# New Approaches to Improving Your Profitability by Controlling Spores

3-A SSI 2015 Education Conference

- The Bridge to Hygienic Design

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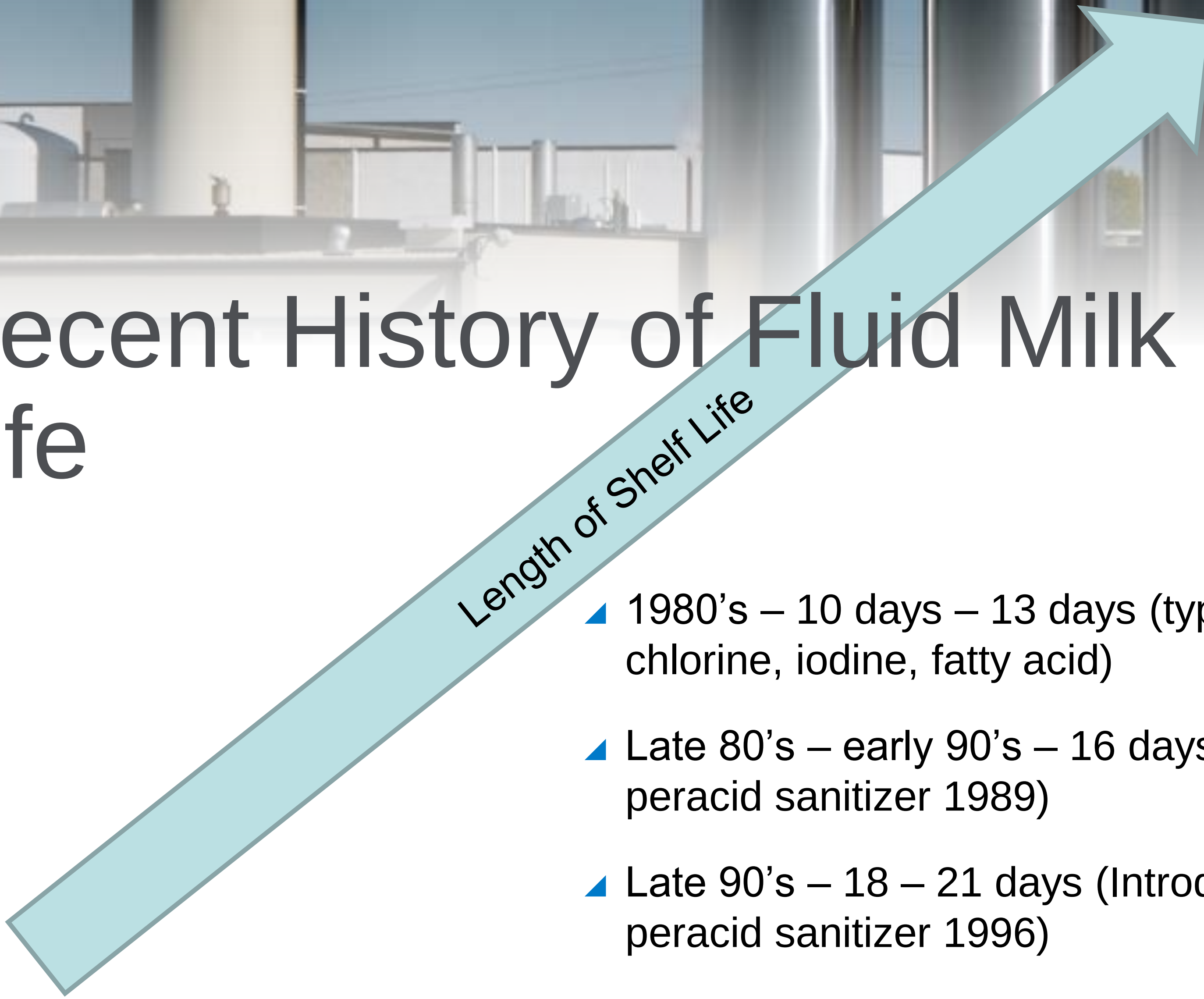
# AGENDA

- Recent history of dairy micro
- Issues preventing improved quality and shelf life
- Technology improvements to increase shelf life
- Potential benefits of new technology
- Potential drawbacks for new technology
- Next steps

