Microbes in the Papermachine Environment

Linda Robertson
TAPPI Monograph: Microorganisms in Papermaking
Chapter 1

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Independent consulting for industry
Microbes in Paper System

- Bacteria: filamentous* & single-cell
- Fungi
- Protozoa*
- Ameba*
- Rotifers*
- Worms*
- Algae*

*primarily enter via inadequately treated water
Why do they grow?

- pH
- Temperature
- Oxygen Levels
- Nutrients
**pH Preference of Microorganisms**

- **Acid bisulfite process** (Orange Juice, pH 0-2)
- **Rosin sizing** (Pure Water, pH 7)
- **White water** (Neutral/alkaline sizing, pH 8-10)
- **Certain pigment systems** (Soap, pH 9-11)
- **Kraft liquors** (Ammonia, pH 12-14)

**Microorganisms**

- **Thiobacillus** (Most Sulfate-reducing Bacteria, pH 5-8)
- **Nitrobacter** (Most Nitrite-oxidizing Bacteria, pH 8-10)
- **Most Fungi** (pH 5-8)
- **Most Bacteria** (pH 7-10)
### Alkaline Vs. Acid

**Affect of pH on microbial growth**

<table>
<thead>
<tr>
<th></th>
<th>Acid</th>
<th>Alkaline</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Typical</strong></td>
<td>fungi</td>
<td>filamentous</td>
</tr>
<tr>
<td><strong>bacteria</strong></td>
<td>single cell bacteria</td>
<td></td>
</tr>
<tr>
<td><strong>Predominant</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>bacteria</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>Organisms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Typical</strong></td>
<td>filamentous bacteria</td>
<td>fungi</td>
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<tr>
<td><strong>Organisms</strong></td>
<td></td>
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<tr>
<td><strong>Minor</strong></td>
<td>protozoa</td>
<td>protozoa</td>
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<tr>
<td><strong>Organisms</strong></td>
<td>algae</td>
<td>algae</td>
</tr>
<tr>
<td><strong>Biocide</strong></td>
<td>1 X</td>
<td>2 - 4 X</td>
</tr>
<tr>
<td><strong>Needs</strong></td>
<td></td>
<td></td>
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</tbody>
</table>
Temperature Growth Ranges of Bacteria

- **Psychrophiles**
  - -10°C (-10°F)
  - 32°F (0°C)

- **Mesophiles**
  - 0°C (32°F)
  - 10°C (50°F)
  - 20°C (68°F)
  - 30°C (86°F)
  - 37°C (98.6°F)

- **Thermophiles**
  - 50°C (122°F)
  - 60°C (140°F)
  - 70°C (158°F)
  - 80°C (176°F)

- **Household Freezer**
  - -10°C (-10°F)

- **Refrigerator**
  - 0°C (32°F)
  - 10°C (50°F)

- **Human Body**
  - 37°C (98.6°F)

- **Paper Machines**
  - 122°F (50°C)

- **Starch Vats**
  - 140°F (60°C)

- **Board machines**
  - 158°F (70°C)

- **Temperature Growth Ranges of Bacteria**

- **37°C (98.6°F)**
  - Mesophiles

- **122°F (50°C)**
  - Paper Machines

- **140°F (60°C)**
  - Starch Vats

- **158°F (70°C)**
  - Board machines
Oxygen Requirements of Microorganisms

- **Acrobe** requires $O_2$ for growth
- **Facultative** can use $O_2$ if present but not required
- **Anaerobe** cannot use $O_2$, may be poisoned by it
Why do we care about microbes?
Deposit scraped from machine & sheet defect

Deposit from foil pan containing fungi & bacteria

Sheet defect and hole

Plastic bag

Paper
Impact of microbes

• Reduced paper quality
  - Rejected paper
  - Loss of customers

• Machine downtime

• Decreased profitability
  - $14,000/hour loss due to downtime on high speed machine based on $700/ton paper price
Why do microbes grow?

