WINS -- How Soil is Removed from a Surface in CIP

Soil Removal is a Multi-Step Process. Soil is Removed Layer by Layer. Velocity: Need to say more?
• Action of cleaning solution alone will not remove the last residual layer of the soil deposit. This can only be attacked & removed by a detergent after a suitable reaction time.

• The reaction time is the time the detergent is in contact with the deposit at the right concentration and the right temperature.
WINS -- Surface
Composition: (See Presentation -- Metal Presentation)

- Aluminum
- Stainless Steel
  - 304
  - 316
- Gasket
  - Buna N
  - EPDM
  - Viton

Texture
- Rough
- Smooth

Shape

Gasket on Stainless Steel Pipe
Gaskets

Surface of Buna-N Gasket

Biofilm with extra-cellular matrix on Buna-N

*S. typhimurium*
Application of Detergents

Application

Exteriors of Food Processing Equipment
- Clean
- Sanitize

Drains
- Clean
- Sanitize

Small Parts (Gaskets; Tees; Valves)
- Clean
- Sanitize

Type of Detergent

Method: Foam
- Chlorinated Alkaline (Oxofoam)
- NaOCl/Quat (Dibac/D’Trol)
  - Double Sanitizing Employed

Manual: Bucket & Brush (Black)
- Chlorinate Alkaline (Diton B)
- Quat (Quat 256)

COP (Clean out of Place)
- Chlorinated Alkaline (Whirl)
- Hard Surface – Acid Anionic (Demand)
- Soak Solution – Iodine (Accord II)
## Application of Detergents

### Application

<table>
<thead>
<tr>
<th>Tanks/Silos/Processing Lines</th>
<th>Type of Detergent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean</td>
<td>CIP (Clean in Place) Non-Foaming</td>
</tr>
<tr>
<td>Sanitize</td>
<td>▪ Chlorinated alkaline (Benefit/Dioklor)</td>
</tr>
<tr>
<td></td>
<td>▪ Acid anionic (FSD–34)</td>
</tr>
<tr>
<td></td>
<td>CIP (Clean in Place) Non-Foaming</td>
</tr>
<tr>
<td></td>
<td>▪ Chlorinated alkaline (Interest)</td>
</tr>
<tr>
<td></td>
<td>▪ High Alkaline (Cipton)</td>
</tr>
<tr>
<td></td>
<td>▪ PPA Sanitizer (Divosan Acitv)</td>
</tr>
</tbody>
</table>

| Fillers | ▪ Clean |
|         | ▪ Sanitize |

| Fryers (Boilout) | ▪ Soak |
|                 | ▪ Powder phosphated caustic (Delvak) |
|                 | ▪ Additives: Foam Control (Tendec) Additional Chelation (Kompleet) |
|                 | ▪ New equipment — Bubbler |

<table>
<thead>
<tr>
<th>Descaling (Removing Mineral Build-up)</th>
<th>Manual/Foam/CIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment Exteriors &amp; Interiors</td>
<td>▪ Stainless Steel (Super Dilac, Acifoam)</td>
</tr>
<tr>
<td></td>
<td>▪ Soft metals – Attitude</td>
</tr>
<tr>
<td>Application</td>
<td>Type of Detergent</td>
</tr>
<tr>
<td>----------------------</td>
<td>--------------------------------------------------------</td>
</tr>
<tr>
<td>Casewashing</td>
<td>Spray Washing</td>
</tr>
<tr>
<td></td>
<td>- Non-Foaming Alkaline Detergent (Solvent cleaner, APC NS)</td>
</tr>
<tr>
<td></td>
<td>- Quat Sanitizer (D’Trol)</td>
</tr>
<tr>
<td>Floors</td>
<td>Solvent/Degreaser/Good Soil Suspension</td>
</tr>
<tr>
<td></td>
<td>- Alkaline, soft metal safe (Super Takeoff; Radiaze)</td>
</tr>
<tr>
<td>General (Bucket &amp; Brush)</td>
<td>High Foam (Chlorinated or Non-Cl₂)</td>
</tr>
<tr>
<td></td>
<td>- Non-Caustic (Multiclean; Shurclean Plus)</td>
</tr>
<tr>
<td>HTST/Jacketed Mixers (Or other heat transfer equipment)</td>
<td>CIP or Modified Soak</td>
</tr>
<tr>
<td></td>
<td>- Alkali (Resource, Spectak G)</td>
</tr>
<tr>
<td></td>
<td>- Acid (Descale, Non-Stick)</td>
</tr>
<tr>
<td></td>
<td>- If Needed, Sanitizer (Demand)</td>
</tr>
</tbody>
</table>
Putting in all Together

Our Challenge
How do we Know if a Surface is Clean?

