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# Testing Cleaning Performance of Milking Systems with a Vacuum Recorder

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Good quality milk starts with the condition of the cow's udder. But maintaining that quality from the milking system to the bulk tank can pose a challenge.

Dairy producers rely on Clean in Place (CIP) systems to clean their milking systems, often with little assurance that the equipment is being cleaned effectively. It takes only a small amount of residual soil to provide a place for bacteria to build—bacteria that will eventually detach and contaminate the milk, resulting in an inferior dairy product.

## Is the milking system cleaning satisfactorily?

This bulletin will help you evaluate your cleaning system using a vacuum recorder. The keys to effective cleaning lie in making sure that:

1) Detergent solutions are at the proper temperature and concentration

2) Solutions contact all milking system surfaces for sufficient time and with sufficient velocity

Many CIP cleaning system failures result when cleaning solutions are applied at inadequate velocity or do not come into contact with system surfaces for a long enough time. Air-injected slug flows are used in modern milking systems to control contact time and velocity. The method presented below will help you evaluate whether an air injection system is providing sufficient slug flow.

## Proper adjustment of the air injector

One air injection cycle is composed of a closed or "off" phase in which water is drawn into the system, and an open or "on" phase in which air is admitted. The only way that all pipe surfaces can come into contact with cleaning solutions is if one slug moves through the entire pipeline without breaking during each air injection cycle.

*Many air injectors are adjusted incorrectly so that the slug formed at the air injection point does not have time to travel completely around the pipeline.* The slug then breaks and travels for some distance as an elongated wave which does not completely fill the pipe section. Although this wave may be picked up as a slug in the next air injection cycle, a portion at the top of the milkline will not have come into contact with the cleaning solution. This results in cleaning failure.

The air injector "open" or "on" time should be set so that the slug formed at the beginning of the line has enough time to travel completely around the milkline circuit.

Slug velocity for optimal mechanical cleaning action is between 7 and 10 m/s (23 to 33 ft/s) (See reference 1). The air flow rate through the injector should be adjusted to obtain slug velocities in this range.

## Using a vacuum recording device to evaluate cleaning

Vacuum recording devices are commonly used to evaluate performance during milking, and can also be used to assess air-injected slug flow during cleaning. Most modern electronic vacuum recorders have sufficiently rapid response time for this task. A typical round-the-barn pipeline system is shown in figure 1. A vacuum recording performed simultaneously at two points on the milkline during cleaning is shown in figure 2. Although the example illustrated here is for a simple pipeline system, the same concepts and procedures apply for complex pipeline and milking parlor configurations.

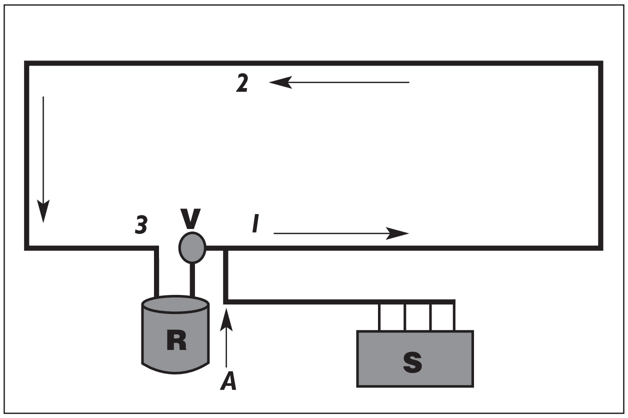


***Figure 1. Single loop round-the barn pipeline system***

S = wash sink A = air injection location
V = milk/wash valve R = receiver
1,2,3... = test points

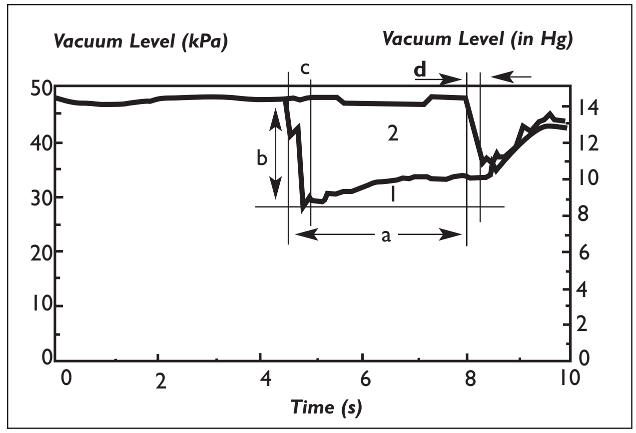


***Figure 2. A two-channel vacuum recording performed on the milkline during cleaning.***

The recorder's two channels monitor the same slug as it moves through the milkline. You can also use a single channel recorder, although it is not as convenient. The physical connection to the milkline (milk inlet or needle through a rubber gasket) is best accomplished with sections of ⅛-in. diameter transparent tubing 3 to 6 m (10 to 20 ft) in length. These tubes should be observed closely and bled often to prevent water from reaching the recorder. Moisture traps will fill with water very quickly and may distort readings.

