Cleaning and Sanitizing

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Sanitation is an important part of any processing operation. It is the very basis of any establishment's HACCP plan. It is a must for producing a high quality safe product. There are many considerations when developing, implementing and assessing the effectiveness of any sanitation program.

Physical Characteristics of Soil

The type of surface to be cleaned affects the type of soil that collects and how it is removed. Soil is difficult to remove from cracks, crevices and other uneven surfaces. It is easiest to remove soil from smooth hard nonporous surfaces.

Removal of soil from a surface takes three steps. First, soil must be separated from the surface. Second, the soil must be dispersed into the cleaning solution. And last, soil must not be allowed to reattach to the surface.

Soil can be separated from a surface mechanically by using high pressure water, steam, air or scrubbing. Soil can also be separated from a surface chemically. A chemical example would be using an alkaline cleaner with a fatty acid to form a soap.

The soil and surface must be thoroughly wet for a cleaning compound to help separate the soil from the surface. The cleaning compound helps loosen the soil from the surface by reducing the strength of the bond between the surface and the soil. Heat or mechanical action (scrubbing, shaking, high pressure spray, etc.) can help reduce the bond. However, heat does not help loosen some protein and fat soils.

Once the soil has been separated from the surface it needs to be dispersed into the cleaning solution. Therefore, enough cleaning solution must be used to dissolve all the soil. Some soils will not dissolve in the cleaning solution. It is important to break up the undissolved soil into smaller particles so it can be carried away from the surface. Mechanical action such as scrubbing, shaking or high pressure sprays help to break the soil down into smaller particles. Cleaning solutions should be changed often enough to prevent dispersed soil from reattaching. A clean surface should be rinsed or flushed to remove all dispersed soil and cleaning residues. Using soft water helps prevent deposits formed when hard water reacts with soap in a cleaning compound.

Cleaning Compounds[3]

The type of soil determines which cleaning compound can be used most effectively. In general, organic soils are most effectively removed by alkaline, general purpose cleaning compounds. Heavy deposits of fat and proteins require a heavy-duty alkaline cleaning compound. Mineral deposits and other soils that are not successfully removed by alkaline cleaning compounds should be cleaned with acid cleaning compounds. The most frequently used types of cleaner-sanitizers are phosphates complexed with organic chlorine.

It is important to select the correct cleaning compound to remove a specific type of soil. Table 1 below shows whether various types of soil are soluble in water, acid, or alkali; whether heat helps remove them, and how hard they are to remove.

Table 1. Removal of Different Types of Soils[3]

Type of Soil	Solubility	Ease of Removal	Effects of Heat
Salts	Soluble in water	Easy to difficult	Reacts with other types of soil and becomes harder to remove
Sugar	Soluble in acid	Easy	Carmelizes and becomes difficult to remove
Fat	Insoluble in water Soluble in alkali	Difficult	Molecules join together and become difficult to remove
Protein	Insoluble in water Slightly soluble in acid Soluble in alkali	Very Difficult	Molecules change shape (denature) and become very difficult to remove

An acid cleaning compound works best to remove inorganic deposits; an alkaline cleaner is more effective for removing organic soil. Table 2 provides some examples.

Table 2. Types of Soils[3]

Type of Soil	Soil Subclass	Examples
Inorganic soils	Hard-water deposits	Calcium and magnesium carbonates
	Metallic deposits	Common rust, other oxides
	Alkaline deposits	Films left when an alkaline cleaner is not rinsed off properly
Organic soils	Food deposits	Food scraps and specs
	Petroleum deposits	Lubrication oils, grease, and other lubricants
	Nonpetroleum deposits	Animal fat and vegetable oils

Soil deposits are often complex mixtures of organic and inorganic materials. It is important to know the type of soil and use the best cleaning compound or combination of compounds to remove it. A two-step cleaning procedure (using more than one cleaning compounds) is often needed to remove a combination of inorganic and organic deposits. Table 3 shows the best type of cleaning compounds for each type of soil.

Table 3. Cleaning Compounds for Different Types of Soils[3]

Type of Soil	Cleaning Compound
Inorganic soils	Acid cleaner
Organic soil	
--Nonpetroleum	Alkaline cleaner
--Petrolelum	Solvent cleaner

Surface characteristics must be considered when selecting a cleaning compound and cleaning method. Table 4 provides some characteristics and precautions for a number of surfaces in food processing plants.

