THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,
AND ENVIRONMENTAL SCIENCES

Technologies and Methodologies Used in CIP Research

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Dale A. Seiberling Food Engineering Research Laboratory

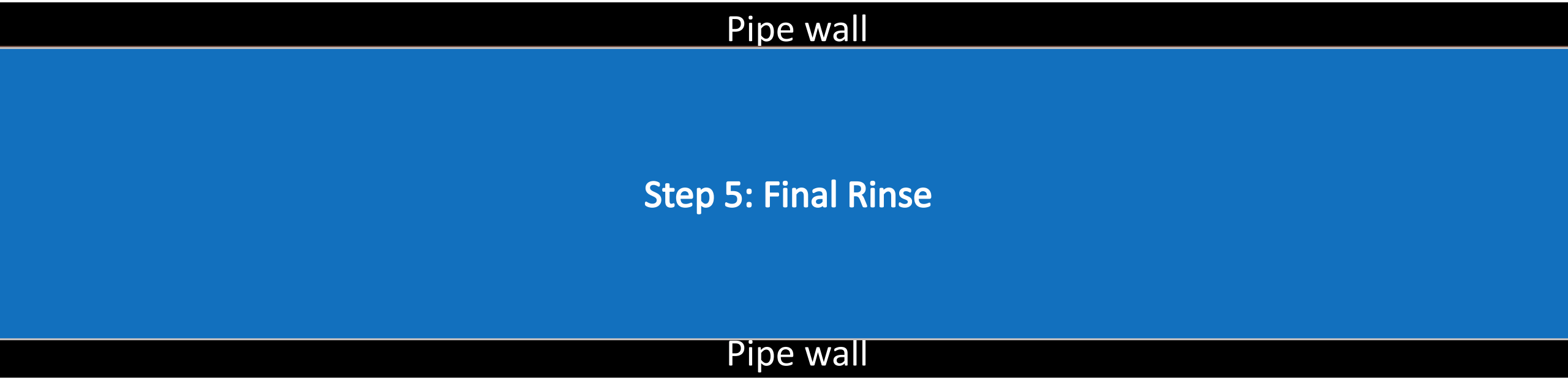
Lab History

- Dale A. Seiberling
  - “Father of Cleaning-In-Place”, CIP
- Dr. Dennis R. Heldman
  - Had Dale A. Seiberling as an instructor at The Ohio State

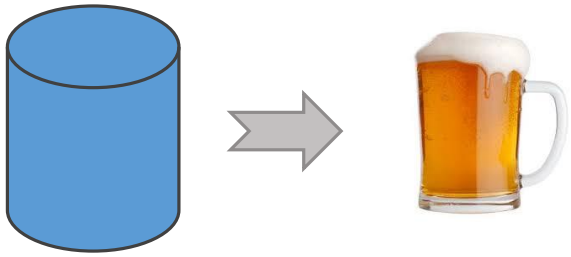
Dale A. Seiberling Food Engineering Research Laboratory

