Efficacy Assessment of CIP Processes in Milking Machines

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Dr. Douglas J. Reinemann, University of Wisconsin – Madison, Milking Research and Instruction Lab, Madison, Wisconsin, USA
Dr. Albrecht Grasshoff, Senior Scientist, Federal Center for Dairy Research, Kiel, Germany.
Dr. Amy C. L. Wong, University of Wisconsin – Madison, Food Research Institute
Anton Muljadi, Graduate Research Assistant, University of Wisconsin - Madison

Introduction

This poster summarizes both laboratory and field research conducted at the University of Wisconsin Milking Research and Instruction Lab to assess the efficacy of CIP processes for milking machines. Studies were undertaken to provide basic information on optimal flow dynamics for air-injected CIP systems, develop a standardized soils typical of those found in milking systems, and develop test methods to assess removal of this soil.

Although system designs vary considerably, typical features of air injected milking parlor CIP systems are shown in Figure 1. Cleaning solutions are transported from the wash vat through the sanitary parts of the system and back to the wash vat during the CIP process. These solutions must make contact with all milk contact surfaces for sufficient time, and with sufficient physical action, to assure cleaning. In milking parlors, milking units are commonly attached to wash assemblies (jetters) fed from a wash line. This water-draw pipe network and jetters make up the wash manifold. Cycled air-injection may enter through the wash manifold (A1 in Figure 1), the milkline (A2 in Figure 1) or both. When air is injected only through the wash manifold (A1) it is common to include a hose or pipe from the water manifold directly to the milkline (the dashed line in Figure 1). Air and water are separated at the receiver jar. The air travels to the distribution tank and is removed from the system by the vacuum pump. Water is returned to the wash vat by the milk pump through the milk transfer line.

Air injection systems have been developed in recent years to reduce the water volume required for cleaning large milking systems. The resulting two-phase flow patterns are determined by the diameter of system components and water and air flowrates through them. Internal diameters range from 10 mm in short milk tubes to 98 mm or more in milklines and in excess of 150 mm in milk meters and recorder jars. Flow velocities and flow patterns therefore vary greatly in the different parts of the system. Air-injection is used to produce slug flow in milklines. The objectives and optimal control strategies for air and water admission to milking units and other components differ from those for the milkline. Milking units are either flooded or alternately flooded and emptied. Large components such as some milk meters and recorder jars are generally cleaned with a spray or sheet of water over the interior surfaces.

Multi Phase Flow Studies

Experiments were performed to characterize the type of unsteady slug flow developed in milklines when cycled air admission is used. Pipe diameters ranging in diameter from 48 to 98 mm were tested. The experimental system monitored air and water admission volume and rates, the liquid fill depth in the pipe, slug velocity, slug length, and vacuum level in the pipe. The slug velocity and wall shear stress produced by varying levels of air admission is illustrated in Figures 2 and 3. Excessive air admission reduced shear stress in the end of the milkline due to air entrainment in the liquid slug. The optimal mechanical action was achieved between slug velocities of 7 to 10 m/s. The level of air admission to produce optimal mechanical effects is shown in Figure 4.

Additional studies were performed to determine the flow characteristics of typical jetter/milking units combination for both flooded and air-injected flow and factors affecting the distribution of water flow between units for typical milking parlor CIP system designs. Control strategies were developed to balance wash water flow between milking units, optimize cleaning of both milking units and the milk pipeline and reduce the vacuum pump capacity needed for milking parlor CIP systems.

Cleaning Assessment Methods

Bacterial attachment to pipe wall: Several methods were developed to apply bacteria, milk soil and combined bacteria and milk soil deposits on milking machine components. Test sections of ½ m stainless steel pipe were designed to allow placement of removable chips into the pipe wall so that the inner surface was flush with the pipe wall. Bacterial attachment was done by mounting the ½ m test section fitted with removable chips, horizontally on a shaft/rotor apparatus. The test section was filled with 100 ml of a 1:1,000 dilution of pasteurized whole milk inoculated with about 10^9 cfu/ml of a *Lactobacillus* culture. The test section was rotated at 10 rpm for two hours at room temperature to allow uniform deposition of milk soil and *Lactobacilli* on the surface of the pipe. The milk was removed from the test pipe section and several test chips removed for enumeration of initial *Lactobacilli* counts. The test section was then placed in the milking machine and subjected to specified cleaning conditions. After cleaning, all test chips were removed. The bacterial residue was measured on 1/2 of the chips using standard plate count methods and for the other ½ of the chips using an ATP bioluminescence method (Lumac). The removal rate was measured as the remaining bacteria as a fraction of the original concentration before cleaning.

