Performing a NMC System Evaluation Prior to Start-Up

Dairy Farm Equipment Installers and Certified Milk Inspectors

Informational Meeting for Dairy Equipment Installers

Rick Watters, PhD
Quality Milk Production Services
rdw32@cornell.edu
Objectives

• Understand the main components of the milking system and how they function
• Understand the importance of completing a NMC Vacuum and Airflow System Evaluation prior to start-up
• Understand the reasons why
Milking system

• The ideal milking system will:
  – Harvest milk gently and quickly
  – Improve labor efficiency
  – Maintain animal health
  – Maintain or improve milk quality
  – Be easily clean and sanitized
  – Routinely serviced for optimum performance
Observations – **look** and **listen** before and during testing

Above photos courtesy of P. Gorden, Iowa State University
Basic Machine Function

• Milk flows in milk line by gravity, not air movement
• Milk line must have a slope of 1% to get the milk to flow to the receiver jar
• Once in Receiver Jar, milk is pumped across into the Bulk Tank, going from the vacuum to atmospheric pressure
Milking system layout – basics

- The Six Basic Parts of a Milking System
  - The Vacuum Pump
  - Vacuum Regulator or Controller
  - Receiver
  - Pulsator
  - Milking units (claw, cups and inflations)
  - Vacuum Lines

Remember to be constantly looking and listening while testing
Air removal by vacuum pump

- Vacuum pumps generate ~10 CFM per HP unit of motor
  - 35 CFM + 1 CFM/unit for ER
  - 35 CFM + 3 CFM/unit at pump for sizing the vacuum pump
    - Why the base of 35 CFM?
      - Hose diameter and reserve requirements

- Bucket Systems [do not appear in the ASAE S518.2 publications any more] We use:
  - 17 CFM - system base
  - 3 CFM/unit
  - 5 CFM for dumping station

1“ Hg = 3.386 kpa; 1 CFM = 28.317 L
Components of Milking Systems

• Regulator
• Variable Speed Drive
Vacuum regulation

• Regulator
• Vacuum sensor
• Lets air in to regulate vacuum
• Air use by system + air inlet in regulator = air removal by vacuum pump
• In fully closed system air inlet through regulator equals air removal of vacuum pump
Air usage

Regulator admits:
250 – 36+12 = 202 cfm

24 * 0.5 = 12 cfm
24 * 1.5 = 36 cfm
Receiver

- Milk collection vat – under vacuum
Components of milking equipment

Pulsator

- Rate +/- 3 cycles
- Ratio +/- 5%
- B-phase minimum 30% - industry standard >45%
- D-phase minimum 15% - industry standard > 20%
Components of milking equipment

Milking unit

- 0.4 CFM air admission claw vent
- 0.1 CFM air admission liner or mouthpiece vent
- Weight of cluster: 3.5 – 7 lbs.

0.1 CFM = 2.83 L; 0.4 CFM = 11 L
Vacuum lines
Milking system components

• What are the 6 components of the milking system?
  
  
  
  
  
  
• What are the two most common components off the milking system that we need to make sure are functioning properly at all times?
Why evaluate milking equipment?

• Objective
  – Minimize vacuum differences throughout the milking system
    • Maintain claw vacuum
  – Vacuum regulation
    • Optimize
    • Stabilize
Potential Contribution to Mastitis

- Herd & Farm Management: 30%
- Milking Machine: 20%
- Cow: 20%
- Milking Management: 30%

G. Mein et al, Storm in a Teatcup, NMC 2004
Methods & Materials

- NMC procedures:
  - www.nmconline.org
  - http://www.nmconline.org/publications.html
  - NMC provides a format for evaluating equipment as outlined by ISO standards
- ISO 6690 and 5707 standards: www.iso.org
  - 5707 Installation
  - 6690 Performance eval

- Procedures deal with proper evaluation of:
  - Vacuum levels
  - Air Flow
# Protocol for Evaluation Milking Systems

## Milking System Evaluation Form

**Daily Operator:** ____________________  **Phone:** ____________________  **Email:** ____________________  **Dealer:** ____________________  **Date:** ____________________

**Address:** ____________________

**Operator’s Comments:** If any ____________________

**Number of Cows:** ____________________  **Milk Production:** ____________________  **SCC:** ____________________

**Milk System:** ____________________  **Height:** ____________________  **Lowline:** ____________________  **Single Loop:** ____________________  **Double Loop:** ____________________  **Number of Milking Units Used:** ____________________

