

The Milking Machine

Introduction
Vacuum Production and Control

1



Objectives



In this module, we will cover the concepts of vacuum and the different parts of the vacuum production and control system.

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Overview



- ☞ Concepts of vacuum
 - ❶ Definition of 'vacuum'
 - ❷ How a vacuum is created in a milking machine
 - ❸ How a vacuum is controlled in a milking machine
- ☞ Parts of vacuum production and control system:
 - ❶ Vacuum pump
 - ❷ Vacuum gauge
 - ❸ Vacuum regulator
 - ❹ Air Lines

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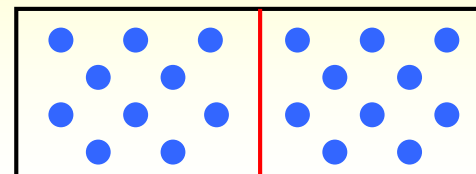


What is Vacuum?



A pressure difference caused by removing part of the air molecules from a confined space (partial vacuum)

- ❶ Think of a box divided into two equal parts by a flexible "balloon."



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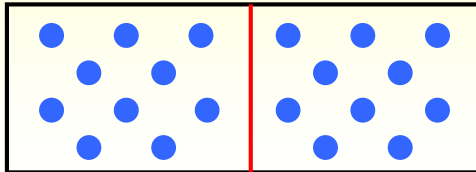
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What is Vacuum?



- If each side of the box contains the same number of air molecules, the pressure will be the same on each side, and the pressure difference between the two sides will be zero.
- There will be no differential force to move the 'balloon', and it will not be stretched as shown by the red line.



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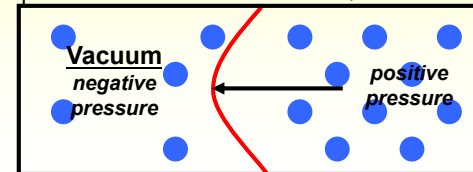
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What is Vacuum?



- If we take $\frac{1}{2}$ of the air molecules out of one side of the box, the pressure in that side will be less than the pressure on the other side.
 - The full side will have a positive pressure (atmospheric) relative to the vacuum side (negative pressure).
 - The negative side is considered to have a partial vacuum, or lower than atmospheric pressure, causing a difference in pressure between the two sides of the balloon.



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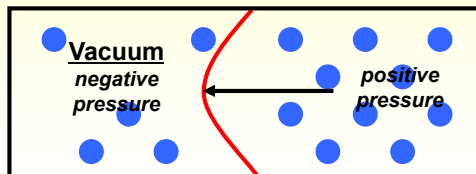
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What is Vacuum?



- When air is removed from one side:
 - The positive pressure will PUSH the balloon
 - The negative pressure will PULL the balloon
 - The balloon will bend towards the vacuum side (the side with less air molecules)



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Rules of Vacuum



- A force is developed toward areas of negative pressure or vacuum.
- Because of this force, air will move toward areas of lower pressure or higher vacuum.
- Air molecules at higher pressure attempts to "fill the void" created by fewer air molecules in areas of vacuum.
- When the pressure is equalized between the two sides, pressure difference is eliminated —no force and no air flow in any direction.

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Vacuum Gauge



- A vacuum gauge is a device used to measure the pressure difference between the inside of the milking machine and the atmosphere.
- It may be a mechanical device or an electronic device.
- The next slide displays some different types of vacuum gauges.

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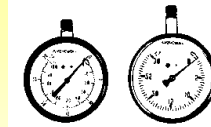
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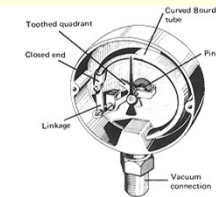
Types of Vacuum Gauges



Permanently mounted digital gauge



Bourdon tube mechanical gauges



Hand-held digital gauge

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Vacuum Principles



Now let's think about a milking machine as a simple jar.

- If the air density is the same inside the jar as it is outside the jar...
- There is no pressure difference between inside and outside.