A series of tests were run using plain water at room temperature to isolate the effects of physical action on bacterial removal. Wall shear stresses ranging from 50 to 250 N/m^2, were examined. A second series was run using plain water and several formulations of chlorinated alkaline detergents at temperatures ranging from 43^{o}C to 70^{o}C and at two levels of shear. One of the detergents was a prototype for a concentrated product. The results of bacterial removal tests are illustrated in Figure 5. Increased shear improved the efficacy of all detergents except for detergent A (the prototype concentrate), which produced an excessive amount of foam at the high shear level. The correlation between ATP bioluminescence and standard plate count measures is shown in Figure 6. The correlation was reasonable at high levels of bacterial contamination but the ATP method appeared to be more sensitive than standard plate count measures at low levels of bacterial contamination.

Bacterial attachment to milking components: Tests were performed on a commercial milking unit and milk meter to examine the flow conditions encountered in objects with complex flow geometry. The same *Lactobacillus* culture described above was used for all trials. The milking unit and milk meter were filled with the bacterial suspension and left stationary for 1 h at room temperature to allow bacteria to attach to the interior surfaces. After 1 h, the bacterial suspension was poured out of the milking components and the components rinsed with distilled water to remove non-adhering bacteria. The milk meter and milking unit were then installed in a milking system according to the manufacturers recommendations. Cleaning tests were performed with both plain water and a detergent solution. Standard plate count methods were compared with ATP-Bioluminescence assessment methods. The efficacy of bacterial removal was considerably reduced at water flow rates below of 3 L/min through the milking units tested.

Multiple-layer milk soil and bacterial deposit: A standardized soil was developed to simulate worst case conditions for combined milk residue and bacteria. A spraying apparatus was constructed to deliver multiple thin layers of milk-soil to test chips. The chips were placed on a turntable that passed the chips under a spray head once per minute. Warm air was circulated in the deposit chamber so that each film would dry between spray cycles. The chips are sprayed for four hours to develop approximately 240 milk soil layers. Three types of milk soil were used. The first type used a mixture of nine parts of pasteurized milk and one part of phosphate buffer solution with 9% albumin added to the mixture. Another soil was created by adding an *L fermentum ATCC 8289* suspension to the milk soil mixture. One of these inoculated mixtures was cleaned immediately and the other was allowed to incubate for 24 hours before cleaning. Examples of a test chip with the sprayed milk soil deposit and an incubated test chip are shown in Figure 7. The bacterial activity during incubation produced a residue, which was much more difficult to remove than the milk soil with no bacterial inoculation and the inoculated soil that was not allowed to incubate.

The test chips were cleaned using a range of shear stresses, number of cleaning slugs and with water and two different detergent treatments. Milk soil and bacterial residuals were then measured using both standard plate count and with the ATP bioluminescence method. An example of test results cleaning the incubated milk soil is shown in Figure 8 using standard plate count measurement and in Figure 9 using the ATP Bioluminescence method. Statistically significant differences at the p=0.05 level were found with both assessment methods between water and both detergents at 15 and 20 slugs but not at 10 slugs. Statistically significant differences at the p=0.05 level were found with both assessment methods between the two 20 slugs but not at 10 or 15 slugs.

Summary

Methods have been developed to assess the efficacy of CIP processes in both pipelines and the other types of components of milking machines. A combination of milk soil and bacteria

that was allowed to incubate produced a residue that was much more difficult to remove than non-incubated residue or either milk soil or bacteria residues alone. The correlation between ATP and plated count methods was reasonable and the ATP bioluminescence assay proved to be a valuable tool for rapid measurement of bacterial residues in these controlled conditions. Using the methods developed, the flow parameters to optimize mechanical cleaning action have been identified for the unsteady slug flow developed in milklines when cycled air admission is used.