**Milking Diameter:** ____________________  **Pulser Line Diameter:** ____________________  **Inches:** ____________________  **Number of Operations:** ____________________

### MILKING-TIME TESTS

**Average Milking Vacuum:** 9.5 to 12.5 in 6.5 to 42 in (9.5 to 12.5 kPa) is desirable

**Low Vacuum Fluctuations:** 3 in 5 to 20 seconds, during peak flow, at least 10 cows

**Pulser Ratio and Rate:** Under the full milking test, the rate is established. Consult operator’s manual for cluster.

**Milkline Vacuum Stability:** 0.1 in (1 kPa) variation in 15 minutes in a round the farm system

**Receiver Vacuum Stability:** 0.1 in (1 kPa)

**Dewatering Time:** 0.1 in (1 kPa)

### DRY TEST OF PULSATORS

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<th>Pulser Number</th>
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<td><strong>Functionality:</strong></td>
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### DIAGNOSTIC DRY TESTS OF VACUUM AND AIRFLOW

**Vacuum Pump:** 1 in 5 to 20 seconds (average)

**Regulator:** 1 in 5 to 20 seconds

**Pulser:** 1 in 5 to 20 seconds

**Vacuum Pump:** 1 in 5 to 20 seconds

**Airflow Check:** 1 in 5 to 20 seconds

### RECOMMENDATIONS: PRIORITIES/CHANGES

**Priority Number:** ____________________

**Acceptance by Owner:**

The undersigned each acknowledge that the above described milking system was analyzed on the _______ (date) of _______ (month and year) and each agrees that the results are, to the best of their knowledge, correctly described above.

**Daily Operator/Owner:** ____________________  **Dealer/Technician:** ____________________
Why do we complete a NMC Vacuum and Airflow test?

• What does the NMC Vacuum and Airflow evaluation tell you?
• Methods are primarily for evaluating adequacy of milking systems to **maintain average claw vacuum within the intended range during milking** and the ability of the pulsation system to operate within the manufacturer's specifications
  — How can you determine claw vacuum or pulsation if you don’t complete a milking equipment evaluation?
• Have you ever read or seen this?
  – A post installation test and system evaluation must be completed prior to the first milking and the report must be available for review at the producer facility.
**Cleaning & Sanitizing System — Attach all water volume requirements for the wash system to this application**

<table>
<thead>
<tr>
<th>Air injector Location</th>
<th>Bulk Storage Tank Wash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk Line Wash System</td>
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<td>Wash Vet Size</td>
<td>Wash Procedure Pre-Rinse</td>
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<td>Wash Cycle</td>
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<td>Acid / Post Rinse</td>
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<td>Wash Cycle Time</td>
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<td>Wash Procedure</td>
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<td>gallons (L)</td>
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<tr>
<td>Total Hot Water Required</td>
<td>gallons (L)</td>
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</tbody>
</table>

**Water Heating Equipment**

1. Type of heater:  
   - Electric  
   - Gas  
   - Oil  
   - Other: ____________

2. Capacity of Hot Water Storage System:  
   - gallons (L)

3. Heating Capacity of System:  
   - Btu / Hr. Input:  
   - gal. / hr. / 100°F Rise Recovery: ____________

4. Additional Water Heating: explain

**Manually Cleaned Components**

- [ ] Diverter Plug(s)  
- [ ] Manual Shut-Off Valve(s)  
- [ ] Milk Tank Outlet Valve(s)

List other components: ____________

A cleaning program, including water hardness and detergent and sanitizer concentration, must be posted in the milkhouse. The program must be accurate for the cleaning chemicals currently available in the milkhouse.

Any future modification of this equipment must have prior written approval.

A post installation test and system evaluation must be completed prior to the first milking and the report must be available for review at the producer facility.

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**FOR OFFICE USE ONLY**

<table>
<thead>
<tr>
<th>Plan Approval, Dairy Products Specialist, Signature</th>
<th>Date Plan Received:</th>
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<tbody>
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<thead>
<tr>
<th>Installation Approval, Dairy Products Specialist, Signature</th>
<th>Date</th>
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This application, when properly filled out by the regulatory agency, serves as the official approval. Please maintain a copy of the application for review by other regulatory agencies.

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Quality Milk Production Services
Start-up...?

• What defines a system start-up?

  – New installation
  – Retrofit or update
    • Pulsators, meters or sensors, vacuum pump, regulator, etc.
  – Tie-stall, Parlor and/or AMS
    • This applies to all systems
If the milking system is not baselined...