- Machines contain:
  - Fluids
  - Diverse microflora
  - Wood fibers, fines, sugars
  - Fillers
  - Various additives
Nutrients

- Sunlight
- Sugars
- Contaminants
- Cellulose
- Lignin
- Other microbes
- Minerals
- *Dilute biocides*
i.e. machines contain:

Multiple & ideal niches for growth & Food!
Industry changes resulting in increased microbial problems:

- High speed machines
  - Increased surface area at wet end/high misting
- Alkaline pH
- Increased filler levels
- Increased recycle pulp
- Water system closure
- Lighter weight grades
- Boilout interval changes
Detrimental microbial activity

• Deposits
  - Biofilm formation
  - Sheet defects

• Spoilage
  - Less visible often overlooked
  - Frequently occurs in:
    • Chests
    • Additives
Microscopy of deposits

• Brightfield
• Stains
• Phase contrast
Unicellular bacteria

- Endospore stain of *Bacillus* colony
- Cells rod shaped
- Endospores green (malachite)
- Vegetative cells red (safranin counter stain)
Bacterial Growth

Vegetative Cells

Cell Growth
MYTH

• If counts go up from 2 million to 1 million
• **YOU ARE IN terrible SHAPE!!!**

• Unlike Enron or your bank account there is no statistical significance between 1 million and 2 million.
PLATE COUNT

1.0 mL

10^0 1 mL

9.0 mL 10^1

9.0 mL 10^2

9.0 mL 10^3

Petrifilm

PaperCon 2011 Page 2330
Myth

- With a “total” count you can identify and count all of the microbes in the system
- Not likely
  - many will not grow on the media you use
  - many will not grow in the standard incubation time period
  - many have probably never been identified!
Filaments

- Many species
- Form long stringers
- Alkaline to neutral machines

Phase-contrast 400x
Filamentous bacteria

Although “normal” bacteria they form long filaments that mat & trap materials. Many types have sheath structures that make them difficult to kill.
Fungi
Fungi AKA mold, yeast

- Form tough rubbery mats
- Different from bacteria genetically, respond to different biocides
- Seen in wet lap, recycle pulp, additives, acid machines, or alkaline using biocides with no anti-fungal activity
- End use product issue
  - Mold-proofing
• Algae enter the mill via inadequately treated water
  - Fresh
  - Run off
  - Outdoor clarifier

• They need light to grow
  - Produce chlorophyll

• Found around light sources

• Green spots on paper

• Safety hazards
“higher” life forms


Videos on request…….
Non-microbial deposits

- In addition to wood fibers, fibrils, fines and fillers other materials deposit

- Mimic microbes:
  - Strength additives
  - Uncooked starch granules
Fresh water

- All types of microbes enter mill via this route
- Filamentous bacteria, algae, protozoa, worms are so called “fresh water contaminates”
- Critical to control of machine
White water system

- Water is recovered and reused on machine
- Water filtered through saveall
- Issue covered in Chapter 5
Fiber-Virgin

Can be sterile if bleached with harsh chemistries

Then the microbes present come from dilution water

“Gentler” bleaching chemistries allow organisms to survive and/or thrive

Recycle water used for dilution can be heavily contaminated
Fiber-Broke Towers

Frequently heavily contaminated

Coated broke is loaded with nutrients to increase microbial activity

Anaerobic spoilage serious problem with pH depression, ORP reduction, fiber strength loss during storage
Fiber-Recycle

Often heavily contaminated
Peroxide bleaching may select for bacteria that produce catalase and consume the bleaching chemical
Reductive bleaching chemicals can inactivate common biocides
Long storage times lead to anaerobic bacterial activity
Fiber

- Dry lap
- Wet lap
  - Moisture allows growth
Machine surfaces

- Headbox
- Approach piping
- Frame

- Microbes prefer to attach to surfaces
- Prevention of adhesion critical to deposit control and reduction of sheet defects
Additives

- Nutrients for microbial growth
- Microbes destroy properties critical for functional properties
- Directly added/Indirectly in system via broke
Additives

- Dyes
- Polymers
- Fillers
  - Clay
  - TiO₂
  - Carbonate
- Protein
- Latex
Summary Chapter 1

• Microbial colonization of machines increases downtime and decreases profitability.

• Understanding the papermaking process and basic microbial physiology is essential in diagnosing and solving problems.

• Biofilms form deposits that lead to sheet defects.