What Everyone Can Do
1. Appearance: Visible Debris/Odor
2. Water Break Free Surface
3. Biological Growth in Area (i.e. Machinery Mold)

Microbiological Tests
1. Swabs
2. Rinse Samples
3. ATP

Use Statistical (SPC) & Management (TQM) Tools to Evaluate the Data Obtained.
What is a H₂O Break Free Surface?
II. Sanitizers

There are many antimicrobial materials:

@ Natural oils: clove, garlic, and orange oils.
@ Organic compounds: aldehydes, esters, and fatty acids.
@ Inorganic compounds: Ag & Hg salts.
@ Oxidizers such as chlorine, peroxides, and nitric acid.

Chemical sanitizers are isolated from these compounds.
Sanitizer

Older definition, came about around 1900 to address unclean dishes/utensils in restaurants.

Quickly destroys disease causing or pathogenic organisms.

Does not adversely affect the equipment, product, or health of the consumer.

Sanitizers used in food plants must be EPA registered & meet the requirements set forth in the Code of Federal Regulations (21CFR178.1010).
Worth Repeating........

![Bacterial Growth Curve](image)

- **Lag Phase**
- **Log Phase**
- **Stationary Phase**
- **Death or Decline Phase**

**Y-axis:** Log Number of Viable Cells
**X-axis:** Time in Hours

*Image Source: Diversey*
1. Sanitizer are applied as the final step in the cleaning process.
2. Re-sanitize, if time between completion of sanitation and start-up exceeds 4 hours.

The purpose of the sanitizer is to make the lag phase as long as possible!!!
Effect of Cleaning & Sanitizing on Microbial Growth Within Production
Today, the Common Means of Sanitizing in Food Plants

Heat

Chemical
# Hot H₂O Sanitizing

**185 °F/15 Minute Contact Time. Correct Time & Temperature Combination is Critical!**

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Usually Available</td>
<td>• Slow (Ramp up, then Down)</td>
</tr>
<tr>
<td>• Broad Spectrum</td>
<td>• Film Forming (Ca²⁺ salts have inverse solubility.)</td>
</tr>
<tr>
<td>• Non-Corrosive</td>
<td>• Creates Condensate</td>
</tr>
<tr>
<td>• Penetration</td>
<td>• Equipment Damaging</td>
</tr>
<tr>
<td></td>
<td>• Safety</td>
</tr>
<tr>
<td></td>
<td>• Cost</td>
</tr>
</tbody>
</table>
What is a Registered Chemical Sanitizer?

Criteria:

1. Produces a fast microbiological kill
   - 5 logs (100,000 fold) in 30 seconds

2. Used for treatment on a **cleaned** surface for destroying pathogenic organisms.

3. Sanitizers are utilized at relatively low concentrations to reduce total vegetative cell population to a "safe level".
Sanitizers Used Today

SANITIZER CATEGORIES

OXIDIZING

Chlorine
Iodine
Mixed Halogen – ICl

PEROXIDE

PERACETIC ACID

NON-OXIDIZING

SURFACTANT

ACID ANIONIC
QUATERNARY AMMONIUM
(Not used for CIP)

Diversey
for a cleaner, healthier future
Sanitizers -- NaOCl

**Examples:**

- **Inorganic Chlorine**
  - Sodium Hypochlorite
  - **NaClO** + **H2O** → **HClO** + **Na** + **H2O**
  - Active Agent: Hypochlorous Acid
    - **HClO**

- **Organic Chlorine**
  - Sodium Dichloroisocyanurate
  - **R2NC1** + **H2O** → **R2NH** + **HClO**
  - Active Agent: Hypochlorous Acid
    - **HClO**