• Why isn’t the vacuum and airflow test completed after an update or start-up?
  – Not enough time between milking shifts and producer won’t allow the test
    • I have not met a dairy producer yet that I have explained the reason for the testing and they have said no to the testing
  – Installer doesn’t have the testing equipment
    • Then hire someone to test after install or update

• Not testing after system updates/retrofit has become systemic
  – Issue requesting NMC information from NY, VT, KS and Canada
  – Conventional parlors, Rotaries, AMS
If not a complete NMC then what...?

• Need to test pulsation, vacuum stability and claw vacuum

• Priorities
  – Claw vacuum
    • 9.5 – 12.5” Hg
  – Vacuum stability
    • Milkline vacuum
      – < 0.6” Hg fluctuation
      – Vacuum difference in the milkline (average minus minimum) or the vacuum rise (maximum minus average) does not exceed 0.6"Hg (2 kPa)
  • Milking unit fall-off test
    – < 0.6” Hg vacuum change during fall-off test

– Pulsation
  • Graph all pulsators
    – Static for all
    – Some under load
Take home message

- Equipment testing is very logical and adheres to laws of physics
  - Movement of fluids in a column that is under vacuum
- Vacuum and airflow testing is part of all start-ups
  - New or retrofit
- Equipment testing is part of general maintenance procedures on dairy farms
- Vacuum stability – minimize fluctuations
- Suggest priorities and changes
- Provide results to client so client can review results with equipment provider in order to make sure milking system is functioning properly
Questions

Test equipment
Vacuum Changes

Dynamic vacuum changes
- High milk flow rates
- Disturbed air flow
- Insufficient vacuum pump capacity

Vacuum drops

Vacuum fluctuations
- Liner movement (open/collapse) + start/stop of milk flow
- Sudden air admission e.g. liner slips, kicking

Cyclic vacuum fluctuations

Irregular vacuum fluctuations

Increasing factors:
- High milk flow
- Disturbed air flow

Farm information

- Obtain contact information
- Why are you evaluating the equipment?
- Is there other information that may be useful based upon why you are evaluating the equipment?
- Who will information be provided to and in what method?
Safety first

• Be aware of how the test you are performing could have a potential negative impact on the milking system.
  – Turning off equipment increases vacuum
    • *Increase air admission before turning off equipment*
• Always turn equipment back on after testing
• Always open valves that were closed for testing
• Always retest vacuum at receiver
Location of five vacuum gauges

- Proper placement of testing equipment
  - The values obtained during equipment evaluation are only valid if the proper test methods are followed
  - The most important aspect of equipment testing is location of testing devices
Setting up system for analysis

- Mimic milking
- Milk/wash plug in milk position
- All milking units with vacuum and pulsation on
  - Manual mode
  - Some systems when turned on after a wash will have vacuum and pulsation to the units
  - No need to turn units on and place in manual mode
MILKING-TIME TESTS

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Standard/Note</th>
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<tbody>
<tr>
<td><strong>Average Claw Vacuum, kPa</strong>, 5-20 second recording, during peak flow, at least 10 cows</td>
<td>9.5-12.5&quot;Hg (32 to 42 kPa) is desirable</td>
</tr>
<tr>
<td><strong>Claw Vacuum Fluctuations, kPa</strong>, 5-20 second recording, during peak flow, at least 10 cows</td>
<td>No standard is established. Consult operator’s manual for cluster.</td>
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<tr>
<td><strong>Pulsator Ratio and Rate</strong>, under full milking load</td>
<td>Comparable to dry pulsator tests</td>
</tr>
<tr>
<td><strong>Milkline Vacuum Stability, kPa</strong>, (avg – min) and (max – avg)</td>
<td>Each less than 0.6&quot; (2 kPa) is desirable</td>
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<tr>
<td><strong>Receiver Vacuum Stability, kPa</strong></td>
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**Dynamic Test**
- **During milking**
  - Vacuum in milk line (with all units milking)
    - Vacuum fluctuations (<0.6"Hg)
    - Test at point that will have the most milk flow – chance for greatest vacuum fluctuation (nearest receiver)
  - Vacuum fluctuations in receiver (<0.6"Hg)
    - Test with special lid or nearest receiver as possible
  - Test/Cow
    - Average claw vacuum full load (9.5-12.5" Hg)
    - Pulsator ratio during milking (within 5% of static pulsator ratio)
Claw vacuum

