Disinfection

It is widely accepted in food production that disinfection plays an important role in the **sanitisation** (or sanitation) of equipment and process areas. This is because soil deposits can harbour potentially harmful (**pathogenic**) **microorganisms** and whilst they will be washed off surfaces and removed during the cleaning process, some may remain and not be killed. Typically, the reduction achieved by cleaning is in the order of 3-4 logs per cm^2 and it is normally necessary to reduce the levels down to 5-6 logs per cm^2 and this is achieved using a suitable **disinfectant**.

Disinfectants are generally applied as aqueous solutions in the same way as **detergents,** by using disinfectant wetted cloths or by spray and foam application. However for **CIP**, disinfectant is usually injected directly into the final rinse water as it is being circulated. Also, some disinfectants can be used for aerial **fogging** by way of **compressed air** or other equipment to generate a fine mist of the disinfectant solution.

When talking about the sanitisation of hard surfaces, disinfectants are applied directly to the **equipment** or **environmental** surface, or in some cases, items may be soaked in disinfectant solution. Generally, the disinfectant is applied manually to surfaces (e.g. using wetted cloths, brushes or spraying). Disinfectants for this type of application must be capable of ensuring a **biocidal** effect within five minutes or less. This is because the disinfectant solution is likely to run off non-horizontal surfaces. However, **contact time** can be increased by applying the disinfectant solution as a foam or **thixotropic** gel, which is able to increase the contact time to ten to fifteen minutes for foam and greater than fifteen minutes for a gel. Soak tanks are useful for small **utensils** or dismantled equipment items, as contact time can be for as long as they are then required for re-use.

Important note**:** in general, disinfectants that require longer contact times should not be used for non-soak tank applications.

Disinfectants need to have activity properties over a whole range of temperatures within an **FBO**, whether it be at low temperature (e.g. at 5°C for chill stores or chill food-production units etc.), ambient temperature (e.g. ±20°C) or at higher temperature (e.g. 45-55°C which is considered to be suitable for manual applications and operator safe). For soak tank applications, even higher temperatures of 60+°C may be used. However, for most applications, disinfectants should be able to give the required **biocidal** kill result at ambient temperature within a contact time of five minutes or less.

It is generally accepted that effective disinfection of surfaces can be achieved in a number of ways:

> ***UV light:*** used for a large variety of applications in the food industry. With high-performance UV light sources and equipment, water, air and surfaces can be reliably treated. UV light has been shown to be effective on most **bacterial microorganisms**, **moulds** and **viruses**.
>
> *Steam:* dry and moist heat in the form of steam under pressure is an accepted way of disinfecting food processing equipment and relies on direct steam contact onto surfaces for a specified time. The main benefit of steam disinfection is that it is rapidly

biocidal (and **sporicidal**) and is non-**toxic**. However, the downside is that it is deleterious to some plastics and gasket materials and can corrode certain metals.

Hot Water: commonly hot water (min. 80°C) is used to disinfect because, as with steam disinfection, it is able to penetrate into surface crevices, it is non-corrosive as well as being non-selective to microbial types. Additionally, it leaves no residue. However, whilst in general this is suitable for **CIP** applications and some soak tank applications, apart from being hazardous, it is not practical for use on open surfaces.

Chemical: for open plant cleaning (**OPC**) it is widely accepted that chemical disinfectants are the preferred option. Obviously, apart from being effective biocides, they need to be both non-toxic and non-tainting and this reduces selection to only a few major types. Because of this, the disinfecting effect will vary depending on the active component in the particular chemical disinfectant, doing this either by attacking the inside of the cell of the **microbe** itself or by interfering with the integrity of its cell wall.

Chemical Disinfectants

Chemical disinfectants can be classed as being either **oxidising** or non-oxidising types. Oxidising disinfectants are fast acting with a broad spectrum of activity against a wide range of microorganisms (bacteria, yeasts, moulds & viruses). Non-oxidising disinfectants, although tending to be less corrosive, are generally more specific in their biocidal killing ability. Universally-used biocides include **chlorine** gas, **ozone**, **hydrogen peroxide**, **chlorine dioxide, hypochlorous acid** (generated using electro-chemically activated water (**ECA**) – also known as electrolyzed oxidising water (EOW), **biguanides** and **alcohols**.