# Recent History of Fluid Milk Shelf Life

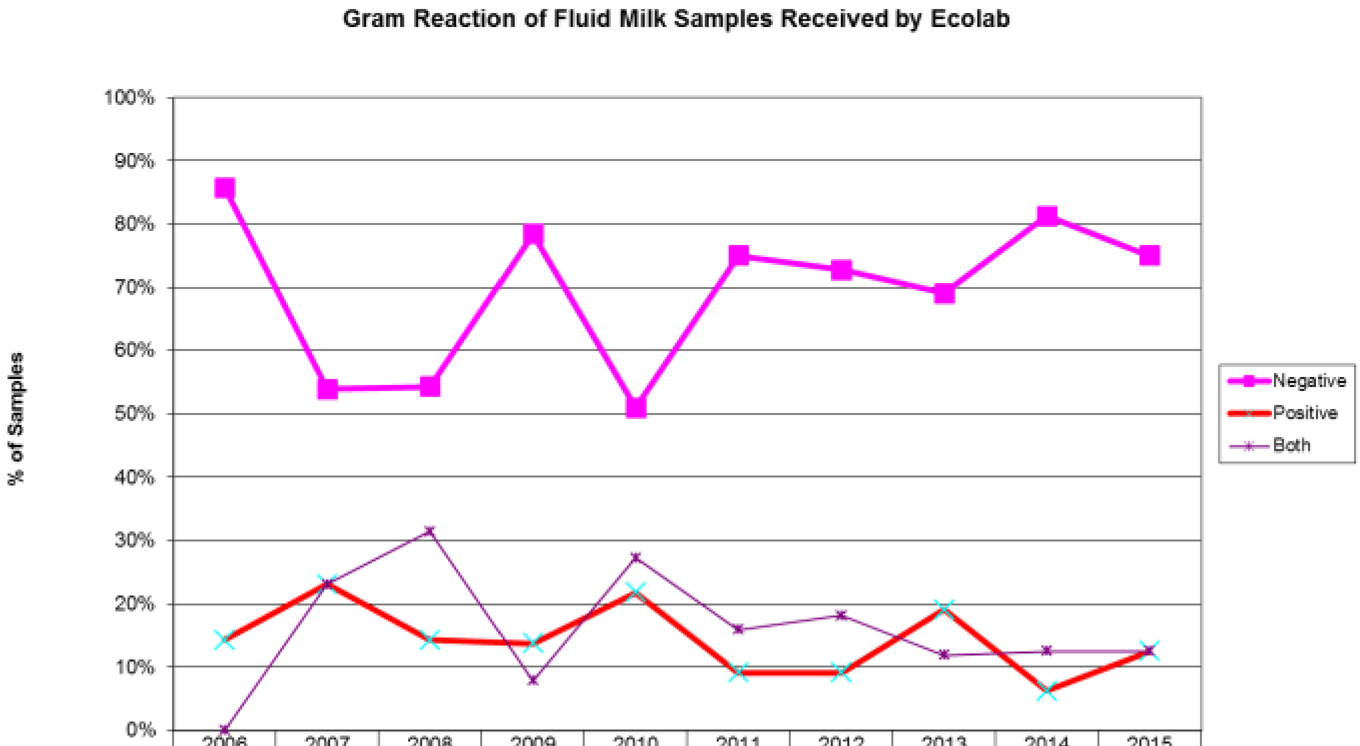



- 1980's – 10 days – 13 days (typical sanitizer - chlorine, iodine, fatty acid)
- Late 80's – early 90's – 16 days (Introduction of 1st peracid sanitizer 1989)
- Late 90's – 18 – 21 days (Introduction of mixed peracid sanitizer 1996)
- Today – Still at 21 days

# Causes of Spoilage

- Gram Negative Bacteria
  - Post pasteurization contamination
- Gram Positive Bacteria
  - Can survive pasteurization
- Heat Tolerant Enzymes
  - Rare occurrence but are due to raw milk issues

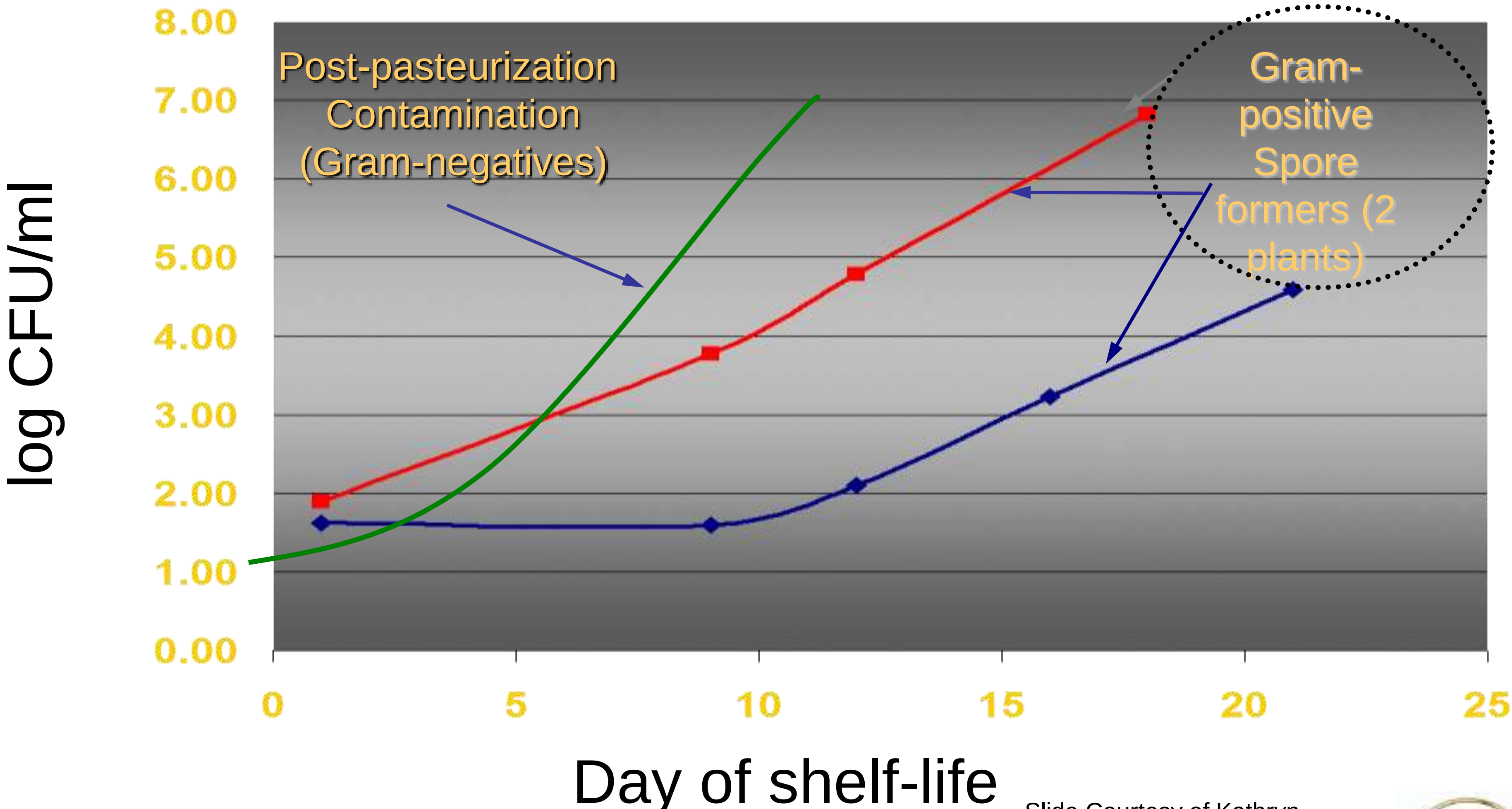
# As shelf life has increased, gram positive organism issues have too.




| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|
| Negative | 86% | 54% | 54% | 78% | 51% | 75% | 73% | 69% | 81% | 75% |
| Positive | 14% | 23% | 14% | 14% | 22% | 9% | 9% | 19% | 6% | 13% |
| Both | 0% | 23% | 31% | 8% | 27% | 16% | 18% | 12% | 13% | 13% |

Year

# Gram Positive organisms show up later than Gram Negatives



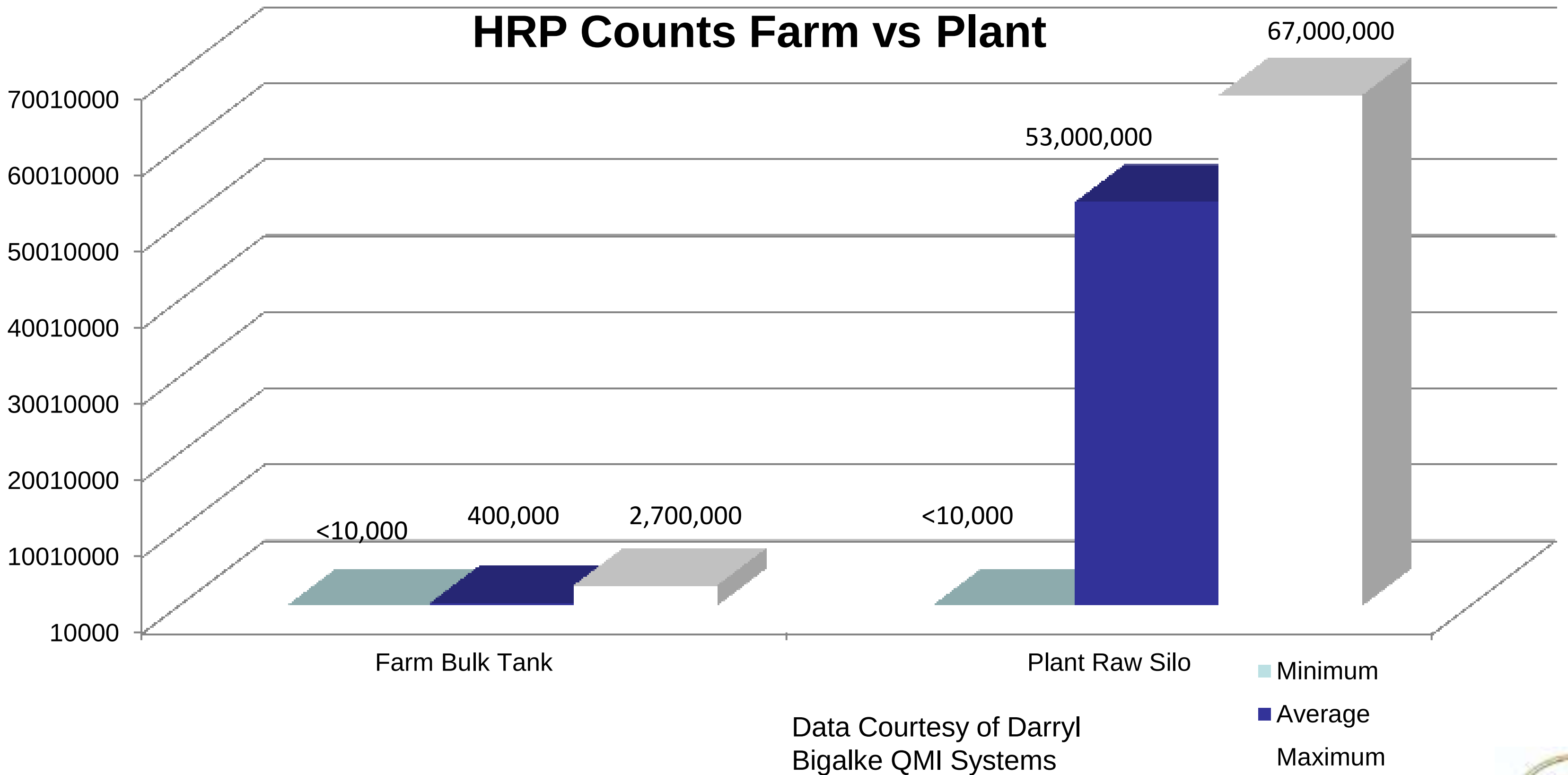

Slide Courtesy of Kathryn Boor Cornell University

# If good quality raw milk gets us to 21 days, how do we get beyond 21 days?

1. Keep it **Cold**, **Clean** and **Moving**
2. Sanitation done right all the time every time
3. Eliminate biofilms. *BIOFILMS START FORMING IN 8 HOURS*