- Pull short milk tube off claw and rotate 180 degrees
  - Push partially back on inlet
- Insert needle with long side of needle head facing the top of the short milk tube or with bevel side down
  - Milk will flow over the tip of the needle and not over the lumen of the bevel
- Or VaDia
- Peak milk flow of highest producing group
- Remove needle and rotate short milk tube 180 degrees back to normal position
- Always ask producer if they have a spare liner before measuring claw vacuum
  - Silicone liners
Line vacuum

- Pull milk hose off milk inlet
  - Push partially back on inlet
- Insert needle with long side of needle head facing the flow of milk or the bevel side down
  - Will force milk over the needle head and not over the lumen of the bevel
- Make sure there is a “shinny” area of the milk inlet exposed
- Remove needle and push milk hose back down over milk inlet
Vacuum during milking

• Mean claw vacuum of 9.5-12.5“Hg (32 – 42 kpa) during peak milk flow
  – With less than 2” of variation during milking.

• < 0.6”Hg drop in milk line vacuum during milking
  – More indicates ‘slugging’

• < 0.6”Hg variation in receiver vacuum during milking
  – More indicates slow regulator response or insufficient effective reserve
### DRY TEST OF PULSATORS

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Graphing pulsator

- Plug all four teatcups
- Alternating pulsation
  - Test each side
  - Test front and rear
- Turn milking unit on
- Hold milking unit upside down
  - Prevents bending of hoses - restrictions
Milking system evaluation

• **Static pulsator tests**
  – Ratio within 5% (within 2-3% from side-to-side)
    • A phase %
    • B phase at least 30%
      – Current industry settings target 500 ms
    • C phase % or ms
    • D phase at least 15% or 150 ms
      – Current industry settings target 220 ms
  – Rate within 3 pulses per min
Pulsators under load

- Graph some pulsators while milking a cow - dynamic
- All pulsators will be graphed with teat plugs in and the machine on - static

- Milk:Rest ratio is an estimate of the proportion of each cycle during which milk is either flowing or not flowing from the teat
- Ratio is never constant but should be very similar
- Liner collapse force, liner tension, claw vacuum and pulsation ratio all affect the real pulsation ratio
Static vs. dynamic testing of pulsators?

Teat plugs in
Milking unit on – vac and puls
57% A-B
43 % C-D

Teat cups attached to cow and milking
Milking unit on – vac and puls
62% A-B
38 % C-D

Pulsation Graphs

Teat Cups Plugged

Fri Jan 12 07:03:19 PM

Pulsation 1 (PLOT)
Rate: 59.93 PPM
Ratio: 65:35
A Phase: 19% 188ms
B Phase: 46% 467ms
C Phase: 18% 180ms
D Phase: 17% 167ms
A+B Phase: 65% 655ms
C+D Phase: 35% 347ms
Vacuum: 13.2inHg

Pulsation 2 (PLOT)
Rate: 59.93 PPM
Ratio: 66:34
A Phase: 19% 185ms
B Phase: 47% 474ms
C Phase: 18% 182ms
D Phase: 16% 159ms
A+B Phase: 66% 653ms
C+D Phase: 34% 341ms
Vacuum: 13.3inHg
Limp: 1%

Milking

Fri Jan 12 07:13:15 PM

Pulsation 1 (PLOT)
Rate: 60.00 PPM
Ratio: 65:35
A Phase: 25% 247ms
B Phase: 40% 401ms
C Phase: 16% 161ms
D Phase: 19% 191ms
A+B Phase: 65% 648ms
C+D Phase: 35% 352ms
Vacuum: 13.3inHg

Pulsation 2 (PLOT)
Rate: 60.06 PPM
Ratio: 66:34
A Phase: 19% 193ms
B Phase: 47% 467ms
C Phase: 18% 181ms
D Phase: 14% 139ms
A+B Phase: 68% 660ms
C+D Phase: 34% 340ms
Vacuum: 13.2inHg
Limp: 1%
## Vacuum and air flow

### Diagnostic Dry Tests of Vacuum and Airflow

<table>
<thead>
<tr>
<th>Working Vacuum and Vacuum Differences Across System</th>
<th>Receiver or Weigh Jar (ROV)</th>
<th>Regulator Sensor</th>
<th>Pulsator Airline</th>
<th>Vacuum Pump Inlet (PIV)</th>
<th>Farm Gauge Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Record operating vacuum level at: (5 to 20 second average)</td>
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<tr>
<td>1a. Tea cups plugged and all units operating</td>
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</tbody>
</table>

