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Milking Machine Introduction Components

What they are and
how they work

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Competencies

- 🔧 Ability to identify the components of a milking machine.

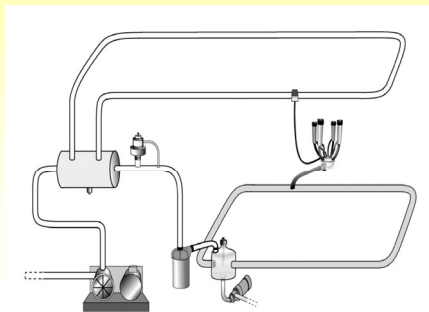
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What is a Milking Machine?

A machine for harvesting milk from the udders of cows, goats, buffalos, sheep or animals.



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Milk Harvesting


- 🔧 Milk harvesting is the process of:
 - 1 Extracting milk from animals.
 - 2 Transporting the milk to a storage tank.
 - 3 Storing the milk until it is picked up for processing.
 - ✓ Milk is usually cooled before /during storage
- 🔧 Milk harvest requires cooperative effort among:
 - 1 The cow
 - 2 The operator
 - 3 Properly functioning milking machine

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Milking Machine Goals


-  A properly designed, installed, maintained, and operated milking machine will:
- ➊ Remove milk from the animal quickly, completely and gently.
 - ➋ Maintain udder health.
 - ➌ Promote milk quality from the time of harvest to delivery.
 - ➍ Be easy to clean and sanitize.

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Milking Machine Components

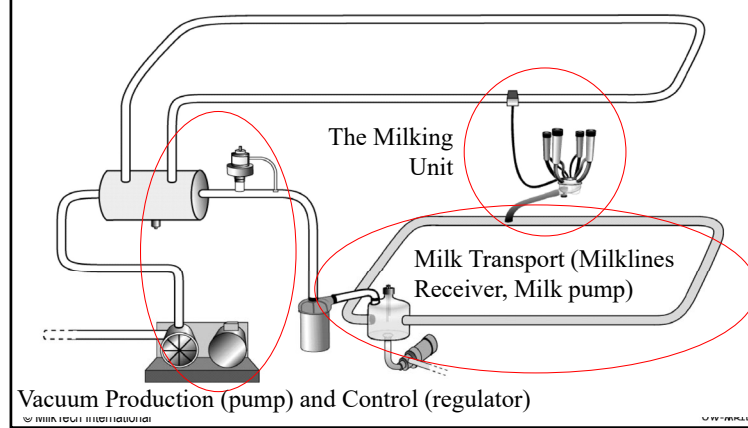
-  A milking machine is made up of several basic functional groups:
- ➊ Milk Harvest
 - ✓ Milking units and pulsation
 - ✓ Vacuum production and control system
 - ✓ Milk transport system
 - ➋ Machine Cleaning and sanitizing
 - ✓ Wash vats, manifolds and delivery lines
 - ✓ Controls and chemical dispensers
 - ➌ Milk Cooling and Storage
 - ✓ Plate coolers, chillers, bulk tank, etc

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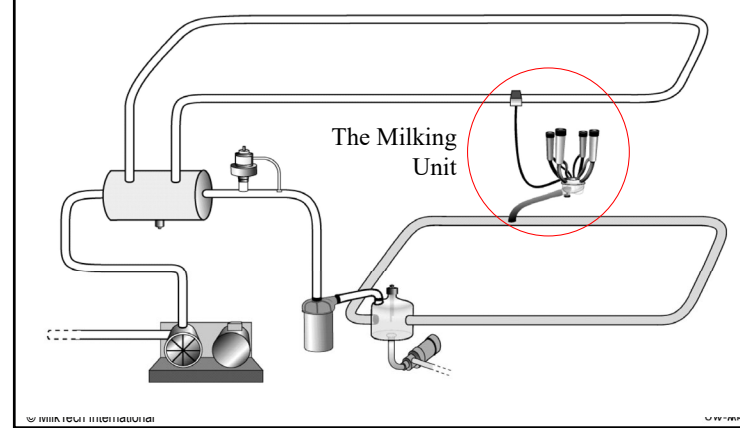
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Let's start with the Milk Harvesting Components



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Let's have a closer look at the milking unit



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The milking unit is made up of several parts

4 Teatcups (for cows)

- The soft rubber liner is the only part of the machine that touches the udder

The claw

- Collect milk from all of the teatcups

The Pulsator

- An air valve that creates 'pulsation' or the opening and closing of the liner
- Usually mounted on a pulsator airline

Connecting tubes

- Short milk tube = liner to claw
- Long milk tube = claw to milking line
- Short pulse tube = shell to air fork
- Long pulse tube = air fork to pulsator

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Teatcups

- Comprised of a shell and rubber liner.
- Rubber liner is inserted into the shell and stretched under tension.
- Creates a chamber that can be pulsated between vacuum and ambient air pressure.
- Rubber liner are different sizes and shapes for different size teats and different manufacturer's shells and claws.