Inside Look: CIP Cleaning Process

- Fundamentals
  - Time, temperature, concentration, flow characteristics

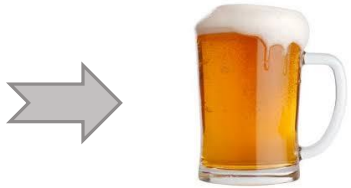


CIP Optimization Opportunities



2.5 : 1

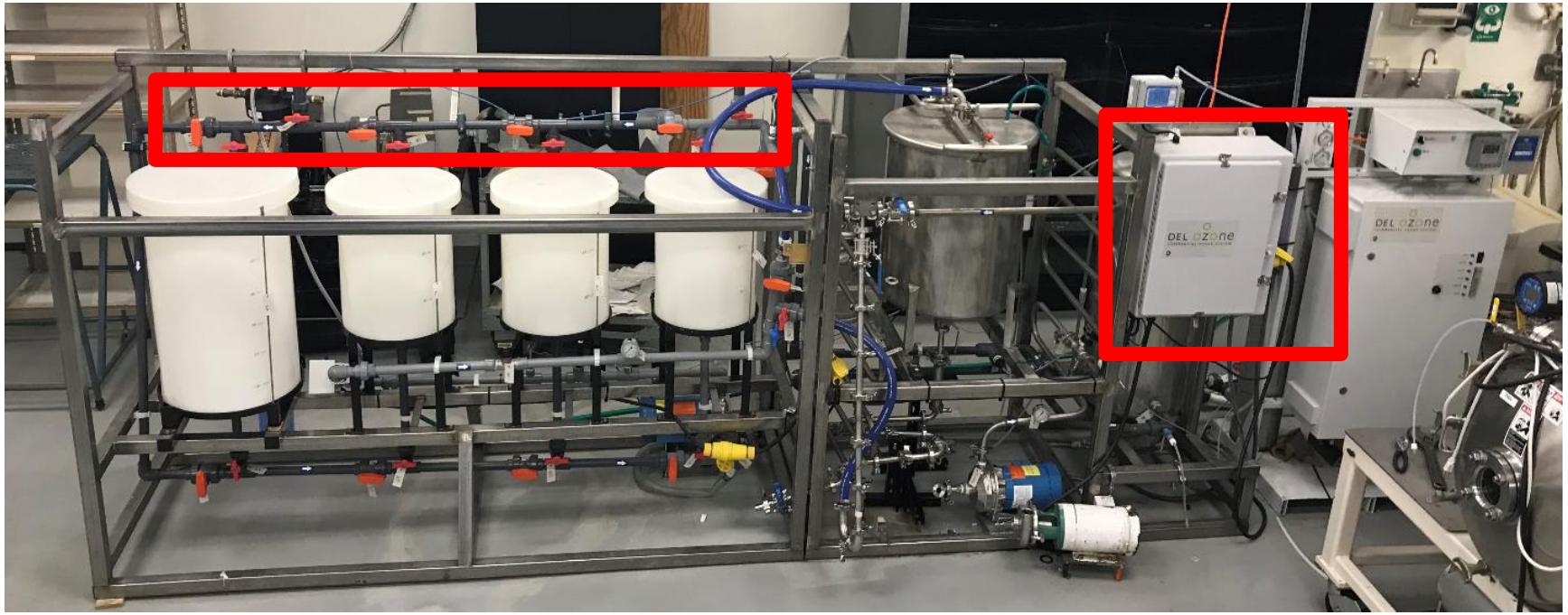
Large commercial



Laboratory Approach

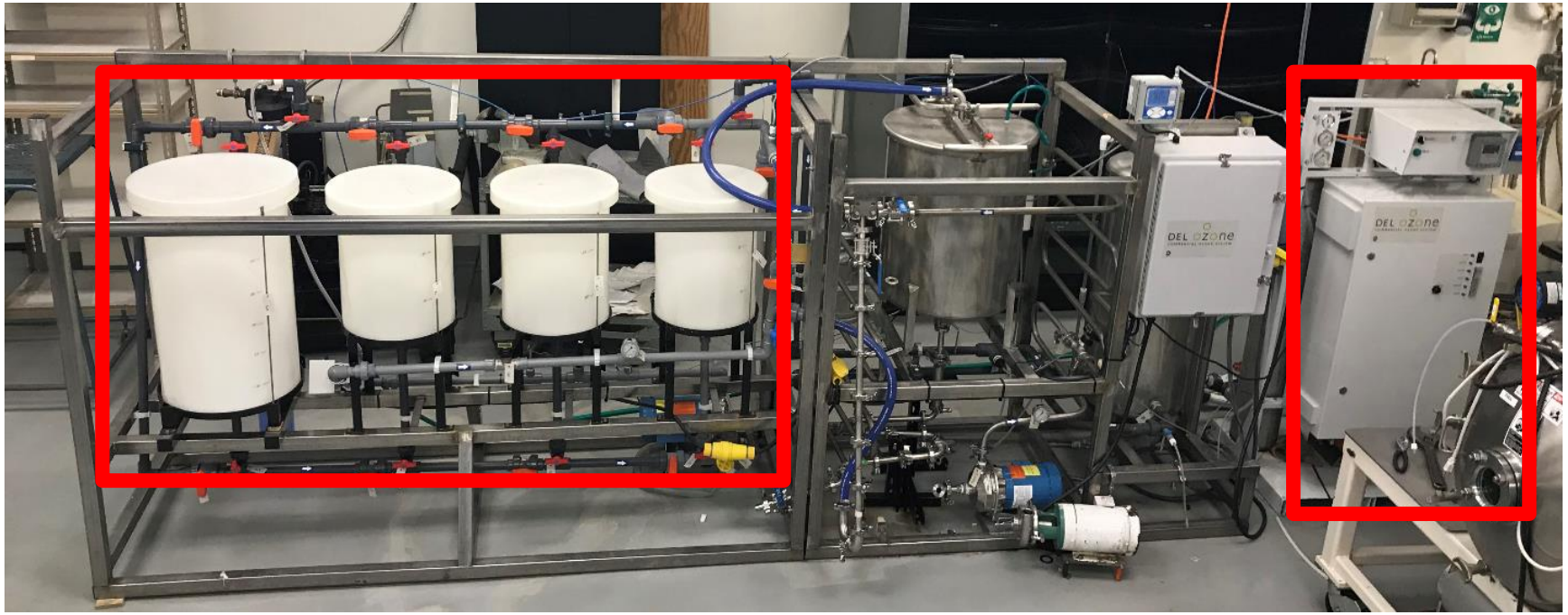
- Purpose
  - Conserve energy
  - Reduce water usage
  - Reduce cleaning agents
- Methods
  - Benchtop systems
  - Pilot plant equipment

Ozone CIP Skid



- Manual operation
- Variable flow rate pump
  - Q=VA
    - Flow rate to velocity conversion

Ozone CIP Skid

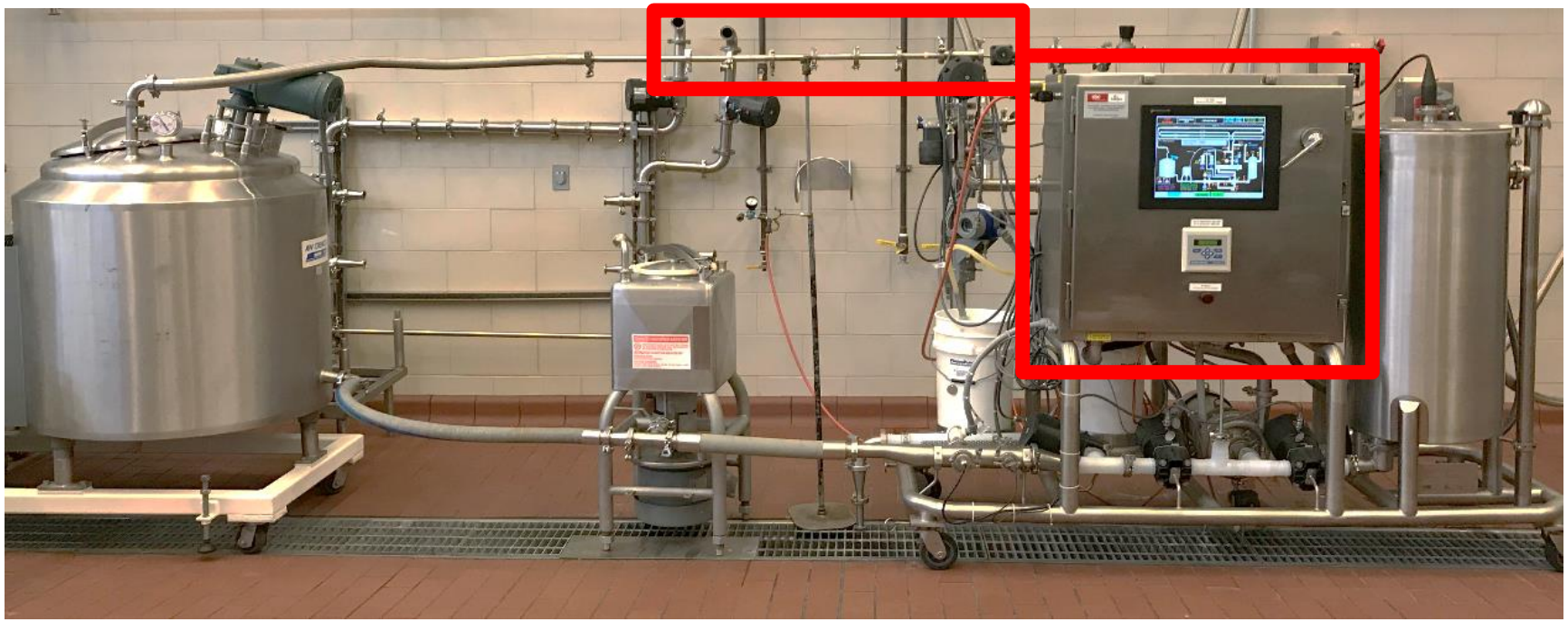


- Traditional CIP and Ozonated Water CIP capabilities
- Generates varying concentrations of ozone

