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Sanitary Design and Construction of Food Processing and Handling Facilities[1]

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Introduction

To ensure safe food and adequate sanitation programs, the facility and surroundings in which food processing and handling operations are conducted must be designed and constructed with sanitary design principles in mind. Many existing facilities do not have optimum sanitary design and construction. Certain adjustments and/or renovations, where feasible, may be necessary. While often discussed separately, sanitary construction and sanitary design are inter-related terminology.

The objectives of designing and constructing a sanitary food handling facility are to minimize harborages, eliminate the entrance of pests and other sources of contamination. To design and build in features that protect the food product from contamination should be the ultimate goal of planners and designers. The sanitary design features of a facility should be thoroughly evaluated on a periodic basis. Such evaluation should include the following:

• Premises, surroundings, and building site;

• Exterior building design and construction features;

• Interior building design and construction features; and

• Operational flow and facility layout.

Premises, Surroundings, and Building Site

The objectives regarding sanitary building site and exterior surroundings are to use every effort and means possible to minimize:

- harborages and infestations of vermin (e.g., rodents, insects, birds, other pests), mold and mildew, and microorganisms; and
- potential for contamination with environmental chemical pollutants.

The role of rodents, insects, birds, and other pests (e.g., frogs, reptiles) in spreading foodborne pathogens has been well documented. It is imperative that an adequate pest control management program is in place for food processing and handling facilities. While it is possible, with good practices and due

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diligence, to self manage pests, it is recommended that the services of a reputable pest management supplier be obtained. It is also a good plan to identify an employee that is assigned to work with the pest management supplier with regard to the location of bait stations, tracking trap and station activity, chemical storage, and the observation of proper pest control procedures. Proper records and documentation of a pest control program is important to the success of an overall sanitation program. The topics discussed below regarding the location of traps and bait stations, maintenance of outside surroundings, and limitation of pest entry into buildings are all part of a successful pest management program.

Location

As with real estate, an important feature of a sanitary food facility is "location, location, location". Ideally, a facility should be located away from any contamination source (e.g., chemical plant, sewage treatment facility, salvage yard, livestock housing, cow pasture, or body of water). For many existing facilities, the location may not be in the control of the facility management as other industries may have moved in around the food facility. If, in the evaluation of the facility, it is found that sources of contamination are adjacent or near the building, special precautions are necessary to keep odors and contaminants from entering the yard or facility. When building a new facility, an inquiry should be made regarding the previous occupants and the type of operations previously conducted at that location.

Site Condition, Preparation, and Maintenance

When preparing a new site for construction, the site should be thoroughly cleaned of any potentially toxic materials and graded for appropriate drainage and prevention of standing or pooled water. Storm sewers should be designed and located to allow for adequate runoff. Where appropriate, paving should be used to minimize dust. In many cases, local, state, or provincial zoning rules may apply. These must be respected during the site selection and preparation phase.

Landscaping is another important consideration as shrubs, grass, and trees too close to the building can increase the chance of harborage of vermin. According to Graham, trees and shrubbery should be no closer than 30 feet from the building, and grass coverings should end 30 inches from the building walls (1991). Further, a gravel buffer should be established between the building and landscaping to discourage rodents. Under-laying the pea gravel with polyethylene film is also recommended.

Maintenance of the surroundings is also very important. Keeping the area uncluttered and free of refuse, and keeping the grass mowed and shrubs pruned on a regular basis will discourage insects and other vermin from taking up residence. The drainage system or landscape design must also be maintained appropriately to minimize standing water.

Exterior Lighting

A qualified lighting contractor should be consulted to evaluate adequacy and location of exterior lighting. While adequate lighting in external areas of a facility is important for an overall sanitary operation, it is also necessary for security protection. However, since outdoor lights may attract insects, the location of these fixtures is of critical importance for preventing insects from entering the facility. The location of fixtures, especially when positioned over doorways, needs special attention. While high intensity, ultraviolet lights are often used for security purposes, these lights are especially attractive to insects. It is recommended that lighting be mounted on poles or standards, be at least 30 feet from buildings, and the light directed towards doorways and entrances (Graham, 1991). Lighting fixtures should be shielded with a non-breakable, transparent material.