References

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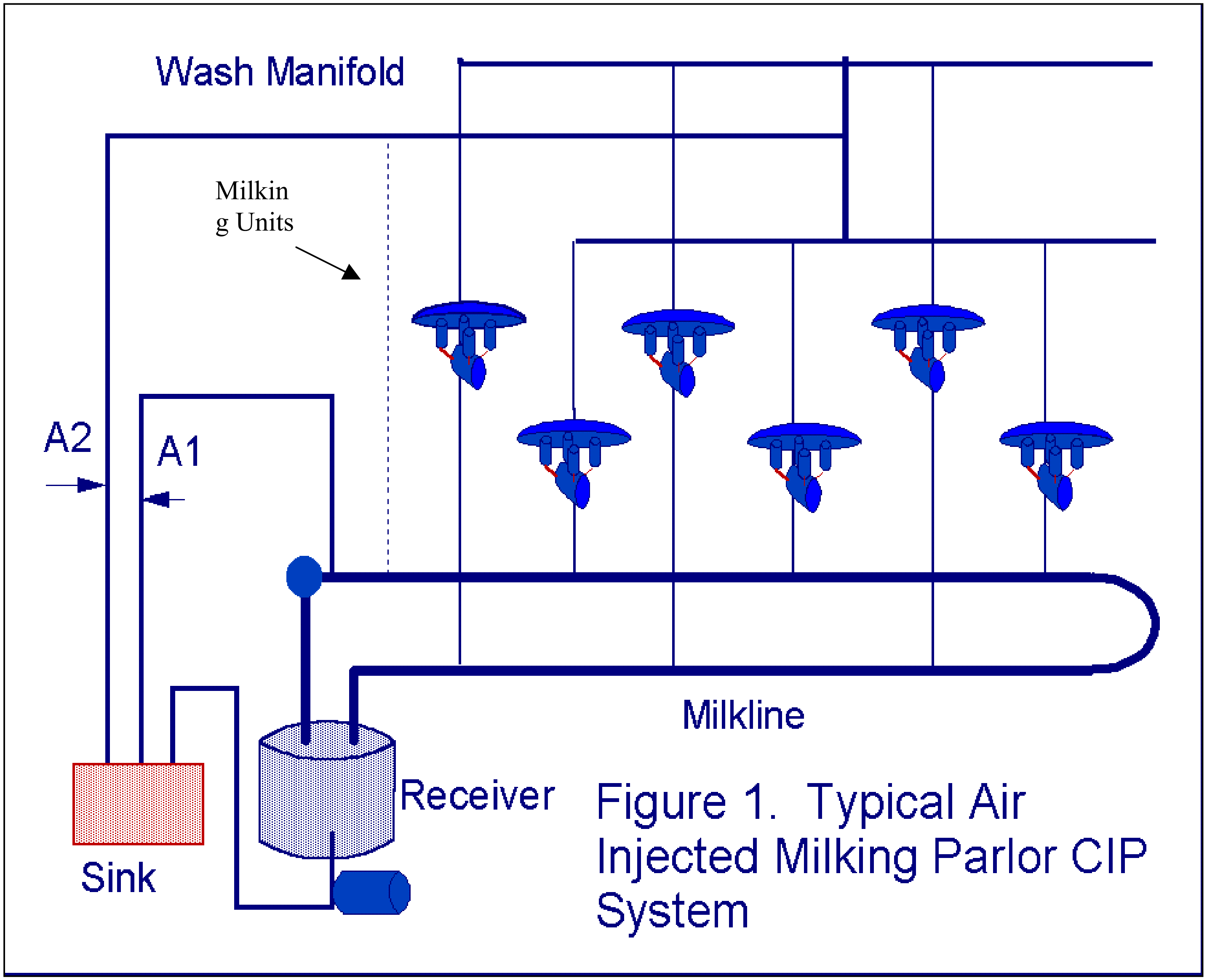


