THE IMPORTANCE OF WATER QUALITY AND AN OVERVIEW OF DETERGENT TECHNOLOGY.

HOW THEY GO HAND IN HAND

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OVERVIEW

- All about water
  - Why is it important?
  - How does it get to my department?
  - What do I need to know about it?
  - What can happen?
  - What does AAMI say?

- Insider look into detergents
  - What ingredients are in them?
  - What do they do?
  - How do they work?
  - What does AAMI say?
**Water Quality is Important?**

- Where is water used in CS/SPD?
  - Sinks
  - Sonics
  - Automatic Endoscope Reprocessors (AER)
  - Washer Disinfectors
  - Cart Washers
  - Sterilizers
WATER QUALITY IS IMPORTANT?

- Consider: in standard washing solutions, the amount of detergent is less than one percent
  - 1 oz/gal dose = 0.78% solution

- Over 99% of washing solution is the water

- Water quality has high prevalence
**WATER QUALITY IS IMPORTANT?**

- Bad water can effect:
  - Instrument quality
  - Washer effectiveness / life-span
  - Detergent efficacy
  - Sterilization itself
HOW DO DETERGENTS MATTER?

- Detergents contain “water conditioners”
  - Specialized ingredients
  - Attack the bad things in the water
    - Prevent the scale
    - Allow cleaning ingredients to work
  - Cost money
WHERE’S THE WATER COME FROM?

- **Aquifer**
  - an underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, silt, or clay) from which groundwater can be usefully extracted

- **Water treatment plant**
  - processes used to make water more acceptable for a desired end-use. These can include use as drinking water, industrial processes, medical and many other uses.

- **Facility**
Ogallala Aquifer
What about the water?

What “things” in the water affect the quality?

- Total Dissolved Solids
- pH
- Hardness
- Bicarbonate Alkalinity
- Chloride
- Iron
- Silica
- Phosphate
TOTAL DISSOLVED SOLIDS

- TDS, for short
- Calculated from measuring the conductivity of the water
  - The more “stuff”, the higher the conductivity
  - Does not distinguish between the “stuffs”
- A quick and general analysis of the water quality
- The higher the worse
- Typical results 1 – 1000 ppm
**pH**

- Normally not a big concern
- Only extreme values indicate a problem
- Scale from 0 – 14 (no units)
- Typical result: 6.0 – 9.0
- Neutral = 7.0
HARDNESS

- Calcium and/or Magnesium Carbonate
- CaCO$_3$ and/or MgCO$_3$
- Causes white rocky scale
- Builds up on washers, sterilizers, and instruments
- Causes lots of problems
  - Exacerbated by high temperature and high pH
- Typical results: 0 – 15 grains (0 – 250 ppm)
**Bicarbonate Alkalinity**

- Bicarb, for short
- Can also cause scale build-up like hardness
  - Is white too
  - More greasy than rocky
  - Exacerbates problems with hardness
- Typical results: 0 – 250 ppm
CHLORIDE

- The chlorine anion: Cl^-
- Corrodes metals, especially stainless steel
- Typical *natural* levels: 0 – 150 ppm
- Artificial sources: bleach, salt (saline), blood
  - For water treatment, from broken softener
  - Left over blood
  - Don’t soak instruments in saline or bleach
- Quat disinfectants
IRON

- Can and does naturally occur in water
- Forms deposits that show rusting
- Coats machines with residue
- Typical results: 0 – 5 ppm
Silica

- Silicon Dioxide: SiO$_2$
- Used as detergent ingredient for aluminum safety
- High levels in water plus high does of Al safe detergent can lead to silica deposition
- Impossible to remove from glass
- Typical results: 0 – 5 ppm
PHOSPHATE

- PO$_4$ (can be reported “as P”)
- Causes odd discolorations in right conditions
  - Blue/purple/green/gold
- Eutrophication
  - Has a bad rap
- Typical results: 0 – 10 ppm
Total Dissolved Solids (TDS)

County Avg (mg/l)
- 1.00 - 150.00
- 150.00 - 300.00
- 300.00 - 450.00
- 450.00 - 600.00
- 600.00 - 800.00
- 800.00 - 1200.00
- 1200.00 - 1600.00
- 1600.00 - 2000.00
CHANGES OVER SEASONS

- Dry seasons – Wet seasons
  - Water table level fluctuates
- Amount of “stuff” fluctuates
- Detergent doses need to accommodate
- Records help troubleshooting
CHANGES OVER SEASONS
# What Are the Levels?