# Where do heat resistant psychrotrophs (HRP's) come from?

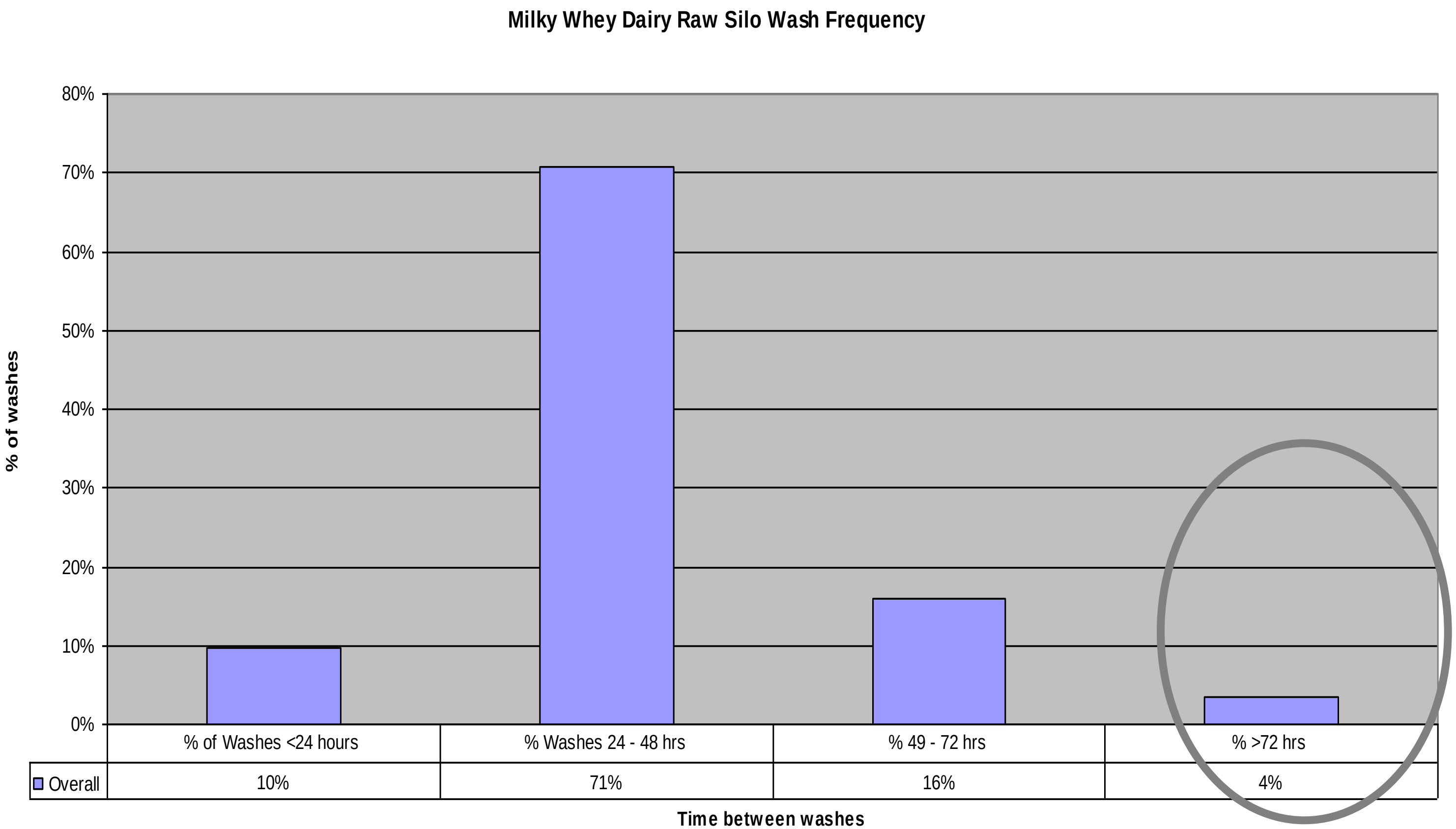
They originate on the farm and grow in the plant




Data Courtesy of Darryl Bigalke QMI Systems

# Where do heat resistant psychrotrophs (HRP's) come from?

## Raw Silo temperatures & Rotation



# Where do heat resistant psychrotrophs (HRP's) come from?

**One problem is the low level of contamination in the raw milk:**

- Dr Mansel Griffiths of the University of Guelph reported the average contamination level of Heat Resistant Psychrotrophs (HRP's) at 17 cfu/L ➔ *Chances of finding it in a typical 5 mL lab pasteurization (SMEDP 17$^{th}$ edition) sample is approximately 1 in 60*

Data Courtesy of Darryl Bigalke QMI Systems

# What are build-up points?

Paper from the Australian Journal of Dairy Technology Volume 47 – May 1992
***Bacterial Growth During Continuous Milk Pasteurisation*** – F.L. Lehmann, P.S. Russell, L.S. Solomon and K.D Murphy

"Total Bacterial numbers increased slightly over the initial 8-9 h, then more rapidly, sometimes exponentially, over the remaining period of operation, reaching in excess of one million per mL and exceeding the total bacterial numbers in the raw milk…. A 20 minute caustic miniwash of pasteurisers after 10 h of continuous operation was shown to reduce bacterial numbers in pasteurized milk…"

Biofilm

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*A 20 minute caustic miniwash of pasteurisers after 10 h of continuous operation was shown to reduce bacterial numbers in pasteurized milk…"*