Figure 1. Typical Air Injected Milking Parlor CIP System

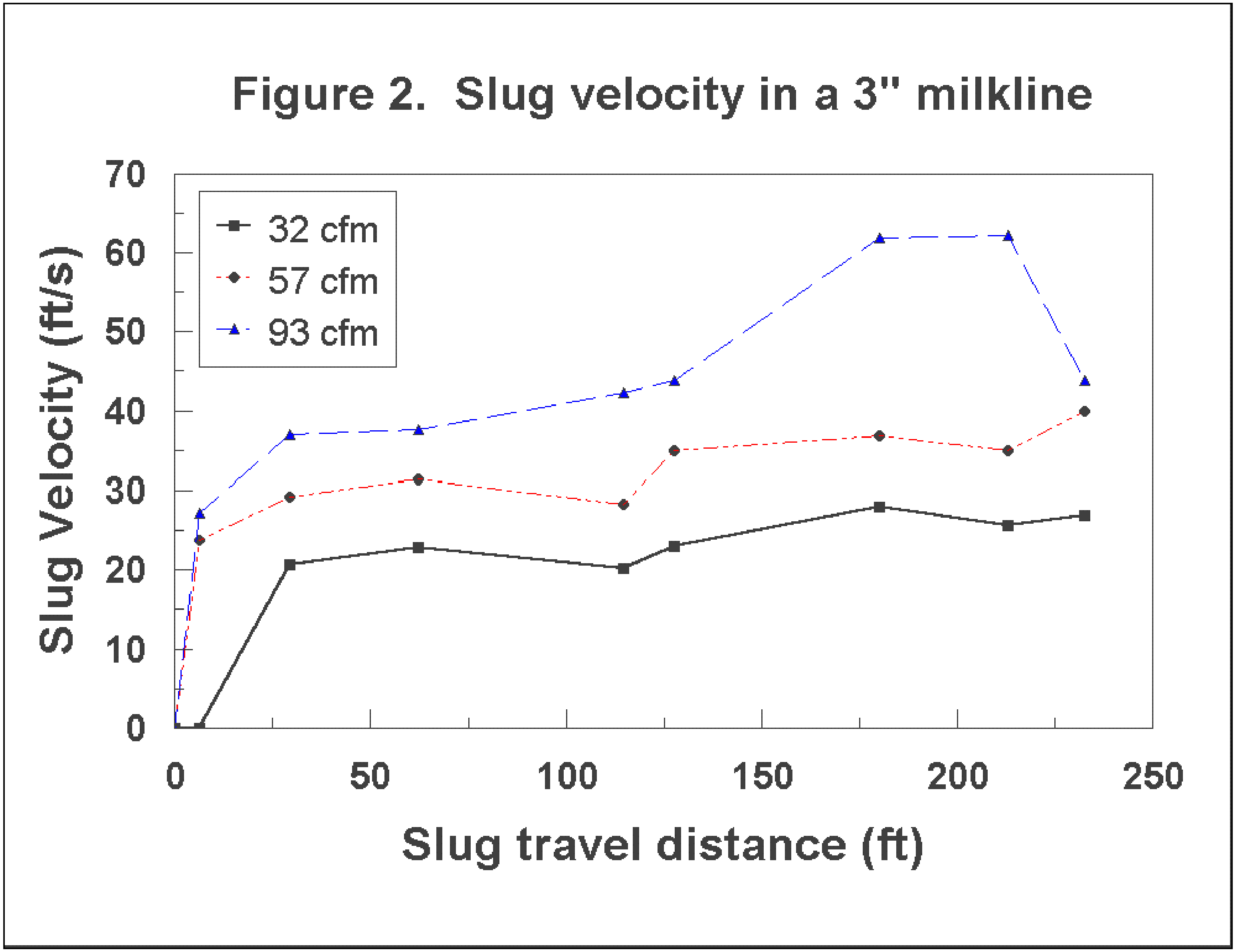


Figure 2. Slug velocity in a 3" milkline
Slug Velocity (ft/s)
Slug travel distance (ft)
32 cfm
57 cfm
93 cfm
0
10
20
30
40
50
60
70
0
50
100
150
200
250

Figure 3. Mechanical cleaning action in a 3" milkline.