### Properties Table:

<table>
<thead>
<tr>
<th>Properties</th>
<th>Inorganic Cl2</th>
<th>Organic Cl2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germicidal Activity/Speed</td>
<td>high / fast</td>
<td>high / fast</td>
</tr>
<tr>
<td>Microbial Range</td>
<td>bacteria, fungi, yeast, sometimes spores</td>
<td>bacteria, fungi, yeast, sometimes spores</td>
</tr>
<tr>
<td>Form</td>
<td>liquid, powder</td>
<td>powder</td>
</tr>
<tr>
<td>Stability</td>
<td>keep at room temp or colder</td>
<td>good</td>
</tr>
<tr>
<td>Irritancy</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Diluted Stability</td>
<td>good, room temp</td>
<td>good</td>
</tr>
<tr>
<td>Use Concentration</td>
<td>100 to 200 ppm</td>
<td>100 ppm</td>
</tr>
<tr>
<td>Use pH Requirement</td>
<td>10 or less</td>
<td>8 or less</td>
</tr>
<tr>
<td>Use Temperature</td>
<td>room temp, max 130</td>
<td>room temp, max 130</td>
</tr>
<tr>
<td>Use Solution Corrosion</td>
<td>moderate</td>
<td>low</td>
</tr>
<tr>
<td>Effect of Soil Presence</td>
<td>decreases efficacy</td>
<td>decreases efficacy</td>
</tr>
<tr>
<td>Effect of Water Hardness</td>
<td>no effect below 500 ppm hardness</td>
<td>no effect below 500 ppm hardness</td>
</tr>
</tbody>
</table>

---

Examples:

**Inorganic Chlorine**
- Sodium Hypochlorite
  - **NaClO** + **H2O** → **HClO** + **Na** + **H2O**
  - Active Agent: Hypochlorous Acid
    - **HClO**

**Organic Chlorine**
- Sodium Dichloroisocyanurate
  - **R2NC1** + **H2O** → **R2NH** + **HClO**
  - Active Agent: Hypochlorous Acid
    - **HClO**
Sanitizers -- NaOCl

ADVANTAGES

- effective on wide variety of microorganisms
- inexpensive
- not affected by hard water
- available in liquid or powder

DISADVANTAGES

- corrosive to gaskets & soft metals
- irritating to skin and tissue
- effectiveness decreases with presence of organic matter
- effectiveness decreases with solution pH increase
- available chlorine dissipates with exposure to light and high temps
Sanitizers -- Iodine

Examples:

- **Iodophors**: A solution of surfactant and complexesed elemental iodine in acid
  \[ \text{Surf} + \text{I}_2 + \text{H}_2\text{O} \rightarrow \text{I}_2 + \text{HIO} \]

- **Tri-Iodine Complex**: Iodine dissolved in alcohol and formulated with an acid
  \[ \text{I}_3 + \text{OH} + \text{H} \rightarrow 3\text{I}_2 \]
Sanitizers -- Iodine

Advantages

 less irritating to skin than chlorine
 less corrosive to equipment than chlorine
 not as sensitive to organic load as chlorine
 color indicates presence

Disadvantages

 may discolor equipment
 increased pH decreases bacterial activity (above a pH of 8 converts to iodide)
 should not be used above 120° F
Sanitizers --
Mixed Halogen

Mixed halogen: Chlorine and iodine (I-Cl) in a nitric acid medium.
Sanitizing concentration: 1 oz per 18 gal water (12.5 ppm halogen)
## Sanitizers -- Mixed Halogen

### ADVANTAGES
- Effective against a wide spectrum of organisms
- Fastest acting of all oxidizers
- Non-foaming
- Mildly passivating
- Not as sensitive to organic load as chlorine
- Low environmental impact

### DISADVANTAGES
- Corrosive to soft metal
- Increased pH decreases bactericidal activity (active to pH 6.5)
- Should not be used above 120°F
Sanitizers -- Peracetic Acid

- **Examples**

  - equilibrium system between acetic acid, hydrogen peroxide and peracetic acid

  \[
  \text{CH}_3\text{-COOH} + \text{H}_2\text{O}_2 \overset{\text{==}}{\rightleftharpoons} \text{CH}_3\text{-COOOH} + \text{H}_2\text{O}
  \]