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Low level</th>
<th>Med. level</th>
<th>High level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness (grains)</td>
<td>0 - 5</td>
<td>5 - 10</td>
<td>10+</td>
</tr>
<tr>
<td>Bicarb (ppm)</td>
<td>0 - 90</td>
<td>90 – 200</td>
<td>200+</td>
</tr>
<tr>
<td>TDS (ppm)</td>
<td>0 – 200</td>
<td>200 – 500</td>
<td>500+</td>
</tr>
<tr>
<td>Chloride (ppm)</td>
<td>0 – 60</td>
<td>60 – 90</td>
<td>90+</td>
</tr>
<tr>
<td>pH (no units)</td>
<td>5.0 – 6.0</td>
<td>6.0 – 9.0</td>
<td>9.0+</td>
</tr>
<tr>
<td>Iron/Silica (ppm)</td>
<td>0 – 2</td>
<td>2 – 4</td>
<td>4+</td>
</tr>
<tr>
<td>Phosphate (ppm)</td>
<td>0 – 5</td>
<td>5 – 10</td>
<td>10+</td>
</tr>
</tbody>
</table>
**Effects of High Levels**

- **Hardness**
  - Scale build-up
  - Rough instruments
    - Stiff hinges
    - Jammed box locks
  - Ineffective detergent
HIGH HARDNESS LEVELS
HIGH HARDNESS LEVELS
EFFECTS OF HIGH LEVELS

- Bicarb
  - Scale build-up
    - White, powdery/greasy
  - Exacerbates hardness problems
  - Can buffer detergent
    - Prevent pH change
Effects of high levels

- TDS
  - No specific effect
  - Depends on “stuffs”
  - General indication of water quality

- Chloride
  - Stainless steel pitting corrosion
  - Instruments and washers
HIGH CHLORIDE
HIGH IRON
HIGH IRON
HIGH PHOSPHATE
WHAT DOES AAMI SAY?

Advancing Safety in Medical Technology
AAMI TIR 34: 2007

“Water for the reprocessing of medical devices.”

- Importance of water quality
- Categories of water quality
- Selection of water quality
- Water treatment systems
- Monitoring water quality
- Strategies for bacterial control
- Personnel consideration
- Continuous quality improvements
CATEGORIES OF WATER QUALITY

- Potable Water: (water as it comes from the tap) requires no further treatment, provided that it meets some basic criteria. (described in table 1 on pages 14,15)

- Softened Water: “…water that received limited treatment (softening) to reduce scaling by replacing calcium and magnesium ions with more soluble sodium ions. This treatment process will not reduce microbial levels, nor will it remove organic material from the water.”
CATEGORIES OF WATER QUALITY

- Deionized Water: “…water that receives limited treatment (deionization) to remove inorganic material from the water. This treatment process will not reduce microbial levels, nor will it remove organic material from the water.”

- High-Purity Water: “…water that is extensively treated (usually by a multi step treatment process that may include a carbon bed, softening, DI, and RO or distillation) to insure that the microorganisms and the inorganic and organic material are removed from the water; a final submicron filtration may also occur as part of the treatment process.”
WATER TREATMENT METHODS

- Sediment Filters/Coarse Filtration
  - Removes particulates and relatively coarse particulate materials from incoming water.
  - Pre-Treatment for additional water conditioning.
  - Replacement of Filters.
  - Bed Filters contain multiple layers.

- Softening
  - Replaces calcium/magnesium with sodium
  - Improper maintenance can cause problems
WATER SOFTENER
WATER SOFTENER
WATER TREATMENT METHODS

- Carbon Filtration (Absorption)
  - Removal of Chlorine and Chloramines.
  - Replacement of filters. (Regenerated Carbon should not be used for medical reprocessing applications.)

- Reverse Osmosis
  - Removes dissolved inorganic solutes.
  - Removes microorganisms including bacterial endotoxins.
  - Requires regular maintenance including membrane replacement and pre-filter replacements.
Water Treatment Methods

- Deionization
  - Removes anions and cations.
  - Regular replacement of pre-treatment filters and regeneration of resin filters.
  - Does not remove bacteria and bacterial endotoxins.
  - Use as a primary means of purification is not recommended.

- Ultrafiltration
  - Membrane based device used to remove particles down to 1,000 daltons.
  - Can remove bacteria and endotoxins.

- Distillation
  - Removes bacteria, inorganic and organic solutes, and endotoxins.
  - Storage tanks require regular sanitizing.
  - Resistivity of the water requires regular monitoring.
MOVING ON TO DETERGENTS
IS IT SOAP? WHAT IS SOAP?