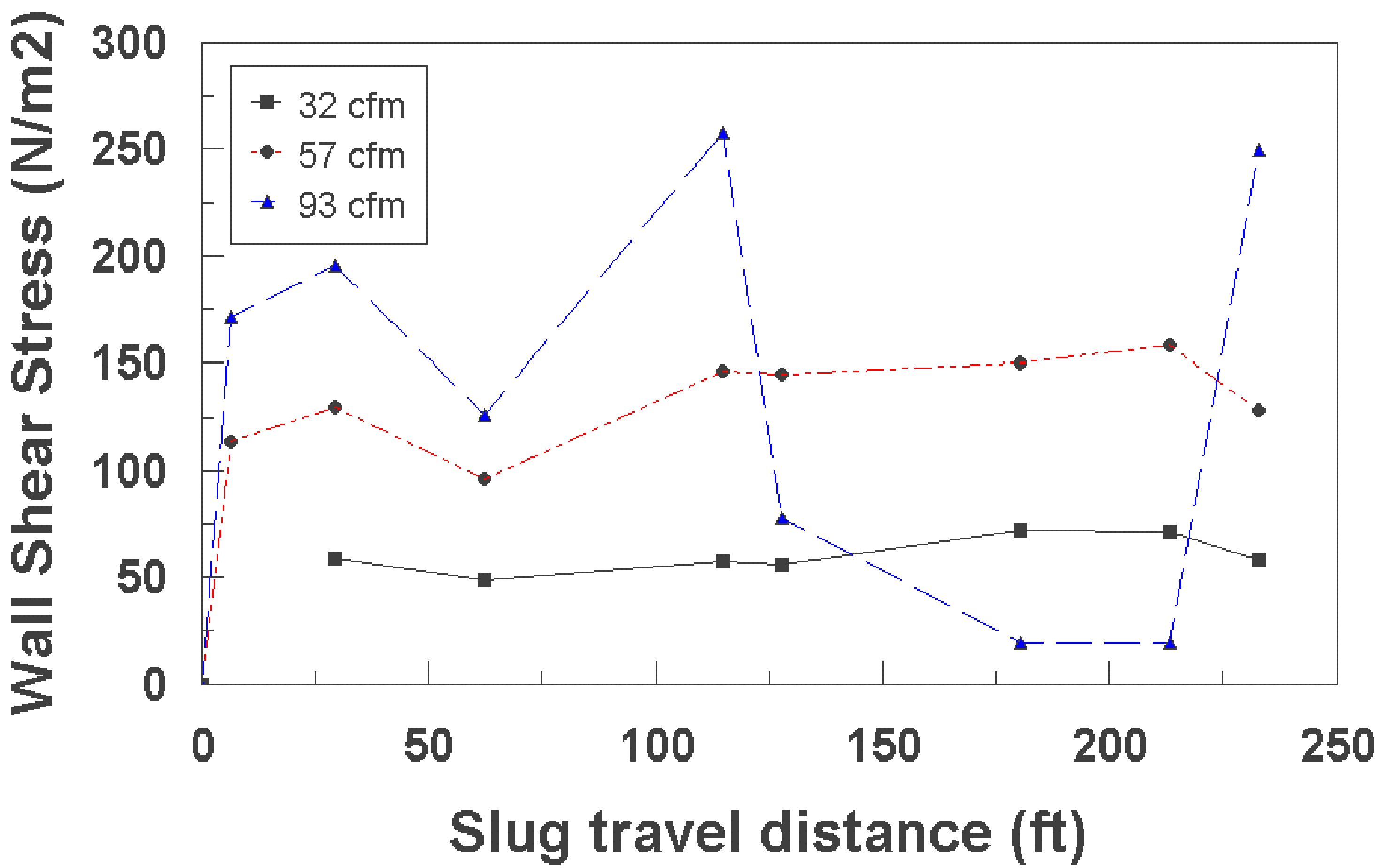


Figure 4. Air Injection Rate for Slug Flow

Slug Speed	Air injection rate (L/min) for various milkline sizes			
m/s	48 mm	60 mm	73mm	98mm
7	390	570	790	1400
8	530	760	1000	1700
9		990	1400	2200
10		1300	1800	2800