  **Active Agent: Peracetic Acid**

<table>
<thead>
<tr>
<th>PROPERTIES</th>
<th>PERACETIC ACID</th>
</tr>
</thead>
<tbody>
<tr>
<td>GERMICIDAL ACTIVITY/SPEED</td>
<td>high / fast</td>
</tr>
<tr>
<td>MICROBIAL RANGE</td>
<td>bacteria, yeast, mold</td>
</tr>
<tr>
<td>FORM</td>
<td>liquid</td>
</tr>
<tr>
<td>STABILITY</td>
<td>good</td>
</tr>
<tr>
<td>IRRITANCY</td>
<td>yes</td>
</tr>
<tr>
<td>DILUTED STABILITY</td>
<td>good at room temp</td>
</tr>
<tr>
<td>USE CONCENTRATION</td>
<td>125 to 200 ppm</td>
</tr>
<tr>
<td>USE pH REQUIREMENT</td>
<td>between 3 to 6</td>
</tr>
<tr>
<td>USE TEMPERATURE</td>
<td>room temp</td>
</tr>
<tr>
<td>USE SOLUTION CORROSION</td>
<td>possible on soft metals</td>
</tr>
<tr>
<td>EFFECT OF SOIL PRESENCE</td>
<td>decreases efficacy</td>
</tr>
<tr>
<td>EFFECT OF WATER HARDNESS</td>
<td>limited effect</td>
</tr>
</tbody>
</table>
## Sanitizers -- Peracetic Acid

### ADVANTAGES
- Effective against wide variety of microorganisms
- Environmentally safe - biodegradable
- Can be used in carbon dioxide environment

### DISADVANTAGES
- Pungent odor
- Concentrate is irritant
- Concentrate will react with metals
Sanitizers -- Acid Anionic

Acid Anionics are formulated with anionic surfactants (negatively charged) and phosphoric acid or organic acids.

<table>
<thead>
<tr>
<th>PROPERTIES</th>
<th>ACID ANIONICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>GERMICIDAL ACTIVITY/SPEED</td>
<td>good / good</td>
</tr>
<tr>
<td>MICROBIAL RANGE</td>
<td>broad bacteria spectrum</td>
</tr>
<tr>
<td>FORM</td>
<td>liquid</td>
</tr>
<tr>
<td>STABILITY</td>
<td>good</td>
</tr>
<tr>
<td>IRRITANCY</td>
<td>yes, acids are corrosive</td>
</tr>
<tr>
<td>DILUTED STABILITY</td>
<td>excellent</td>
</tr>
<tr>
<td>USE CONCENTRATION</td>
<td>200 to 400 ppm</td>
</tr>
<tr>
<td>USE pH REQUIREMENT</td>
<td>1.9 to 2.5</td>
</tr>
<tr>
<td>USE TEMPERATURE</td>
<td>wide range</td>
</tr>
<tr>
<td>USE SOLUTION CORROSION</td>
<td>possible for iron</td>
</tr>
<tr>
<td>EFFECT OF SOIL PRESENCE</td>
<td>decreases efficacy</td>
</tr>
<tr>
<td>EFFECT OF WATER HARDNESS</td>
<td>no effect</td>
</tr>
</tbody>
</table>

Acid Anionics are formulated with anionic surfactants (negatively charged) and phosphoric acid or organic acids.
### Sanitizers -- Acid Anionic

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>low corrosion on equipment</td>
<td>antimicrobial activity decreases with increasing pH</td>
</tr>
<tr>
<td><strong>not affected</strong> by hard water</td>
<td>may foam too much for some CIP systems</td>
</tr>
<tr>
<td>combines acidified rinse and sanitizing step</td>
<td>more expensive than other sanitizers</td>
</tr>
</tbody>
</table>
Sanitizers -- Quaternary Ammonium Compounds

Referred to as ‘quats’. Solutions of cationic charged surfactants. 1st generation quats are all the same chain length (n-alkyl dimethylbenzyl ammonium chloride). Dual chain and acid quats also are popular today.

<table>
<thead>
<tr>
<th>PROPERTIES</th>
<th>ACID ANIONICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>GERMICIDAL ACTIVITY/SPEED</td>
<td>varied/moderate</td>
</tr>
<tr>
<td>MICROBIAL RANGE</td>
<td>mold, yeast &amp; some bacteria</td>
</tr>
<tr>
<td>FORM</td>
<td>liquid</td>
</tr>
<tr>
<td>STABILITY</td>
<td>good</td>
</tr>
<tr>
<td>IRRITANCY</td>
<td>yes, acids are corrosive</td>
</tr>
<tr>
<td>DILUTED STABILITY</td>
<td>excellent</td>
</tr>
<tr>
<td>USE CONCENTRATION</td>
<td>200 to 1200 ppm</td>
</tr>
<tr>
<td>USE pH REQUIREMENT</td>
<td>3 - 10</td>
</tr>
<tr>
<td>USE TEMPERATURE</td>
<td>wide range</td>
</tr>
<tr>
<td>USE SOLUTION CORROSION</td>
<td>only with acid quats</td>
</tr>
<tr>
<td>EFFECT OF SOIL PRESENCE</td>
<td>decreases efficacy</td>
</tr>
<tr>
<td>EFFECT OF WATER HARDNESS</td>
<td>decreases efficacy</td>
</tr>
</tbody>
</table>
Sanitizers -- Quaternary Ammonium Compounds