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Teatcups

Liners

Teatcup Assemblies

Shells

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Claws

- Collect milk from all of the teatcups
 - 4 teat cups for dairy cows
 - 2 teat cups for goats and sheep
- Milk is then comingled and directed to the long milk tube in route to the milk line.

Dairy Cow Claw

Dairy Sheep/Goat Claw

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Bottom unloading claws

- Milk exits through a tube at the bottom of the claw.
- Made of stainless steel and plastic.
- Junction for milk and air tubes.



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Top Unloading Claws

- Milk exits claw through a vertical tube out the top of the claw bowl.



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Tubes and hoses

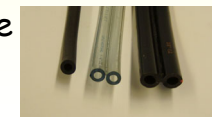
- Air Fork** - distributes air from pulsator to teatcup pulsation chamber. Connection between short and long air tubes.
- Short milk tubes** - usually part of liner but can be a separate tube.
- Short air tube** - routes air between air fork and pulsation chamber of shell - typically 5-7 mm (3/16" to 9/32") ID and 6-1/2 to 9 inches long.
- Long milk hose** - connection between claw outlet and milk line - 13 - 22 mm (1/2" to 7/8") inside diameter and up to 9 ft long.
- Long pulsation hose** - connection between air fork and pulsator - 6 - 9.5 mm (1/4" to 3/8") ID and up to 9 ft long.



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Tubes and hoses

- Air forks
- Short air tubes
- Long milk hose
- Long Pulsation hose



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Pulsation

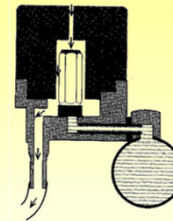
- 🔧 An air valve that creates 'pulsation' or the opening and closing of the liner.
- 🔧 Changes air pressure in the pulsation chamber between milking system vacuum level and atmospheric air pressure.
- 🔧 Electro-magnetic or pneumatic (air) operating valve.
- 🔧 Typically Pulsates air at 60 pulses per minute (ppm) for cows, 90 ppm for goats and 120 ppm for sheep.
- 🔧 Usually mounted on a pulsator airline.



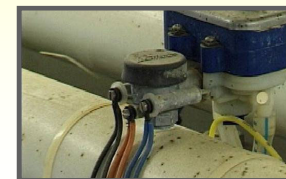
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Pulsators

Electro-Magnetic Pulsators



Pneumatic Pulsators

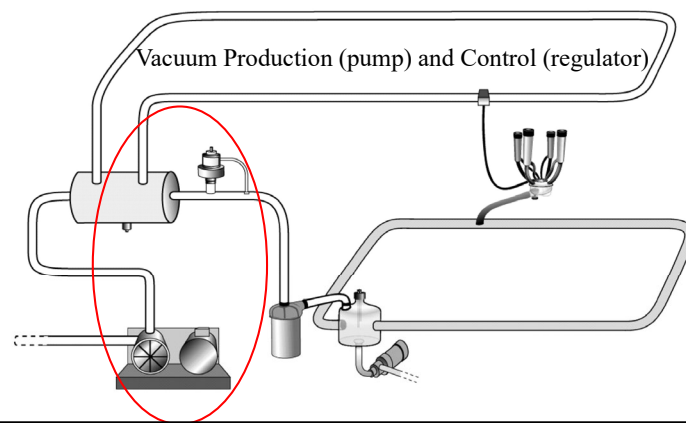


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Now let's look at the vacuum production and control system



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The vacuum production and control system is made up of:

- 🔧 Vacuum Pumps
- 🔧 Vacuum controller
 - ⚙️ Regulator, or
 - ⚙️ Variable Speed Drives
- 🔧 Airlines
- 🔧 Distribution tanks and manifolds
- 🔧 Must maintain a stable vacuum level within 1.2 kPa or 0.6 inches Hg of set point.

