The Society of Food Hygiene and Technology

Effective Cleaning and Disinfection

INTRODUCTION

Cleaning and sanitation are essential in the hygienic production of foodstuffs. Cleaning programmes are a prerequisite to ensure good manufacturing practice.

EU Regulation (EC) No 852/2004 on the hygiene of foodstuffs states that:

1. Food Premises are to be kept clean and maintained in good repair and condition.

2. The layout, design, construction, siting and size of food premises are to:
a) permit adequate maintenance, cleaning and/or disinfection, avoid or minimise air-borne contamination, and provide adequate working space to allow for the hygienic performance of all operations;
b) be such as to protect against the accumulation of dirt, contact with toxic materials, the shedding of particles into food and the formation of condensation or undesirable mould on surfaces;
c) permit good food hygiene practices, including protection against contamination and, in particular, pest control."

Before we involve ourselves with technical aspects of detergents, we must first of all justify their existence. We can do this by examining the reasons why we clean things, whether this means ourselves, our clothes, our possessions or industrial items that we never see. The various reasons why we clean things are:

Appearance

Perhaps the most obvious reason but not the easiest to explain - appearance, from a customer's point of view, gives confidence. For example, the tableware in a restaurant. In the Food Processing Industry we hope that appearance gives operators pride in their equipment and that they are happier working in a clean environment than in a dirty one. Thus appearance alone is valuable from a personal satisfaction point of view.

Product Integrity

Cleaning alone is no guarantee that articles are necessarily disinfected. It is, however, very much easier to disinfect a clean surface than a soiled one. In fact, we can go so far as to say that cleaning is essential before attempting disinfection.

Plant Efficiency

A dirty plant does not operate at its most efficient. Scaled heating coils are slower to raise the water temperature and take more steam to do so. Scaled conveyors, or those carrying excessive sludge, are unnecessarily heavy and need more power to move them. Heat exchangers become less efficient at the heat transfer surface. These are just a few examples of how the gradual decrease in plant efficiency can cause a gradual increase in expenditure.

Safety

An accident in a factory can have expensive repercussions in terms of insurance claims, absenteeism and bad feeling amongst employees. Dirty equipment is often slippery and dangerous. Greasy floors and stairs are treacherous, greasy utensils can slip from hands, fork lift trucks can skid on wet or greasy floors. Thus a clean environment makes the working conditions much safer as well as making employees happier.

CLEANING PROCEDURES AND METHODS

Cleaning can be carried out by the separate or the combined use of physical methods, such as heat, scrubbing, turbulent flow, vacuum cleaning or other methods that avoid the use of water, and chemical methods using detergents, alkalis or acids.

Cleaning procedures will involve, where appropriate:

- removing gross debris from surfaces;
- applying a detergent solution to loosen soil and bacterial film and hold them in solution or suspension;
- rinsing with water which complies with section 4, to remove loosened soil and residues of detergent;
- dry cleaning or other appropriate methods for removing and collecting residues and debris; and where necessary, disinfection.

CLEANING PROGRAMMES

Cleaning and disinfection programmes should ensure that all parts of the establishment are appropriately clean, and should include the cleaning of cleaning equipment.

Cleaning and disinfection programmes should be continually and effectively monitored for their suitability and effectiveness and where necessary, documented.

Where written cleaning programmes are used, they should specify:

- areas, items of equipment and utensils to be cleaned;
- responsibility for particular tasks;
- method and frequency of cleaning; and monitoring arrangements.
- where appropriate, programmes should be drawn up in consultation with relevant specialist expert advisors.

STANDARD OF CLEANING REQUIRED

The reasons why any item of plant is cleaned and the standards of cleaning required are obviously very closely interlinked. The standard of cleaning can be broadly divided into three categories:

Physically Clean – Visually clean to an acceptable standard.

Chemically Clean – Clean to a standard where anything in contact with the cleaned surface (for example, product) is free from contamination. This may also be defined as a water break free surface, i.e. if the surface is water-break free, the whole surface remains wet upon rinsing, with no beading or localised drying.

Microbiologically Clean – Chemically clean and disinfected so that product in contact with the cleaned surface suffers no physical or microbiological contamination.