## Vacuum drop

The vacuum drop across a slug (*b* in figure 2) measures the mechanical cleaning action produced. A rapid vacuum drop is recorded when the slug passes the test points (*c* and *d* in figure 2). The recommended ranges of vacuum drop across a slug are given in table 1. The vacuum drop across a slug will decrease slowly as it travels through the line due to a slug decay and air entrainment.

Inadequate vacuum drop across the slug indicates that the slug is too short (less than 3 m, 10 ft) and/or that excessive air is passing through the slug. A slow rate of vacuum drop indicates that the slug is moving slowly, usually because of excessive water in the pipeline or an excessively leaky milk/wash valve.

| | Line diameter, inches | | | |
|---|---|---|---|---|
| | 4 | 3 | 2.5 | 2 |
| Slug speed ft/sec | Vacuum drop across a 10-ft. slug (inches Hg) | | | |
| 23 | 3.4 | 4.0 | 4.5 | 5.2 |
| 24 | 3.7 | 4.4 | 4.9 | 5.7 |
| 25 | 4.1 | 4.8 | 5.4 | 6.2 |
| 26 | 4.4 | 5.6 | 6.3 | 7.3 |
| 28 | 5.2 | 6.1 | 6.8 | 7.9 |
| 29 | 5.6 | 6.4 | 7.4 | 8.5 |
| 30 | 6.0 | 7.0 | 7.9 | 9.1 |
| 30 | 6.0 | 7.0 | 7.9 | 9.1 |
| 31 | 6.4 | 7.5 | 8.5 | 9.8 |
| 32 | 6.9 | 8.0 | 9.0 | 10 |
| 33 | 7.3 | 8.6 | 9.6 | 11 |

***Table 1. Slug flow in milklines: Recommended slug velocity and vacuum drop across slug.***

### Slug velocity

You can calculate slug velocity by dividing the slug travel distance between the two measurement points (for example, 1 to 2 in figure 1) by the time between vacuum drops (*a* in figure 2). The test points should be at least 10 m (30 ft) apart in order to get an accurate measurement. The slug accelerates rapidly in the first 5 m (15 ft) of travel. The slug velocity in this region will therefore be lower than in the rest of the system.

### Slug length

Slug length can be calculated by multiplying slug velocity by the length of time it takes the vacuum drop to occur (*c* in figure 2). Rapid sampling and display rates are required to accurately measure the length of the slug. Set the vacuum recorder on the highest sampling rate and chart speed. The duration of rapid vacuum drop early in the line (*c* in figure 2) will normally be longer than that later in the line (*d* in figure 2) as the slug accelerates and shortens.

**Set air injector closed (off) time:** The amount of water drawn in during each cycle is determined by the amount of time the air injector is closed off. If the sanitary trap is flooding or excessive water is being transferred through the trap, the air injector close time should be reduced. The close time should be adjusted so the size of the slug reaching the receiver is just sufficient to wash the receiver. If the close time is reduced to the minimum value available on the controller and flooding still occurs, the capacity of the milk pump may need to be increased. Many parlors use “add water” lines to supply water to the milkline in addition to that supplied by the milking units. The water flow through this “add water” line may need to be restricted to avoid flooding the trap.

## If you identify problems

You can use this testing method to determine whether all parts of the pipeline are receiving adequate cleaning action from the slug. If slug action is insufficient in any part of the pipeline, a qualified milking equipment service person should evaluate and recommend changes needed in the system configuration, the air injector timing and air flow rate, water draw line restriction, and milk pump capacity. For a more detailed discussion of system testing and design, see Reference 2.

## Additional reading

(1) Reinemann, D.J., and A. Grasshoff, 1993. Milkline cleaning dynamics: design guidelines and troubleshooting. Proc. National Mastitis Council 32 Annual Meeting, Kansas City Mo.

(2) Reinemann, D.J., 1995. System Design and Performance Testing for Cleaning Milking Systems. Proc. Designing a Modern Milking Center, Northeast Regional Agricultural Engineering Services National Conference, Rochester New York, Nov. 29-Dec. 1, 1995.

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