Below are the most commonly used acceptable chemical disinfectant types:

Organic chlorine release compounds: these are chlorine donor chemicals (e.g. sodium dichloroisocyanurate & dichlorodimethylhydantoin), which when dissolved in water allow slow release of chlorine to form **hypochlorous** acid, which is the active **biocide**. They are solid compounds widely used for a number of general disinfection applications and can be formulated into sanitiser products which act to both clean and disinfectant surfaces.

Hypochlorites: - the most common chlorine-release chemicals used to disinfect surfaces in the food production industry because their solutions show a broad antimicrobial effect and are fast acting. Calcium hypochlorite is available as a powder whilst sodium hypochlorite is liquid. As with the organic chlorine donors the primary active biocide is hypochlorous acid. Hypochlorous acid (HOCl or HClO) is a weak acid that forms when hypochlorite dissolves in water, and itself partially dissociates, forming hypochlorite (OCl^-). The pH of the water determines how much HOCl is formed and the table below shows the relationship between hypochlorite solution pH and dissociation to give hypochlorous acid and be actively biocidal.

pH	% HOCl (Hypochlorous acid)	% OCl (Hypochlorite)
4.0	Almost 100	±0.1
5.0	99.6	0.4
6.0	95.8	4.2
7.0	69.7	30.3
8.0	18.7	81.3
9.0	2.2	97.8
10.0	0.2	99.8

However, whilst low **pH** is shown to be preferable, acidic hypochlorite solutions are not very stable. Also acidic hypochlorite solutions become corrosive towards most grades of **stainless steel** used to fabricate food process equipment as well as galvanised iron and mild steel.

Hypochlorite solutions are suitable for both manual applications and **CIP**. Unfortunately, because of its chemical nature, hypochlorite is not suited to being used at temperatures above 40°C as it will degrade and become less effective.

Peracetic acid (PAA) – also known as peroxyacetic acid: known to be effective against all microorganisms and its activity is maintained even at temperatures lower than ambient. Peracetic acid is oxygen-based being composed of hydrogen peroxide, peracetic acid and acetic acid combined in equilibrium. Its benefits are that it remains effective in the presence of organic material unlike hypochlorite, it is completely **biodegradable** with its decomposition products being harmless and it leaves no residue. Whilst it is safe to use on stainless steel and most plastic surfaces, it can be corrosive towards galvanised iron, **mild steel**, copper, brass and bronze metals as well as rubber gasket materials. Because peroxyacetic acid (**PAA**) solutions can be irritating and unpleasant to handle then its manual use is generally not recommended, it is however, an effective biocide. It is widely used for CIP as it is non-foaming.

Non-Oxidisng Disinfectants

Quaternary ammonium compounds (QACs or 'Quats'); are amphipolar cationic **surfactants**, derived from substituted ammonium salts with a chlorine or bromine ion. Because they are surface active they can act as one-step sanitisers especially when combined with detergents. QACs are generally more **biocidal** in slightly alkaline conditions and are effective biodegradable disinfectants, offering a broad range of activity against most types of microorganisms. The use of QACs is mostly limited to manual application, soaking, spraying and foaming and not widely used for CIP as they are considered to be high foaming. One other disadvantage that the QACs have is that they are 'substantive' which means that they can cling to surfaces, which then tends to make them difficult to rinse off, resulting in possible taint problems.