In most food and beverage operations, these standards can readily be applied to all parts of all items of plant. Ideally, of course, all surfaces in contact with raw materials or finished product should be microbiologically clean. Due to constraints imposed by plant design, materials of construction, time available, and safety, each item of plant should be fully assessed during preparation of cleaning schedules in order to achieve the best practical standard of cleaning. (See Hygiene in Focus: Cleaning Schedules).

FACTORS AFFECTING CHOICE OF DETERGENT AND METHOD OF APPLICATION

Result required – Physically, chemically or microbiologically clean.

Type of soiling – In general terms, alkaline detergents are used for the removal of organic soils, while acidic detergents are used on inorganic soils.

Materials of Construction and Equipment Design and Function - Any detergent which is used must not damage any parts of the process plant or cleaning in place (CIP) equipment. A specific example is the corrosive effect of caustic products on soft metals (e.g. aluminium). The design of equipment used for both production and cleaning will determine the type of material used. The process or electrical components may require essentially dry conditions, hence a cleaning method using little or no water is essential (e.g. gel cleaning, use of alcohol wipes etc).

CLEANING TECHNIQUES AND SERVICES AVAILABLE

For safety reasons manual applications restrict the choice of detergent to neutral or near neutral materials, whereas with automated processes such as CIP or traywashing there are few limitations. The availability of water, air, drainage and other plant services will again determine the method of application and hence the type of detergent required.

Water Conditions

Water is often called the 'universal' solvent and practically all substances are soluble in it to some degree. As a result of this property, water is readily contaminated by substances it comes into contact with, be they of inorganic, organic or microbiological origin. Water hardness greatly influences the

choice of detergent, since hard water salts are precipitated by both heat and high alkalinity.

The microbiological quality of water will again determine both the products used and method of application.

Concentration, Temperature, Time and Mechanical Action
The effectiveness of any cleaning application is reliant on the use of the correct detergent, the correct concentration and temperature, applied for the correct length of time using appropriate mechanical action or energy, (e.g. flow, pressure, brush, wipe).

In general terms, any cleaning operation is more effective at elevated temperatures and cold cleaning may require a "stronger" detergent or higher concentration. As with temperature, shorter contact time may require a stronger detergent or higher concentrations.

CLEANING METHODS AND MATERIALS USED

Pre-Cleaning – Removal of gross debris (fat, bones, visible debris) prior to cleaning.

Manual Cleaning – Manual cleaning applications employ neutral or near neutral detergents and sanitisers used by hand to clean stripped down components, fillers, conveyors and open plant areas. The major energy input in this instance is mechanical rather than thermal or chemical energy.

Foam Cleaning – Foam cleaning is carried out using self foaming acidic, alkali or neutral detergents and sanitisers through specific apparatus. They are used to clean large areas of open plant and areas with difficult access.

Gel Cleaning – Gel cleaning detergents and sanitisers are materials which, on dilution, form adherent gels. These may be applied to all food production surfaces where extended contact times are required.

AUTOMATED, CLOSED PLANT APPLICATIONS

These include CIP, bottlewashing, tray washing and other automated processes. In general high alkalinity and high acidity products are applied by circulation methods where a greater emphasis on chemical and thermal energy is required.

DISINFECTANTS

Given the correct conditions, micro organisms reproduce by dividing and rapidly reach large numbers. To reproduce they require certain conditions:

- Nutrients - e.g. soil, on surfaces and moisture;
- Correct temperatures - low temperatures inhibit growth, high temperatures kill organisms;
- Absence or presence of air - depending on particular organism;
- Lack of radiation;
- Correct pH.

Some micro organisms are either harmless or even necessary, but many are undesirable because they are pathogenic, they produce poisonous toxins, or they produce "off" smells and tastes in a finished product.

Micro organisms may be destroyed by physical or chemical methods. Physical methods include (moist) heat and high energy radiation (typically UV and gamma rays). However, food contact surfaces are most frequently disinfected with chemical products.

Before detailing the types of chemical used as disinfectants, it is important to realise that any chemical must be able to achieve contact with the micro organism to kill it, and that a dirty surface cannot be chemically disinfected.

There are various types of disinfectants in use in the food industry. The purpose of disinfection is to destroy:

- Micro organisms which cause infection;
- those which are harmful; and
- those which are not harmful but indicate that disinfection is inadequate.