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Vacuum Production: Vacuum pumps

There are several types of vacuum pumps

- Rotary Vane
- Water Ring
- Turbine
- Blowers

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Vacuum Pump Efficiency

Type	Efficiency	
	lpm/kW*	cfm/hp*
Vane	419	11.0
Blower	402	10.6
Water Ring	275	7.2
Turbine	181	4.8

* Higher values indicate higher efficiency

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Rotary Vane Vacuum pump:

- Vaness slide in and out of rotor to form pumping cavity and seal.
- Oil lubricates the pump housing.
- Oil in exhaust air
 - Oil reclaimer to remove oil from air
- Noisy
- Moderate speed range
- Common on small systems



Rotary vane vacuum pump.

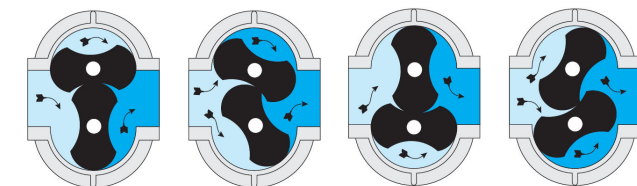
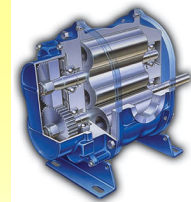
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Blower Vacuum Pump

- Positive displacement
- Widest speed range
- Most common on VFD applications



From Manufacturer's literature- Dresser, Inc.

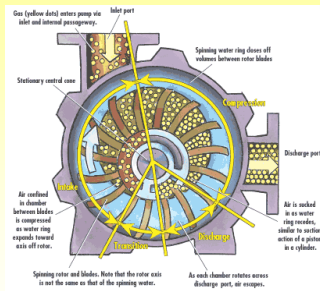
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Vacuum pump: Water Ring

- 🚚 A ring of water forms the vacuum seal.
- 🚚 Use lots of water.
- 🚚 Hard water can be a problem.
- 🚚 Freezing is deadly.
- 🚚 Quiet
- 🚚 Minimal speed range



Source: Machine Design, Penton Media, March 4, 2004

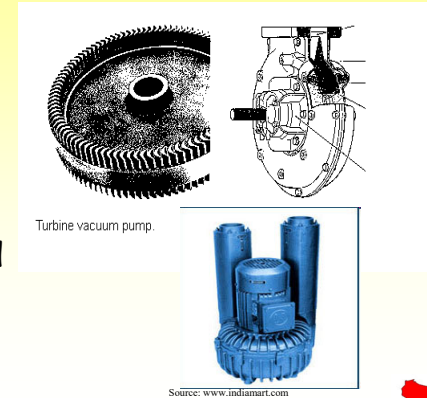
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Vacuum Pump: Turbine

- 🚚 High speed turbine (jet engine)
- 🚚 Loud
- 🚚 Hot Exhaust
- 🚚 Minimal speed range



Turbine vacuum pump.

Source: www.indiamart.com

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Blower Vacuum Pumps



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Vacuum Regulation

- 🚚 Traditional Vacuum Regulator
Balances Air Admission (variable) with Vacuum Pump Capacity (constant pump speed)
- 🚚 Adjustable Speed Vacuum Pump
Adjusts Vacuum Pump capacity, motor speed, (variable) to match Air Admission (variable)



A vacuum regulator (taken from Manufacturer's literature)

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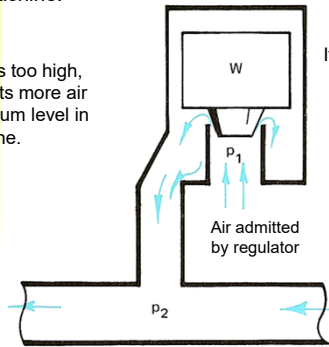


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Traditional Vacuum Regulator

Most vacuum regulators are valves that admit a controlled amount of air into the milking machine.

If the vacuum gets too high, the regulator admits more air to reduce the vacuum level in the machine.



If the vacuum gets too low, the regulator admits less air to increase the vacuum level in the milking machine.

Air removed by vacuum pump

Air admitted to milking machine

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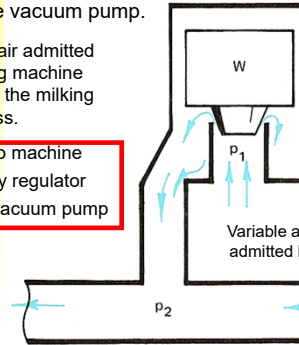
The Vacuum Regulator

In most milking machines air is removed from the milking machine at a steady rate by the vacuum pump.