• Microbial spoilage of additives and fibers can alter pH, cause odors, and reduce sheet strength and quality.
Chapter 3:
Control of Microorganisms in Papermaking Systems:
Development of Treatment Strategies

Authors: Lynda Kiefer & Tod Stoner

Presented by: Janet H. Woodward

Commitment makes the best chemistry.
Introduction

• Microbial contamination can cause numerous issues
  - Holes
  - Defects
  - Off-spec paper (e.g. liquid packaging)
• Typical deposits seen in a paper machine are a combination of organics, inorganics, and microorganisms
Key Elements of a Successful Microbial Control Program

• Engineering survey
• Microbiological survey
• Product selection
• Implementation / Follow-up
• Housekeeping
Engineering Surveys

- Three major systems of concern
  - Water
  - Stock
  - Additives

- Tank/Chests
  - Volumes / capacity / flows
  - Agitation
  - Sampling points
Engineering Surveys, Con’t

• Recycle lines / Dead legs
• Freshwater / Dilution water sources
• Temperature and pH
• Process additives
• Current biocide program
• Grades produced
Microbiological Survey

• General microbiological survey of machines
  - Visual observations, odors, collecting deposits, gathering production data

• Deposit analysis
  - Microbiological analysis of deposits
    • Can include wet mounts, simple stains, differential stains
    • Looking for type of organism(s) and quantity
  - Chemical analysis (inorganic salts, organics)
Microbiological Survey, Con’t

• Micro audit of process waters, additives, stock chests
  - pH and temperature should be noted
  - Plating for aerobic/anaerobic bacteria, fungi, other problem-causing organisms
## Paper Machine Deposit Analysis

<table>
<thead>
<tr>
<th>Inorganics</th>
<th>Organics</th>
<th>Biological</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>Fatty acids</td>
<td>Bacteria</td>
</tr>
<tr>
<td>Aluminum</td>
<td>Rosin acids</td>
<td>Fungi</td>
</tr>
<tr>
<td>Silica</td>
<td>Machine oils</td>
<td>Algae</td>
</tr>
<tr>
<td>Iron</td>
<td>Cellulose</td>
<td>Protozoa</td>
</tr>
<tr>
<td>Barium</td>
<td>Lignin</td>
<td>Nematodes</td>
</tr>
<tr>
<td>Clay</td>
<td>Dyes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Polymers (size)</td>
<td></td>
</tr>
</tbody>
</table>
Product Selection

• Microbiocides
  - Biocide (slimicide; quick killer)
    • Kills microorganisms
    • Used for wet-end applications
  - Biostat (preservative)
    • Inhibits reproduction; doesn’t necessarily kill
    • Used for stock, broke, and additive preservation
  - For an effective biocide program, have to consider:
    • Product
    • Contact time
    • Concentration
Product Selection

• Regulatory requirements
  - Environmental Protection Agency: All microbiocides must be registered
  - Food and Drug Administration: Four allowances that affect microbiocides used in the production of paper/board that may contact food
    • 21 CFR § 176.300: Wet-end applications
    • 21 CFR § 176.170: Dry-end applications where paper/board may contact aqueous or fatty food (strictest regulation)
    • 21 CFR § 176.180: Dry-end where paper/board may contact dry food (e.g. cereal boxes)
    • 21 CFR § 170.105: Adhesive applications
Product Selection

• Regulatory requirements
  - Parallel regulations in Canada and Europe

• Safety / Environmental
  - MSDS
  - Discharge permits
Product Selection

• Oxidizing biocides
  - Hypochlorous acid, hypobromous acid, chlorine dioxide, chloramine chemistries
  - May be “stabilized”; e.g. hydantoin
  - Typically applied on a continuous basis

• Organic biocides
  - Organosulfurs, organobromines, cationics, isothiazolones, and aldehydes
  - Typically applied on an intermittent dosing

• Non-biocidal technology
  - Enzymes, biodispersants, and adjuvants
Lab-Based Bioassay Screening (Biocide Dose Response Study)

Control          Biocide            Biocide             Biocide
Conc #1 Conc #2 Conc #3

Incubate with Aeration

Count Bacteria at Time = 0 and Appropriate Intervals

% Kill = 1 – \frac{\text{Treated Count}}{\text{Control Count}} \times 100
Biocide Dose Response Curve

% Kill

Biocide Dose (ppm)
Field Evaluation of Biocides (Biocide Pulse Test)

1. Biocide is pulse-fed (slug dosed) to a tank to achieve target dose immediately

2. Bacterial counts taken over time with no further biocide added

3. See effect of dilution
Monitoring and Follow Up

- Perform routine monitoring
  - Machine runnability, quality, defects, deposits, etc
- Compare new program to old one
Summary

• Monitor microbiological contaminants throughout the process
  - Utilize chemical analyses as needed
• Define biocide treatment with lab studies and confirm with field testing
  - Evaluate best options
• Follow biocide manufacturers recommended dosing and safety information
• Follow up with routine monitoring
  - Do not allow microbiological problems to get established; they are easier to prevent than to remove
Effect of Water Recovery & Reuse on Microbial Activity

