Chapter 4

Design and layout of Fish Processing Units

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Manufacture of products, which are safe and of high quality is the aim for any food manufacturer. The products made should be traceable and free from contamination of any kind. It is in this context that the designing of a food manufacturing plant assumes importance. The Codex Alimentarius Commission (CAC) defines food hygiene as 'all conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain'. Similarly, the EU's General Food Hygiene Directive has defined food hygiene as 'all measures necessary to ensure the safety and wholesomeness of foodstuffs'. The Directive includes all stages of the supply chain in this definition, from harvesting to the point of consumption.

A good plant design is one which has incorporated measures to prevent contamination of the food manufactured there in broad terms, from a physical, microbiological or chemical source, at any stage of production. In the US there is greater focus on the concept of food sanitation defined, for example, as the 'hygienic practices designed to maintain a clean and wholesome environment for food production, preparation and storage. This second definition links hygiene more specifically with maintaining a clean working environment during food processing.

Hygienic plant design

We should always bear in mind that plant is a food processing facility which provides an appropriate environment for processing operations, while ensuring compliance with all applicable building safety and environmental regulations. The design must be legally compliant to all food laws. Layouts, for example, should allow ready access to equipment for installation and both routine and non-routine maintenance. Materials selected should be sufficiently rugged and non-corrosive to withstand wet conditions prevailing inside the plant.

General considerations

The primary aim of hygienic plant design should be to set up effective barriers to all sort of contamination. Contamination includes Biological, chemical and physical. When we design a plant be constructed these concept should be borne in mind to effectively tackle entrance of contaminants. Within a plant itself, there will be areas with differing levels of hygienic requirements. Broadly, these can be classified into three viz. Non-production areas, finished goods handling area and processing area

Non-production areas include office space for management and administrative staff, facilities for production staff such as canteens and rest rooms, car parking and storage facilities, for example. Hygienic design requirements and procedures will be less stringent than in other parts of the plant. Non-production areas must be clearly segregated from production areas so that unauthorised staff, for example, is not allowed to move from one area to the other, contaminating production areas in the process. Toilet and washroom facilities must be sufficient to allow production staff to maintain appropriate levels of personal hygiene. Premises and storage areas must, for example, be designed to be easily maintained, and be kept in good order, if they are not to attract pests and become sources of contamination themselves. Poor hygienic design and operation in this area will increase the contamination 'load' on barriers protecting production areas and make it more likely that they will be breached.

Finished goods handling areas include food processing operations dealing with contaminated product. These include any food components of the final product that have not been decontaminated so that they are effectively free of bacteria prejudicing or reducing the microbiological safety or shelf-life of the finished product.

As an example, the layout of processing areas should be designed on the unidirectional flow principle to prevent cross-contamination. That means the flow should start from the raw material receiving and extend up to the finished products section in a single channel mode Please note that material should not be handled by personnel also handling finished product (except with the appropriate hygiene controls and separation), or allowed to enter high risk areas. Hygienic areas should be designed and constructed for easy cleaning so that high standards of hygiene can be achieved to prevent pathogens.

The final and most stringent level of hygienic design and operation is 'high-risk areas' (HRA). A high-risk area is a well-defined, physically separated part of a factory which is designed and operated specifically to prevent the contamination of ingredients and products after completion processing, assembly and packaging.

The factory site

The management of the premises and site will give us ample opportunity to build up our first line of defence against contamination. The site should ideally be in an area with good air quality, no pollution problems (e.g. from other industrial plants), uncontaminated soil, well-planned and with an ample supply of uncontaminated water. It should be noted that properly maintained landscaping of the grounds can assist in the control of rodents, insects and birds by reducing food supplies and breeding and harbourage sites. Figure 1 shows a layout of a factory with key barriers