The amount of air admitted into the milking machine changes during the milking process.

The regulator makes up the difference.

Air admitted into machine
+ Air admitted by regulator
= Air removed by vacuum pump



Steady rate of air removed by vacuum pump

Variable amount of air admitted to milking machine

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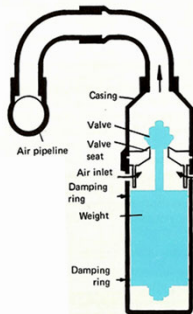
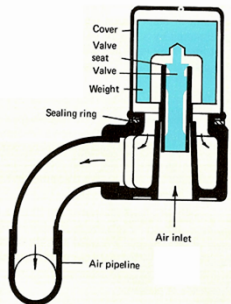
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Different types of vacuum regulators

Weighted regulators use a 'dead weight' or a weight mounted on a lever system.

The force of the weight acting to close the control valve is balanced by the force of the system vacuum acting to open it. The rapid movement of the valve stem or weight may be impeded by a damping mechanism.



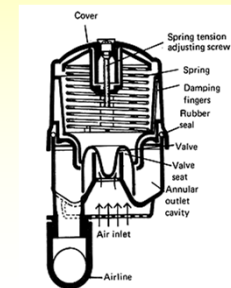
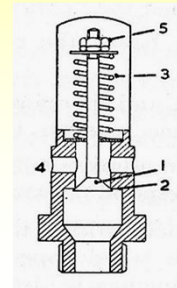
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Different types of vacuum regulators

Spring actuated regulators use the same principle as weighted regulators except that the closing force on the control valve is supplied by a spring. The tension of the spring is adjusted by changing the length of the fully extended spring, usually with a screw-type adjusting mechanism. Spring actuated regulators may be damped using an oil fill reservoir or other mechanism.



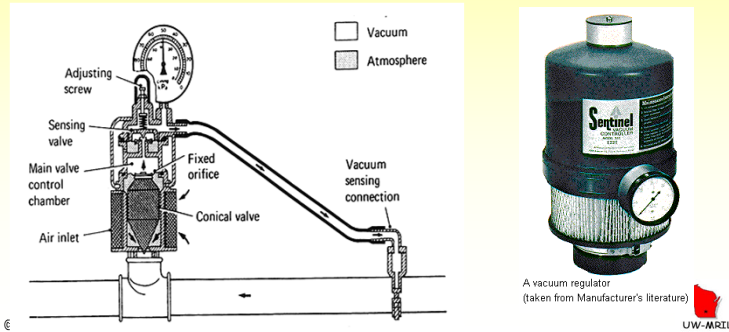
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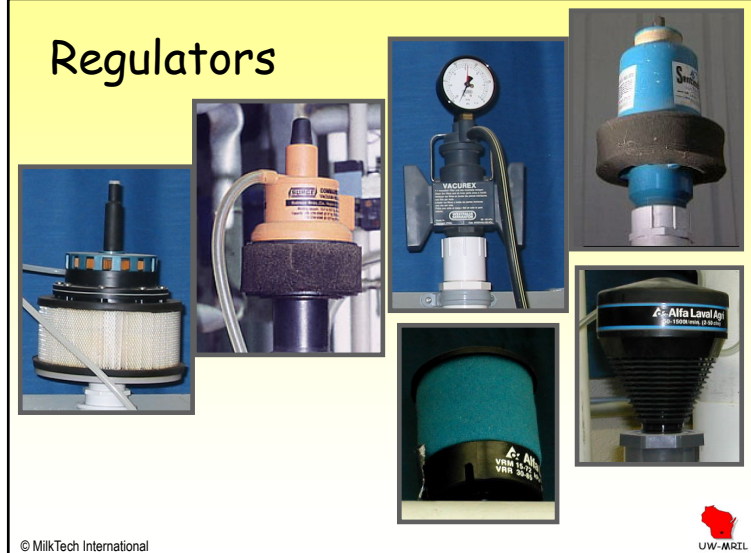
Different types of vacuum regulators

Modern **servo-operated regulators** use a feedback system consisting of a sensing element and a mechanical amplification system. These devices are a more sophisticated version of spring type regulators as the vacuum level is controlled by varying the force of a spring attached to the sensing element.