Biofilm Generator

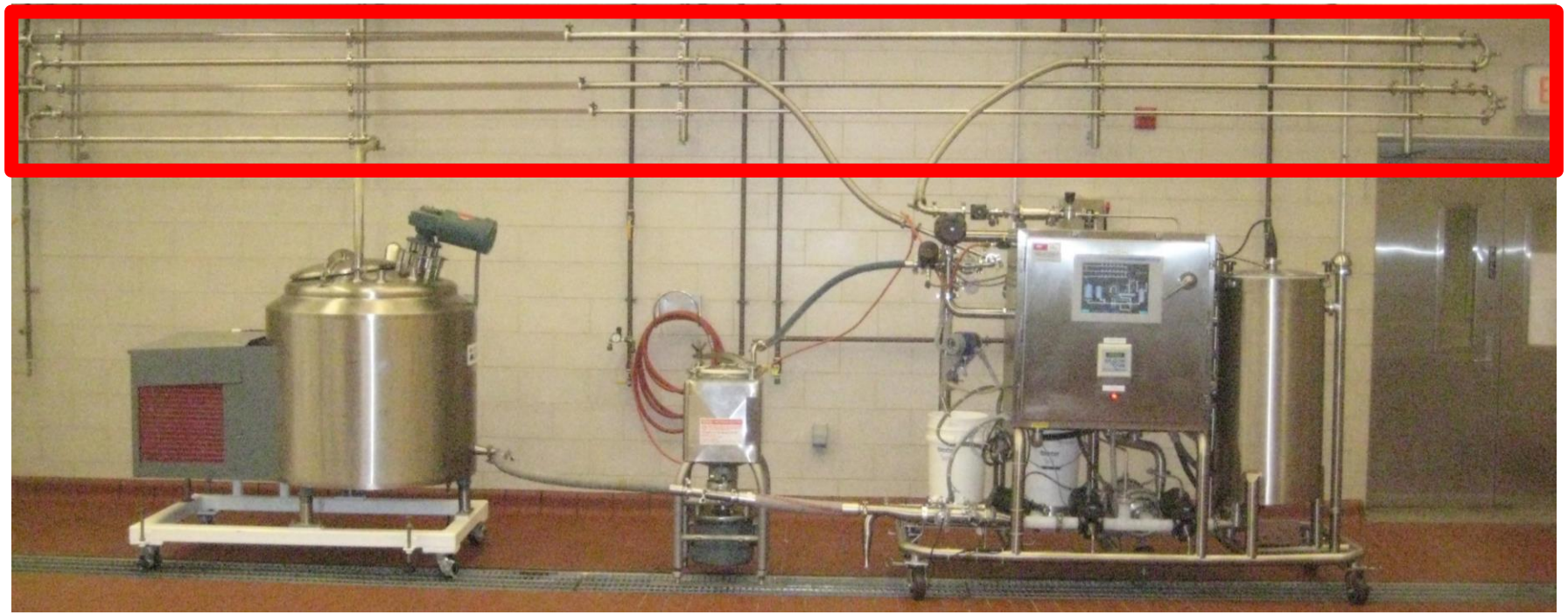
- 1.0” sanitary stainless steel tubing
- Reynolds number for system calculated
- Entrance Region

Pilot Plant CIP Skid



- Real time Data Acquisition Software
  - Conductivity, resistivity, temperature, flow rate, pressure
- Touch Screen Human Machine Interface, HMI
- Multiple system configurations

Pilot Plant CIP Skid

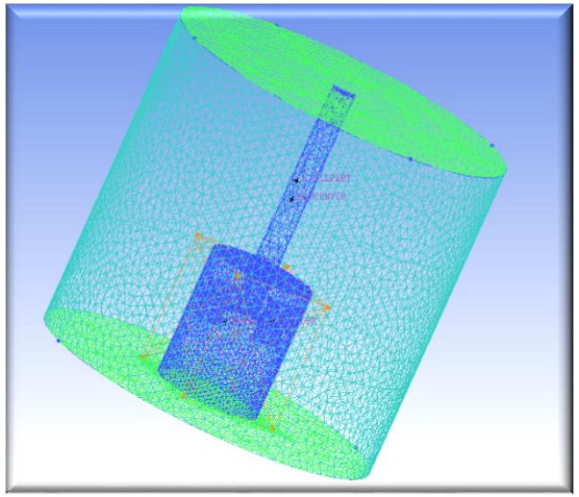


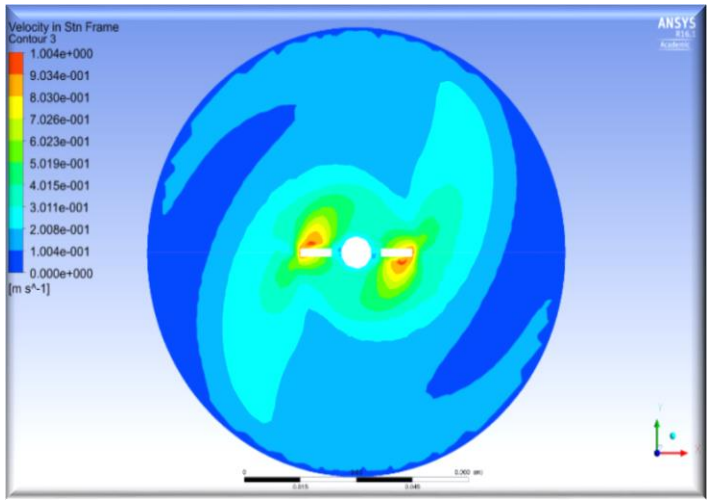
Alternative configuration pilot plant CIP System

Benchtop CIP Unit

- Temperature controlled
- Flow characteristics
  - Spindle
  - Variable velocity
- Saves time

Theoretical Considerations



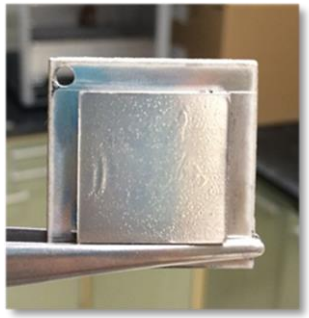


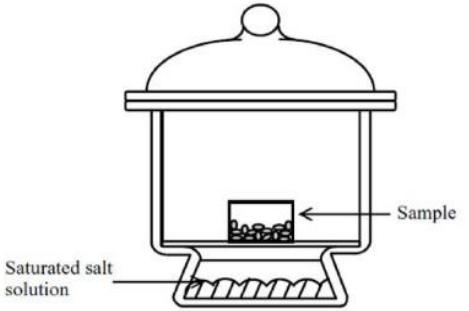
➡ Computational Fluid Dynamics to create a scaleable system