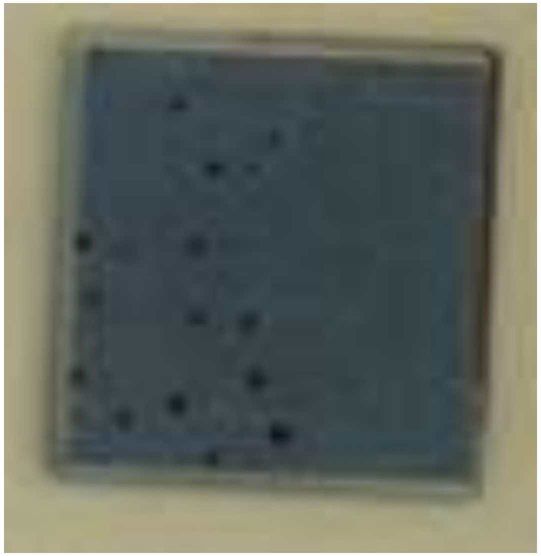
*Unfortunately this biofilm is not completely removed by conventional short washes and returns more quickly the second time*

Biofilm

# Biofilm Formation

- Vegetative cell population is needed to get spores
- Residual soil acts as hybrid biofilm/soil matrix
- Nooks and Crannies
  - Gasketed joints
  - Valves
  - Plate heat exchangers
  - Evaporators
- Low flow areas
- Biofilms generated/rejuvenated during long runs
- Spores quickly attach and are TENACIOUS

# Spores are TENACIOUS



$10^2$ cfu/ml spores in suspension

316 Stainless Steel coupons
Soaked in dairy plant isolate spore cocktail suspended in milk
Rinsed THOROUGHLY with sterile DI water
Covered in nutrient agar w/ metabolic dye (dark spots)

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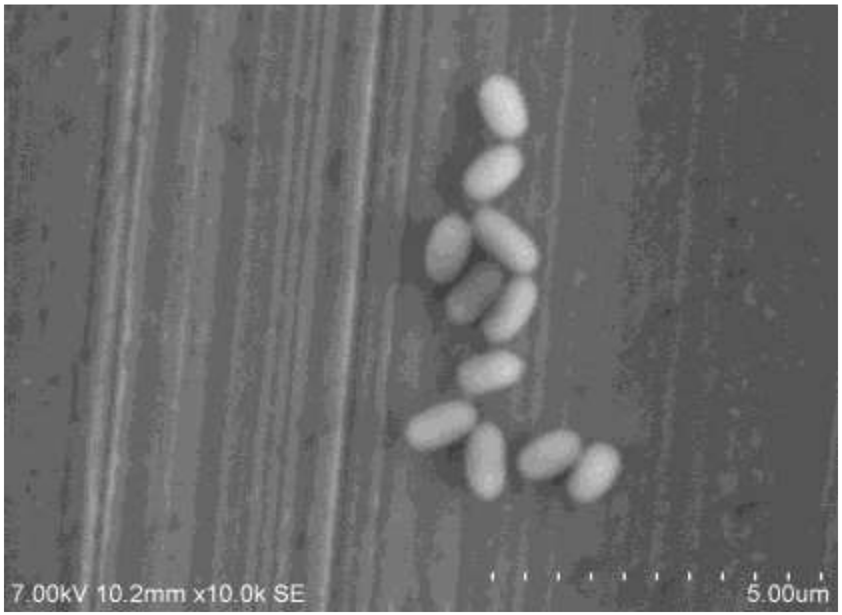
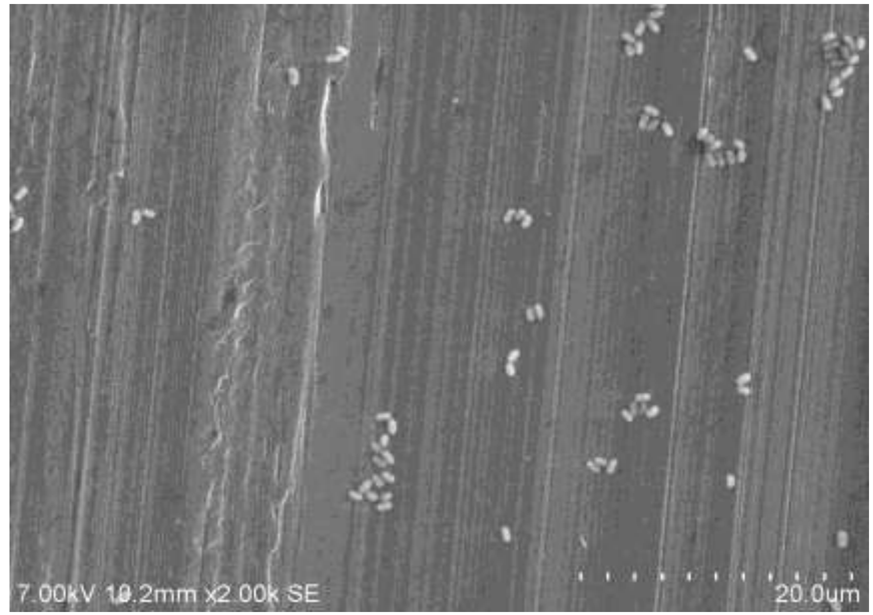
# Spore Adhesion to Stainless Steel