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Regulators



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Variable Speed Controller

- ☞ Also called Variable Frequency Drives (VFD)
- ☞ Changes Vacuum pump motor speed to maintain a pressure set point.
- ☞ More adjustments than traditional vacuum regulators
- ☞ Equal or better vacuum control
- ☞ Reduce energy use by approximately 60%



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Vacuum Pump, Silencer, VFD Control



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Airlines and Air Handling Components

The air handling system transports air to and from other parts of the milking machine.

Main Components:

- Main Airline
- Pulsator Airline
- Distribution Tank
- Interceptor

Airlines and air handling components will be further discussed in the next lesson.

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Let's look at the milk transport system

Milkline

Receiver Group

- Receiver Jar
- Milk pump and level control
- Sanitary Trap

Milk discharge lines

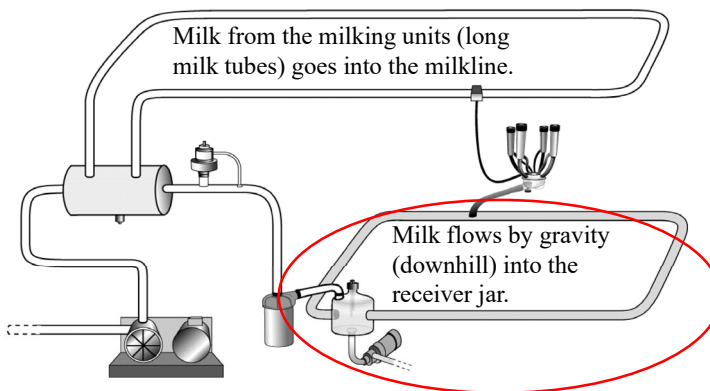
Connection to milk storage vessel

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Milklines: Stainless steel tube (glass lines in the old days)



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Milk line Classification

Lowline system - Cow's udder is higher than the milkline.

- Minimal vacuum drop between claw and milk line.
 - ✓ Little or no lifting of milk
- Most parlor systems have lowliness.

Highline system - Milkline is above the cow so milk has to be lifted to the line.

- Typical of a stall barn with a pipeline milking system.
- High vacuum drop between claw and milk line.



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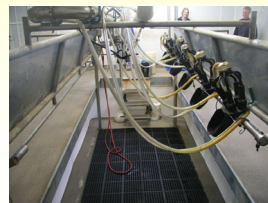


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Milk line Classification

🚗 **Mid-line System** - The milk line is typically above the udder but below the cow's back.

- Typically found on a swing parlor with the milk line located just above the operator's head.



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Weigh Jar System



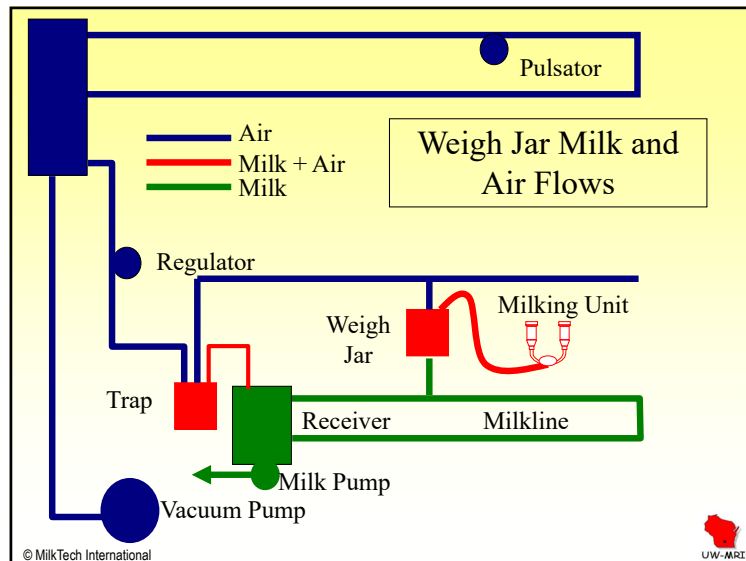
Source: Iowa State University Dairy Facility

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- 🚗 Milk and air separation occurs in jars.
- 🚗 Visual assessment of milk quantity and quality.
- 🚗 Manually release milk to milk line.
- 🚗 Rarely used in new installations.



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Receiver Group

Includes the receiver, sanitary trap, and control panel and milk pump.