Linda Robertson
TAPPI Monograph: Microorganisms in Papermaking
Chapter 5

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Water

• 21st Century severe competition for planet’s resources
• Historically mills sited near abundant water
• Water critical:
  - Pulping,
  - Chemical dilution
  - Process makeup, etc.
• Treatment of incoming and exiting water expensive
Costs of an Open System

- water treatment
- chemicals loss
- fines loss
- energy
Optimizing Water

• Conservation
  - Example: minimize water loss by shutting off continuously running hoses

• Water Reuse
  - Reclaim water from one source and use it in another without making changes to water quality

• Water recycling
  - Improve the water quality before reuse
  - Becomes more expensive
Degree of closure

• Difficult to define
  - zero effluent
  - tons or gallons of fresh water/ton of paper

• Grade specific
  - fine vs. board mill
  - many board mills zero effluent

• Water use
  - 1993 Panchapakesan
    • <19 m³/t good
    • 19-30 m³/t average
    • >30 poor
  - 2005 fine paper machines
    • 12-15 m³/t common
    • 9-11 m³/t frequent
    • China reports 5-6 m³/t
Changes in operational practices increase microbial problems:

- Water system closure
  - Noxious chemical cycle up
  - Nutrients cycle up
  - Stagnant chests
- Neutral to alkaline conditions allow anaerobes to thrive
- Increased use of recycle fiber
  - Coatings on paper
  - “Extra” nutrients and contaminants
  - “Poorer” quality recycle fiber
- Large chests constructed with long dwell times
- Reduced biocide programs due to cost constraints
Freeze dried/cycled up water

<table>
<thead>
<tr>
<th>Water Analysis</th>
<th>Inductively Coupled Plasma Argon Analysis:</th>
<th>Ion Chromatography:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>81</td>
<td>53</td>
</tr>
<tr>
<td>Calcium</td>
<td>46</td>
<td>&lt; 2.9</td>
</tr>
<tr>
<td>Magnesium</td>
<td>5.4</td>
<td>&lt; 2.9</td>
</tr>
<tr>
<td>Aluminum</td>
<td>1.5</td>
<td>&lt; 2.9</td>
</tr>
<tr>
<td>Iron</td>
<td>&lt; 0.1</td>
<td>&lt; 2.9</td>
</tr>
<tr>
<td>Potassium</td>
<td>2.5</td>
<td>55</td>
</tr>
<tr>
<td>Manganese</td>
<td>&lt; 0.1</td>
<td>120</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>&lt; 0.1</td>
<td>430</td>
</tr>
<tr>
<td>Sulfur</td>
<td>43</td>
<td>COD (Filtered)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>470</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1200</td>
</tr>
<tr>
<td></td>
<td></td>
<td>As received Concentrated</td>
</tr>
</tbody>
</table>
anaerobic problems

H₂S

Butyric

Odor

Propionic

Acetic

Toxic Gases

H₂

H₂S

Explosions

Acids

Toxic Gases

PaperCon 2011  Page 2376
Mill Safety Issues

• **H₂S & H₂** have caused deaths of workers in industry
  - Known problem
  - More serious in recycle systems

• **Hydrogen Sulfide**
  - Detected by the human nose at 0.1 ppm
  - 3 ppm the odor is objectionable
  - 10 ppm health affects are noticeable (headaches)
  - 100 ppm people lose their ability to smell.
  - By 300 ppm life threatening.
  - 1000 ppm the person goes into irreversible respiratory failure
  - Found at 55 ppm in gypsum mill
  - Linerboard 45-300 ppm over walk space & chests
ORP/oxidative reductive potential

- Available electrons measured with an ORP probe (platinum electrode) to give RELATIVE mV readings of oxidizing (+mV) or reducing (-mV) conditions.
- Typically a fine paper oxidizing program will have ORPs in the headbox in the range of +200 to +300 mV.
- Closed reductive systems will be lower.
RPTA & IPST
Survey of board mills

• Corrosion
  - *Not as severe as predicted*

• Presence of corrosion elements
  - *didn’t correlate to:*
    • extent of corrosion
    • degree of closure

• Minimize Problems by:
  - *Treating Recycled water*
  - *Upgrading construction materials*
Acidic microbial odors (VFA)