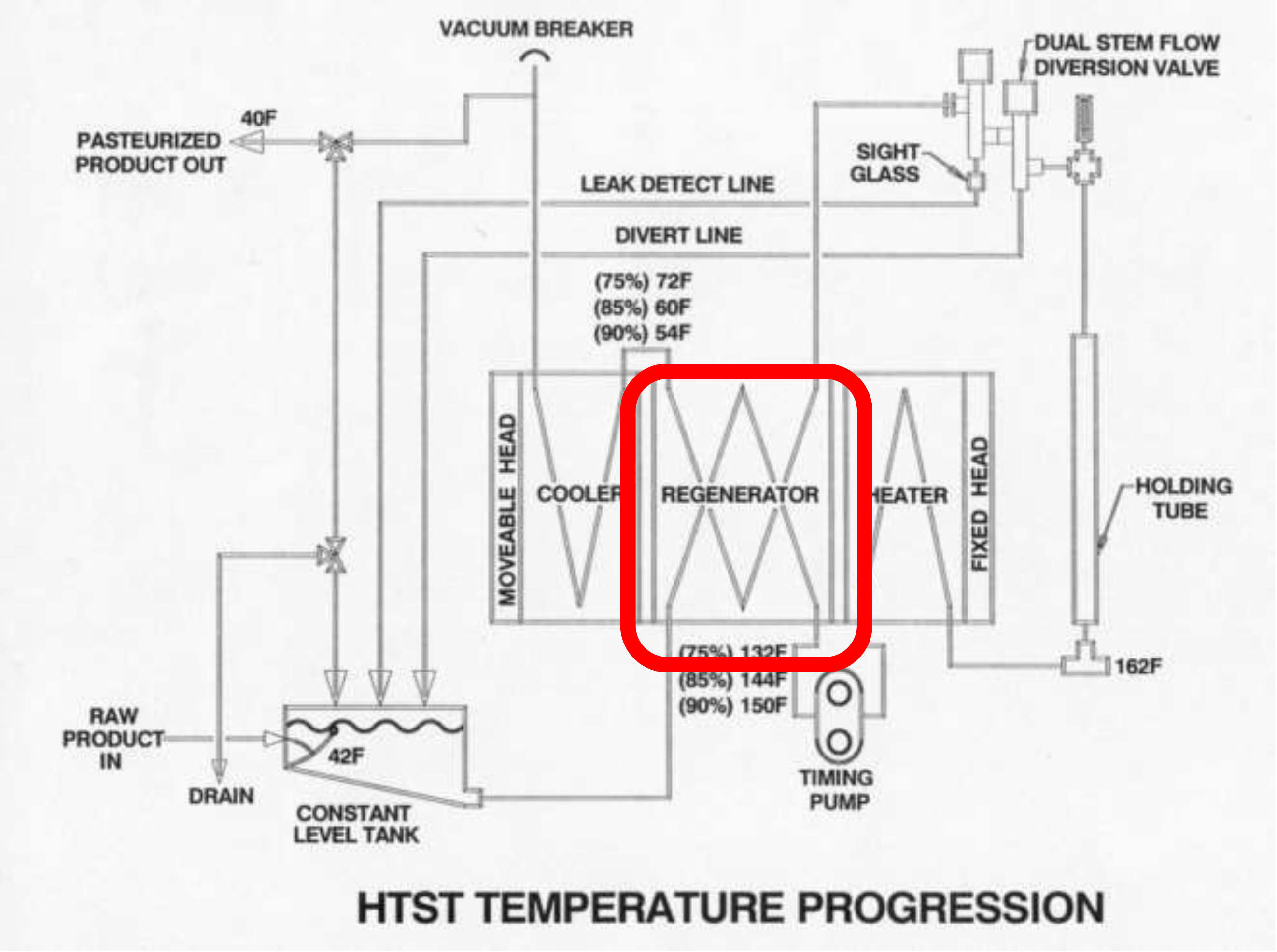



Cleaning with strong caustic DID NOT REMOVE THE SPORES

Peroxide/peracid cleaning removed most of the soil but did not get all the bacterial residue off the surface. (No viable cells recovered)

# What are build-up points?



# Separator/Clarifier

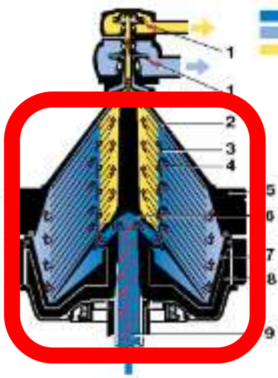



**Fig. 6.2.25** *Section through the bowl with outlets of a modern hermetic separator*
*1 Outlet pumps*
*2 Bowl hood*
*3 Distribution hole*
*4 Disc stack*
*5 Lock ring*
*6 Distributor*
*7 Sliding bowl bottom*
*8 Bowl body*
*9 Hollow bowl spindle*

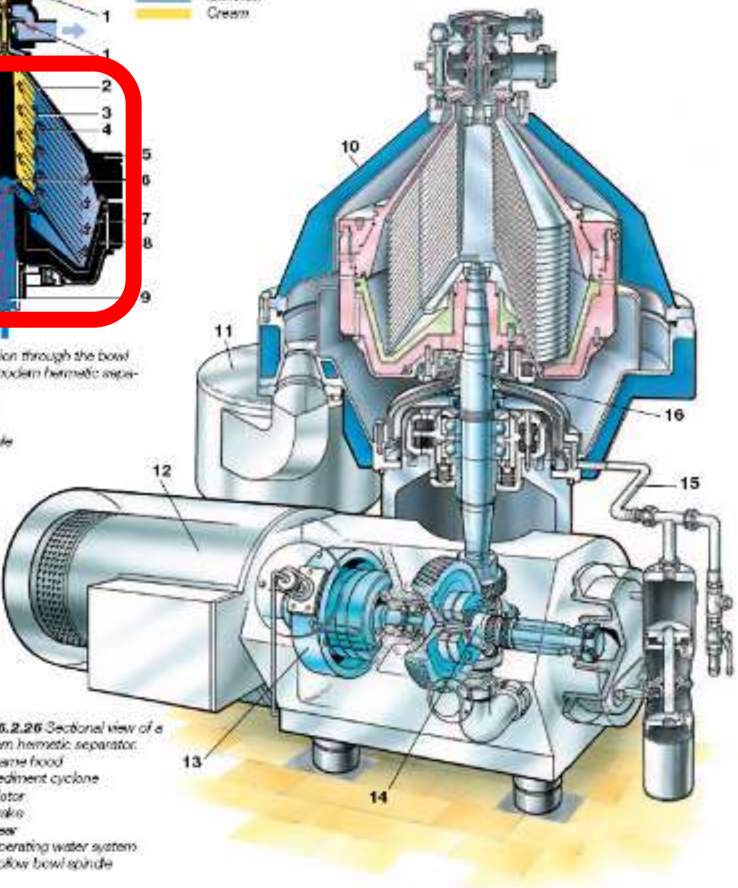
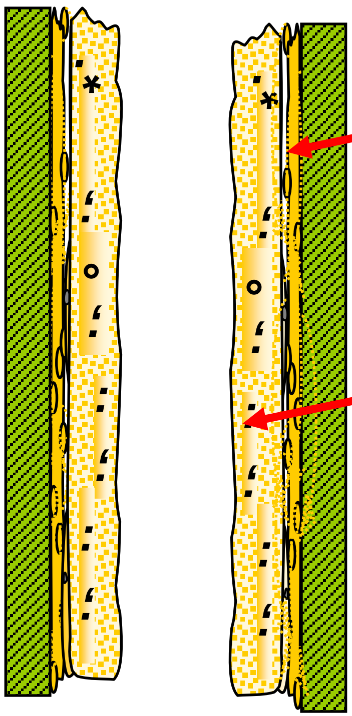



