



Hygienic Design in the Food Industry

INTRODUCTION

Until the 1970's microbial product safety was based on inactivation of microbes by:-

- heat treatments, such as pasteurisation and sterilisation, after packing in jars or cans
- chemical preservation
- compartmentalisation, where the growth supporting aqueous phase is dispersed as very small droplets in a fat phase, trapping any microbe present in a small droplet
- cooling and freezing
- hurdle technology, the combination of methods that on their own would not stop or slow down multiplication of microbes, but together they would
- fermentation, often using lactic acid bacteria

During the production, however, the number of microbes should be low enough to prevent the development of harmful concentrations of substances like toxins and off-flavours. This meant frequent cleaning, denying microbes enough time to multiply to harmful numbers. This, however, is labour intensive, requires dismantling and reassembly of machinery, which had been designed for a certain function, not for ease of cleaning. The equipment had many non-cleanable "dead" areas that contained multiplying microbes. Cleaning also means loss of production time or expensive labour during night shifts and the use of large amounts of cleaning chemicals, water and energy. Moreover, product residues in pipelines, vessels and pumps are wasted. At one time, this was "normal" and generally accepted, because the products made that way were microbiologically safe.

Gradually it was realised that the costs of cleaning and the amount of product lost (often up to 5%) were high and becoming too high. To reduce the cleaning frequency, continuous processing could be applied, like in the chemical industry, preventing any micro-organisms having sufficient residence time to multiply to large numbers. This requires the absence of areas where product



could reside for a long time. This includes tees (in pipelines) or stubs (on tanks) on which process sensors (for temperature, pressure, etc.) are mounted and dead areas in pumps, valves, pulsation dampeners, and other equipment. One microbe in a “dead leg” can multiply to billions in a short time and contaminate all product passing that area. Without dead areas, a microbe would have been washed out from the process line without enough time to multiply to a harmful number. Very long runs would become possible if microbes could be completely eliminated by sterilisation of the product and the processing equipment. In addition ingress of microbes would be prevented, i.e. the equipment would be impervious to microbes.

In the 1970's such equipment did not exist. Unilever and TetraPak, independently, started the development of hygienically designed equipment early in the 1970's. (Unilever to make long continuous runs possible and TetraPak to make aseptic packaging possible.) In the 1980's this resulted in cooperation, later also with a number of other equipment manufacturers and food processing companies, eventually resulting in the foundation of the European Hygienic Engineering and Design group, EHEDG (see www.ehedg.org) in 1989.

Around the same time consumers started to demand products with a taste not affected by heat-treatments, and without chemical preservatives. Therefore, the products self-evidently had to be safe. As a response, the European Commission decided that for food production, hygiene is a “must”, resulting in several directives that made hygienic handling of food at all stages compulsory. While the EC specified the requirements, EHEDG started to publish guidelines on how these requirements can be met.

Hygienic design of equipment

Microbes multiply given the right conditions, i.e. temperature, moisture, nutrients and time. In food processing, the practical options for reducing the temperature and moisture are limited and by nature, nutrients generally are in abundance. Hence, to keep the number of microbes in the product under control, they should be denied time to multiply. This means that areas in the process line where product resides for a long time should be avoided. This can be done by avoiding areas where the product does not flow, the so-called “dead areas”. Typical examples of such areas that were always present in process lines are the T-shape pieces on which temperature and pressure sensors (in the past thermometers and pressure gauges) are mounted. Other, less obvious dead

areas are crevices between components. Microbes can be as small as 0.2 micrometre and hence a crevice of 1 micrometre wide is sufficient to allow microbes to hide and multiply to contaminate the product passing the crevice. Therefore, hygienic equipment must be crevice-free.



Mounting of temperature probes in a process line.

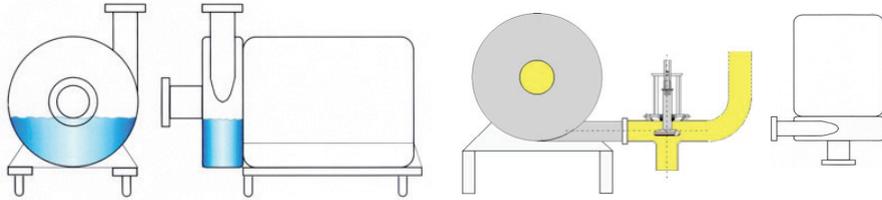
Left: unhygienic design, with a narrow space that cannot be cleaned without dismantling; during production, product in the narrow space will have a long residence time, allowing microbes to multiply to high numbers. Right: modern hygienic design, cleanable-in-place and without a dead area (courtesy of WIKA).

Microbes that have been growing in the process line must be inactivated before the production is started again. To be destroyed, microorganisms need to be in contact with hot water, steam or disinfecting chemical solutions. Microbes covered by product residues or any soil, are not in contact with the agent intended to inactivate them so that many - if not all - will survive. Therefore all parts of the line must be cleaned. This is possible by taking the equipment apart and reassembling after cleaning and disinfection. This is time consuming and therefore expensive. It also increases the risk of damage to components of the equipment, which is one more reason for eliminating crevices and other dead areas from process lines.

To multiply microbes need water and nutrients. Some microbes need such small amounts of nutrients that they are capable of reaching large numbers even in tap water. Equipment to be used for food processing therefore needs to be thoroughly dry when not in use, such as during the night (if there is no night production) and weekends. Thus equipment must be completely drainable. Equipment often has not been designed to be drained and sometimes equipment that in principle is drainable is mounted in such a way



that it no longer can be drained.