- Soap is saponified fat
- A detergent is anything used to clean something.
- Remove a residue from a substrate
- All soaps are detergents but not all detergents are soaps.
- Detergents in CS do not contain true soap.
WHAT IS TRUE SOAP?

- Saponification
  - An oil or fat is reacted with a high alkaline solution.
  - Hydrolyzation yields alkali salts of fatty acids (soap) and glycerin.
- Opaque
MODERN DETERGENTS

- Combine many different types of ingredients
  - Surfactants
    - Hydrotropes
    - Dispersants
  - Builders
  - Water conditioners
    - Chelants
    - Sequestrants
  - Alkalies / Acids
  - Enzymes
  - Preservatives
  - Other – dyes, fragrances, abrasives
- Clear / Transparent
**Surfactants**

- **Surface active agents**
- Have a head and tail like a tadpole
SURFACTANTS

- The “soapy” ingredient
  - Bubbles
  - Low-foaming surfactants
- Make water wetter
  - Decrease surface tension
  - Increase wetting angle
- Suspend solids
- Emulsify oils
MAKE WATER WETTER

decreasing surface tension : increasing wetting angle: more wetter
WETTER WATER WORKS BETTER
SURFACTANTS

- Solubilize water-insoluble soils by forming micelles
EMULSION
SURFACTANTS

- Hydrotrope
  - Micelle formation
  - Hydrophobic vs. hydrophilic
  - Lipophilic vs. lipophobic

- Dispersant
  - Improve separation of particles in a suspension
  - Prevent redeposition
MODERN DETERGENTS

Combine many different types of ingredients

- Surfactants
- Hydrotropes
- Dispersants
- Builders
- Water conditioners
  - Chelants
  - Sequestrants
- Alkalis / Acids
- Enzymes
BUILDERS

- Aid/upgrade cleaning action
  - Add some “umph”
- Protect cleaning efficiency of surfactants
  - Condition water
  - Prevent inactivation
- Phosphate, carbonate, silicate
- Soap Scum:
MODERN DETERGENTS

- Combine many different types of ingredients
  - Surfactants
  - Hydrotropes
  - Dispersants
  - Builders
  - Water conditioners
    - Chelants
    - Sequestrants
  - Alkalis / Acids
  - Enzymes
WATER CONDITIONER

- Chelant
  - Grab metal ions like a claw
  - Prevent combination with carbonate to form scale
  - EDTA, NTA(boo)

- Sequestrant
  - Think sequestered jury
  - Keeps hardness isolated
  - Prevents sticking to itself
EDTA
MODERN DETERGENTS

- Combine many different types of ingredients
  - Surfactants
  - Hydrotropes
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  - Builders
  - Water conditioners
  - Chelants
  - Sequestrants
  - Alkalies / Acids
  - Enzymes
ALKALI / ACID

- The general “work horse” of the product
- Hydrolysis
  - -lysis = to break apart
  - Hydro- = in the presence of water
- Breaks soils into smaller pieces
- Allows surfactants to solubilize them

- Machine application
  - Non-manual
MODERN DETERGENTS

- Combine many different types of ingredients
  - Surfactants
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  - Builders
  - Water conditioners
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  - Sequestrants
  - Alkalis / Acids
  - Enzymes
ENZYMES

- Are proteins, not biological beings
- Typically anthropomorphized
  - They “eat” stuff, too hot and they’ll “die”
- Pacman analogy
- Activity vs. Temperature
- Work because of their shape
  - Fold other proteins until they break
  - Target Specific
    - Protease, lipase, amylase
ENZYMES
TEMPERATURE vs. ACTIVITY

- low temp enzyme
- high temp enzyme

Temperature: 90°F, 150°F

Activity
DETERGENTS IN CS/SPD

- Categorized by chemistry
  - Alkaline
  - Acidic
  - Neutral
  - Enzymatic

- Categorized by application
  - Manual
  - Automatic
    - By machine phase
      - Pre-wash - enzyme
      - Mainwash – alkaline or neutral
      - Final Rinse - Rinse Aid / Lube
APPLICATION DEPENDENCE

- Throw the right chemical at the right soil
- Use the opposite chemistry

- Acid + Alkali (Base) → Salt + Water
- HCl + NaOH → NaCl + H₂O

- Opposite chemistries neutralize each other

- Organic vs. Inorganic soils
  - Organic: from a person
  - Inorganic: from the ground
SOIL DIFFERENCES