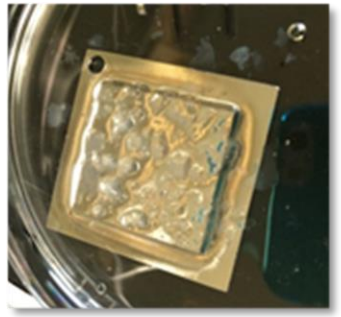
Research Methodology: Rinse Water Effectiveness

NFDM

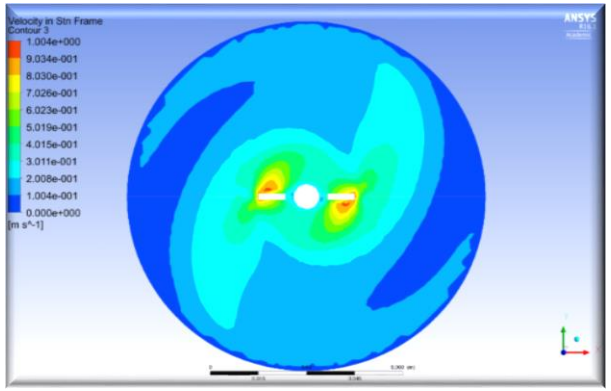
HEATING







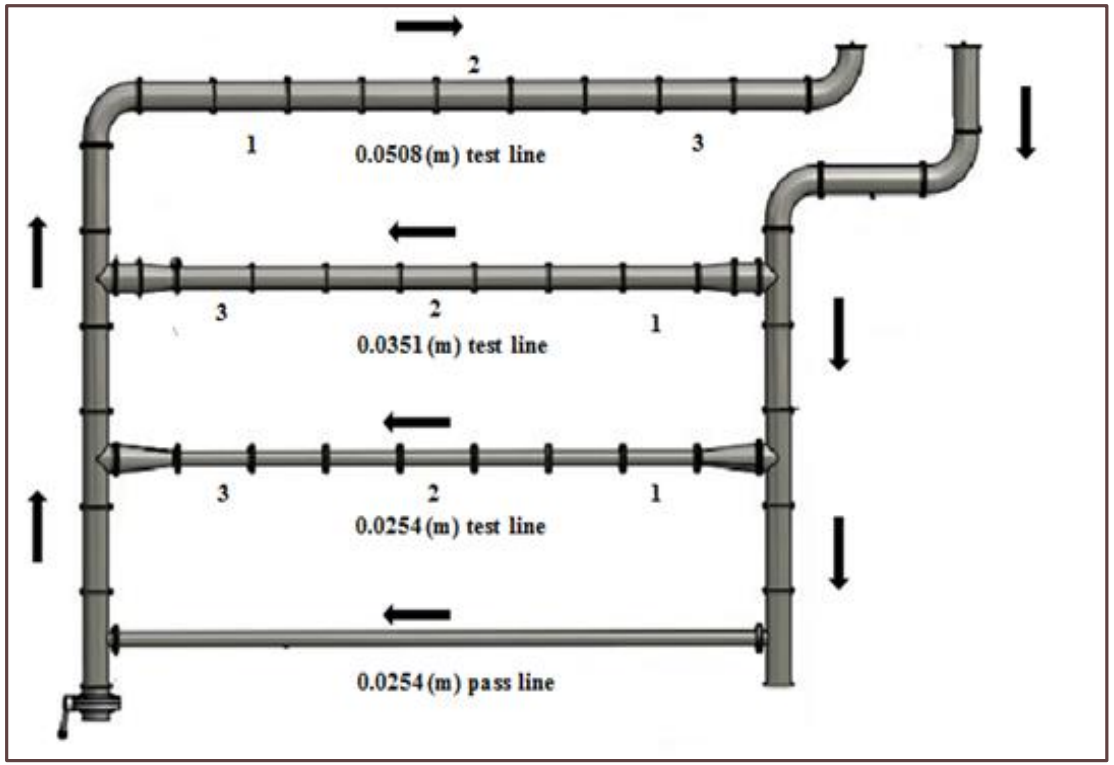
Residual film%



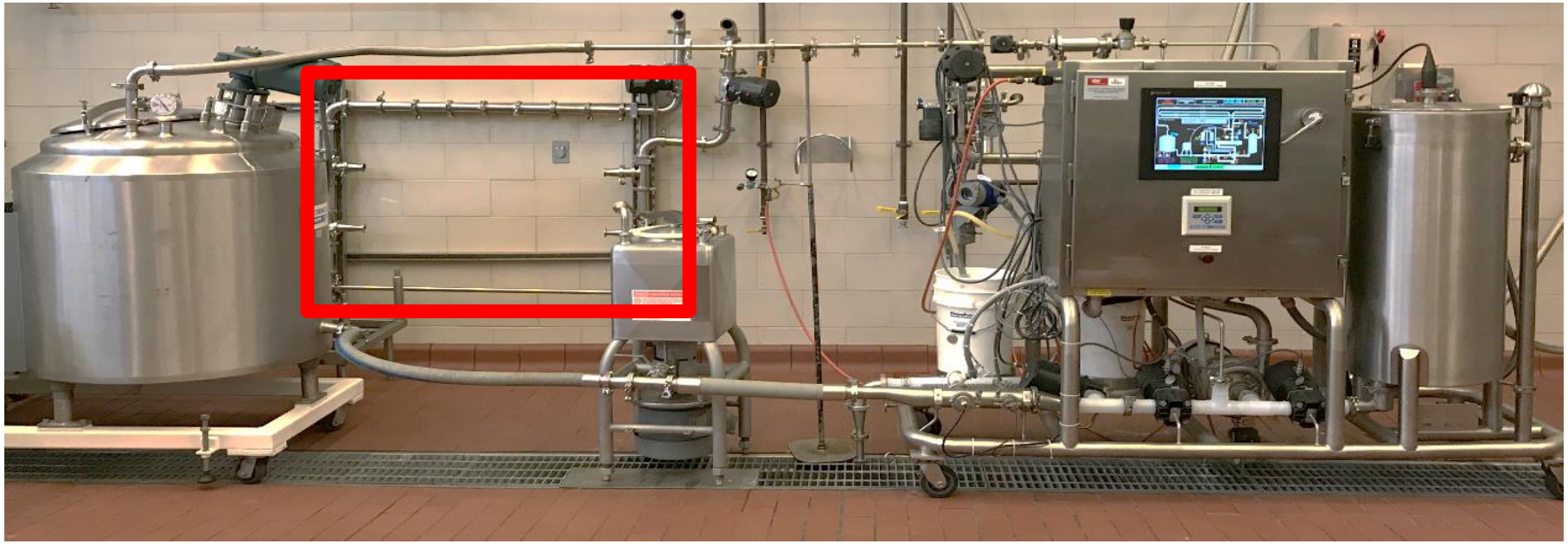
Fan, et. al (2015)