Driveways and Receiving Areas

As the area used for receiving is the last line of defense in protecting the building, care should be taken to make sure that such areas are designed to

minimize contamination and intrusion from pests. Driveways leading to receiving areas should be appropriately paved and constructed for adequate drainage. Asphalt driveways should be avoided, as this material may, in fact, attract rodents. Drains should be designed with catch baskets for debris, and hose stations should be provided to facilitate cleaning and maintenance. Bait stations and traps, where used, should be properly located.

Exterior Building Design and Construction

The primary objective of sanitary design in building construction is to design and construct a building that is cleanable. Other major considerations are to minimize contamination and adequately seal food processing and handling areas from sources of contamination

Rather simple and inexpensive preventative measures can be built into building construction with regard to vermin proofing the building. For example, installing flanging to foundations below grade level will discourage rodents from burrowing under the floor slab. Further, avoiding any horizontal ledges or overhangs in construction will discourage roosting or nesting of birds. If ledges cannot be avoided, they should be sloped rather than flat or horizontal. Preventing the entry of rodents and insects into buildings can be accomplished by sealing all openings to the outside which are 1/4 inch or greater. The caulking and sealing of all joints has proven useful in preventing rodent entry. The vermin proofing aspects of the building needs to be regularly evaluated and maintained.

Loading Docks, Platforms, and Receiving Rooms

Receiving areas and rooms should be enclosed as much as is practicable. An improperly designed and constructed receiving room will provide an attractive harborage for birds, rodents, and insects. Enclosed receiving areas and rooms are less desirable to birds, rodents, and insects than a more open receiving area. Such areas must be critically evaluated to determine the adequacy of protection from contamination and entrance of pests. Loading docks and platforms should be designed to minimize entry of pests. Ideally, loading docks should be at least 3 feet above ground with the underside lined with a smooth, galvanized metal or similar material with a 12 inch over-hang to prevent rodents from climbing into the building. Properly installed rapid open/close doors or air curtains should be used to discourage entrance of insects and birds. Overhangs should be constructed to be free of roosting and nesting areas for birds.

Exterior Walls

Building materials used for exterior walls vary in their need for preventative maintenance with regard to re-caulking of joints. For example, a poured concrete wall, while being expensive, needs less maintenance than other materials becuase it does not have seams. A concrete block wall, if appropriately sealed, is also fairly maintenance free. Low-density concrete block (e.g., cinder block), commonly used in domestic building, should be avoided unless an adequate sealer is used to avoid moisture intrusion and penetration of mold and mildew. Concrete block walls should be sealed at the base and capped at the top. Corrugated metal siding is the least desirable material for wall construction in a food handling facility. If used, it is imperative that it be adequately caulked along the base and at the seams. Further, corrugated metal siding needs a good maintenance program to maintain an effective seal. The maintenance frequency is also affected by climate conditions.

Roofs

Roof construction and design should not be overlooked. The roof should be designed and built so it can be kept clean, especially where there is the possibility of product spillage or deposition on the roof. Food related dust (e.g., flour, powdered milk, or grain) can accumulate on the roof and is an invitation to birds and insects. Smooth membrane type roofs are often the most desirable type of roof for food processing facilities. Tar and gravel roofs are usually not recommended as they tend to attract dust and are very difficult to clean and maintain.

Openings into the Building

Any openings into buildings, including doors, windows, ventilation ducts, and other openings must

be appropriately sealed and protected. Openings into the roof such as exhaust fans for air handling systems, ventilation ducts, and plumbing vent pipes must be sealed, and appropriately flashed and screened. Windows are discouraged in food processing operations as they present sanitation problems due to glass breakage and overall maintenance considerations. If used, windows should be designed to be flush with the inside wall and be permanently closed. Sills should be sloped away from the wall at not less than a 45 degree angle to prevent birds from nesting or dust from collecting.

Interior Building Design and Construction

The sanitary objectives for interior building design and construction are to:

- minimize potential harborages of pests and microorganisms;
- maximize cleanability; and
- maximize the protection of the food products from contamination.