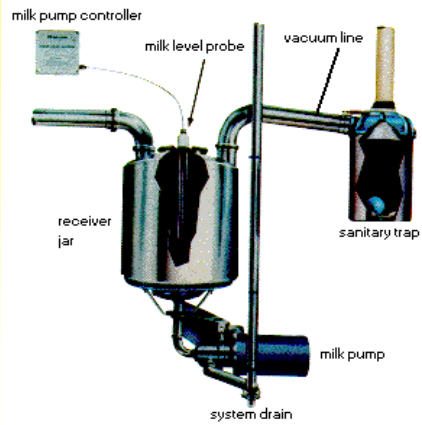
- 🚗 The milk pump provides the energy to move milk from the receiver, which is under vacuum, to atmospheric pressure.
- 🚗 Milk pump forces the milk through a check valve, milk filter and sometimes a precooler in route to the milk storage tank.
- 🚗 Milk pump controller starts and stops the milk pump based on level of milk in the receiver vessel.
- 🚗 Milk flows by gravity in the milkline to the receiver. Milk lines are sloped, typically 0.6 to 1%.

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Receiver Group



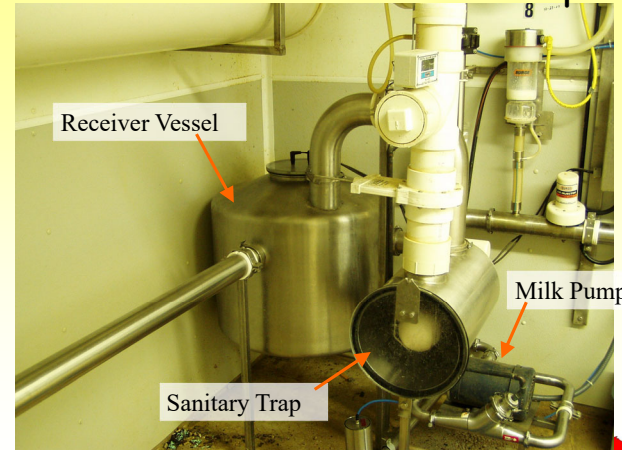
Receiver Group
(from manufacturer's literature)

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Stainless Steel Receiver Group

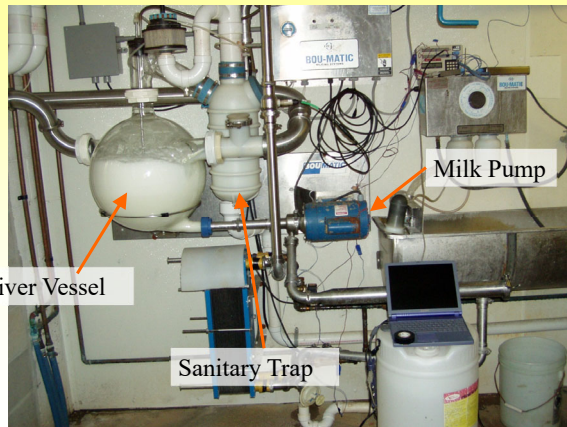


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Glass Jar Receiver Group

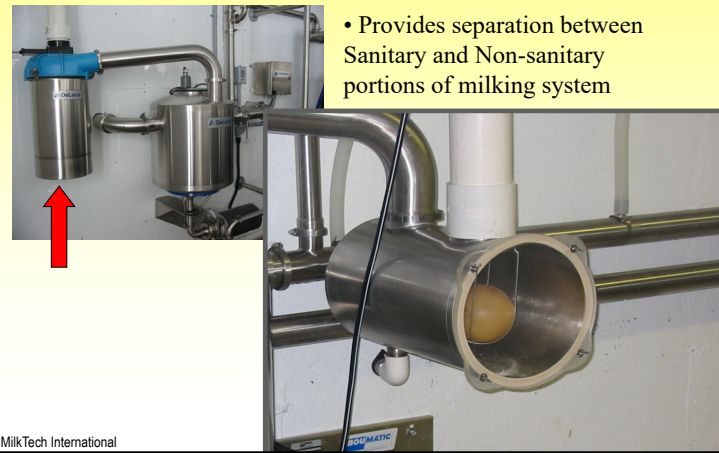


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Sanitary Trap

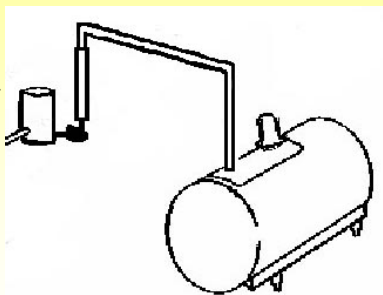


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Milk Discharge Lines

- ☞ Milk travels from the milk pump to the milk storage tank (or tanker truck) in the discharge lines.
- ☞ These lines are under pressure (not vacuum like the rest of the milking machine).
- ☞ A milk filter is always present in the discharge line, usually near the milk pump.
- ☞ In-line coolers (plate coolers) may also be present in discharge line.
- ☞ Typically 1-1/2" or 2" tubing (38 to 51 mm).