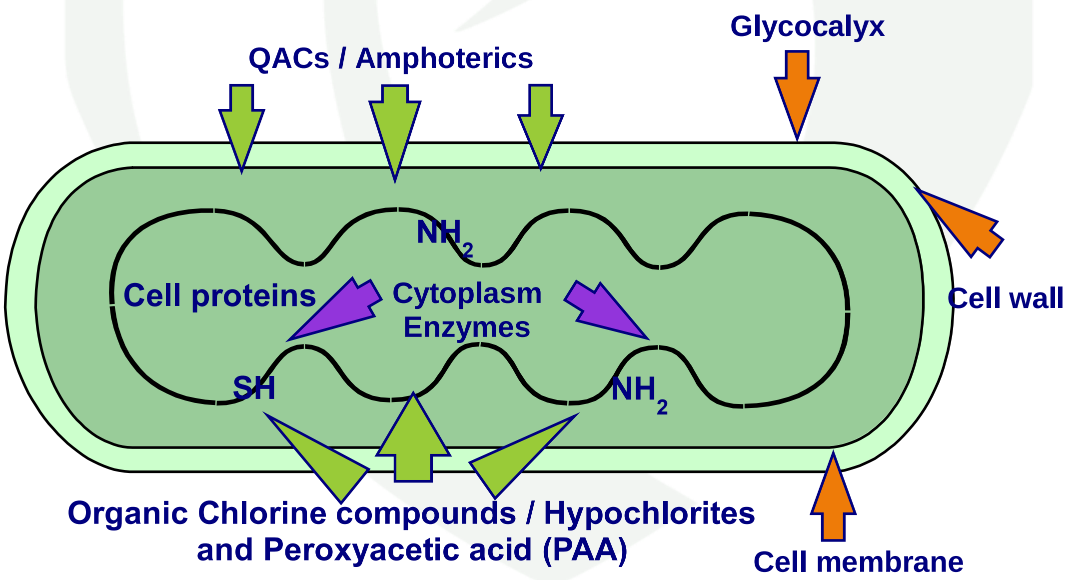
Amphoterics: amino acids based on **glycine**, often incorporating an **imidazole** group (aromatic NH compound). In general, the biocidal effectiveness of amphoterics increases with an increase in the number of amine (NH_2) groups incorporated. Amphoterics have all the same inherent traits to those of QACs but are substantially more surface active. They also tend to be higher foaming than the QACs and much more free-rinsing. As with the QACs they can be used for manual applications, soaking, spraying and foaming but not generally used for CIP.

Mode of Action of Chemical Disinfectants

Oxidising disinfectants: the one common property that all oxidising disinfectants exhibit is that they are able to attack the enzyme system within cells, which quickly destroys them. However because they can combine with any and all organic material, including any soil residues, then this may cause deactivation with a reduction in the overall biocidal effectiveness.

Non-oxidising disinfectants: in general rather than attacking the organic nucleus of cells the non-oxidising disinfectants act to rupture the cell wall which causes an osmotic imbalance with leakage of cell constituents, leading to cell death. Alcohols, however, act to poison and dehydrate cells to cause their death.

Drawing of a typical bacterial cell showing the mode of action of the different disinfection types:



Disinfectant & Sanitisation Requirements

To successfully fulfil their role disinfectants must satisfy the following criteria:

- *be suitable for typical food factory application:*
  - disinfectant concentration is critical to performance and a simple-to-use and rapid test should be available to give some assurance of the likely performance of the disinfectant. Also, it is appropriate that disinfectant products are suitable and meet the necessary standards. Generally speaking, this information may be obtained from the product label, or by contacting the supplier directly.
- *be effective:*
  - Ideally, disinfectants should have the widest possible spectrum of activity against microorganisms (viruses, bacteria, fungi and spores) in a time relevant to application contact times. The biocidal efficacy of disinfectants is normally evaluated in suspension tests. There are a number of officially recognised laboratory standards for assessing the effectiveness of disinfectants against a range of microorganisms under a set of specified conditions (e.g. at a particular temperature, dilution and contact time). These are: EN 1276:1997, EN 1650:2008, EN 13624:2013 and EN 13697:2001
- *be non-toxic in the product:*
  - In certain cases some disinfectants can be classified as 'no-rinse' where it is acceptable to leave disinfectant residues on surfaces without rinsing these off prior to commencement of food production. However, generally speaking, chemicals must be rinsed off prior to food production. In either case the contamination of food products with disinfectant residues is unavoidable. Disinfectants, even at low concentrations, must therefore present no health risks to the food consumer.
- *be non-tainting:*
  - The major taints associated with disinfectants are described by sensory scientists as 'antiseptic', 'disinfectant' or 'soapy' and obviously such **complaints** can be a major issue. Therefore, it is important to understand the chemical nature of disinfectants and for them to be assessed as being suitable for use when used as recommended.
- *be safe for cleaning operatives:*
  - Operator aspects of the disinfectant and the form of application are crucial and as a general guide, the following information (**MSDS**) should be available:
    - product description and intended use
    - physical data (appearance, odour, pH, flammability, solubility)
    - health hazards and first aid treatment (inhalation, eye contact, skin contact, ingestion, special precautions)
    - fire hazards - hazardous reactions with other chemicals - spillage/leakage procedures and disposal - transport, storage and handling precautions.