Table 4. Characteristics of Various Surfaces of Food Processing Plants[3]

Material	Characteristics	Precautions
Wood	• Previous to moisture, fats and oils • difficult to maintain • softened by alkali • destroyed by caustics	Wood should not be used because of its unsanitary features. For sanitary reasons, stainless steel, polyethylene, and rubber materials should be used instead of wood
Concrete	• May be etched by acid foods and cleaning compounds	Concrete should be dense, acid resistant, and nondusting. Acid brick may be used in place of concrete.
Paint	• Surface quality depend on method of application • Etched by strong alkaline cleaning compounds	*Certain* edible paints are satisfactory for use in food plants
Rubber	• Should be nonporous, non-spongy • Not affected by alkaline detergents • Attacked by organic solvents and strong acids	Rubber surfaces can dull knife blades.
Stainless Steel	• Generally resistant to corrosion • Smooth surfaced and impervious (unless corrosion occurs) • Resistant to oxidation at high temperatures • Easily cleaned • Non-magnetic	Certain varieties are attacked by halogens (chlorine, iodine, bromine, and fluorine)

Cleaning Methods[1]

Cleaning operations consist of four steps—pre-rinse, cleaning, post-rinse and sanitizing. The first three will be discuss in this section and the last in the sanitation section of this paper. These operations are essential in all cleaning procedures regard of the cleaning method utilized.

Pre-rinsing is important to minimize the soil load. Pre-rinsing can effectively remove up to 90 percent of the soluble material. By removing the initial load, the cleaning step can more effectively reach and remove the loosened soil. The post-rinse prevents the redeposition of the soil on the clean surface.

There are a number of ways to reduce soil build-up on equipment and ease cleaning.

- Minimize processing temperature and holding times
- Cool product heating surfaces before and during empting of processing vats
- Rinse foam and product from equipment surface immediately after processing
    - Drying will cause increased difficulty in cleaning the surface
- Keep soil films moist by leaving water in processing vats until cleaned
- Rinse with warm (100°-115°F), but NOT hot water
- Mineral deposits on equipment can be minimized
    - by avoiding the use of calcium hypochlorites as a sanitizer
    - reducing water hardness
    - reducing the pH of the cleaned equipment to less than 7.5

How cleaning compounds work[2]

One of the oldest and best known cleaning compounds is plain soap. Fats, oils, and grease do not dissolve in water, but soap disperses tiny particles of these materials in the solution. After the soap disperses the fat or oil, the soil is easily flushed away. Food processors rarely use soap because it does not clean well and reacts with hard water to form an insoluble curd like the ring around a bathtub.

. The following is a discussion of the different types of cleaning compounds most often used in the food industry. You will find several of these chemicals in a typical cleaning compound.

Alkaline cleaning solutions have a pH between 7 and 14. There are several different types of alkaline cleaners. Strong alkaline cleaners have strong dissolving powers and are very corrosive. If these cleaners come in contact with skin they can cause burns and can harm the lungs if inhaled. An example of a strong alkaline compound is sodium hydroxide (caustic soda). It will destroy many microorganisms, dissolve protein and is good at dispersing and emulsifying soil. Silicates make sodium hydroxide less corrosive, better at penetrating soil and better at rinsing away soil. These cleaners are used to remove heavy soils such as those in commercial ovens and smokehouses. They are not good a removing mineral deposits.

Heavy duty alkaline cleaners have moderate dissolving powers and are either slightly corrosive or not corrosive at all. These cleaners are often used for cleaning in place, high pressure or other mechanized systems. They are very good at removing fats but do not remove mineral deposits. Sodium carbonate is a low cost widely used heavy duty cleaner used for manual cleaning procedures. It is also used to buffer many cleaning compounds.

Mild alkaline cleaners such as sodium bicarbonate are used to clean lightly soiled areas by hand. These compounds are good at softening water but do not remove mineral deposits.

Acid cleaning compounds remove materials that are dried on or encrusted on surfaces and dissolve mineral scale. They are especially good at removing mineral deposits formed by alkaline cleaners. When hard water is heated above 176°F (80°C) some of the mineral are deposited. These deposits stick to metal surfaces and leave a rusty or whitish scale. Organic acids such as citric, tartaric, sulfamic and gluconic acids are excellent water softners, rinse off easily and do not corrode surfaces. Inorganic acids are excellent at removing and controlling mineral deposits, but they can be very corrosive to surfaces. Acid cleaning compounds are used for special purposes rather than all-purpose cleaning. Acid cleaning compounds are less effect than alkaline compounds against soil caused by fats, oils and proteins.

Strong acid cleaning compounds corrode concrete, most metals, and fabrics. Heating some acid cleaners produces corrosive, toxic gases which can damage the lungs. Strong acid cleaners remove encrusted surface matter and mineral scale from steam equipment, boilers and some food processing equipment. When the solution is too hot, the mineral scale may redeposit and form a tarnish or whitish film on the equipment being cleaned. Phosphoric acid is widely used in the US and is not very corrosive and works well with many surfactants.