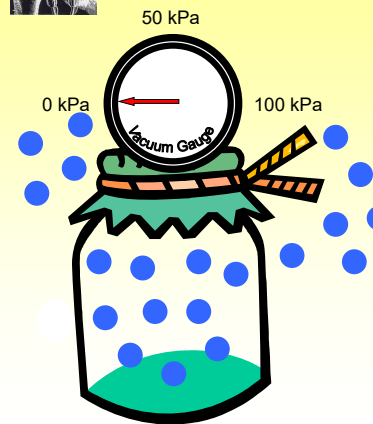
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Vacuum Principles



If half of the air in the jar is removed, a partial vacuum will be created inside the jar relative to the outside atmosphere.

A milking machine operates under a partial vacuum. This vacuum creates the pressure difference to establish milk flow out of the cow's udder.

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What is a Vacuum Pump?



- The vacuum pump is considered the component of the milking system that produces vacuum.
- The vacuum pump removes air from the milking machine system to create this partial vacuum.

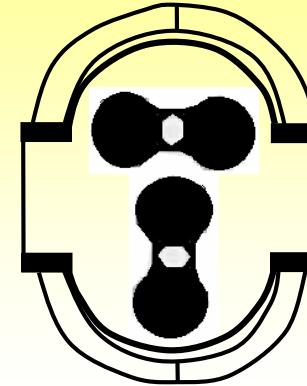
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The Vacuum Pump



This is a lobe vacuum pump.

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There are several other types of vacuum pumps but they all do the same job.



Turbine Vacuum Pump

Rotary Vane Vacuum Pump

Water Ring Vacuum Pump

Vacuum pumps remove air from the milking machine system creating vacuum.

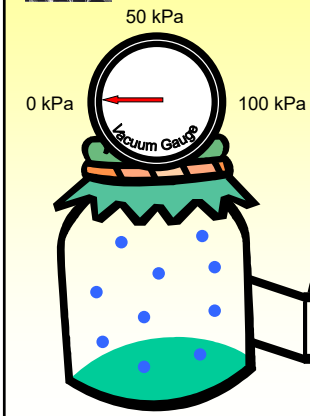
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Vacuum Production




If this vacuum pump removes half of the air from the jar, a partial vacuum (50 kPa) will be created inside the jar relative to the outside atmosphere.

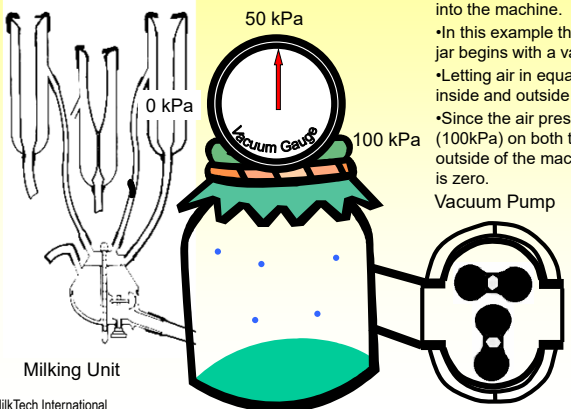
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Vacuum Production




The diagram shows a milking unit connected to a jar, which is connected to a vacuum pump. A vacuum gauge is mounted on the jar. The gauge needle points to 50 kPa. The jar contains a small amount of milk at the bottom. The milking unit is labeled '0 kPa'. The vacuum pump is labeled '100 kPa'.

- The milking unit allows air to enter into the machine.
- In this example the milking machine jar begins with a vacuum of 50 kPa.
- Letting air in equalizes the pressure inside and outside of the machine.
- Since the air pressure is equal (100kPa) on both the inside and the outside of the machine, the vacuum is zero.

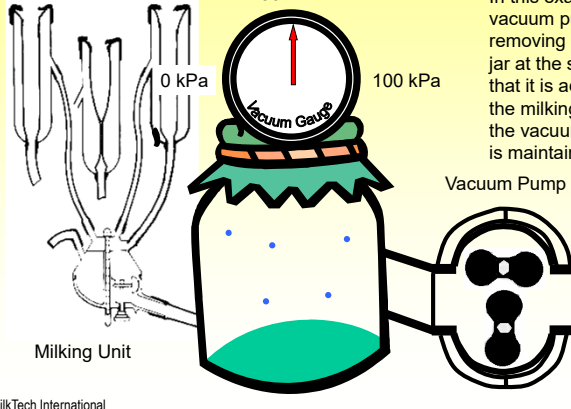
Vacuum Pump

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Vacuum Production




The diagram shows the same setup as slide 17, but the vacuum gauge needle now points to 50 kPa. The jar is now filled with milk up to the level of the milking unit. The milking unit is labeled '0 kPa'. The vacuum pump is labeled '100 kPa'.