- **Organic**
  - Made of proteins, made of amino acids
    - “acidic” in nature
  - Opposite chemistry = alkaline

- **Inorganic**
  - Made of minerals, e.g. calcium carbonate
    - “alkaline” in nature
  - Opposite Chemistry = acidic
APPLICATION BY SOIL

- Alkaline detergents are used to clean organic soils
  - Protein, blood, fat, etc.
- Acidic products are used to clean inorganic soils
  - Hardwater scale, discoloration, rust, etc.
What does AAMI say?
AAMI RECOMMENDATIONS


- Comprehensive guide to steam sterilization and sterility assurance in health care facilities, aka “ST79”
  ○ 1 Scope
  ○ 2 Definitions and abbreviations
  ○ 3 Design considerations
  ○ 4 Personnel considerations
  ○ 5 Receiving
  ○ 6 Handling, collection, and transport of contaminated items
  ○ 7 Cleaning and other decontamination processes
  ○ 8 Packaging, preparation, and sterilization
  ○ 9 Installation, care, and maintenance of sterilizers
  ○ 10 Quality control
  ○ 11 Quality process improvement
  ○ 12 New product evaluation
ST79 Section 7

Cleaning and other decontamination processes

- 7.1 General rational
- 7.2 Policies, procedures, and manufacturers’ instructions
- 7.3 Presoaking
- 7.4 Disassembly
- 7.5 Cleaning
- 7.6 Microbicidal processes
- 7.7 Servicing and repair of devices in the health care facility
ST79 SECTION 7.5 CLEANING

- 7.5.1 General considerations
- 7.5.2 Cleaning agents
- 7.5.3 Methods of cleaning
- 7.5.4 Rinsing
- 7.5.5 Verification of the cleaning process
- 7.5.6 Cleaning of instruments
- 7.5.7 Utensils
- 7.5.8 Reusable textiles
- 7.5.9 Rigid sterilization container systems
7.5.2 Cleaning Agents

- Many types of soils
  - Dried blood especially difficult
    - present in difficult-to-clean locations
    - Coagulated/dried = not water soluble

- Need for good cleaning agents
  - High pH or enzymatic
  - Mechanical scrubbing / water spraying

- Primary cleaning = detergent solution
  - Ideal cleaning agent
7.5.2 Cleaning Agents

Ideal cleaning agent:
- a) be nonabrasive;
- b) be low-foaming;
- c) be free-rinsing;
- d) be biodegradable;
- e) rapidly dissolve/disperse soil;
- f) be nontoxic;
- g) be efficacious on all types of clinical soil;
- h) have a long shelf life; and
- i) be cost-effective.
MAINTAINING THE WASHING PROCESS

- Descaling
  - Water best holds its harness in cool temperatures with a low pH
  - Instrument decontamination = hot water with high pH
  - Scale build-up inevitable in some places
  - Descaling necessary
  - Get on a cycle
MAINTAINING INSTRUMENT QUALITY

- Start with quality
  - Inexpensive can be low quality
- Keep the quality
  - Don’t engrave
  - Handle well
  - Use proper detergents
- Maintain the quality
  - Instrument reclaiming
CHOOSING A DETERGENT

- For manual application
  - Neutral
  - Enzymatic

- Soaking or Sonic
  - Enzymatic
  - Sonic Detergent
CHOOSING A DETERGENT

- Automated / machine application
  - Pre-wash
    - Enzymatic
  - Main Wash
    - Alkaline
    - Neutral
  - Final Rinse
    - Lubricant
    - Rinse Aid
    - Acidic
CHOOSING A DETERGENT

- Little pre-processing / high soil load
  - Alkaline over neutral

- High hardness
  - High conditioning detergent
  - Rinse aid over lube
  - Possible acid in rinsing

- Unexpected scaling
  - Switch to a different water conditioner (from chelating to sequestering or visa versa)

- Aluminum
  - Neutral
  - Aluminum safe
Detergent Review

- Detergents rely on many types of ingredients to perform their functions:
  - Hydrolyze, solubilize, emulsify, condition
- Detergent selection is important
  - Throw the right chemistry at the right soil
  - Proper detergent selection for application
  - Quality detergents compensate for poor water quality
Water Quality Review

- Water is the biggest factor in cleaning
- Bad water can mess stuff up
  - Hardness scale, metal corrosion
- There are many ways to treat the water
  - Soften, DI, RO
- Purified water is limited
- Detergents pick up the slack
QUESTIONS?