Scaleup of Benchtop Model

- Uniform and reproducible deposit on pipe sections
- Measured the influence of rinse water on removal
  - Temperature
  - Flow characteristics



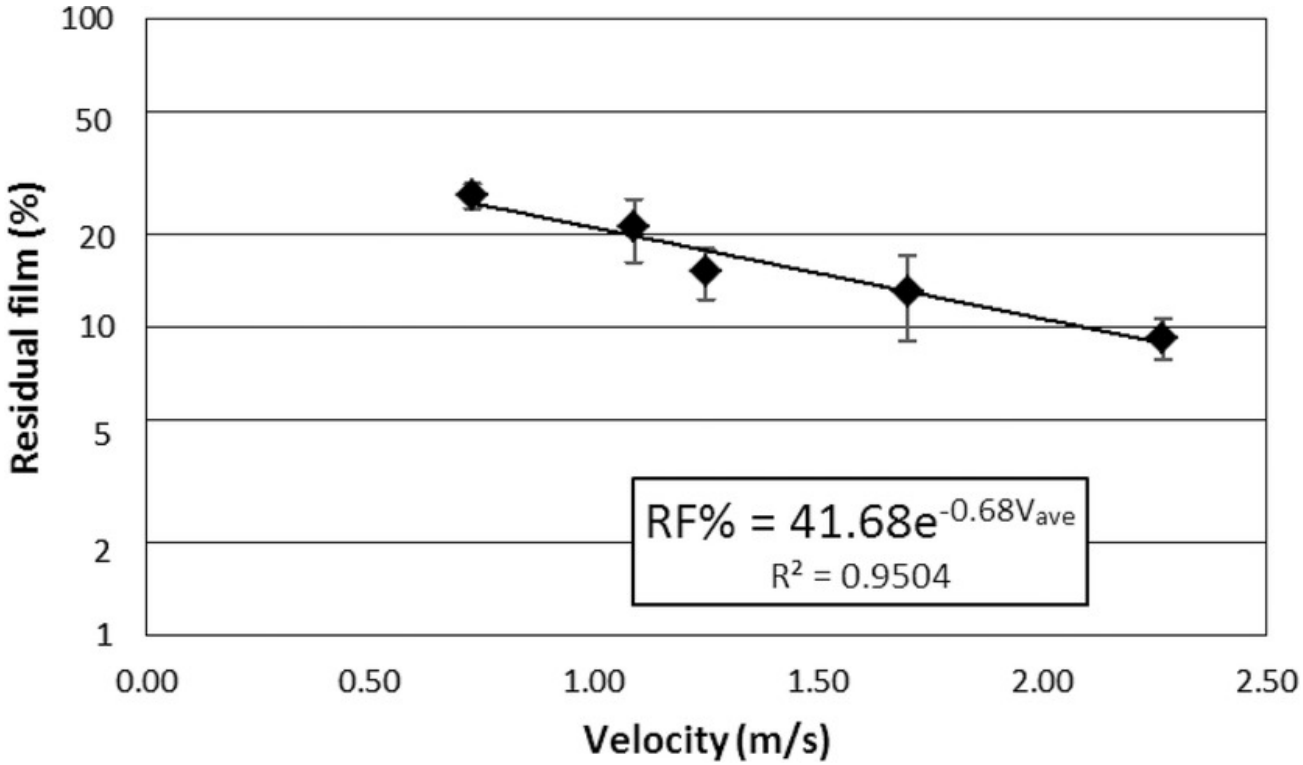
How Pilot Plant CIP Skid was used



- Determined quantities of rinse water to provide effective removal of deposit

Results: Rinse Water Effectiveness

- Increasing fluid velocities provides:
  - Higher mass transfer rate
  - Greater removal of the deposits



Influence of velocity on the removal of protein deposits

Ozonated Water CIP: What is Ozonated Water?

- Ozone, (O_3) dissolved in water
- Antimicrobial agent: 21 CFR 170.3 (o)(2)
- Generally Recognized as Safe: 21 CFR 184.156
- Used as a disinfectant in drinking water treatment plants

CFR (2018)

Ozonated Water CIP: Research Purpose

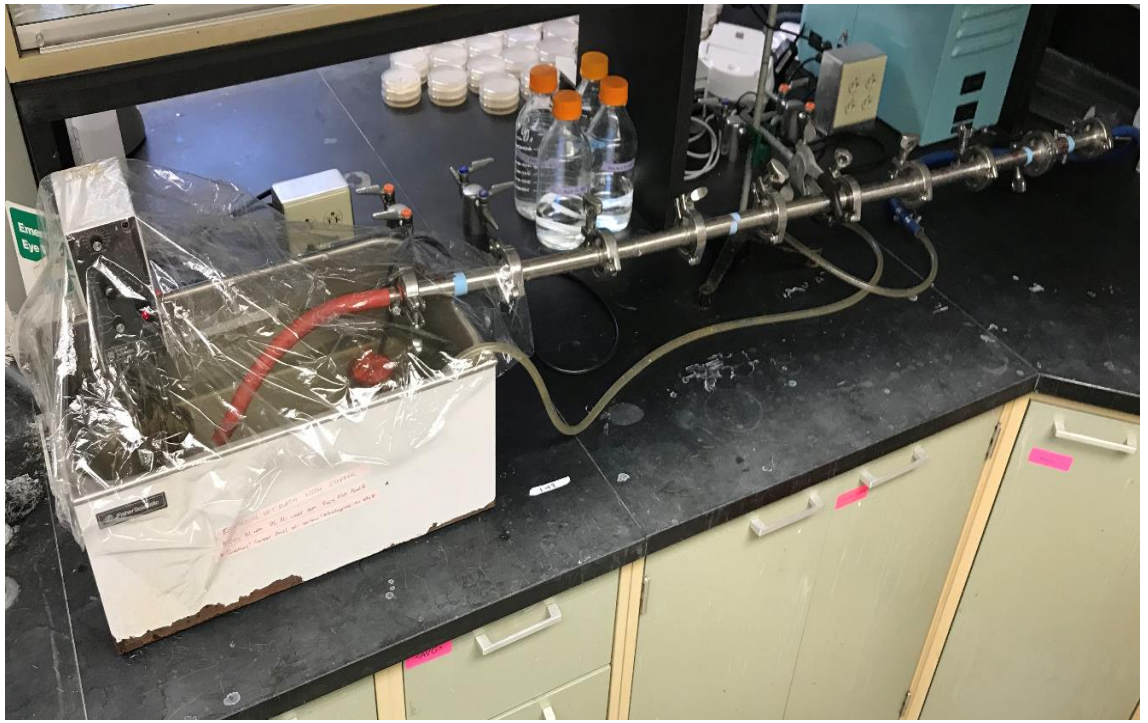
- Limitations with traditional CIP
  - Water usage
  - Caustic
  - Environment
- Ozone CIP for biofilm removal:
  - Step 1: Pre-rinse
  - Step 2: Ozonated Water