In this example, the vacuum pump is removing air from the jar at the same rate that it is admitted by the milking unit so that the vacuum in the jar is maintained.

Vacuum Pump

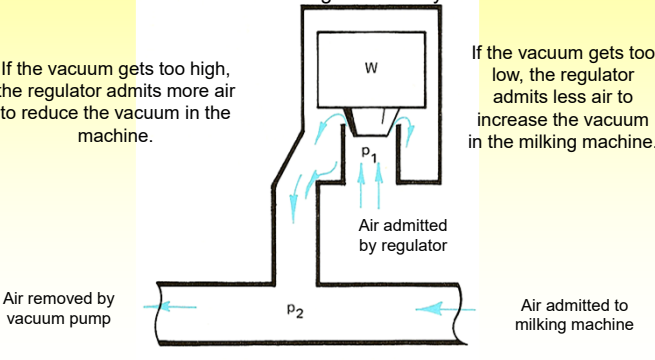
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The Vacuum Regulator

Most vacuum regulators are valves and vacuum sensors that control the amount of air admitted into the milking machine system.



The diagram shows a vacuum regulator (W) connected to a milking machine system. The regulator has two ports: one for air admitted to the milking machine (p₁) and one for air removed by the vacuum pump (p₂). The regulator is shown admitting air to the machine when the vacuum is too high and admitting less air when the vacuum is too low.

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


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

Air admitted to milking machine

Air removed by vacuum pump

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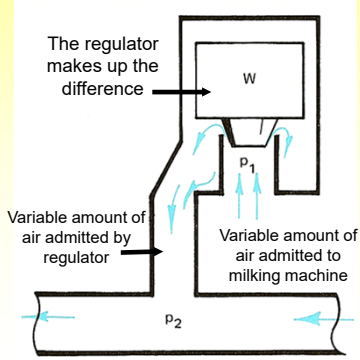
The Vacuum Regulator

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

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

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

Steady rate of air removed by vacuum pump



The diagram shows a vacuum regulator (W) connected to a milking machine system. The regulator has two ports: one for air admitted to the milking machine (p₁) and one for air removed by the vacuum pump (p₂). The regulator is shown admitting a variable amount of air to the machine to maintain a steady rate of air removal by the vacuum pump.

The regulator makes up the difference

Variable amount of air admitted by regulator

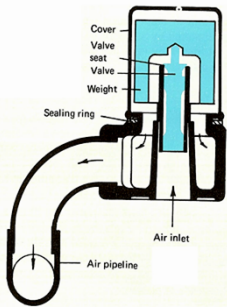
Variable amount of air admitted to milking machine

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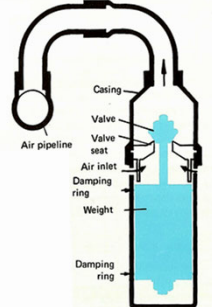
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Here are some different types of vacuum regulators



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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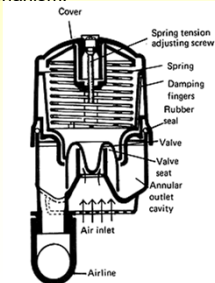
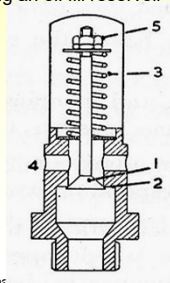
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Here are some different types of vacuum regulators



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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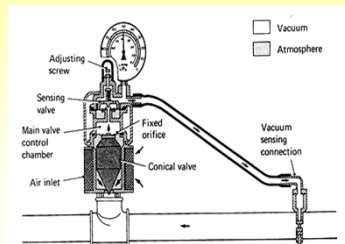
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Here are some different types of vacuum regulators



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.