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Milk Filter

- ☞ Filters out particles that may get sucked into the milking unit during attachment, takeoff or because a cow kicked it off.
- ☞ Woven textile material supported by a frame.



Source: DeLaval.com

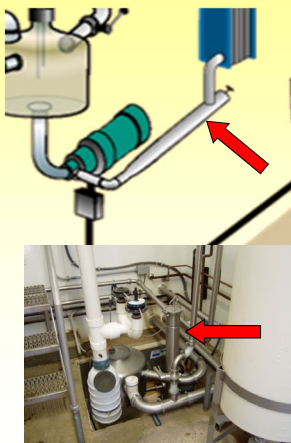


Source: Coburn.com



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Milk Filters



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Let's look at the Milk Cooling and Storage System



- ☞ On-Farm Bulk Milk Storage tank
 - ❶ Refrigeration capacity sized to expected fill rate - gallons/hr (l/hr).
 - ❷ Sized for one extra milking than pickup schedule.
 - ✓ Everyday milk pickup - to hold 1.5 X daily production.
 - ❸ Milk Tanker Truck (Direct Load)
 - ✓ Large farms ~ 500 cows and larger
 - ✓ Milk must be cooled as fast as it is harvested from cows.

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Connection to the Milk storage Vessel

-  The milk may enter the milk storage vessel in several ways:
- ❶ Dumped into the top of a bulk tank.
 - ❷ Through a special fitting at the bottom of the bulk tank.
 - ❸ Through a special fitting into a tanker truck.
-  Some of these connecting fittings are hand clean items and must be disassembled and hand cleaned.

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Top loading Bulk Tank Connection

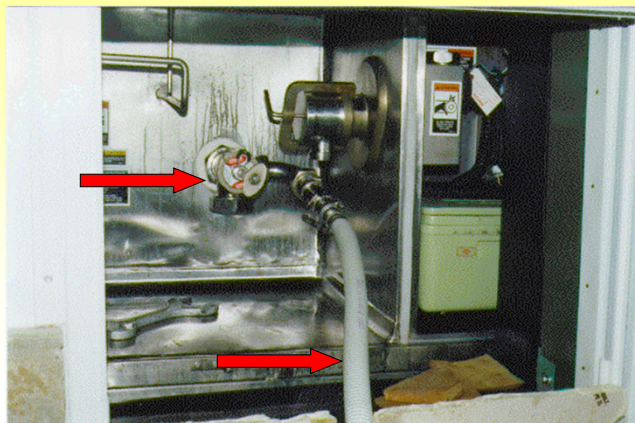


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Connection to Tanker



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Direct to Tanker Milk Loading



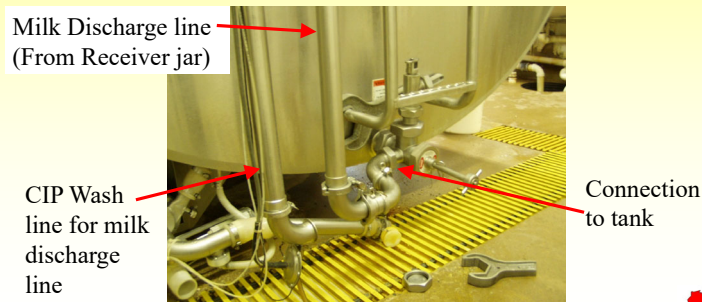
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Bottom loading Bulk tank

- Milk flows into tank near refrigeration plates in tank.



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Cooling System

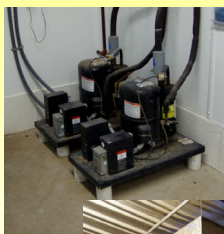
- Bulk Tank Refrigeration**
 - Typically reciprocating or scroll compressors.
 - Air cooled condenser units most common.
- In-Line Heat Exchangers**
 - Well water pre-cooling
 - Use well water as coolant.
 - Water required typically 2X milk volume.
 - Possible to cool milk to within 3°F or 2°C of well water temperature.
- Chilled water cooling**
 - Instant cooling for direct load to a tanker or other un-refrigerated storage tank.