As previously discussed, a new facility is easily built with sanitary design criteria in mind. Building designers can integrate sanitary objectives without adding a great deal of cost to a construction project. Existing facilities present a different set of challenges due to construction practices that are now considered obsolete, and cost considerations for updating these facilities. Having a facility designed and built to sanitary specifications does not guarantee a safe food product if the facility is not adequately cleaned and maintained on an appropriate schedule.

Interior Walls

A cleanable, sanitary wall is one that is

- hard, flat, and smooth;
- free of pits, cracks, checks, and crevices;
- impervious and non-absorbent;
- resistant to cleaning and sanitizing chemicals;
- corrosion resistant;
- durable, easily maintained, and wear resistant; and
- properly installed, sealed, and covered.

The wall should be installed and maintained to assure these properties are met from the floor to the ceiling. In addition, if used openings and windows are used they should be installed and sealed to maintain the floor to ceiling properties.

There are several acceptable surfaces and materials available for walls in food processing and handling areas. Some of these are described below:

Seamless Poured Concrete is often recommended, because of its lack of seams and associated maintenance requirements. However, such walls should be finished smooth

and sealed. They can be improved by painting with a semi-gloss or gloss epoxy enamel. Specialized spray coatings for concrete walls using epoxies and fiber glass are the most recent innovations which have proven to be impervious, cleanable, and durable.

Concrete Block walls should be heavy density, non-porous blocks. Concrete block walls should be installed in a stack bond pattern (with reinforcement), rather than a running bond pattern (see Fig. 1), as there is less hold up of dust and moisture. As stated previously, the concrete blocks should be installed with a solid cap on the top course and without ledges or crevices. For additional durability and cleanability concrete block walls should be appropriately sealed and finished by painting with semi-gloss or gloss epoxy enamel paint covering.

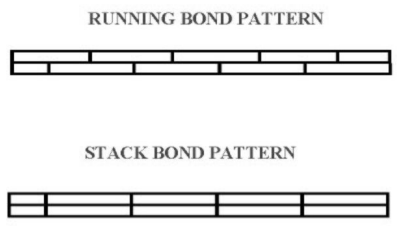

Figure 1. Bond Patterns on Concrete Block Walls

Fiberglass Panels are a highly acceptable wall material and are commonly used in newly constructed facilities. These panels are available from several different suppliers. While most of the available panels are acceptable; gel coated, reinforced fiberglass panels are most recommended. This material, when properly installed and sealed at the seams, provides a continuous, hard, durable, and cleanable surface. However, if fiberglass board is improperly installed, improperly maintained, or becomes damaged, it can lose its desirable features. If the panels extend to the floor, they are vulnerable to damage from forklifts and related equipment. In high impact locations, a concrete curb may be recommended. To prevent creation of a ledge (which will collect dust) the top of the curb should be sloped at a 45 degree angle or greater or the curb constructed in a bull nose design.

Glazed Ceramic Tile, due to its durability and resistance to a wide range of chemicals, is the most highly recommended wall material in wet processing areas and is often used in dairy and beverage plants.

Wood (e.g., plywood, pressed wood), due to its porosity, is not recommended and should be avoided for interior walls in food facilities. Wood cannot be adequately sealed.

Metal panels (e.g., stainless steel, galvanized metal) are not usually recommended for walls in a food facility due to condensation problems. Plus, expansion and contraction of metal panels make maintenance of the seam seals very difficult. Due to problems with zinc flaking and potential product contamination, galvanized metal should be absolutely avoided.

Walls should be covered with a light colored paint and caulked, sealed or grouted appropriately at joints and junctions. Such coverings and sealants are used to enhance the impervious properties, cleanability, and ease of maintenance. However, if such coverings are not maintained, checks and flakes can form, decreasing the cleanability of the surface. Thus, a preventative maintenance program should be in place to keep walls in good repair.

Junctures between walls and ceilings, and between walls and floors should be rounded (or coved) with a radius of one inch or greater. Coving minimizes a right angle crevice, which is difficult to clean and maintain. An example of a wall to floor juncture is shown in Figure 2.