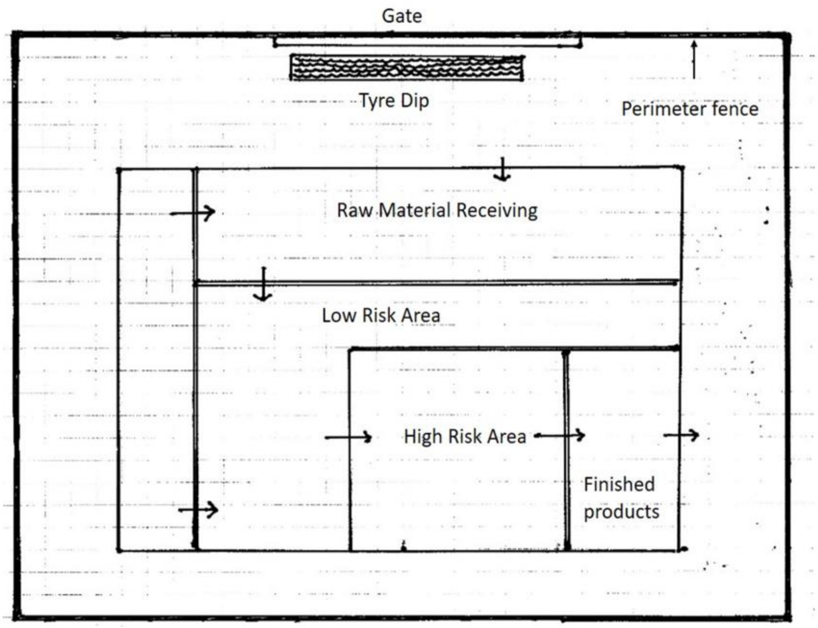


Figure 1: A layout of a factory with key barriers

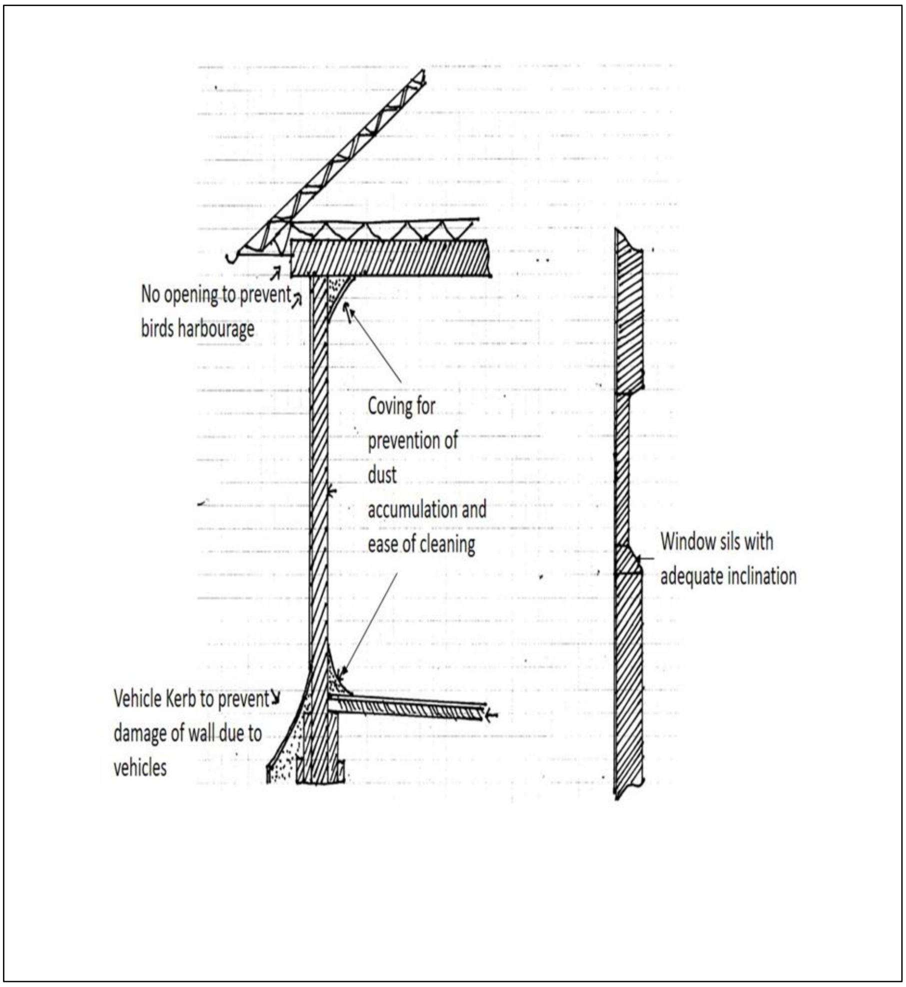
According to European Union guidelines, the area immediately adjacent to buildings be kept free of trees and bushes, and that it also be kept grass-free and preferably concreted, without any water logging. Landscaping and concreting will reduce the dust blown into the factory. Some agencies also recommend a tyre wash system built near the gates to decontaminate the tyres of vehicles brining raw materials and other goods to the factory. Facility to place at least two lines of rodent baits in every 15-20 m of the perimeter, near the entrances and near the foundation walls should be made. Kindly note that these traps should be glue based and crushing type of traps should be avoided.