- Acetic vinegar
- Butyric rancid butter
- Valeric dirty socks manure
- Propionic Swiss cheese

Miscellaneous microbial odors

- Chloranisoles musty
- Geosmin musty
- 2-methylisoborneol musty
- H$_2$S rotten eggs at machine & air
- Putrescine putrid, nauseating

Hexanal green, fruity

- Butyric rancid butter

Butanal sharp, pungent

- Geosmin musty

Cleaning agents citrus, green

- Petrochemical Kerosene

Butanole medicinal

- Chlorophenols medicinal

Octanal citrusy, sweet, fruity

- 2-methylisoborneol musty

Putrescine putrid, nauseating

Hexanal green, fruity

Pentanal rancid, green

- Hexanal green, fruity

Heptanal green, soapy

Nonanal citrusy, sweet, fruity

- Heptanal green, soapy

Decanal fatty, sweet

- Nonanal citrusy, sweet, fruity

Autooxidized wood resins

- Octanal citrusy, sweet, fruity

Miscellaneous odors

- Decanal fatty, sweet

Examples of malodors in paper products

- Cleaning agents citrus, green
- Petrochemical Kerosene
- Chlorophenols medicinal
- Butanol sharp, pungent
- Putrescine putrid, nauseating
- Hexanal green, fruity
- Heptanal green, soapy
- Nonanal citrusy, sweet, fruity
- Decanal fatty, sweet

Miscellaneous odors

- Amines rotting fish
- Methyl isothiocyanate fishy, sulfur
- Styrene plastic
- 4-methyl-4-mercapto pentan-2-1 "catty"
- Oil based inks petroleum from printing solvent
- Perfume (recycle) flowery, spicy
White water system

- Water is recovered and reused on machine
- Water filtered through saveall
Microbiologically

- Treated whitewater for pulp dilution excellent
- Stagnant recovered water for dilution a serious problem
- Treated whitewater for starch makeup is still a problem due to endospores and amylase producers
Volatile Fatty Acid Odor Case Study

- Recycle mill with 2 machines with same furnish, water and additives
- Odor increased when water discharge decreased from 946 m$^3$/day to 340 m$^3$/day
- Paperboard from cylinder machine (#1 PM) had foul aroma
  - heavyweight stock (535 g/m$^2$) with a moisture content averaging 6%
- Paperboard from Fourdrinier (#2 PM) acceptable
  - lighter weight board (150-g/m$^2$) had slightly lower moisture content (5%)
VFA levels in finished board made from each machine

PM#1 board had complaints

<table>
<thead>
<tr>
<th></th>
<th>Acetic</th>
<th>Propionic</th>
<th>Butyric</th>
<th>Total VFA</th>
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</thead>
<tbody>
<tr>
<td>PM#1 Board</td>
<td>1006</td>
<td>142</td>
<td>192</td>
<td>1340</td>
</tr>
<tr>
<td>PM#2 Board</td>
<td>800</td>
<td>110</td>
<td>124</td>
<td>1034</td>
</tr>
</tbody>
</table>
VA levels in process waters conducted at the mill site for 5 months.
VA & VFA matched set comparison of process fluids and board

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Volatile Acids*</th>
<th>&quot;Total&quot; VFA**</th>
<th>Acetic**</th>
<th>Propionic**</th>
<th>Butyric**</th>
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</thead>
<tbody>
<tr>
<td>PM#1 vat cylinder water</td>
<td>2025</td>
<td>1895</td>
<td>1400</td>
<td>160</td>
<td>335</td>
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<tr>
<td>PM#2 tray water</td>
<td>2088</td>
<td>1860</td>
<td>1370</td>
<td>160</td>
<td>330</td>
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<tr>
<td>PM#1 Board</td>
<td>no data</td>
<td>2545</td>
<td>1930</td>
<td>175</td>
<td>440</td>
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<tr>
<td>PM#2 Board</td>
<td>no data</td>
<td>1530</td>
<td>1140</td>
<td>130</td>
<td>260</td>
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</tbody>
</table>

*HACH method
**GC method

Reported as parts per million
Key Discoveries

• Board formed on #1 machine had higher VFA concentrations and odor complaints

• Both machines had:
  - Similar populations
  - Similar ORP Ranges
  - Similar VFA levels in the fluids
  - Similar biocide programs

• Moisture content:
  - #1 is 6%
  - #2 is 5%

• Less VFA is volatilized during drying in the high odor paperboard
VFA Case Study

- Understanding machine operations, microbial metabolism and how this influenced odor in the finished board led to changes in biocide program.
- Lower VFA targets needed on machine producing the heavyweight board due to higher carryover of VFA.
- The problem-solving approaches and program changes used at this mill nearly eliminated odor complaints.
Biocides and closure

• Certain biocides may not function as well under changed ORP conditions
  - Isothiazolins/DBNPA/etc.