Sanitisation programmes are undertaken with the following aims in mind:

- to remove microorganisms, or material conducive to microbial growth; this reduces the chance of contamination by **pathogens** and, by reducing **spoilage organisms**, may extend the **shelf life** of some products.
- to improve the appearance and quality of the product by removing food materials remaining on production lines (which may deteriorate and re-enter subsequent production runs).
- to remove materials which could lead to foreign body contamination, or provide food or shelter for pests.
- to prevent damage to and extend the life of equipment and services; providing a safe and clean working environment for employees, thus boosting morale and productivity.
- to increase process performance and productivity (e.g. **HTST** heat exchangers, plate and scraped-surface heat exchangers, etc.).
- to present a favourable image to customers; on audit, the initial perception of an 'untidy' or 'dirty' processing area will be seen as a a poorly managed operation.

Factors Affecting Disinfection Performance

Disinfectant effectiveness is dependent upon a number of factors:

	Factor	Effect on performance
1.	Absence of organic matter from surfaces to be disinfected.	Soiling causes deactivation issues resulting in loss in efficacy.
2.	Type of surface the disinfectant is being applied to.	Porous surfaces can cause effectiveness issues and also the disinfectant solution can be corrosive to certain surfaces.
3.	Hardness properties of the water that the disinfectant is diluted in to make up the in-use strength.	Some disinfectants can be deactivated, resulting in loss in efficacy
4.	Length of time the disinfectant is in contact with the surface.	Killing ability can be compromised if contact time is too short.
5.	Use temperature of the disinfectant solution.	Incorrect disinfectant application temperature can cause deactivation issues. Also, solutions can be corrosive to certain surfaces at increased temperature.
6.	In-use strength of the disinfectant.	Killing ability can be compromised when in-use strength is incorrect. Also, solutions can be corrosive to certain surfaces at increased incorrect solution strength.
7.	pH of the chemical disinfectant solution.	Solutions can be corrosive to certain surfaces.
8.	Compatibility between the detergent and the disinfectant being used.	Some disinfectants can be deactivated, resulting in loss in efficacy.

Effective Disinfection Procedures

1. ***'Single-Step' Sanitising:*** is generally only suitable in **low risk** process areas or as an **interim 'clean-as-you-go'** measure and never as a disinfection control for cross-contamination, unless the soiling level is only very low.
   NOTE: If the use of a single sanitising product is preferred, rather than separate detergent and disinfectant, then the sanitising product must also meet the requirements of the BS EN 1276:1997 or the BS EN 13697:2001.

2. ***'Two-Step' Separate Cleaning & Disinfecting:*** is best suited in **high risk** process areas where foods supporting the growth of **pathogens** is likely to lead to risk of food poisoning, **spoilage** or reduced **shelf life.**
3.