#### Unit Fall-Off Tests

<table>
<thead>
<tr>
<th>Record vacuum level at:</th>
<th>Receiver or Weigh Jar</th>
<th>Calculation</th>
<th>Vacuum Drop, Overshoot, &amp; Undershoot</th>
<th>Guidelines or Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1b.1. Minimum vacuum after one unit is opened</td>
<td>Undershoot 1b.2 - 1b.1</td>
<td></td>
<td></td>
<td>Less than 0.6&quot;Hg (2 kPa) is desirable</td>
</tr>
<tr>
<td>1b.2. Average vacuum with one unit open for 5 to 20 seconds</td>
<td>Vacuum drop 1a - 1b.2</td>
<td></td>
<td></td>
<td>Less than 0.6&quot;Hg (2 kPa) is desirable</td>
</tr>
</tbody>
</table>

1b.3. Maximum vacuum after one unit is closed

<table>
<thead>
<tr>
<th>Overshoot 1b.3 - 1a</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 0.6&quot;Hg (2 kPa) is desirable</td>
<td></td>
</tr>
</tbody>
</table>

For systems with more than 32 units or multiple operators, repeat the unit fall-off test by opening two units.

<table>
<thead>
<tr>
<th>1c.1. Minimum vacuum after two units are opened</th>
<th>Undershoot 1c.2 - 1c.1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 0.6&quot;Hg (2 kPa) is desirable</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1c.2. Average vacuum with two units open for 5 to 20 seconds

<table>
<thead>
<tr>
<th>Vacuum drop 1a - 1c.2</th>
<th></th>
</tr>
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<tbody>
<tr>
<td>Less than 0.6&quot;Hg (2 kPa) is desirable</td>
<td></td>
</tr>
</tbody>
</table>

1c.3. Maximum vacuum after two units are closed

<table>
<thead>
<tr>
<th>Overshoot 1c.3 - 1a</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 0.6&quot;Hg (2 kPa) is desirable</td>
<td></td>
</tr>
</tbody>
</table>
Milking system evaluation

- Vacuum within +/- 0.6” Hg of set point during milking:
  - Regulator, Receiver, Milkline

- System Vacuum Differences
  - Vacuum at:
    - Receiver
    - Regulator
    - Vacuum Pump
    - Pulsator Airline
    - Vacuum gauge
  - Units Plugged

- No ports = System never tested

<table>
<thead>
<tr>
<th>System Vacuum (in. Hg)</th>
<th>Receiver</th>
<th>Regulator (sensor)</th>
<th>Vacuum Pump</th>
<th>Pulsator Line</th>
<th>Farm Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a) Static System Test</td>
<td>14.0</td>
<td>14.1</td>
<td>14.1</td>
<td>14.1</td>
<td>13.5</td>
</tr>
<tr>
<td>b) 1 milking unit/s open</td>
<td>14.0-14.1</td>
<td>14.0-14.1</td>
<td></td>
<td></td>
<td>14.1</td>
</tr>
</tbody>
</table>
Vacuum sensing point – Multiple receivers

• Multiple receivers and vacuum sensing point
  – Should only be one sensing point
  – Locate sensing point half way between both receivers
    • Balance tank may be halfway
  – ONLY ONE SENSING POINT WITH MULTIPLE RECEIVERS
Vacuum sensing point

• Vacuum sensing point should be closest to receiver on trap side
  – Multiple receivers locate vacuum sensor equal distance between receivers
  – Locate vacuum sensing point on vacuum line in attic
  – Install pipe half way between the two ends of the vacuum lines to connect the two vacuum lines in attic
    • Install vacuum sensor on middle of pipe connecting two main vacuum lines
Vacuum levels

- Working vacuum at receiver:
  - High line: 14.0 – 15.0 “Hg
  - Low line: 12.5 – 13.5 “Hg

- Farm vacuum gauge: within 0.6”Hg

- Less than 0.9”Hg difference between vacuum pump and receiver
  - Which one has higher vacuum?

- Less than 0.3 “Hg difference between receiver and regulator sensor
  - Which one has higher vacuum?