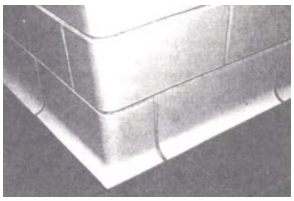

Figure 2. Coved Wall/Floor Juncture

Ceilings

Ceilings in food handling facilities are often neglected from a sanitary design and construction perspective. Ceilings should meet the same objectives mentioned for walls. In addition, they need to be included in a preventative maintenance program. Improperly installed ceilings, ceilings that promote condensation, or poorly maintained ceilings (e.g., flaking paint) can actually increase the potential for overhead contamination of food products.

Concrete ceilings are often recommended due to durability and minimal maintenance requirements. The most recommended installation is the concrete slab with exposed double tee beam construction, which avoids ledges associated with I-Beam construction. Concrete ceilings should be ground smooth, appropriately finished, and caulked at the joints.

Metal ceilings are not recommended due to condensation maintenance problems. Joints in metal panel ceilings are very difficult to maintain. Corrugated or ribbed sheet metal ceilings are very difficult to clean and maintain, and have areas for harborages of insects and rodents.

Wood ceilings, due to their porosity, are impossible to clean and maintain and must be avoided.

Dropped ceilings are acceptable only if properly installed. False ceilings, which create a crawl space above the ceiling for utilities and services, should be avoided. The crawl space also becomes very attractive to insects and rodents, increasing the

potential of product contamination. Because fiberglass panels can be glued in and sealed at the joints they are acceptable in dropped ceiling application. However, they are very difficult to maintain in a continuously sealed condition. Permanent dropped ceilings, which essentially create a walk-on second floor above the processing area, are more desirable, especially those with a permanent smooth concrete ceiling. The additional floor is used to run utilities, air handling ducts, fans, and similar services. In dairy and beverage plants, clusters of air operated valve systems are used in automated process control systems for transporting liquids and cleaning solutions. Due to the complexity of such valve clusters, they can create dust collection points over processing areas. They are often conveniently located in this upper floor over a dropped ceiling and away from the processing area. Pipes, conduits, and similar accoutrements can be installed in vertical runs through the ceiling into the upper floor. However, the junctures of these pipings need to be properly sealed and the seals maintained in good repair.

Insulation

Insulation materials available do not meet the requirements for walls and ceilings in a food facility and are easily punctured or torn. Thus, insulation, where used, should be installed so that it is not exposed and is sealed off from food processing and handling areas. The type of insulation material used must also be considered. The insulation material should be:

- nontoxic;
- odorless;
- unattractive to pests; and
- non-contaminating.

With these criteria in mind, asbestos insulation is avoided. Fiberglass batting insulation should also be avoided as it attracts insects and rodents, and the fibers may become airborne causing a contamination hazard. Acceptable materials may include: Styrofoam panels, foam glass, and urethane. For special applications requiring insulation of equipment (e.g., steam piping), it is recommended that manufacturers supply documentation of acceptance of the material in food applications.

Floors

Due to heavy day to day exposure to a variety of chemicals and food products, the floor in a food processing and handling facility is the most difficult surface to maintain. Floors should be smooth, impervious, non-absorbent, corrosion resistant, cleanable and in good repair. For safety considerations, floors should not be so smooth that they cause employees to slip and fall. In addition to being constructed and sealed adequately, the floor should be installed to provide adequate slope for drainage and prevention of pooled water.

Today, highly acceptable materials are available for constructing and surfacing of floors in a food processing and handling facility. The most recommended are sealed concrete, epoxy sealed concrete, quarry tile, and glazed tile. Each of these materials would provide an acceptable floor surface if properly installed and maintained in good repair. Once the integrity of any of these surfaces becomes compromised, they can harbor microorganisms, especially in wet areas. Unsealed concrete floors should be avoided as they are highly porous and break down with continued exposure to chemicals. Once cracks, crevices, spalls, or other damage occurs, a concrete floor is especially vulnerable to harboring microorganisms. Quarry tile or glazed tile floors require additional maintenance as grout lines can erode causing a multitude of problems. As mentioned for walls and ceilings, metal and wood must be avoided as a floor construction material.