The main priorities of a disinfectant are as follows:

- Activity at low temperatures and concentrations;
- Non-tainting;
- Non-toxic;
- Non-corrosive to plant materials;
- Solubility/free rinsing;
- Detectability;
- Biodegradability;
- Stability;
- Cost effectiveness.

The above criteria are covered for all commonly used disinfectant types.

GROUP 1 - HALOGENS

Chlorine and chlorine-release agents are supplied as:

- A liquid, as sodium hypochlorite NaOCl; and
- As powders, either inorganic, based on chlorinated trisodium phosphonate, or organic chlorine compounds such as sodium dichloroisocyanurate.

The organo-chlorine compounds are slower acting than the inorganic forms, but are generally more stable, less irritating and less corrosive. Chlorine is highly reactive with organic material which includes micro organisms. It reacts with cell wall constituents, with cytoplasmic membrane and the cytoplasm.

The amino groups of proteins are chlorinated and the sulphydryl groups of proteins are oxidised. The nuclear material is also affected. The main chlorine compound used is sodium hypochlorite.

Another halogen commonly used is iodine. Iodine is an effective disinfectant. It is usually used in the form of iodophor, where iodine is complexed with a carrier such as a surfactant or polyvinyl pyrrolidone. Iodophors are prepared to give an acid pH for maximum activity. The activity of iodophors is due to free iodine: as the free iodine is used up more iodine is released. A major disadvantage is that they are generally too high foaming for CIP. The iodine oxidises sulphydryl groups in proteins and consequently affects enzyme activity.

Chlorine

- Very effective and fast acting against bacteria at low concentration. Higher concentrations needed against yeasts, moulds and spores. The activity is affected by low temperature, but significantly less than other disinfectants. Typically used at 50-250 ppm available chlorine;
- Generally non-tainting but can react with gaskets and food soils on inadequately cleaned surfaces;
- Decomposes to non-toxic products;
- Corrosion can be a problem at higher concentrations or if residues are allowed to dry;
- Freely soluble and free rinsing;
- Available chlorine is detectable chemically;
- Biodegradable;
- Stability of concentrate is limited and dilutions very limited. Affected by organic soil. Water hardness does not affect significantly.

Iodine

- Activity is affected by low temperatures. Effective at low concentrations against most bacteria. Higher concentrations needed for yeasts, moulds and spores. Typically used at 5-50 ppm available iodine.
- Possible tainting problems;
- Non-toxic at use concentrations;
- Corrosion can be a problem; also staining of plastic and rubber can occur;
- Soluble and free rinsing;
- Detectable chemically; self-indicating, decolourised when depleted;
- Biodegradability – depends on carrier;
- Stability – good in concentrate, not in dilution. Not as sensitive to organic soil as hypochlorite. Not affected significantly by hard water.

In addition, mixed halogens are available either as powders or as acidic liquids. The activity and applications of the powdered products are similar to those of chlorine or iodine based products. The liquid products are, however, designed for use in CIP applications specifically in the dairy industry.

GROUP 2 – OXYGEN RELEASING COMPOUNDS

These are hydrogen peroxide and peracetic acid products.

The hydrogen peroxide breaks down to water and oxygen. Hydrogen peroxide attacks the cytoplasmic membrane. It also oxidises the sulphydryl groups and amino groups of protein and the carbon double bonds in liquids. The principal application for hydrogen peroxide in the Food Industry is for aseptic packaging, where the only residues are water and oxygen.

Peracetic acid supplied in aqueous solution as an equilibrium mixture of peracetic acid, water, acetic acid and hydrogen peroxide. The peracetic acid is believed to be primarily responsible for disinfection activity, and is more potent than hydrogen peroxide. The action is on the cytoplasmic membrane, cell wall, and on enzymes where the sulphydryl groups and sulphur-sulphur bonds are oxidised.

Because of the unpleasant smell of the peracetic acid, it is not recommended for manual use.

Peracetic acid

- Effective at low temperatures. Very effective against most bacteria at low concentrations and generally effective against yeasts, moulds and spores at higher concentrations. Typically used at 50-200 ppm active PAA;
- Non-tainting;
- Non-toxic in use dilutions, decomposition products are all toxicologically safe;
- In use, solutions generally non-corrosive; can be used on stainless steel but not on brass and copper;
- Freely soluble and free rinsing;
- Can be detected chemically;
- Biodegradable;
- Stability – good in concentrate, less so in dilution. Affected by organic soil. Not significantly affected by hard water.