• Oxidant demand can increase dramatically
  - Chlorine/bromine/and other oxidants

• Odiferous biocides like carbamate may be more noticeable

• Tolerance or resistance may develop more rapidly
  - Glutaraldehyde/quaternary ammonium compounds/peroxides/isothiazolins/etc.

• Requires knowledge to manage and avoid problems
Water Sources

• Well, reservoir, river
  - Normally easiest to treat and purest
  - Use for chemical dilution---nutrients: protein starch
• Water reused within mill
  - Known quantity
  - Best used for pulp dilution, showers
• Biologically stabilized water
  - Reduces sugars/BOD
  - Reduces VFA odor on machine
  - Purple water in California
• Reverse Osmosis
  - Closest to freshwater
Summary

• Water Reuse is achievable with proper planning

• This avoids
  - Anaerobe problems
  - Odors
  - Hazardous gases

• Biocides
  - may need to change type
  - may need to increase dose
Chapter 6: Boilouts – Chemical Cleaning Programs

Author: Doug Caulkins

Presented by: Janet H. Woodward

Commitment makes the best chemistry.
Definition - Boilout

• Noun: A chemical cleaning solution composed of alkaline, acid or enzymatic cleaning agents in combination with penetrants, dispersants and water

• Verb: A periodic chemical cleaning of the papermaking system under controlled pH and temperature conditions
Goals of a Boilout

• Remove organic and inorganic build-up in and on process equipment, tanks, lines, filters, chests etc
• Remove deposits that can break loose and cause holes and breaks
• Clean the forming fabric
• Housekeeping = Runnability
  - Regular boilouts combined with simple housekeeping measures can account for up to 60% of the overall success of a deposit control program
Benefits of a Boilout

• Prevent premature buildup of microbiological deposition
  - Reduce costs associated with slime control program

• Prevent corrosion pitting
  - Anaerobic activity underneath scale, stock, and biofilm cause microbiologically induced corrosion

• Control/eliminate scale formation
  - Long term scale deposits can restrict flow

• Removal of organic deposits
  - Can cause sheet defects if not removed
Boilout Components

• Caustic (Sodium Hydroxide)
  - 2-5% typical use level
  - Do not exceed pH 13
  - Enables saponification and emulsification of hydrophobic organic components
  - Kills slime forming bacteria and fungi

• Acid (Sulfuric)
  - Use level dictated by consumption during boilout
  - Critical to monitor pH and temp during boilout as potential for corrosion is higher than with caustic boilout
  - Mostly used to dissolve CaCO₃
Boilout Components

• Organic penetrants & dispersants
  - 0.1-0.5% typical usage rates
  - Main purpose is to speed up process by softening inorganic deposits

• Inorganic dispersants & chelants
  - Wide variety, tailored to specific types of inorganic deposits
  - Most act through anionic dispersion and crystal modification

• Foaming agents
  - Carry boilout solution to areas not normally reached

• Fiber
  - Scrubbing action
Typical Boilout Procedure

- Pre boilout wash-up
- pH of 12 - 12.5
  - P alkalinity must be maintained between 10,000-15,000 ppm
- pH 2 – 3 for acid
- Temperature of 130° - 145° F
- Re-circulation for 1 to 3 hours
- Post boilout wash-up - very important!
- Neutralization of boilout solution during dump to effluent
Alternatives to Traditional boilouts

• Enzymes
  - 0.1-0.5% typical usage rates
  - Proprietary combinations of dispersants and surfactants such as Buzyme® Boilout Programs
  - Effective in removing MB, starch, cellulosic and protein containing deposits
  - Alternative if high or low pH solutions are problematic

• Neutral pH Boilouts
  - Use of dispersants and penetrants with standard temperature and time
  - No adjustment of pH
Pre-boilout

After enzyme boilout
Summary

• Successful boilouts depend on:
  - Adequate time
  - Proper pH (alkalinity)
  - Correct temperature
  - Solution formulation
  - Proper wash-up after the boilout