Research Objectives

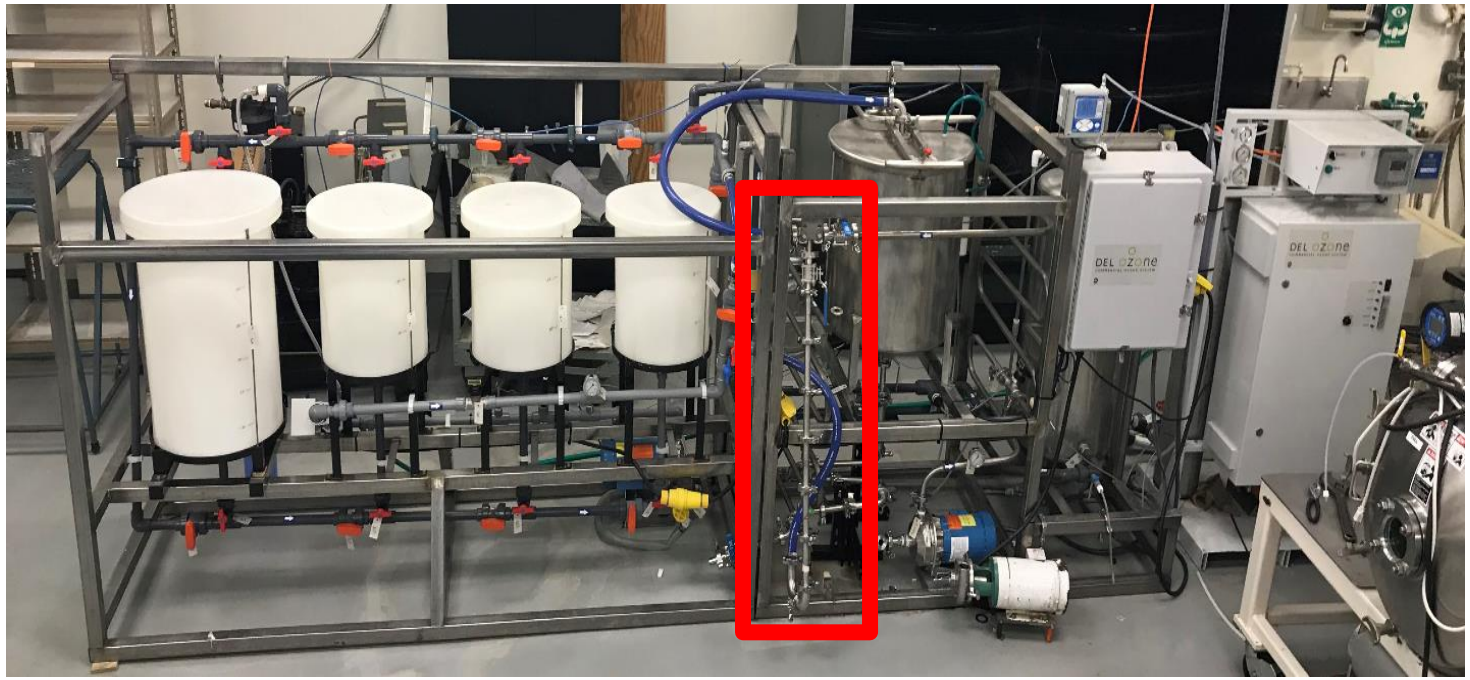
- Confirm the methods for quantification of an industrially relevant biofilm
- Quantify the rate of biofilm cleaning and sanitation
- Determine the influence of ozone concentration on the rate of biofilm cleaning and sanitation
- Develop methods to determine the water efficiency of the ozonated CIP system

Use of Biofilm Generator

- Mimics industrial biofilm building
- 1.0” sanitary stainless steel tubing
    - Nominal piping chart
- DIRO water added
- pH, electrical conductivity, dissolved oxygen and temperature measured