GROUP 3 – CATIONIC AND SURFACE ACTIVE COMPOUNDS

Quaternary Ammonium Compounds (QAC)

QACs are many and varied and show a range of micro-biocidal activities, with better activity against Gram positive bacteria than Gram negative. Many have detergent properties. QACs are generally not used in CIP.

The bacterial cell wall is negatively charged, which attracts the QAC molecules.

The QACs penetrate the cell wall and damage the cytoplasmic membrane, therefore affecting cell permeability. At low concentrations low molecular mass materials are leaked, e.g. K+ions. At higher concentrations the cytoplasm is coagulated and a reaction occurs with the carboxylic acid groups of enzymes. Due to the coagulation of the cytoplasm the leakage of cellular contents decreases.

- Effectiveness is reduced at low temperatures and concentrations. Activity against yeasts, moulds and spores is very low. Typically used at 100-200 ppm active QAC;
- Possible taint problems;
- Moderately toxic in the concentrated form;
- Non-corrosive in dilute solution;
- Soluble and substantive to certain surfaces which may result in inhibition of starter cultures in the dairy industry;
- Detectable chemically;
- Generally biodegradable;
- Effect on organic soil depends on the QACs, but in general deactivation occurs. Also affected by hard water; affects beer head retention; stable in both concentrate and dilution.

AMPHOTERIC DISINFECTANTS

Freely soluble in water, these exhibit substantial detergent activity and are suitable for manual, spray and soaking application. Amphoteric disinfectants are effective against most vegetative bacteria and, at higher concentrations, yeasts and moulds. They also have low mammalian toxicity and are generally non-tainting. Their mode of action is similar to that of QACs.

- Activity dependent on the molecule used. General formula R-NH-CH2 - COOH. Loses some activity at low temperatures and concentrations. Extended contact time required. Use rate similar to QACs.
- Non-tainting;
- Low toxicity;
- Non-corrosive;
- Soluble and free rinsing;

- Detectable chemically;
- Biodegradable;
- Stability - have higher tolerance to organic soil and hard water than QACs. Stable in concentrate and dilution.

Biguanide Disinfectants

Polymeric biguanide disinfectants are water soluble, non foaming and can be applied manually or by spraying, soaking or recirculation to combat Gram negative and Gram positive vegetative bacteria. At higher concentrations, they are also effective against yeasts and moulds.

Again, their mode of action is similar to that of QACs:

- Lose some activity at low temperatures. Effectiveness reduced in acid solution and inactivated above pH9;
- Non-tainting;
- Low toxicity;
- Non-corrosive;
- Soluble and free rinsing;
- Detectable chemically;
- Biodegradable;
- Stable in concentrate and dilution but affected by organic soil.

ESSENTIAL CONSIDERATIONS

- All of the disinfectants mentioned in this paper are adversely affected by soiling. Therefore the key to good disinfection is good cleaning and, in many cases, a three stage process of cleaning followed by disinfection is recommended;
- Failure to clean a surface properly before disinfection has accounted for many false claims of microbial resistance to disinfectants;

- Detergent sanitisers, possessing both detergent and disinfectant properties, are available and the better ones are capable of performing both functions in one operation on lightly soiled surfaces;
- It is important to ensure that suppliers can provide proof of the efficacy of their disinfectants and those who cannot should be treated with suspicion;
- When selecting a cleaning agent always choose the least hazardous product suitable for the application.
- Alternation of disinfectant types may be recommended to prevent the build-up of microbial resistance.

EFFICIENCY AND VERIFICATION OF CLEANING AND SANITATION

The efficiency of cleaning and sanitation should be checked and recorded at routine intervals and verified by management. The frequency of verification should be based on risk assessment. Methods of monitoring may include:

- Visual inspection
- Microbiological swabs
- In process/finished product testing
- Microbiological checks of rinse water.
- Hygiene/Housekeeping Audits

The monitoring of cleaning and sanitation should be formally documented. Corrective action should be carried out accordingly to improve cleaning practices.