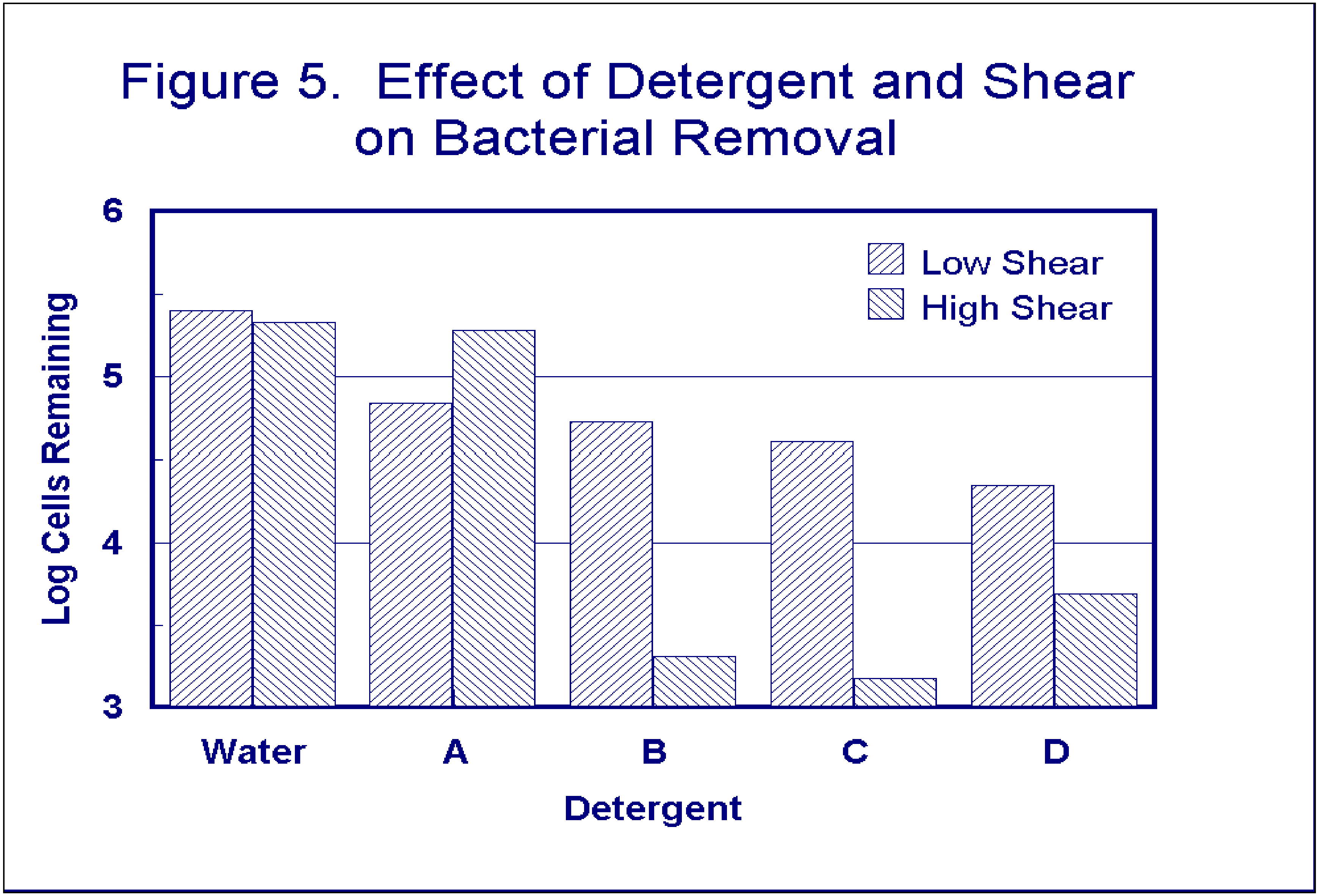
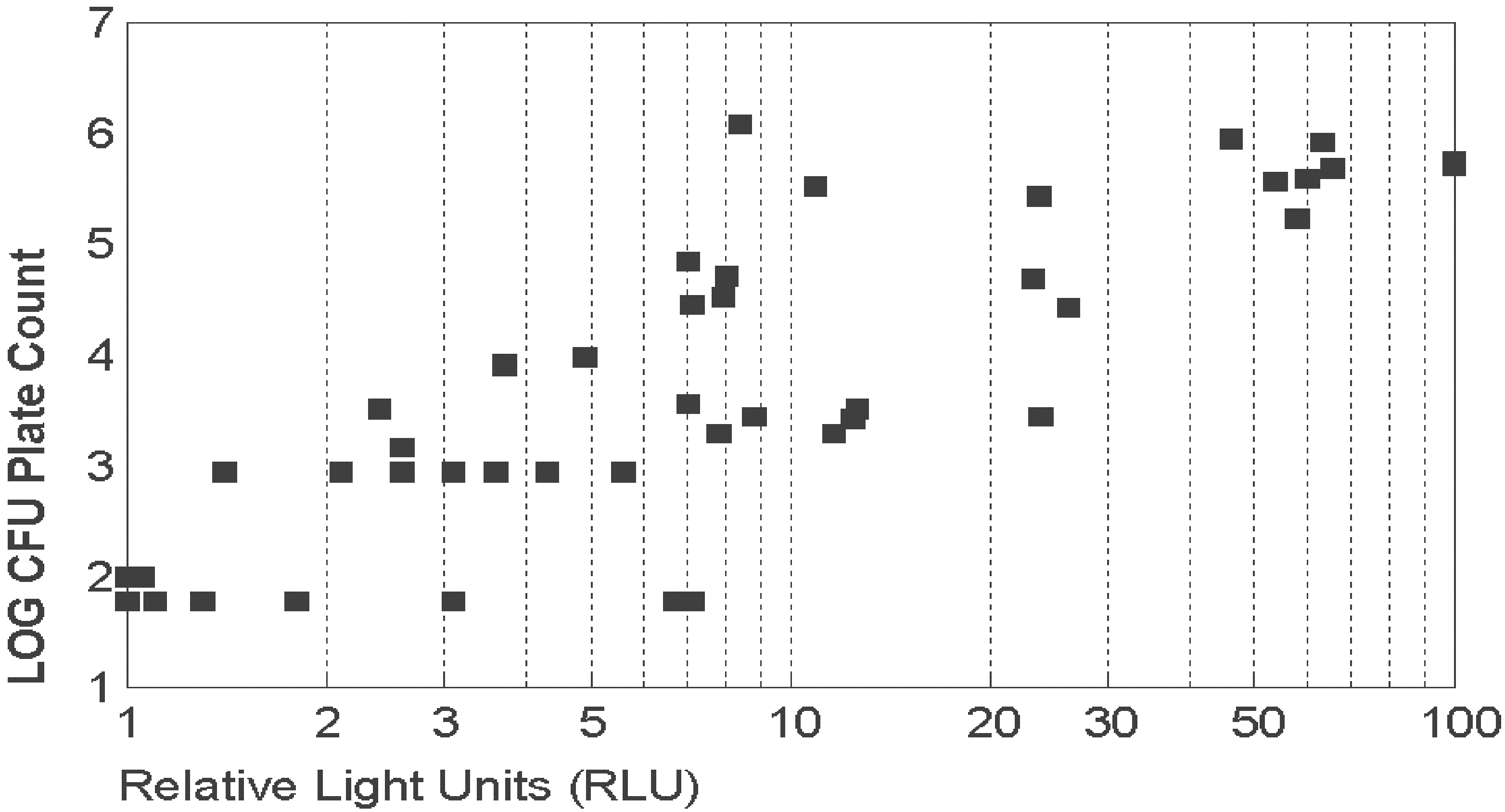