1. General 'Single-step' Combined Sanitising Procedure

Step		**Key Points**
1.	*Manual soil removal*	1. *To remove any loose soiling by wiping down, brushing and/or rinsing.*
2.	*Apply sanitiser. **Important note:** Sanitiser should be used according to the manufacturer's instructions, with particular attention paid to in-use strength, temperature and contact time recommendations.*	1. *To remove soiling (e.g. sugars, carbohydrates, proteins, fatty & oily soils, mineral deposits, etc. remaining on surfaces.* 2. *Pay special attention to equipment with surfaces that are difficult to get at, such as stab mixers, blenders, meat slicers and can openers. etc. Equipment may need to be dismantled to gain proper access to the surfaces that need to be sanitised.* 3. *All surfaces to be sanitised should be completely covered with the sanitising solution by soaking, spraying or foaming.*
3.	*Terminal Rinse.*	1. *To remove any remaining soiling and sanitiser residues* 2. *After sanitising, utensils and surfaces should be thoroughly dried. Care should be taken not to re-contaminate sanitised utensils and equipment; for example by ensuring they are packed away with clean hands and stored in a clean and sanitary place.* 3. *Air drying is preferable. If towels are used they should be clean, dry and ideally single use, because if they become contaminated they may then transfer pathogenic microorganisms between items.* 4. *The standard of the terminal rinse water is important to ensure that disinfected surfaces are not re-contaminated.*

2. <u>General 'Two-Step' Separate Cleaning & Disinfecting Procedure</u>

Step		***Key Points***
1.	*Remove debris and gross soiling. **Note:** optional step depending on the level of soil present on surfaces*	1. *To remove loose soiling.* 2. *Manual removal done dry using scrapers & brushes etc. to remove all debris and process soiling larger than fingernail size. Collected material should be placed in waste receptacles and removed from the area.* ***Important note:*** *All process ingredients, food and packaging materials should be removed from the area prior to gross cleaning.*
2.	*Rinse*	1. *To remove any remaining loose soiling.*
3.	*Apply Detergent.* ***Important note:*** *Detergent should be used according to the manufacturer's instructions, with particular attention paid to in-use strength, temperature and contact time recommendations*	1. *To remove soiling (e.g. sugars, carbohydrates, proteins, fatty & oily soils, mineral deposits, etc. remaining on surfaces.* 2. *Detergent may be applied to surfaces by wiping, spraying, foaming or thixotropic gel.*
4.	*Rinse*	1. *To remove any remaining soil and detergent residues.* ***Important note:*** *After rinsing surface should be free of all visible deposits and detergent residues which may deactivate the action of the subsequent disinfectant.*
5.	*Apply Disinfectant solution.* ***Important note:*** *Disinfectant should be used according to the manufacturer's instructions, with particular attention paid to in-use strength and temperature recommendations.*	1. *Disinfectant solution should only be applied to visually clean, well rinsed surfaces and allowed to contact surfaces for 10-20 minutes to ensure effectiveness.* 2. *All surfaces to be disinfected should be completely covered with the disinfectant solution by soaking, spraying or foaming.*
6.	*Terminal Rinse (optional if the disinfectant has "no-rinse" status)*	1. *Most disinfectants are safe to leave on non-food contact surfaces without final rinsing.* 2. *Food-contact surfaces in general require a terminal rinse.* 3. *The standard of the terminal rinse water is important to ensure that disinfected surfaces are not re-contaminated.*

		4. *After rinsing allow surfaces to air dry.*

Recommended Disinfectant Usages

Name	Typical Use Concentration
Organic Chlorine-release compounds and Hypochlorites (calcium & sodium)	50-200ppm (as available Cl_2)
Peracetic acid (PAA)	50-200ppm (as active PAA)
Quaternary Ammonium Compounds (QACs)	100-400 ppm (as QAC)
Amphoterics	100-400 ppm (as active amphoteric)

In summary

Disinfectants play a crucial role in food production and their use may be one of the major factors in preventing **microbial spoilage** and food safety problems in products. But if selected or used incorrectly, then disinfectants are likely to be ineffective, or they may cause issues associated with product taint, health & safety hazards or toxicity towards end-product **consumers**.