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Refrigeration Compressors (for bulk tank)



Air cooled condenser unit



Water cooled compressors



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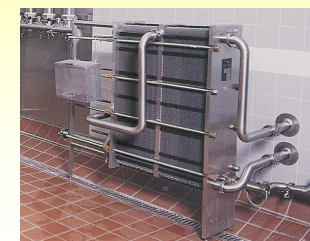
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Plate Type Heat Exchanger

- Milk and water pass through alternate plates.
- Can use well water, chilled water or both for coolant (called pre-cooler when well water is used).
- Needs 2X to 3X milk volume in water volume.
- Well water can be re-used for animal water or cleanup.



Single Coolant Heat Exchanger



Dual Coolant Heat Exchanger

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Water/Glycol Chiller (for instant cooling)



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Falling Film Chillers

- ☞ Typically used with direct loading or long run-time dairies.
- ☞ Chills a water/glycol solution.
- ☞ Solution used in a plate heat exchanger to transfer heat from milk.
- ☞ Uses about 5% more energy than bulk tank with direct expansion cooling.



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Cleaning systems

- ☞ Milk Pipeline
 - ❶ Clean after each use or every 12 hours.
 - ❷ Pre-rinse - warm water - flush out residual milk to reduce soil load for detergent.
 - ❸ Wash - hot water ~ 160°F with detergent - removes protein and fat residue.
 - ❹ Acid rinse - cold or warm - controls mineral deposits, leaves interior pipe environment hostile to bacteria growth.
 - ❺ Sanitizer rinse - cold water with chlorine - kills bacteria - run immediately before milking.
- ☞ Washing can be controlled manually or with an automatic washer.



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Pipeline washing components

- ☞ Water reservoir
 - ❶ Sink or vertical tank
- ☞ Wash manifold / CIP Assembly
 - ❶ Used to connect milking units to wash system.
- ☞ Air injector
 - ❶ Provides pulses of air to aid in providing slugging action in the milk line to enable washing the top of the pipe.



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Water Reservoir



- Vertical wash reservoir used for parlors with CIP systems.

- Plastic or stainless steel

- Lower heat loss due to cover



- Horizontal wash sinks used for tie stall barns and small parlors without CIP.



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Pipeline Washer



☞ Washer can be used with powder or liquid cleaners.

☞ Manual filling of chemical into jars.



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Pipeline Washer

☞ Peristaltic chemical pump Dispenser

● Handles liquid cleaners.

● Pumps directly from chemical containers.

● Accurately dispenses.



Source: www.farmandranchdepot.com



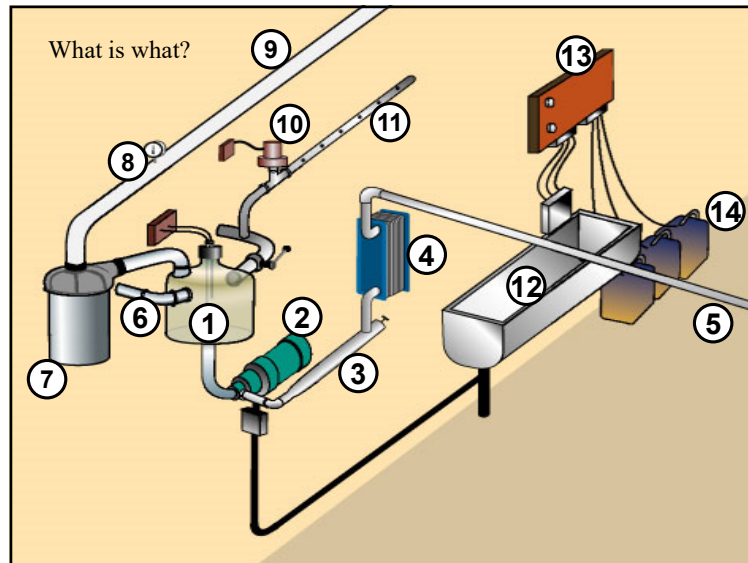
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CIP Wash Manifolds

☞ CIP - Clean in Place - allows milking units to be washed in parlor.




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Key

1 - Receiver Jar	9 - Main air line
2 - Milk pump	10 - Air injector
3 - Milk Filter	11 - Wash Manifold
4 - Precooler	12 - Wash sink
5 - Milk discharge line	13 - Pipeline washer
6 - Milk line	14 - Wash Chemicals
7 - Sanitary trap	
8 - Vacuum gauge	



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