It is also stressed the importance of ensuring that waste material is not left in uncovered containers and that any spillages of raw material are cleared up promptly so as not to attract birds, animal or insect pests. All areas where water could collect or stand for prolonged periods of time need to be removed or controlled. Experts suggest the use of high pressure sodium vapour lamps instead of mercury lamps to minimise the attracting of flies.

The building

The building is the second major barrier which provides adequate protection for raw materials, processing facilities and manufactured product from contamination or deterioration. The building should have adequate protection from rain, wind, water from surface run off, dust, pests and uninvited people. While designing the factory, consideration also should be given to facilitate installation and maintenance of factory equipment.

All points where cables, drains and services pass through foundation walls and floors must be sealed. Drains and sewers must be proofed and regularly maintained to prevent rodents gaining access and using them as arbourage or as a means of entry to buildings. Any defective drains must be located and repaired. Inspection chambers, covers, hatches and rodding caps must be inspected regularly and all disused lengths of drain either filled with concrete to the connection with the sewer or collapsed and the trench filled with dense hard-core.



Any storm water drains should be protected with top-hung flaps and maintained regularly to remove silt and leaves. Swan neck pipes should be used to prevent rodents from entering and climbing the inside of rainwater pipes at ground level. Roofs should preferably be made of concrete and should be kept in good repair, regularly inspected and any damages should be repaired immediately. It is desirable to have roofs or ceiling washable with electric fittings in flush with it to prevent accumulation of dust above it. Any ventilation or exhaust fan opening should be proofed with 10 mesh steel mesh mounted in a removable frame of metal or PVC to allow regular inspection and cleaning. Exhaust fans should be fitted with shutters which are self-closing when the fan is idle.

In general, openings such as windows and doors should be kept to a minimum. It is a general observation that ‘Regardless of the sophistication of the heating, ventilating and air-conditioning systems, there are always those who are uncomfortable with the surrounding temperature conditions and feel the need to open a window or a door.’

Doors should be designed in such a way it can be opened in both ways and should have a kick plate; Door handles should not be present at any cost. The material for window frames should be a low maintenance type such as UPVC or steel. Windows should be provided with Window sills. Internal sills should be sloped (20º–40º) to prevent their use as ‘temporary’ storage places, with external sills sloped at 60º to prevent birds roosting.

External doors may be one of the following types chosen for its security, hygienic and/or practical application:

- Swing
- Horizontal sliding
- Roller shutter
- Hinged
- Folding sliding
- Vertical sliding.

In all cases, the following design criteria should be met:

- A tight fit is achieved between the door and its frame.
- The correct material is used.
- Each door is self-closing.
- Opening and closing is smooth.
- Surfaces are cleanable.
- Door handles are easily cleaned and do not trap dirt (it is preferable not to have door handles)
- The design is hygienic, having a smooth finish, radiuses edges and minimal seams.

All external doors should be self-closing and fit closely in the opening with no gaps exceeding 6mm and preferably less than 3 mm. All external door frames should be sealed at the junctures with the walls and floors and kept in good repair. Doors should be provided with vision panels, kick plates and push plates.

All doors which have to remain open for entry and/or loading can be proofed by installing heavy duty PVC strip curtains with the correct overlap, as specified by the manufacturers. These type of doors has to be fitted with air curtain outside. The use of air curtains can be effective against insects.

Access to processing areas from outside should be via double doors with an air lock or by use of a lobby with a door at each end

General design issues for the factory interior

The main principles of hygienic design of the interior of a factory unit should be to remove any potential internal sources of contamination and to prevent any external contaminants from accumulating. The first principle can be achieved in a number of ways, including the following:

- Materials in the proximity of food processing operations should be non-toxic.
- Glass, wood and other materials that could present a serious hazard to consumers, if fragments, contaminate food, should be avoided.
- Materials must be durable and able to withstand the operational environment, including extremes in temperature, physical impact vibration, moisture and corrosion from food materials (e.g. those containing organic acids).
- Services such as water or steam should be designed so they do not provide a growth medium for contaminants (e.g. through condensation) or become contaminated themselves.
- The pipe carrying treated water for the processing should be colour coded and should be easily distinguishable from those carrying non potable water.
- No inaccessible areas, cavities or seams where dirt can gather.