**Fig. 6.2.26** *Sectional view of a modern hermetic separator.*
*10 Frame hood*
*11 Sediment cyclone*
*12 Motor*
*13 Brake*
*14 Gear*
*15 Operating water system*
*16 Hollow bowl spindle*

# Fouling Mechanism Theory Tube Example

## How does fouling build-up in heat exchangers?



**The fouling layer is built-up by two different types of deposit:**

- **On the stainless steel surfaces of the pipe a dense mineral deposit layers is formed**
- **On top of this first layer forms a second layer consisting of a matrix of proteins, fat, and carbohydrate depending on process stream**

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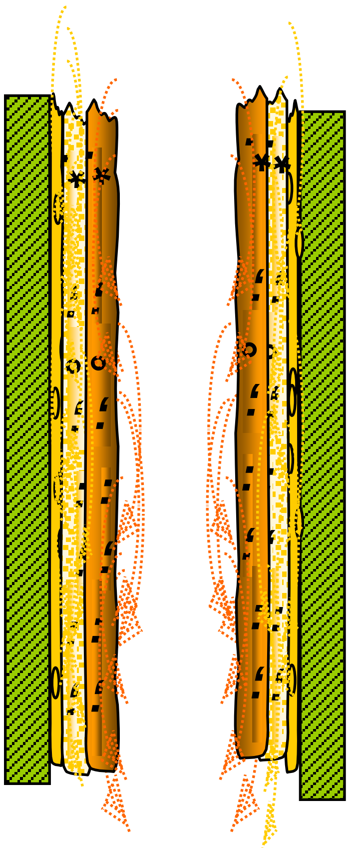
# Caustic Cleaning Details Dairy Example

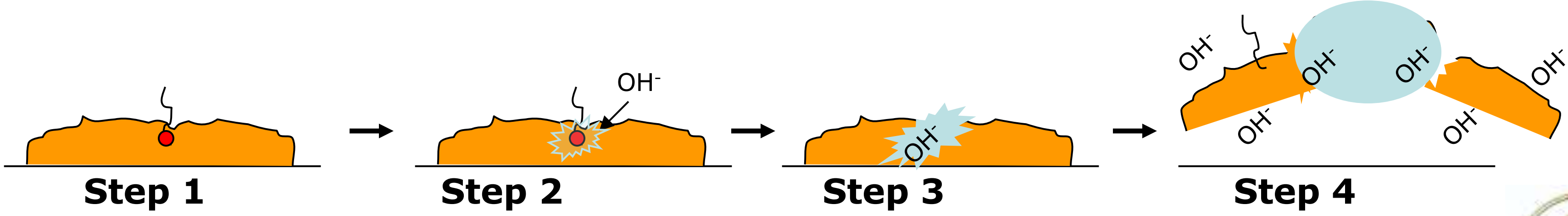
## The influence of NaOH concentration



- High caustic concentrations cause the fouling layer to swell causing gel formation of the protein (rubber-like top layer), thus preventing further penetration of the alkaline cleaning solution into the soil layer.
- Consequently the soil removal takes more time.
- The degree of "polymerisation" depends on NaOH concentration, soil temperature and contact time.

# Step-by-Step Cleaning Approach

- **STEP 1:** The pre-treatment product (peroxide/peracid) is circulated through system prior to alkaline wash - active ingredients penetrate the soil layer
- **STEP 2**: Immediately following Step 1, an alkaline detergent is circulated through the system; the rise in pH triggers Step 3
- **STEP 3:** The hydroxide ions interact with the oxygen components, triggering a reaction that ruptures the burnt-on soil matrix into pieces
- **STEP 4:** With the soil removed from the surface and broken into smaller pieces the mixed cleaning solution easily removes the remaining soil



# New Cleaning Procedure – Heated Surfaces

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- Pre-Rinse
- Alkaline Wash
  - Add peroxide/peracid additive
  - Circulate for 1-2 circuits (time varies with size of equipment)
  - Add caustic and heat to $170^{\circ}$ F
- Post Rinse
- Normal acid wash
- Post Rinse
- Sanitize with mixed peracid at 140 degrees


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# New Procedure – Cold Wall Equipment – Fillers, Lines, Tanks, Trucks

- Prerinse
- Alkaline wash with peroxide/peracid additive
  - Add peroxide/peracid and circulate for 1-2 rounds as it is heating up
  - Add alkaline cleaner  as heating continues and wash at normal temperatures
- Post rinse
- Sanitize with mixed peracid sanitizer at 140 degrees
- If needed, cool the surfaces with sanitizer at ambient