- Mean difference between the receiver and most distal part of the pulsator line less than 0.6”Hg
Milking unit fall-off

- Record receiver vacuum
- Turn off unit(s) required for fall-off test and remove teat plugs
- Begin recording receiver vacuum and then turn on milking unit(s) and hold upside down
- Record vacuum with milking unit open
- Record vacuum when turning vacuum off
Testing regulator response

Milkline vacuum = average A
Fall-off vacuum = average A – average C < .6”Hg
Undershoot = average C – minimum B < .6”Hg
Overshoot = maximum D – average D(orA) < .6”Hg

2 units open when > 32 milking units

How does the number of milkers affect this test?

0.6 “Hg = 2kpa
Receiver Operating Vacuum (ROV)  
= Avg of A

Avg of A(ROV) = 13.9”

Vacuum Drop (VD)  
ROV– Avg C  
13.9 – 14.0 = -0.1”

Vacuum Undershoot  
Avg C – Min B  
14.0 – 13.6 = 0.4”

Vacuum Overshoot  
Max D – Avg A  
14.2” – 13.9” = 0.3”

0.6 “Hg =2kpa
Regulator response

• Excessive vacuum drop is usually caused by restrictions in airline between receiver and vacuum sensor
  – Distinguish between slow response (vacuum eventually recovers) and insufficient effective reserve (no recovery)
• Excessive undershoot is often caused by sticking regulator or plugged filter in regulator
• Excessive overshoot is often caused by improperly adjusted variable frequency drive vacuum controller
Regulator

- Regulator is the most common cause for system dysfunction
- More than one sensor in the system:
  - System should have only one sensor
- Sensor between regulator and milk pump
  - Sensor should be as close to the sanitary trap as possible, regulator positioned toward the pump
### Effective Reserve, Manual Reserve And Regulation Efficiency

<table>
<thead>
<tr>
<th>Description</th>
<th>As found</th>
<th>Retest after changes</th>
<th>Guidelines or comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2a. Effective Reserve: air admission to reduce operating receiver vacuum 2 kPa (0.6 &quot;Hg), LPM (CFM)</td>
<td></td>
<td>1000 LPM + 30 LPM/unit (35 cfm + 1 cfm/unit)</td>
<td></td>
</tr>
<tr>
<td>2b. Vacuum at regulator sensor KPa (&quot;Hg)</td>
<td></td>
<td></td>
<td>Not applicable for VFD regulators</td>
</tr>
<tr>
<td>2c. Manual Reserve: regulator disabled LPM (CFM)</td>
<td></td>
<td></td>
<td>At least 90% is desirable</td>
</tr>
<tr>
<td>2d. Regulation Efficiency (ER/MR) x 100</td>
<td></td>
<td></td>
<td>At least 1.3 kPa (0.4 &quot;Hg) is desirable</td>
</tr>
<tr>
<td>2e. Vacuum change at regulator sensor (1a sensor - 2b)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What impact will hose diameter have on air admission? 5/8” vs. ¾” vs. 7/8”

<table>
<thead>
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<th>Description</th>
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<th>Retest after changes</th>
<th>Guidelines or comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2a. Effective Reserve: air admission to reduce working receiver vacuum 0.6&quot;Hg (2 kPa), CFM (LPM)</td>
<td></td>
<td></td>
<td>Air usage of 1 unit (from 3b) plus (3% of 1 unit air usage/unit multiplied by the number of units [up to 96 units])</td>
</tr>
<tr>
<td>2b. Vacuum at regulator sensor &quot;Hg (KPa)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2c. Manual Reserve: regulator disabled CFM (LPM)</td>
<td></td>
<td></td>
<td>Not applicable for VFD regulators</td>
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<td>2d. Regulation Efficiency (ER/MR) x 100</td>
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<td>At least 90% is desirable</td>
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<tr>
<td>2e. Vacuum change at regulator sensor (1a [Regulator sensor] - 2b)</td>
<td></td>
<td></td>
<td>At least 0.4&quot;Hg (1.3 kPa) is desirable</td>
</tr>
</tbody>
</table>

20 units in parlor
OLD: 35 +20 = 55
NEW: Air usage of 1 unit (from 3b) plus (3% of 1 unit air usage multiplied by the number of units) Ex: 1 unit admits 30 cfm
30 + ((30*0.03)*20)=48
Effective & manual reserve

• Effective reserve is measured with milking machine turned on, flow meter at receiver:
  – open flow meter until milking vacuum has dropped 2 kPa (.6”hg): measure air going through flow meter (AFM)
  – Open air flow meter before testing
• Effective Reserve
  – 0.6”Hg below receiver vacuum
• Manual Reserve
  – 0.6”Hg below receiver vacuum with regulator disconnected
• Regulator efficiency ER/MR = %
  – ≥ 90%
Effective reserve