Figure 5. Effect of Detergent and Shear
on Bacterial Removal
6
5
4
3
Log Cells Remaining
Low Shear
High Shear
Water
A
B
C
D
Detergent

Figure 6. Comparison of Plate Count and ATP Measurement



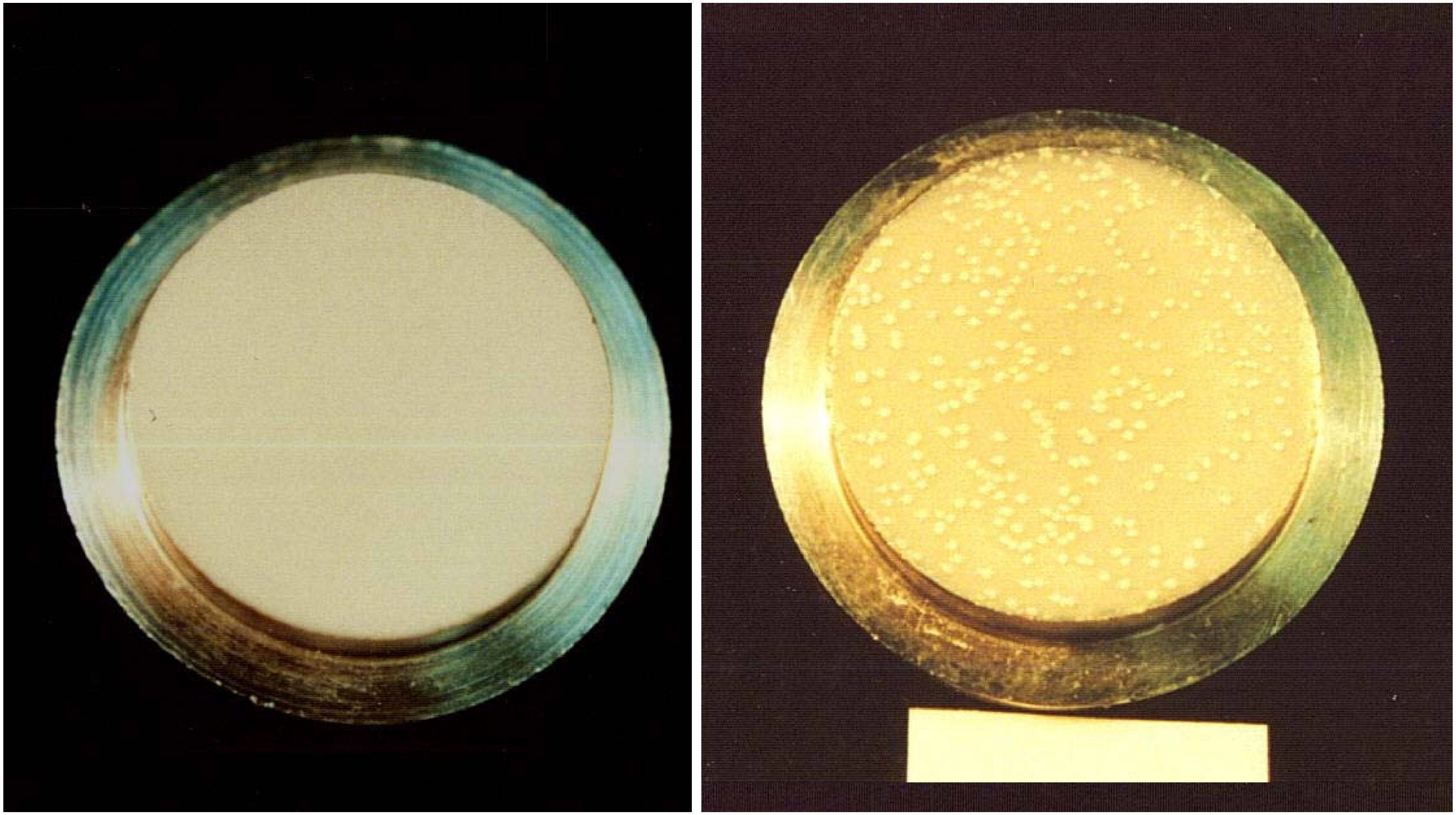


Figure 7. Test chip sprayed with milk soil (left) and incubated chip (right)

Figure 8. Test results for incubated milk soil removal using high shear. The residue is measured using Standard Plate Count.