- All areas and corners easily accessible for inspection and cleaning.
- Surfaces should flow off (at > 3º) to prevent dirt or fluid accumulating.
- No horizontal surfaces. If there is possibility dirt can gather, a vertical gradient of 45º is recommended with a round or half-round profile. Joints such as welds should be continuous and smooth with the surrounding surface.
- No sharp corners or right-angles. Corners should be radiused with the use of coving.
- Materials should be easily cleaned, smooth and non-porous so that dirt cannot accumulate.

Walls

Hygiene standards for walls as defined in various EC Directives require that they must be constructed of impervious, non-absorbent, washable, non-toxic materials and have smooth crack-free surfaces up to a height appropriate for the operations (Normaly 6-7 ft). For high-risk areas the standard of construction and finish must apply right up to ceiling level. The same hygienic assessment techniques as described for flooring materials are also directly applicable to wall coverings and finishes. Materials need to be resistant to corrosion from food materials (for example those containing organic acids). They should also be resistant to temperatures up to 85ºC.

Modular insulated panels are now used very widely for non-load-bearing walls. The panels are made of a core of insulating material between 50 and 200mm thick, sandwiched between steel sheets, which are bonded to both sides of the core. Careful consideration must be given, not only to the fire retardation of the wall insulation or coating material, but also to the toxicity of the fumes emitted in the event of a fire as these could hamper a fire-fighting operation. The steel cladding is generally slightly ribbed to provide greater rigidity and can be finished with a variety of hygienic surface coatings, ready for use. The modules are designed to lock together and allow a silicone sealant to provide a hygienic seal between the units. The modules can be mounted either directly (in a U shaped channel) onto the floor or on a suitable concrete basement.

The overall shape of the wall is also important. The presence of ledges and similar features (e.g. around windows) can result in a significant hazard as regards accumulation of debris, and this has to be considered at the design stage.

Having installed hygienically suitable floors and walls, it is important that floor-to-wall, wall-to-wall and wall-to-ceiling joints are hygienically constructed. Covings should provide an easily cleaned surface at wall, floor and ceiling junctions. A 50mm radius curve is generally considered to be large enough to enable easy cleaning (although extra consideration will have to be made to prevent damage from moving traffic such as trolleys and fork-lift trucks).

Ceilings

Ceilings should be smooth with no seams. Seams should be sealed. If the ceiling is suspended the space above the ceiling should be accessible and cleanable. A minimum clearance of 1.5m is advisable to allow access. Suspended ceilings can be constructed using suitable load-bearing insulation panels or suspending sections of insulated panels, as used for the internal walls, from the structural frame of the building. Cables may be run in trunking or conduit but this must be effectively sealed against the ingress of vermin and water. All switchgear and controls, other than emergency stop buttons, should, whenever possible, be sited in separate rooms away from processing areas, particularly if wet operations are taking place.

Lighting may be a combination of both natural and artificial. Artificial lighting has many advantages in that, if properly arranged, it provides illumination over inspection belts and a minimum of 500–600 lux is recommended. Fluorescent tubes and lamps must be protected by shields, usually of polycarbonate, to protect the glass and contain it in the event of breakage. Suspended units should be smooth, easily cleanable and designed to the appropriate standards to prevent the ingress of water.

Floors

The floor in a food factory forms the basis of the entire processing operation, and a failure in the floor often results in lengthy disruptions of production and financial loss while repairs are carried out. Unsatisfactory floors increase the chances of accidents, cause difficulties in attaining required hygiene standards and increase sanitation costs. Both its physical durability and hygienic qualities have to be considered. The overall design of the floor must be such that it can be effectively cleaned and disinfected, is safe in use (e.g. antislip) and that it is stable under these cleaning regimes and to normal processing activities (i.e. does not begin to disintegrate, which may result in microbial or physical contamination of the food being processed). A further aspect that needs to be considered is whether the proposed floor meets legislative requirements.