Drains

Floor drains are a major source of microbial contamination in a food processing facility. Thus, they require special attention. Floor drains should be:

- of adequate number and size;
- appropriately located;
- designed and installed so that they are cleanable; and

• maintained in good repair.

Circular, catch basket drains are most often recommended provided that they are appropriately sealed and grouted to the floor, and are maintained in good repair. Trench drains, although used in many operations, can have problems. A trench drain should be constructed and installed to provide adequate slope or grade ensuring there is no standing water in the trench. The grouting and sealing of trench drains at the floor junctures is also more difficult to maintain than the seals of circular drains.

Interior Lighting

Adequate lighting is important for all operations conducted in a food facility. This is especially true in cleaning and sanitizing and related operations. Recommended lighting levels vary between regulatory officials and other sources. A general suggested range of lighting recommendations has been presented in Table 1.

Table 1.

Area	Light Intensity (Foot Candles)
Raw material receiving	20 - 30
Ingredient warehouse	20 - 30
Bulk ingredient storage	30 - 40
Processing departments	55 - 65
Product inspection	110 - 130
Packaging	70 - 80
Finished product warehouse	20 - 30
Maintenance areas	70 - 80
Administrative offices	60 - 90
Cafeteria	40 - 50
Locker rooms/restrooms	30 - 50

Light fixtures should be of the type approved for food facilities, and should be equipped with break resistant lenses or shatterproof shielding. The fixtures should be designed to be moisture resistant and cleanable.

Heating, Ventilation, and Air Conditioning (HVAC) Systems

Heating, ventilation, and air conditioning (HVAC) systems function to maintain the temperature and humidity of a facility. Day to day sanitary operations are dependent upon a properly functioning system for prevention of condensation as well as overall employee comfort. In addition, it is desirable to create positive air pressure differentials in critical or sensitive food handling rooms (e.g., packaging rooms). Because of these demands, the facility should have properly sized units and an adequate distribution system to do the job. Because HVAC systems have proven to be a source of contamination with pathogenic microorganisms (especially *Listeria monocytogenes*), certain sanitary construction, design, and installation features need to be considered. Systems should be constructed, designed, installed, cleaned, and maintained so that they are not a source of contamination. For example, the air supply should be located to not draw air from nearby sources of contamination (e.g., chemicals, bird droppings); adequate filters should be installed (and changed frequently); and duct work should be located outside of the processing areas. Finally, air handling systems should be designed to be cleanable. HVAC systems available today, that can be adequately cleaned, should be considered in new construction or renovation. However, many existing systems are not designed and constructed with cleanability in mind. Care should be used in using corrosive chemicals in cleaning these older systems.

Handwashing sinks

Handwashing sinks, lavatories, or stations should be:

• conveniently located near food operations;

• of sufficient number based on the size and function of the operation;

• constructed and installed to meet plumbing codes including appropriate backflow prevention and no submerged inlets;

- installed with faucets of sanitary design (preferably foot or electric eye operated);
- supplied with hot (not steam) and cold water in order to provide an adequate flow of water at 85° - 100° F;
- provided with an adequate supply of soap, single service towels, and a covered waste receptacle; and
- maintained, cleaned, and kept in good repair.

Employee Facilities, Locker Rooms, and Restrooms

Employees need suitable facilities where they can safely store their clothes and other personal items. Maintenance and construction recommendations for walls, ceilings, and floors of locker rooms, restrooms, and related facilities should meet the same criteria as those for other areas of the facility. Lockers should be sealed to the wall and should have sloped, rather than flat, tops to prevent accumulation of dust and debris. Employee facilities should not open directly into processing or other critical areas. Most food regulations require a two-door separation between locker rooms or restrooms and food processing areas or food handling areas.

Freezers, Refrigerators, and Coolers

Permanent freezing and refrigeration rooms should meet the same sanitary construction and design criteria as other rooms in the food facility. With the exception of the refrigeration units and drain trays discussed below, an appropriately constructed and designed freezing or refrigeration room should present minimal sanitation problems. However, when modular type units are installed in a facility, they can be a source of dust and debris accumulation and contamination concerns. These units must be installed with sufficient space between the unit and the wall (approximately 18 inches) to allow accessibility for cleaning. Because the units or boxes are of flat-top design they tend to collect dust and debris, unless they are caulked and sealed to the ceiling. If they are free standing units, sufficient clearance should also be allowed above the unit to provide access for cleaning.