- Effective reserve should be >90% of manual reserve (=regulation efficiency)

- Variable Speed vacuum pump
  - Pump speed is regulator
  - No manual reserve measurement
    - (no regulator function expected)
    - Regulator set at higher vacuum
Effective reserve

• 35 CFM at pump + 3 CFM/unit for sizing the vacuum pump

• Effective reserve at receiver $\rightarrow$ 35 CFM + 1 CFM/unit (OLD)

• Effective reserve at receiver CFM admitted by 1 milking unit plus (3% multiplied by CFM admitted by 1 unit times the number of units (NEW)
Mechanical regulators

Disable by removing sensing tube or taping off air inlet

• Sentinel 100, 350 or 500
  – Tape off air inlet
• Vacurex 5000
• Surge Commander 5K
• BouMatic BouVac
• DeLaval Servo

Disable by removing regulator from system

• Sentinel Mark I or Mark II
• Vacuum Regulators

– Optional Mounting- The regulator may be remote mounted from the main vacuum supply line when using a vertical mounted sweep tee.

---

**FIGURE 1 Typical Horizontal Installation**

- B = Minimum 5 pipe diameters from any Fittings
- A = Minimum 2 pipe diameters from any Fittings

**FIGURE 2 Typical Vertical Installation**

- Air flow to Vacuum Pump
- Recommended:
  - A = Sensor tube Nipple 5 pipe diameters minimum from any pipe fitting
- Adapter as Needed
- Reducer as Needed
- Drain
- Sensor Tube
- From Receiver

---
## Component air admission

### Air Admitted By System Components

<table>
<thead>
<tr>
<th>All measurements taken with AFM adjusted so receiver is at working vacuum level (1a)</th>
<th>AFM reading, CFM (LPM)</th>
<th>Air admitted CFM (LPM)</th>
<th>Retest after changes CFM (LPM)</th>
<th>Guidelines or comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>3a. All teatcups plugged and components operating</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3b. One unit open, four teatcups unplugged.</td>
<td>3b.1. Air admitted by one unit (3a – 3b)</td>
<td></td>
<td></td>
<td>Varies with type of unit and system design</td>
</tr>
<tr>
<td>3c. One teatcup open – three plugged (Optional)</td>
<td>3c.1. Air admitted by one teatcup (3a – 3c)</td>
<td></td>
<td></td>
<td>Varies with type of unit and system design</td>
</tr>
<tr>
<td>Re-plug all teatcups and adjust AFM to return to ROV (1a).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3d. All Pulsators disconnected or deactivated</td>
<td>3d.1. Air admitted by pulsators (3d – 3a)</td>
<td></td>
<td>0.75 to 1.5 CFM (20 to 40 LPM) / pulsator</td>
<td></td>
</tr>
<tr>
<td>3e. Clusters disconnected</td>
<td>3e.1. Air admitted by clusters (3e – 3d)</td>
<td></td>
<td>0.3 to 0.5 CFM (10 to 15 LPM) / cluster vent</td>
<td></td>
</tr>
<tr>
<td>3g. Other equipment disconnected</td>
<td>3g.1. Air admitted by other equipment (3a – 3f)</td>
<td></td>
<td>Consult operator’s manual.</td>
<td></td>
</tr>
<tr>
<td>3h. Record Pump Inlet Vacuum with all equipment disconnected:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Turning off components

• Turn off pulsation control box
  – Record change in airflow to maintain ROV

• Turn off milking units
  – Record change in airflow to maintain ROV

• What if pulsators turn off with milking units?
  – How do you obtain an airflow measurement for both the pulsators and milking units
  – Is it necessary to have an airflow reading for both pulsators and milking units?
Component air admission

• Each piece of milking equipment allows air into the vacuum system
  – Removing components from the vacuum system will increase vacuum
    • ALWAYS LET AIR IN BEFORE DISABLING OR REMOVING EQUIPMENT
  – Think ahead as to how much air you should let in before disabling
    • Pulsators: 1.0 - 1.5 CFM/unit
    • Claw (vents): 0.3 - 0.5 CFM/unit
    • Regulators: 2.0 - 10 CFM
Component air admission

• Air usage - components
  – Regulator disabled, measure air flow at receiver at operating vacuum
  – All teat cups plugged and components operating
    • Record value
  – Remove components one by one and adjust air flow meter at receiver to obtain same operating vacuum
  – Difference in air flow for each component is equal to its air admission
  – Vacuum levels should increase as equipment is turned off
Air loss in equipment

