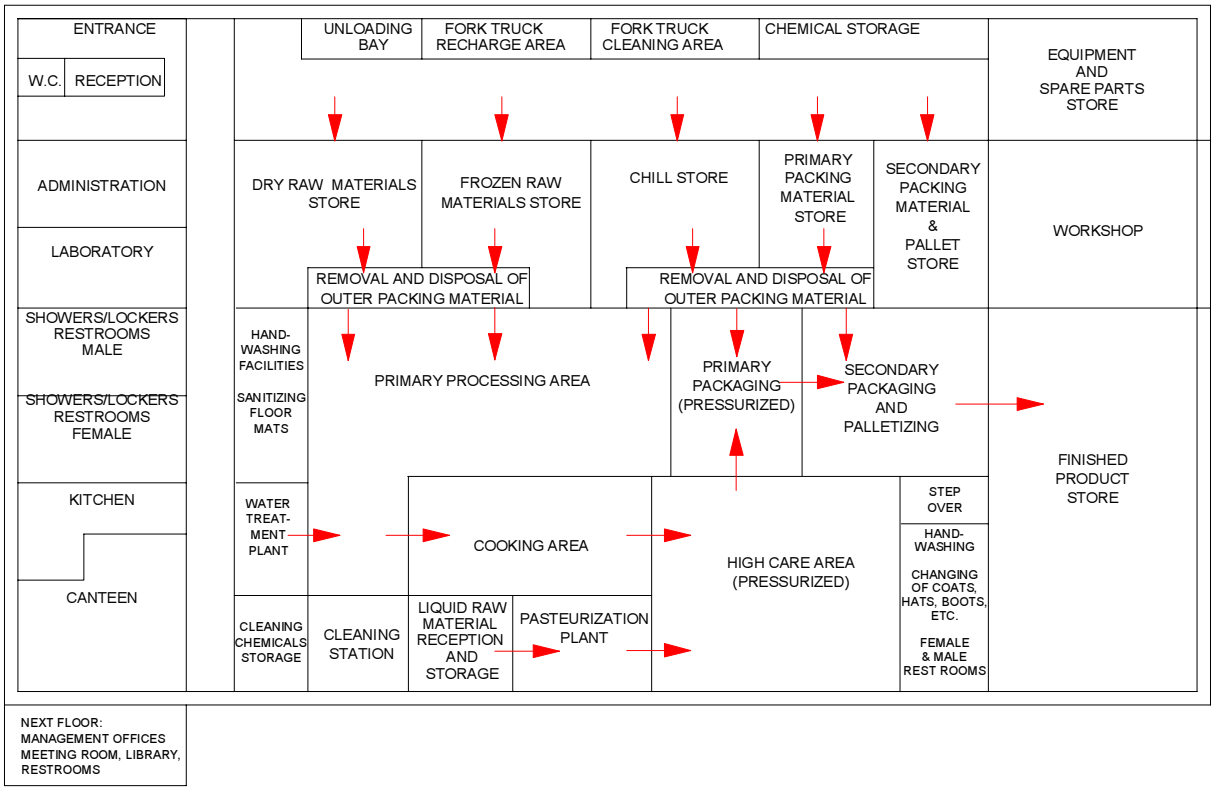



**Figure 4.31 General layout of a factory. Arrows indicate flow of material through the factory .**

To prevent contamination between different areas, zoning is necessary to separate high care areas from less vulnerable areas.

Characterisation of areas in low, medium and high care depends on the stage in the production process and the product requirements. A storage room is usually a low care area. Open processing of the final product is usually indicated as high care area, since especially process steps after inactivation are vulnerable for recontamination through the environment. The higher the care in an area the more regulations for preventing contamination of the product are necessary. For example, when people enter a high care area, they should change shoes and wear special coats (see 5.8).

In these high care areas, the presence of people should be limited. Therefore, the use of visitor galleries, to limit the number of people in a process area, is advised.

**Figure 4.32 Visitor gallery.**

## *4.12. Further reading*

1. H.L.M. Lelieveld (2000). Hygienic design of

factories and equipment. In: Lund, B.M., Baird-Parker, T.C. and Gould, G.W. Microbiological safety and quality of food 2. Aspen Publishers Inc. Gaithersburg, 1656-1690

2. Anonymous (1994). Hygienic plant engineering requirements, SHE 8, Hygienic Processing Working Party, Unilever

3. ISO 14159. Safety of machinery-Hygiene requirements for the design of machinery

4. EN 1672 (1997). Food processing machinery-Basic concepts-Part 2: Hygiene requirements

EHEDG guidelines:

5. Document 13: Curiel, G.J., Hauser, G. and Timperley, E.A. (1995). Hygienic design of equipment for open processing. Trends in Food Science & Technology 6(9), 305-310.