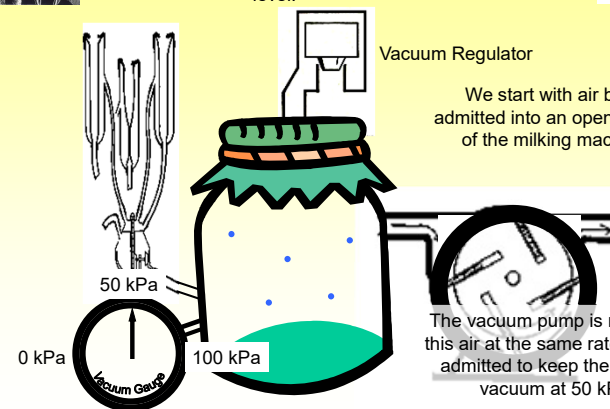
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In this animation we will see how the vacuum regulator balances air admission to keep the system vacuum at a constant level.



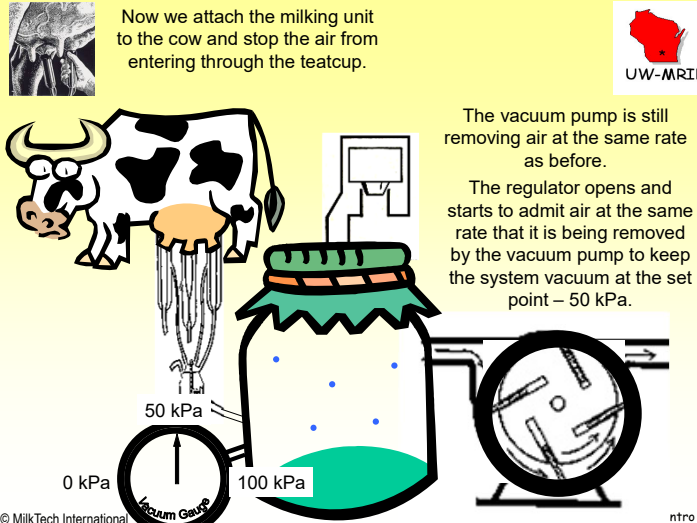
We start with air being admitted into an open teatcup of the milking machine.

The vacuum pump is removing this air at the same rate that it is admitted to keep the system vacuum at 50 kPa.

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Now we attach the milking unit to the cow and stop the air from entering through the teatcup.

The vacuum pump is still removing air at the same rate as before.

The regulator opens and starts to admit air at the same rate that it is being removed by the vacuum pump to keep the system vacuum at the set point – 50 kPa.

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Vacuum Regulation

UW-MRIL

- In a real milking machine, the situation is more complicated because air is admitted from many sources both steady (referred to as planned) and intermittent referred to as unplanned). However, the basic concept is the same.
- The regulator makes up the difference between air admission and air extraction to keep the system vacuum at a constant level.

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Let's Review

UW-MRIL

- A milking machine operates under a partial vacuum and is commonly measured by the use of a vacuum gauge.
- This partial vacuum is created by removing volumes of air from the milking system with a vacuum pump.
- This vacuum level is kept steady by the vacuum regulator.

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Let's Review

UW-MRIL

- The vacuum regulator balances the air admission with the air extraction to keep the system vacuum steady.
 - If the system vacuum drops as a result of more air being admitted than extracted, the regulator will admit less air to bring the system vacuum back up.
 - If the system vacuum rises as a result of less air being admitted than extracted, the regulator will admit more air to reduce the system vacuum.
 - The result of both of these scenarios is the constant volume of air movement of air through the vacuum system.
- Newer vacuum regulation technology uses a variable speed control on the vacuum pump. This will be discussed in a future module.

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Let's Review

The Rules of Vacuum



- ☞ Vacuum is a term used to describe a reduction of pressure within a milking system that is used to create a pressure difference.
- ☞ Vacuum refers to an area of negative pressure relative to the atmosphere (or some other reference point).
- ☞ The vacuum pump removes the planned and unplanned air from the milking machine system.
- ☞ Air is admitted into the milking machine from many sources, both steady and intermittent.

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Let's Review

The Rules of Vacuum



- ☞ All of the air that is admitted is removed by the vacuum pump.
- ☞ Therefore, the path of air flow in a milking machine is toward the vacuum pump.
- ☞ A force is developed toward areas of pressure differences. High pressure areas will attempt to equalize with lower pressure areas.
- ☞ Because of this force, air moves toward areas of lower pressure or higher vacuum.
- ☞ The vacuum pump inlet will always be the point of highest vacuum level in the milking machine and keeps all of the air moving towards it.

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Machine Intro Vacuum Control

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