- Pulsators: 1.0 - 1.5 CFM/unit
- Claw (vents): 0.3 - 0.5 CFM/unit
- Regulators: 2.0 - 10 CFM
- Unit attachment: 1 - 10 CFM
- Unit kick off: 30 - 90 CFM
- ATO’s - variable
- Vacuum powered equipment – variable
- Leaks → variable

Total loss shall be less than 5% of pump capacity

- It’s not always as simple as turning the milking unit off
  - Pulsators turned off with milking unit
Vacuum pump capacity

<table>
<thead>
<tr>
<th>Vacuum Pump Capacity</th>
<th>Pump 1</th>
<th>Pump 2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>4a. Pump Airflow Capacity at pump's rated vacuum level</td>
<td>compare with manufacturers' specifications.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4b. Pump Airflow Capacity at working pump inlet vacuum, from 3h.</td>
<td>total pump capacity under operating conditions should ensure that milking-time vacuum stability conditions are met and should be sufficient for cleaning.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>System Leakage</th>
<th>CFM (LPM)</th>
<th>Percent leakage [(4c/4b) x 100]</th>
<th>System leakage can alternatively be estimated by taking the difference between vacuum pump capacity measured at the pump inlet (4b, gate valve closed) and the AFM reading taken at the same location and at the same vacuum level with all components deactivated and the gate valve open (piping connected).</th>
</tr>
</thead>
<tbody>
<tr>
<td>4c. (4b - 3g)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Recheck Receiver Vacuum And Effective Reserve (Safety check to assure the system is reconnected and operating properly) | |
| Receiver vacuum, Hg" (kPa) | Effective Reserve, CFM (LPM) |
Pump capacity

• **Be sure to open AFM before testing the vacuum capacity**
• Measuring pump inlet vacuum
  – All components disabled and vacuum at receiver at operating level
• Isolate the vacuum pump by closing the gate valve
• Measure air flow from pump with vacuum adjusted to pump inlet vacuum
• Measure air flow from pump with vacuum adjusted to pump capacity (15” Hg)
• Vacuum pumps generate ~10 CFM/HP of the motor

_Open gate valve when done testing_
Milking system evaluation

• Recheck
  – Receiver vacuum
  – Effective Reserve
  – Assures milking system is reconnected correctly and operating properly
  – Safety check
Testing milking equipment – How often?

• Complete NMC 1x/year
• Pulsators and claw vacuum 4x/year small farm
• Pulsators and claw vacuum 1x/month large dairy
• Robotic dairy pulsators and teat vacuum 1x/month
Take home message

- Equipment testing is very logical and adheres to laws of physics
  - Movement of fluids in a column that is under vacuum
- Vacuum and airflow testing is part of all start-ups
  - New or retrofit
- Equipment testing is part of general maintenance procedures on dairy farms
- Vacuum stability – minimize fluctuations
- Suggest priorities and changes
- Provide results to client so client can review results with equipment provider in order to make sure milking system is functioning properly
Questions

Test equipment
What is the problem?
What should have been observed first?

12.9" Hg at vacuum controller

Vacuum controller sensing point – near trap

14.1" Hg on the lowline
Vacuum pump motor speed

- Vacuum pump motor
  - Motor is operating at 8 Hz which is too slow
  - Motor is air cooled and the slower the motor operates the slower the cooling fan operates
  - Motor should operate between 12 – 15 Hz under normal milking load or ≥ 20% of maximum
  - Install “weep holes” in the vacuum system to allow air in which will increase the speed of the motor to maintain the vacuum setpoint.
Weep holes installed behind pump and between shutoff valve and pump – weep holes always in system
Intentional air admission to vacuum system –
Weep hole or vent

- Clean air filter installed over top of weep holes
- Insert bolts into weep holes to close off if too much air admitted
Vacuum

- No milking units attached
  - Vacuum 14.5” Hg
  - Motor 6.0 Hz
- 13 milking units on
  - Vacuum 12.5” Hg
  - Motor 6.0 Hz
- 26 milking units on
  - Vacuum 12.3” Hg
  - Motor 18 Hz
- Vacuum is too high for the first milking units attached
- Vacuum is too high for the last few milking units to detach
- Install weep holes in order to increase motor speed and reduce vacuum when no milking units are attached
• Mechanical regulators as safety valves in milking system