Mild acid cleaners are slightly corrosive and cause sensitivity reactions. Examples of mildly acid cleaning compounds are levulinic, hydoxyacetic, acetic and gluconic acids. These cleaners may contain other chemicals such as wetting agents and corrosion inhibitors. Organic acids are good manual cleaners. However, they are more expensive than the other acid cleaning compounds, but they can soften water.

Solvent cleaners are based on ether or alcohol. They work well on petroleum based soils such as lubricating oils and greases. Food establishments generally use alkaline cleaners to remove organic soils. Solvents are generally used to remove large deposits such as in maintenance shops, etc.

Soaps and detergents emulsify fats, oils and grease so that they are easily washed away. Soaps and detergents usually contain chemical builders to make them clean more effectively. Chemical builders are usually alkaline.

Manufacturers add various chemicals (sequestrants, surfactants and scrubbing compounds) to cleaning compounds to protect sensitive surfaces or improve the cleaning properties of the compound. Sequestrants, also known as chelating agents, soften water. Surfactants wet, penetrate, emulsify, disperse and suspend soil particles.

Cleaning detergents are made up of a surfactant and a builder. Builders make cleaners more effective. Phosphates are excellent builders, especially for heavy duty cleaning compounds.

Scouring compounds or chemical abrasives are normally made from neutral (volcanic ash, pumice, silica flours, or feldspar) or mildly alkaline (borax or sodium bicarbonate) ingredients. Abrasives are usually mixed with soaps and used with brushes or metal sponges. Neutral scouring compounds are often mixed with acid cleaners to remove alkaline deposits and encrusted materials. Abrasive cleaning compounds should be used carefully on stainless steel to avoid scratching it.

Time, Temperature and Concentration of Cleaning Solutions[2]

The application method of the cleaning compound and the characteristics of the cleaner will affect the exposure time. As a general rule, the longer the cleaning compound is in contact with the soil, the cleaner the surface.

As temperature and concentration of the cleaning solution increase, the activity of the compound increases. However, an extreme temperature (above 131°F or 55°C) and concentration exceeding recommendations of the chemical company supplying the cleaning compound can cause protein denaturation of the soil deposits, which can reduce the effectiveness of soil removal.

Sanitizing Methods

Sanitizers are used immediately after cleaning to reduce pathogenic and spoilage organisms on equipment. Any soil deposits remaining on the equipment after cleaning can reduce the effectiveness of a sanitizer through a dilution effect and reaction of the organic material in the soil with the sanitizing compound.

Sanitizing methods include thermal sanitizing and chemical sanitizing. Thermal sanitizing is relatively inefficient because of the energy required. Its efficiency depends on the humidity, temperature required and the length of time a given temperature must be maintained. Microorganisms can be destroyed with the correct temperature, if the item is heated long enough, and if the dispensing method and application and equipment design permit the heat to penetrate to all areas. The two major sources for thermal sterilization are steam and hot water.[2]

Chemical sanitizers are most often used in the food processing plant. Active ingredients must be stated on all sanitizer labels. The individual characteristics of each chemical sanitizer must be know and understood so the most appropriate sanitizer for a specific sanitizing application can be selected. Since chemical sanitizer lack penetration ability, microorganisms present in cracks, crevices, pockets, and in mineral soils may not be totally destroyed. For sanitizers to be effective when compounded with cleaning compounds, the temperature of the cleaning solution should be 131°F (55°C) or lower, and the soil should be light. The efficacy of sanitizers is affected by factors such as exposure time, temperature, concentration, pH, equipment cleanliness, water hardness and bacterial attachment. Chlorine and iodine compounds generally decrease in effectiveness with an increase in pH. Hypochlorites, other chlorine compounds, iodine compounds, and other sanitizers can react with organic material that has not been removed from equipment. Quaternary ammonium compounds are incompatible with calcium and magnesium salts and should not be used with over 200 ppm of calcium in water or without a sequestering or chelating agent. As water hardness increases, the effectiveness of these sanitizers decreases.[2]

Chlorine dissipates rapidly from solutions. It can deteriorate during storage and when exposed to light. Therefore, bottled bleach should NOT be used as a sanitizer in a food processing plant. Chlorine powders should be kept in tightly closed containers to prevent combustion. In tightly closed containers they are relatively stable. Chlorine concentrations of less than 50 ppm do not destroy *Listeria monocytogenese*, but higher concentrations do.[1] Chlorine dioxide is less effective than chlorine at pH 6.5, but more effective at pH 8.5. Hypochlorites are the most active of the chlorine compounds and are the most wide used. Calcium hypochlorite, sodium hypochlorite, and chlorinated trisodium phosphate may be used to sanitize after cleaning or hypochlorites may be added to compatible cleaning solutions for a combined cleaner-sanitizer.