# Case Study: Skim Milk Evaporator

- Challenge:
  - Soiled evaporator that was not passing inspection
  - Fouled and plugged tubes reducing efficiency
- Results:
  - Significantly improved cleaning results
  - Reduction in plugging of tubes

CONTROL AFTER
CONVENTIONAL CIP PROGRAM

AFTER ADVANCED CLEANING
CIP PROGRAM

Photos: Paul Schacht - Ecolab

# Peroxide Cleaning Program Benefits

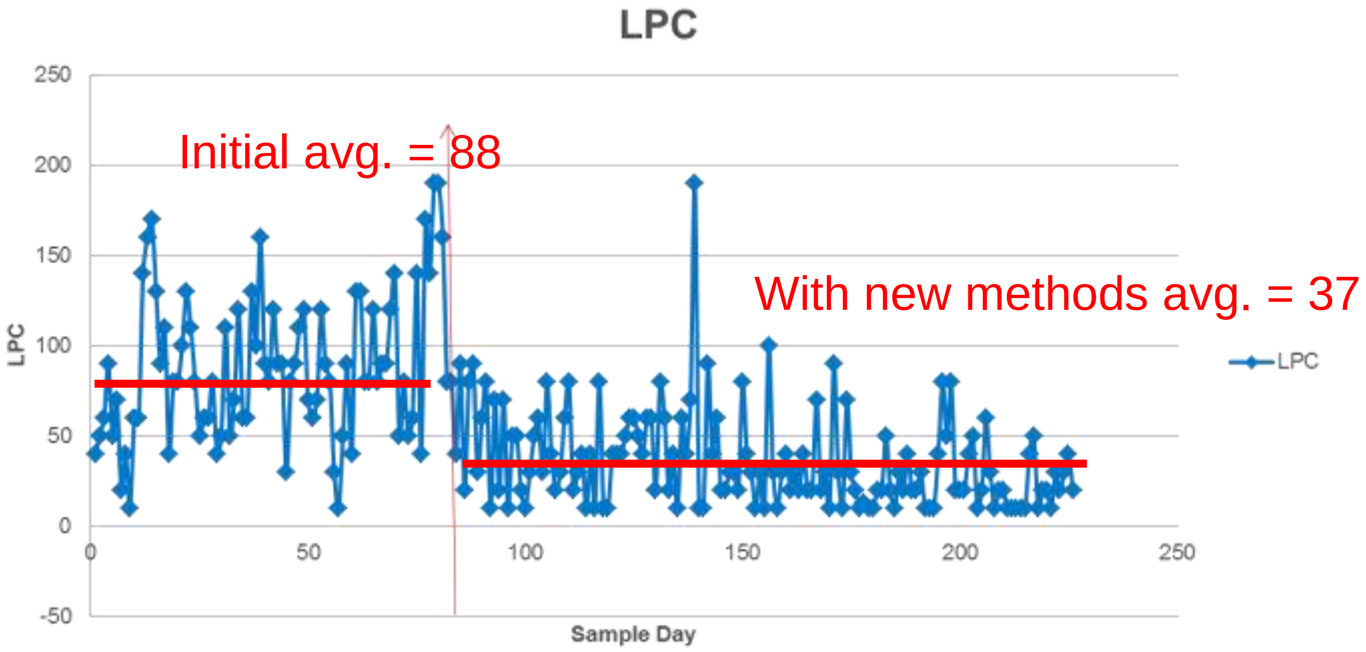
- Penetration of cracks and crevices for better cleaning – helps remove soils in damaged gaskets
- Temperatures above 170º F  and alkaline solutions break down peroxide & peracid to give mechanical action
- The oxidizing effect of the additives and the additional mechanical action have shown to remove soils more effectively
- Time savings have been achieved by faster removal of soils
- Significantly lower SPC counts have been documented in powder operations
- Spore related defects have been eliminated in Swiss cheese
- Late blowing defect has been controlled in cheddar cheese

# Peroxide Cleaning Program Potential Drawbacks

- Oxidizing effects of products may decrease life of gaskets
  - Effect is not likely to be more than the use of nitric acid
- Odor of high temperature peracid may be objectionable
  - Watch for improvements in this later this year

# Cost Benefits of the Program

- Powder plant was able to make 8 fold increase in low spore count product. Increased sales dollars by approximately $15,000,000
- Farm saw LPC counts stabilize. ***Monthly Premium was $25,000*** when average <50



# Farm Program Challenges & Solutions

- Most farms can't achieve high temperature
  - Even at temperatures below 170 degrees, the peroxide/peracid additive provides oxidizing ability which will remove soils
  - Alternately a low temperature two part cleaner provides mechanical action to achieve better soil removal
- Most farms use a chlorinated alkaline cleaner
  - The peroxide and chlorine produce an "exited oxygen molecule" (singlet oxygen species) that also enhances the soil removal

# Where will we go from here?

- Low count powder will become the norm
- Fluid milk shelf life will start reaching 24 days and beyond. Those that do not increase shelf life will use it to improve overall microbial quality of their products
- Producers of fresh/soft cheeses will use this technology to improve cleaning, reduce complaints extend shelf life allowing them to expand their distribution
- Producers of traditional cheese will be able to reduce defects like slits, large eyes, late blowing and heterofermentative lactics in their products
- Yogurt plants will use this to improve soil removal to reduce issues with phage and spoilage organisms
- Dairy farms will use this to reduce their overall counts to achieve exceptional levels of microbial quality
- New products will be developed to capitalize on the higher quality raw milk supply

# Questions????