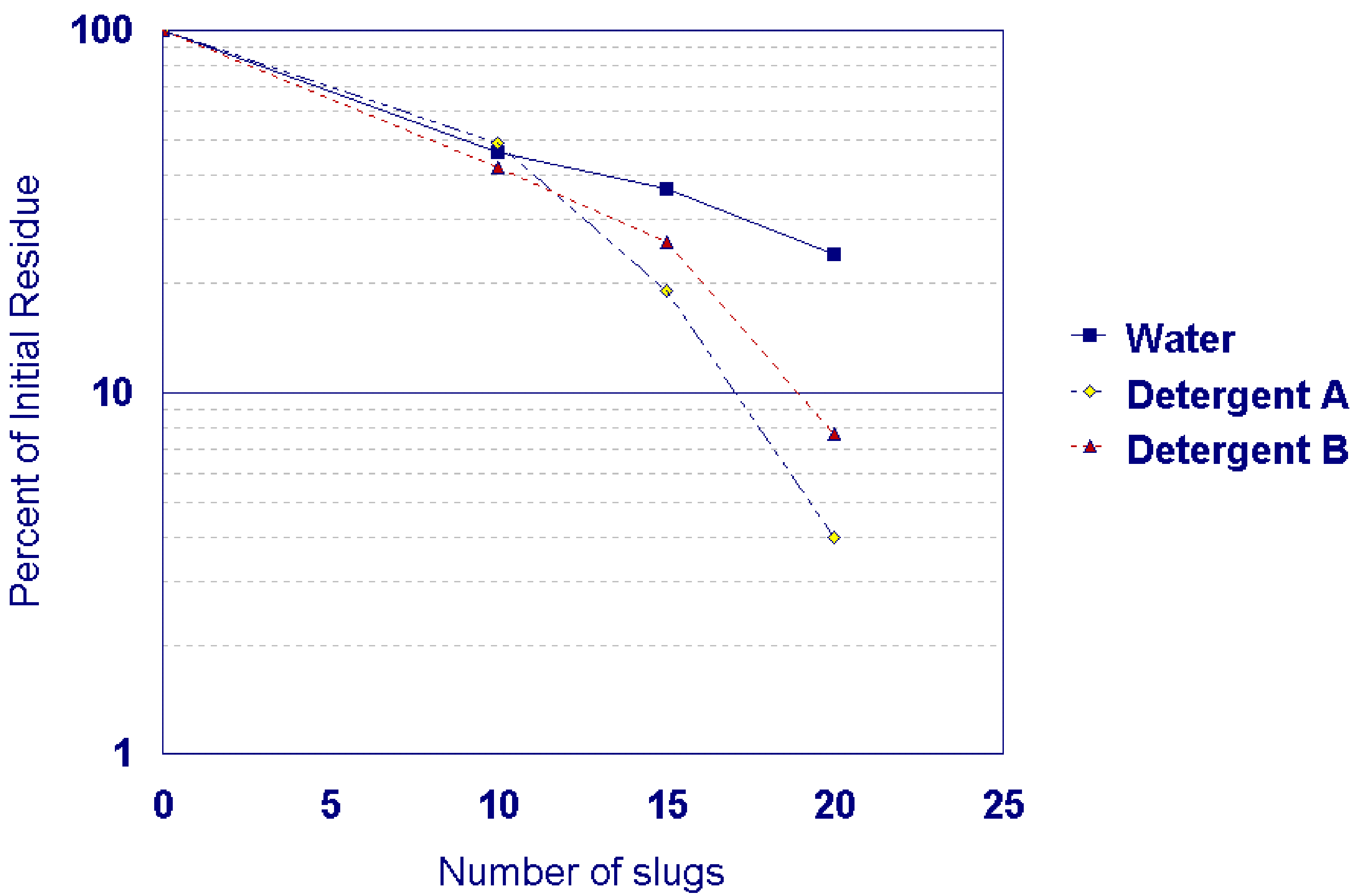


Figure 9. Test results for incubated milk soil removal using high shear. The residue is measured using ATP Bioluminscence method.