Use of Ozone CIP Skid



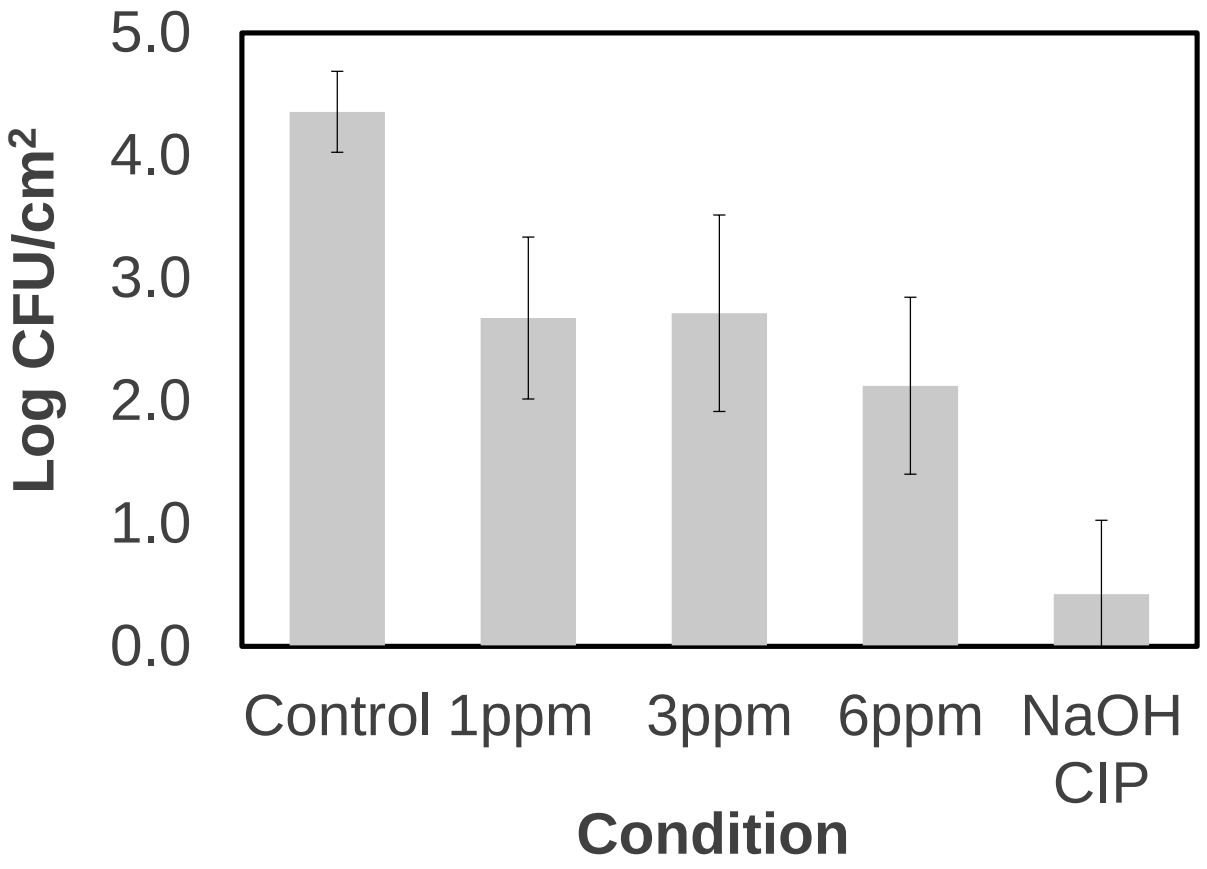
- Ozonated Water
  - 1ppm, 3ppm, 6ppm
- Safety Considerations

Analysis of Pipe Sections

- Standard Plate Count, SPC
  - Viable microorganisms
  - Colony Forming Units per cm^2
- Adenosine Triphosphate, ATP
  - Luminometer
  - Relative Light Units

Preliminary Results: SPC

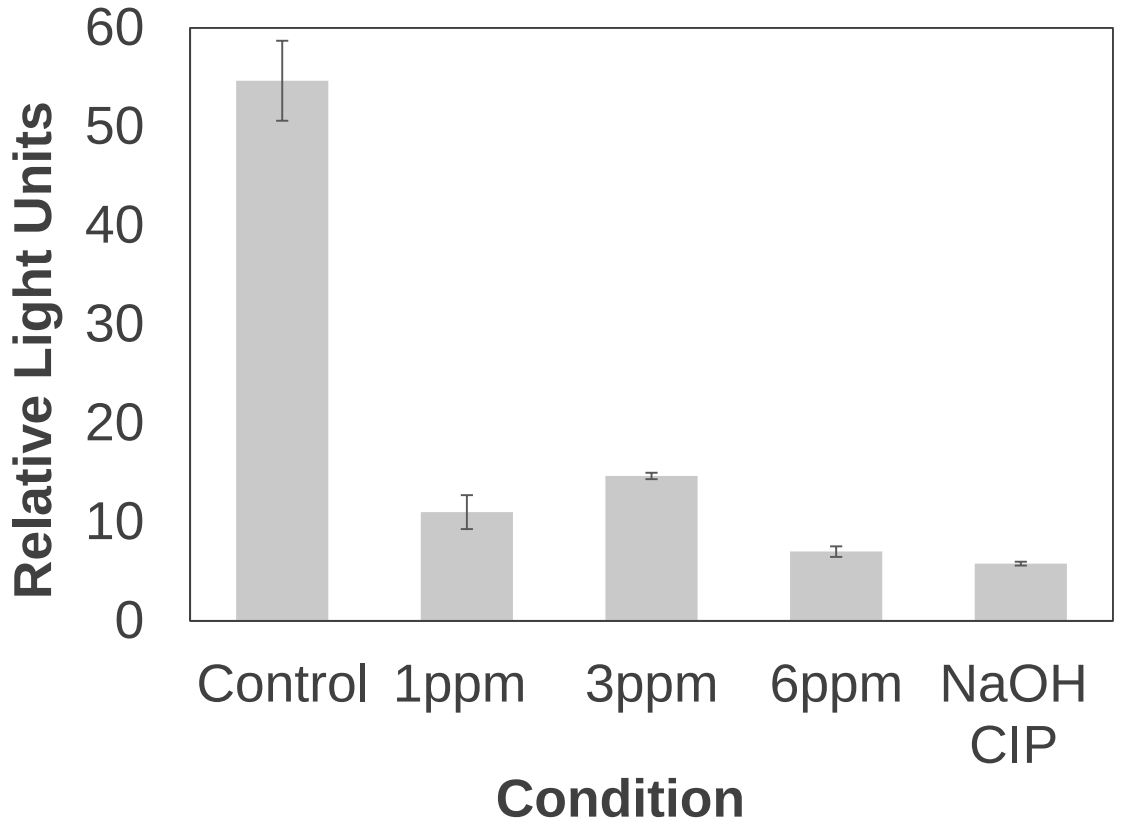
- Ozonated Water CIP
  - Nearly 1.5 to 2 log reduction from control
- CIP using NaOH
  - Nearly 4 log reduction from control
- Reductions the biofilm control compared to all ozone treatments were significant