Refrigeration units, due to coils, fins, and other dust collection points, can also be a source of contamination. These units should be designed and installed for adequate cleaning. A major contamination problem area is the condenser draining system. Drains, trays, and pans should be installed to prevent overhead contamination of stored food products, and should be flushed and cleaned daily. Drain lines exiting refrigeration rooms or boxes should be installed to drain into a floor drain, with an appropriate air gap, and should not drain directly into critical food processing and handling areas.

Overall "Protection from Contamination" Features of Interior Construction

In addition to having sanitary walls, ceilings, and floors, a sanitary food processing and handling facility must also have designed-in (integrated) features to protect the food products from contamination. Facilities should be periodically inspected and evaluated for potential contamination of product due to the facilities themselves. Utility and water supply lines, and other accoutrements hung or attached to the wall or ceiling must be appropriately caulked and sealed to the wall or mounted in such a way to allow cleaning behind and around. For example, it is recommended that a minimum of 1 inch clearance be allowed for cleaning around and behind items hung on walls (Graham, 2004). Further, electrical boxes and related equipment should be water proof and of acceptable sanitary design. Exposed threads should be minimized on hangers used for piping and other equipment or other attachments, as they accumulate dirt and dust. If threads are used, they should be of sanitary design to be cleanable, rather than the standard threaded rod from the hardware store. Wherever appropriate, shielding should be provided over product conveyances and areas where food products are exposed. However, such shielding should be constructed of appropriate, cleanable material. Rather than horizontal or flat, the shielding should be gabled or sloped at a minimum of a 20 degree angle to prevent ledges that can collect dust and dirt.

Operational Flow and Facility Layout

Operational Flow-through Pattern

Ideally, a facility should be designed to provide a flow pattern for food products (as well as personnel and equipment) to prevent potential contact of the finished product with raw materials. Flow should be in one direction and follow a logical sequence from raw material handling to finished product storage as shown in Figure 3.

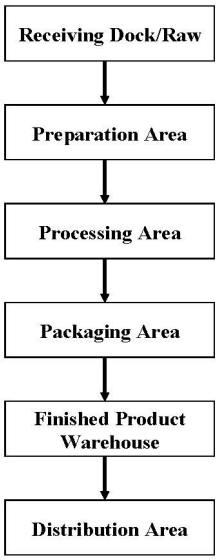

Figure 3.

Physical Separation

As much as is practicable, there should be a physical separation between raw and finished products and minimal entry into critical areas. Such physical separation should be accomplished by installation of walls and doorways with anti-back tracking features, and by adjusting air handling systems to provide positive pressure in finished product rooms. As the best physical separation can be undermined by human error or improper personnel flow, there should be an operational and philosophic separation between raw and finished product. This can be accomplished by barring employees working with raw materials from entering finished product rooms, this includes maintenance and janitorial staff. It is recommended that standard operating procedures be developed and implemented regarding product flow.

In addition to providing procedures for personnel and equipment within the facility, the movement of equipment in and out of the facility by maintenance crews should also be considered. Color-coding is often used, with different colors identifying different areas of the facility. Color-coding can be applied to clothing (e.g., uniforms, frocks), cleaning supplies (e.g., brushes, brooms, pails), containers (e.g. ,pails, lugs), gaskets, forklifts, and any other equipment. Separation can also be accomplished by the installation of sanitizer systems (e.g., foot baths, spray systems) inside entrance doors to critical areas. It is imperative that these sanitizer systems be maintained in good repair and working order and that they are used. Visitors, suppliers, laboratory personnel, truck drivers, inspectors, management, and all other individuals should be made aware of operating procedures with regard to separation between raw and finished products. Self-inspections by quality assurance personnel, regulatory inspections, or tours should be done in a counter product traffic direction starting with finished product rooms and ending in raw material handling areas.

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