Installation of centrifugal pumps

Installing a pump in the traditional way, as shown on the left, does not allow draining. The two positions shown on the right both make the same pump drainable.

Food processors need to know if the equipment they buy for their food processing lines are hygienic and cleanable. They also know, usually from experience, that equipment offered as hygienic often is not. For that reason, EHEDG certifies equipment that is of hygienic design. The certification is based on a thorough inspection of the design, the specification of the materials of construction, followed in almost all cases by testing in an accredited laboratory. A list of EHEDG certified equipment can be consulted on <http://www.ehedg.org/?nr=82&lang=en>.

The above text deals with only a fraction of hygienic equipment for processing of food products. For a description of the requirements for hygienic design of equipment, see EHEDG guideline no.8¹ and for meeting these requirements, see Hygiene in food processing: Principles and practice²

Hygienic design of factory buildings

The risk of contamination of food with microbes is proportional to the number of microbes in the environment. A hygienic food factory therefore must be designed to keep the number of microbes low and that requires:-

- The interior of the factory must be cleanable and hence, surfaces must be smooth and free from crevices. Special attention should be paid to the corners, where the floor meets the wall. To allow floors and walls to be cleaned, and in general to enable the use of water when needed, the floor needs drains. These drains, however, should not become reservoirs



of bacteria and insects. Hence also the design of gutters and drains must be hygienic and it may be necessary to use designs that make it possible to insert antimicrobial substances.

- While the ingredients, intermediate products and the end products move from the less clean, raw materials areas through the various processing and decontamination stages to the clean area, where the product is packed and from then on protected against recontamination, the staff working in the factory should move only from the cleanest area to the less clean area and never the other way, without appropriate actions, like washing hands and changing garments and footwear. Similarly, air should also move from the clean area to the less clean areas. This requires that the cleanest area be kept under a higher pressure than the other areas. The same applies to the water in the gutters (drains), which therefore should slope from the cleanest area to the less clean areas.
- Pests, such as insects, rodents and other animals, must be kept at bay and those present for whatever reason, should not find places where they could breed:
 - There should be no horizontal surfaces that cannot easily be inspected and cleaned
 - There should be no narrow spaces between equipment and walls, floors and ceilings. Thus the space between the floor and the bottom of equipment must be large enough for inspection and cleaning or there should be no such space, meaning that the equipment is sealed to the floor. This of course is applicable only to permanently positioned equipment.
 - There should be no space between lighting armatures and the ceiling. These armatures should in principle be built into the ceiling, and then sealed, or hanging down from the ceiling and have a sloping top so that dust cannot accumulate.
 - Windows should always be closed or where this is impossible, they should be provided with screens that stop even the smallest insects from entering the factory.
 - Walls and doors must be rodent-resistant.
 - There should be no false ceilings, above which animals would nest and dust would accumulate and fall down on exposed product through the openings between the elements.
- Because people also carry dust and microbes and may carry small insects, the layout of the factory must be such that unauthorised

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personnel cannot enter the production area. Staff entering the areas of the factory where the product is exposed should pass a barrier with step-overs, where they can change into clean garments, put on hair nets, take off their shoes, move their legs over to the clean side where they step into clean footwear. There should be facilities to clean and disinfect hands and put on gloves.

Detailed information on designing food factories can be found in Hygienic design of food factories³.

Inspection, education and training

Despite the fact that there are regulations and guidelines on the safe manufacture of food, all emphasising the importance of hygiene, food poisoning incidents happen. Most of the incidents take place at home and many in the catering industry, and relatively few in the food industry. The main cause is that the hygienic aspects of food handling do not receive much attention during education. In today's food processing industry, many machines are used but most people working in the food industry have no idea about how such machinery works and what safety risks they may present. Machinery is left to mechanical engineers, who have no training in hygiene. Inspections often do not work, because in many countries food safety inspectors are veterinarians, skilled in veterinary medicine, with limited training in machinery used for food. If the number of food incidents is to be reduced, hygienic design and operation of food processing machinery should be incorporated into education programmes, from Kindergarten to University. Apart from the EHEDG documents and the series of books published by Woodhead^{2, 3}, I strongly recommend the short story "Invisible Things"⁴, about a little girl with food poisoning who tries cleverly, and successfully, to find out the cause. In the process, she learns much and so will the reader.

References

- 1 Hygienic equipment design criteria (second edition). G. Hauser, G.J. Curiel, H.-W. Bellin, H.J. Cnossen, J. Hofmann, J. Kastelein, E. Partington, Y. Peltier and A.W. Timperley. EHEDG 2004. Downloadable (free) in many languages from <http://www.ehedg.org/index>.

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- 2 Hygiene in food processing - Principles and practice (second edition). Edited by H. L. M. Lelieveld, J. Holah and D. Napper. Woodhead Publishing Limited, Cambridge, UK, 2014.
- 3 Hygienic design of food factories. Edited by J. Holah and H.L.M. Lelieveld. Woodhead Publishing Limited, Cambridge, UK, 2011.
- 4 Invisible Things. Sara Andersson with illustrations by Susan Litsios. Elstir Editions 2010, ISBN 978-2-9700762-2-3. French version ISBN 978-2-00512-5-1.

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