Influence of cleaning agents on Standard Plate Count

Preliminary Results: ATP

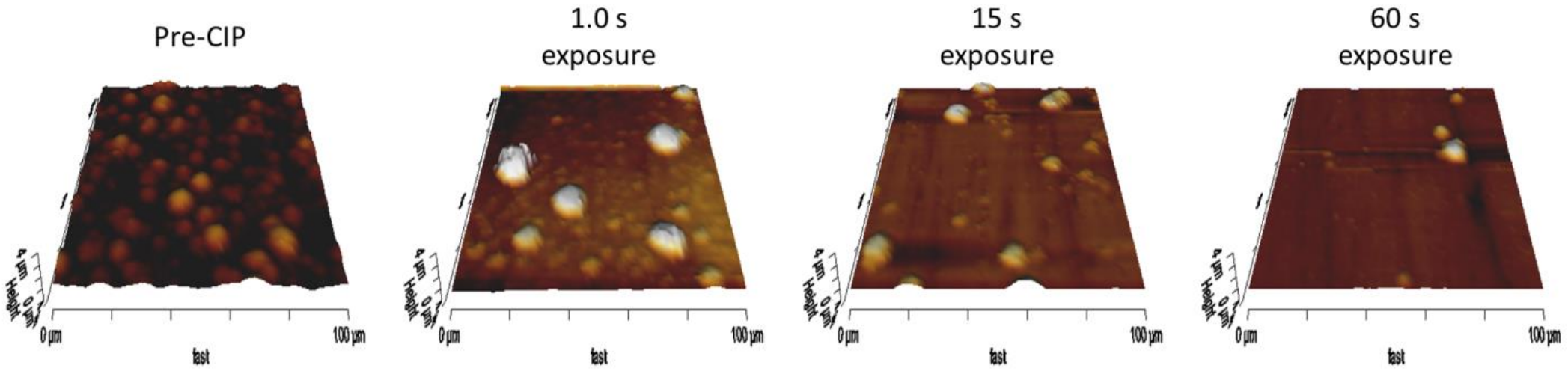
- Similar trends to SPC
- Ozonated water CIP
  - Nearly 80% reduction
- CIP using NaOH
  - Nearly 90% reduction
- Reductions from control due to all treatments were significant



Influence of cleaning agents on adenosine triphosphate

How clean is clean?

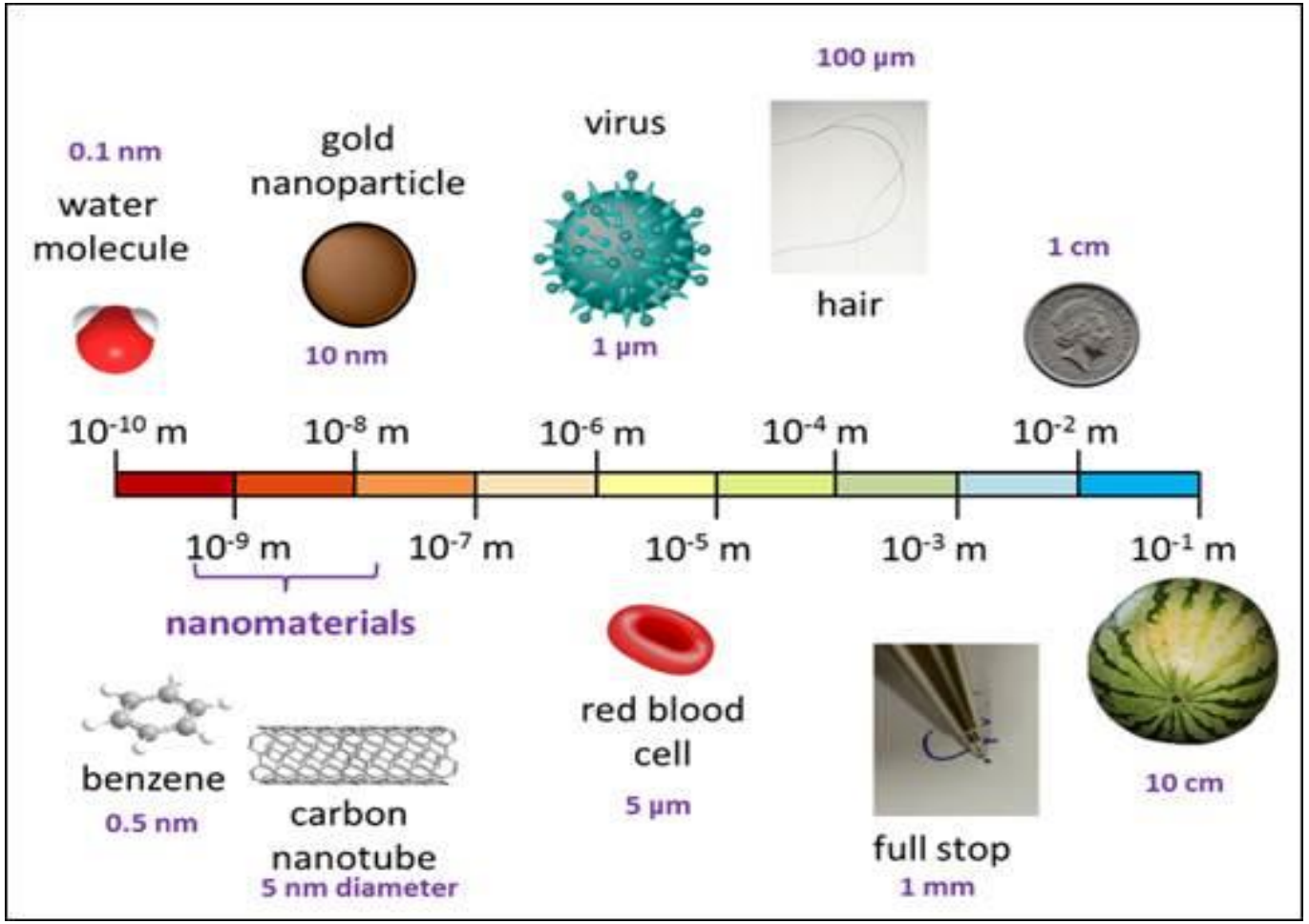
Nanoscale Residues



Changes in stainless steel surfaces as function of time during cleaning

- 0.5% NaOH
- 4 exposure times
- Cleaning results

Nanoscale


100 µm
virus
0.1 nm
gold nanoparticle
water molecule
1 cm
hair
10 nm
1 µm
10^{-10} m
10^{-8} m
10^{-6} m
10^{-4} m
10^{-2} m
10^{-9} m
10^{-7} m
10^{-5} m
10^{-3} m
10^{-1} m
nanomaterials
red blood cell
5 µm
benzene
0.5 nm
carbon nanotube
5 nm diameter
full stop
1 mm
10 cm

Conclusion

- Further characterization of the biofilm
- Effectiveness of ozonated water as a cleaning and sanitizing agent
  - Different ozone concentrations and turbulences
- Demonstrating the feasibility for food manufacturers to use this technology
  - Reduce water usage

Thank you!

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