**Advantages**

- non-irritating
- non-corrosive (except acid quats)
- relatively stable to organic matter
- active over wide pH range

**Disadvantages**

- moderate to high foaming
- leaves residual bacteriostatic film on most hard surfaces
- activity decreases with anionic contamination
- aerosols irritating
Factors That Effect the Performance of Sanitizers  1/3

Concentration - Increasing sanitizer concentration will generally enhance biocidal activity however, too much sanitizer can actually be detrimental. Label instructions should always be observed. Sanitizer concentrations should be checked by titration.

Water Hardness - Some sanitizers are incompatible with excessively hard water. Quats and iodophors are examples.

pH - Effectiveness of sanitizers is dependent on pH. Chlorine is most effective at pH 6-8.5.
Factors That Effect the Performance of Sanitizers  2/3

**Temperature** - The higher the temperature, the greater the biocidal effectiveness. The practical optimum temperature level for sanitation is 70° to 100° F.

**Time of Exposure** - Increasing the contact time results in greater kill of organisms.

**Cleanliness of Equipment** - Cleaner equipment results in greater sanitizer effectiveness. A dirty surface can’t be sanitized!!
Factors That Effect the Performance of Sanitizers  3/3

**Incompatible Agents** - Detergents remaining on equipment surfaces can inactivate sanitizers or decrease effectiveness. Alkaline detergents decrease the effectiveness of chlorine and iodine sanitizers. Anionic detergents and phosphates can inactivate QUATS.
Methods of Applying Sanitizers

SPRAY SANITIZING - use of spray devices to sanitize equipment surfaces
CIP SANITIZING - sanitizing by circulation of the chemical agent inside pipes, lines, and equipment
IMMERSION/COP SANITIZING - sanitizing equipment by immersion in a tank of sanitizing solution
FOGGING - fogging the chemical agent to sanitize the air and surfaces in a room
Today’s Concerns for Sanitizers

What are the concerns for today's sanitizers:

1. Hypochlorite reaction by-products in the environment:
   a. Trihalomethanes (THM)
   b. Chlorinated hydrocarbons
      1) Carcinogenic?
      2) Mutagenic?

2. Are sanitizers contributing to resistant strains of microorganisms in the environment?
Where is the Industry Going?

Chemical Side

- Automated systems
- More 'forgiving products'
- Greener
- Decrease of chlorine
- Chemicals composed of 'food grade' components
- Chemicals effective against allergens

Sanitizer Side

- Broader efficacy spectrum
- Decrease of hypochlorite
- Increased cost effectiveness
- Lower phosphorus loads
- Micro-emulsion Technologies
- Molecules with 'biorecognition'
ENERGY REQUIREMENTS

Largest emitters from coal fired plants
US Brewers spent $200MM in 2008
~ 3–8 % of cost
Water ratio >5:1
Energy costs for moving, heating, treating and disposing are 30% of the operating cost.
# Sanitizer Chemistry

<table>
<thead>
<tr>
<th>Product</th>
<th>Cost/ Kg E</th>
<th>Conc./ PPM</th>
<th>Cost/ m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halogen</td>
<td>1.5</td>
<td>.5—1.0</td>
<td>7.5—15</td>
</tr>
<tr>
<td>H2O2</td>
<td>2.3</td>
<td>.5</td>
<td>11.5</td>
</tr>
<tr>
<td>PAA</td>
<td>1.7</td>
<td>.3</td>
<td>5.1</td>
</tr>
<tr>
<td>ClO2</td>
<td>0.5</td>
<td>.5—2.0</td>
<td>.25—1.0</td>
</tr>
</tbody>
</table>

Source: Dr. Hans-Jörg Menger- Ludwingburg GmbH
Two Things to Remember:
First, A Dirty Surface Can’t be Sanitized!

- Soil
- MICROBES
- SANITIZER FLOW
Second: Gaskets Need Periodic Replacement

Broken/Cracked Gaskets are Excellent Harborage Areas for Biofilms!
The needs to be a gasket replacement program.
Questions???