A tabulated relative comparison of properties of the three most common types of sanitizers are provided in Table 5.

Table 5. Relative Comparative Properties of Selected Chemical Sanitizing Agents[1,3]

	Relative Effectiveness		
	Chlorine	Iodine	Quaternary Ammonium
Gram + bacteria	2nd in effectivenss	Most effective	3rd in effectiveness
Gram - Bacteria	Most effective	2nd in effectivenss	Poor
Spores	Most effective	2nd in effectivenss	Least effective
Thermoduric organisms	2nd in effectivenss	Least effective	Most effective
Bacteriophage	Most effective	2nd in effectivenss	Not effective
Affected by hard water	2nd	Least	Most
Corrosiveness	Most corrosive	Slightly corrosive	Noncorrosive
Affected by organic matter	Most	2nd	Least
pH	Effectiveness decreases with increasing pH of solution	Most active pH is 3.0. Very slow acting at 7.0 pH.	Active over wide pH range.
Storage stability	Low	Varies with temperature	Excellent
Penetration	Poor	Good	Excellent
Film forming	None	None to slight	Yes
Cost	Low	Moderate	Moderate

Table 6 provides recommended sanitizers along with recommended concentrations for specific areas or conditions.

Table 6. Choosing a Sanitizer

Specific Area or Condition	Recommended Sanitizer	Concentration (ppm)
Bacteriostatic film	Quat Acid-Quat Acid-anionic	200 Per instructions 100
CIP Cleaning	Acid sanitizer Active Chlorine Iodophor	130
Concrete Floors	Active chlorine Quat	1,000-2,000 500-800
Prevention of film formation	Acid sanitizer Iodophor	130
Atmosphere fogging	Active chlorine	800-1,000
Hand-dip (production)	Iodophor	25
High iron water	Iodophor	25
Plastic crates	Iodophor	25
Porous surface	Active chorine	200
Aluminum Processing equipment	Quat Iodophor	200 25
Stainless Steel Processing Equipment	Acid sanitizer Acid-Quat Active chlorine Iodophor	130 Per manufacturer recommendations 200 25
Rubber belts	Iodophor	25
Tile walls	Iodophor	25
Walls	Active chlorine Quat Acid-Quat	200 200 Per manufacturer recommendations
Wood crates	Active chlorine	1,000

Sanitizers work best when they are used at the appropriate temperature for the surface being sanitized and used at the appropriate strength.

Cleaning and Sanitizing Systems[1]

Mechanical cleaning and sanitizing equipment can cut the time spent on cleaning and make cleaning more efficient. A good mechanical cleaning system can cut labor costs 50% and should pay for itself in less than 3 years. A mechanical cleaning unit can do a better job of removing soil from surfaces than hand cleaning. Skilled employees should be chosen to operate the cleaning equipment and technical representatives from chemical companies should work with individual establishments to recommend specific cleaning equipment and cleaning formulations to be used for specific operations in the establishment.

Properly designed cleaning-in-place (CIP) systems can clean some equipment in food plants just as well as when it is dismantled and cleaned by hand. The typical cycle in a CIP system is a preliminary rinse (hot or cold water) to remove most soil, followed by a detergent wash to remove the remaining soil, followed by a rinse to remove the cleaning compounds, followed by a sanitizer to destroy remaining microorganisms. Depending on the sanitizer used, a final rinse may be utilized to remove CIP solutions and sanitizers.

Summary

Cleaning operations consist of four steps—pre-rinse, cleaning, post-rinse and sanitizing. Most cleaning compounds used in the food industry are blended products. The type of surface to be cleaned affects the type of soil that collects and how it is removed. The type of soil determines which cleaning compound can be used most effectively. It is important to select the correct cleaning compound to remove a specific type of soil. Manufacturers combine ingredients to make a specific product for a particular type of surface or dirt. Sanitizers are used immediately after cleaning to reduce pathogenic and spoilage organisms on equipment. Any soil deposits remaining on the equipment after cleaning can reduce the effectiveness of a sanitizer through a dilution effect and reaction of the organic material in the soil with the sanitizing compound. Sanitizer work best when they are used at the appropriate temperature for the surface being sanitized and used at the appropriate strength.

References

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