Floors should be 'waterproof' or 'impervious' and 'cleanable'. Water uptake is unacceptable because if fluids are able to penetrate into flooring materials, microorganisms can be transported to harbourage sites that are impossible to chemically clean and disinfect. When considering the selection of flooring materials, therefore, evidence for imperviousness and ease of cleaning should be sought. The floor should be coved where it meets walls or other vertical surfaces such as plinths or columns as this facilitates cleaning. As part of the design of floors, allowance has to be made for adequate drainage of water – that is, the physical shape of the floor should allow water to drain away easily. A slope (or 'fall') of 1 in 60 is normally adequate; 1in 40 may be required for floors that are habitually very wet, whilst 1 in 80 may be sufficient for normally dry tiled.

Drainage

The drainage is often neglected and badly constructed. Detailed consideration of the drainage requirements is an important aspect of floor design. Ideally, the layout and siting of production equipment should be finalised before the floor is designed to ensure that discharges can be fed directly into drains. In practice, this is not always possible, and in the food industry in particular there is a greater chance that the layout of lines will be frequently changed. Equipment should not be located directly over drainage channels as this may restrict access for cleaning. Discharges from equipment, however, should be fed directly into drains to avoid floor flooding. Alternatively, a low wall may be built around the equipment from which water and solids may be drained. Where the channels are close to a wall they should not be directly against it to avoid flooding of the wall-to-floor junction.

Satisfactory drainage can be achieved only if adequate falls to drainage points are provided. A number of factors should be taken into consideration when establishing the drainage system.

- *Volume of water:* wet processes require a greater fall.

• *Floor finish:* trowelled resin surface finishes require a greater fall than self-levelling ones. Otherwise 'puddles' created by small depressions in the surface may remain.

• *Safety:* falls greater than 1 in 40 may introduce operator safety hazards and also cause problems with wheeled vehicles.

The type of drain used depends to a great extent upon the process operation involved. For operations involving a considerable amount of water and solids, channel drains are often the most suitable. For operations generating volumes of water but with little solids, aperture channel drains are more favourable. In most cases, channels should have a fall of at least 1 in 100, have round bottoms and not be deeper than 150mm for ease of cleaning.

They must be provided with gratings for safety reasons. The channel gratings must be easily removable, with wide apertures (20mm minimum) to allow solids to enter the drain. In recent years there has been a marked increase in the use of corrosion resistant materials of construction, such as stainless steel for drain gratings.

The drainage system should flow in the reverse direction of production (i.e. from high to low risk) and, whenever possible, backflow from low-risk to high risk areas should be impossible.

Solids must be separated from liquids as soon as possible, by screening (with, for example, removable sediment baskets), to avoid leaching and subsequent high effluent concentrations. Traps should be easily accessible, frequently emptied and preferably outside the processing area.

Services

Hygienic building design must take account of service equipment such as pipework for water, eliminates a major source of contamination from the process area. Service pipes should be routed outside the process area and pass through walls local to their point of usage. Where this is not possible, services should be grouped 50mm apart on a stainless steel structure around the plant with minimum support rackets to walls or plant.

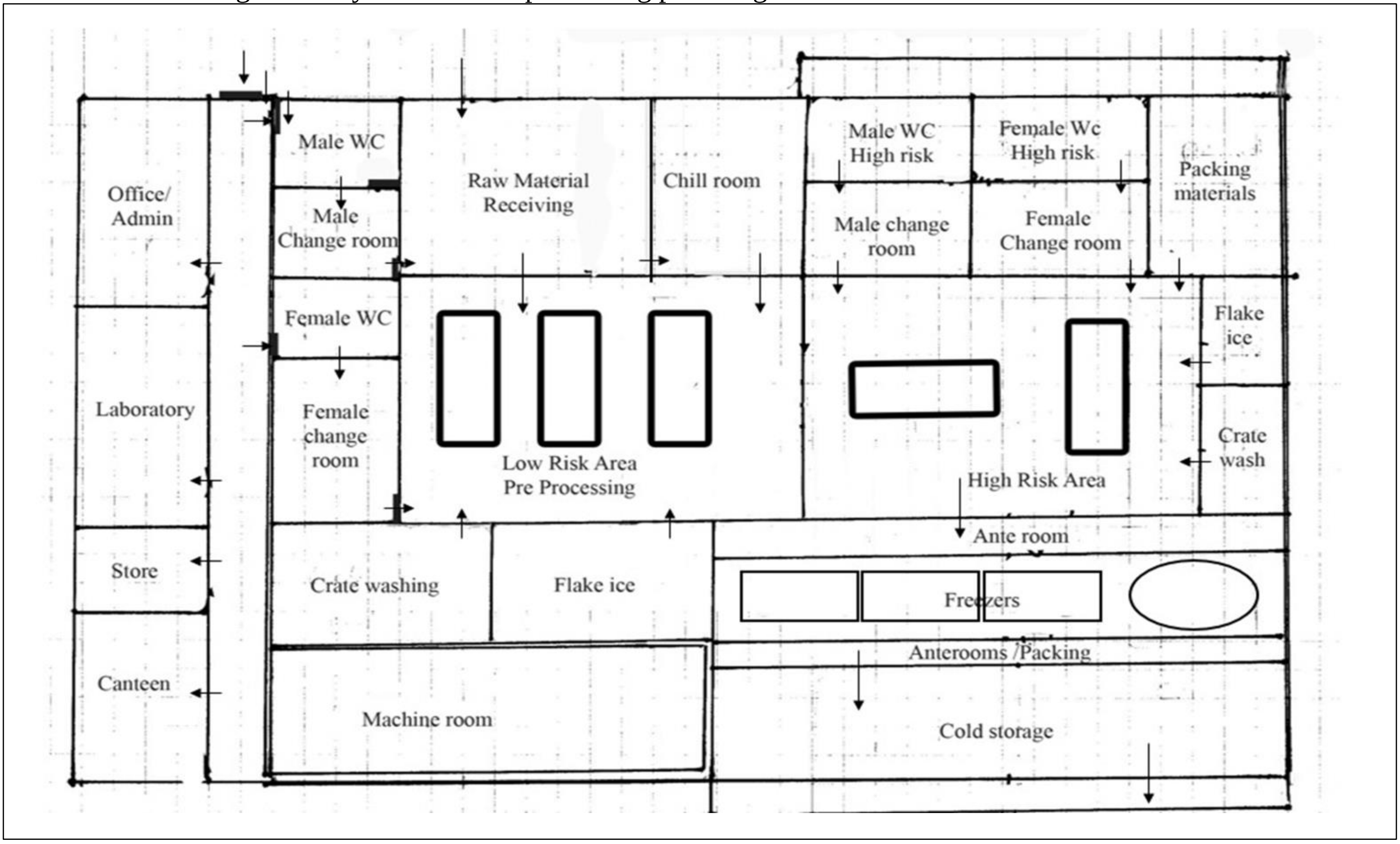
Overhead pipes should not pass over open vessels or production lines. This is to prevent dripping of condensation droplets, which may form if the pipes are above a process area, and contamination from leakage, lagging, flaking paint or dust. Services should not be positioned too closely to walls and floors in production areas and should have a minimum 50mm clearance to allow for cleaning, inspection, maintenance and repair.

Pipework entering production areas should be grouped together and sheathed in an appropriate material. The number of openings in walls around the process area should be kept to a minimum in order to prevent pest access, limit the ingress of airborne contamination, and facilitate environmental control. All pipes and cables passing through internal walls and floors should be built in to prevent pests from using them as runways.

Ideally, all cables should be situated behind walls or above the ceiling. If this is not possible cables in production areas should be placed in enclosed, rounded conduits or racks which will not accumulate dirt and are accessible for cleaning, pest control and maintenance. No cables should be routed above processing machinery. To avoid dirt accumulating, cable racks should preferably have vertical rounded supports. Light fittings should fit smooth against surfaces like the ceiling or construction parts. Good lighting is essential to ensure clean conditions, encourage good housekeeping and safety and facilitate maintenance. Lighting levels should be no less than 500 lux in most areas where operators are required. This level may be less in areas such as loading bays or conveyor halls or more in areas such as inspection, filling or packaging.

Natural ventilation should be avoided in most instances because it varies and therefore cannot be controlled. Extraction systems are a relatively inexpensive way of drawing out hot or stale air and steam, but excessive use of this method results in the build-up of negative pressure unless there is a corresponding supply of fresh air to balance the atmosphere.

A model generic layout of a food processing plant is given below for reference



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