



Energy Conservation in Agriculture

Vacuum systems

Scott Sanford

Variable speed vacuum pump

The vacuum system on a typical dairy farm consumes about 20% of the electricity used in the operation. A variable speed vacuum pump can reduce the vacuum system's electrical consumption by 50% or more compared to a conventional vacuum regulator system, and it offers the same or sometimes better control of the vacuum level.

A vacuum system used for milking dairy cows uses an air pump to continuously remove air from the milking system to reduce the pressure to 12.5 to 15 inches of mercury (42 to 51 kPa)

Typical variable frequency drive.



vacuum. A conventional vacuum system runs the vacuum pump motor at a constant speed and admits air through the vacuum regulator into the system to make up for the air not being used by milking operations at any moment in time.

A variable speed (VS) vacuum pump adjusts the motor speed instead of admitting air to regulate the system vacuum level. When the vacuum pump motor slows down it uses less electricity, thereby reducing energy costs

Variable speed controllers, sometimes called variable frequency drives, can be used only on blower or lobe type vacuum pumps. Pump manufacturers do not recommend using a VS controller with rotary vane or water ring type vacuum pumps.

A VS vacuum pump system is made up of a vacuum pump with a three-phase electric motor, a variable frequency drive unit (see photo) and a pressure transducer. Variable speed drives are electronic devices that modify the voltage and frequency of the electricity delivered to the vacuum pump motor so it runs at a regulated speed.

As with any electronic device, variable speed drives are sensitive to dusty, damp conditions and can be damaged by lightning strikes. When purchasing a unit, be sure it has an enclosure suitable for damp conditions (rated NEMA 4X recommended).

It should be installed with proper grounding in a dry and dust-free heated location.

The operating temperature for most VS drives ranges between 32°F and 104°F. Before installing a VS vacuum pump, check that the vacuum pump is properly sized for the system. An undersized pump will not provide energy savings or perform properly.

A rule of thumb for vacuum pump sizing is 35 cfm plus 3 cfm per milking unit for systems with less than 32 units and 70 cfm plus 3 cfm per milking unit for systems with 32 units or more up to a maximum of 120 cfm. The industry performance standard requires the vacuum level variation be no greater than 0.6" Hg in the receiver or milk line during normal milking or with a simulated one milking unit fall-off (two for systems with 32 units or more).

An oversized vacuum pump will not provide maximum savings because it cannot be slowed down enough without the risk of overheating which shortens vacuum pump life. Vacuum pumps rely on the air passing through the pump to aid in cooling the pump. If a pump is at risk of overheating, more air needs to pass through the pump. This is usually accomplished by placing a hole in the vacuum system to admit more air (refer to manufacturer's recommendations).

Table 1 below provides a rough guideline for a four-year payback based on energy savings alone.

Other benefits of a VS vacuum pump

Aside from the energy savings there are several other benefits that are hard to quantify. The first is the reduced noise level. If the vacuum pump is in a utility room with the door closed, the difference may not be noticeable to the persons milking, but it will be to nearby neighbors.

Using a variable speed controller slows the average speed of the pump to less than half of a constant speed pump. In the long term, this reduces wear and maintenance costs and could result in longer life for the pump.

There is an additional environmental benefit, aside from the reduced air admissions. Unlike a rotary vane pump, a blower pump does not require constant lubrication of the pump cavity. The oil lubrication of a rotary vane pump contaminates the air with oil aerosols and often leads to oil-contaminated soil near the pump's exhaust vent.

Vacuum system maintenance

Lobe or blower type vacuum pumps use either an oil bath or grease to lubricate the drive gears for the blower. Refer to the manufacturer's recommendations for the lubrication interval.

Blower pumps are susceptible to damage from dirt particles and organic matter build-up that can increase the torque and power required to drive the pump. Most manufacturers use an inlet filter to trap dirt particles, keeping them from the pump cavity. If the filter gets dirty, the pressure drop across the filter increases, adding to the load on the vacuum pump and using more energy.

Filters should be checked and cleaned every 50 hours per manufacturer's recommendations. Aerosols from milk and cleaning compounds may be deposited in the pump. The pump may require flushing to remove the buildup. Follow manufacturer's recommendations for cleaning procedures.

All vacuum systems have drains at various locations in the system to remove moisture. These are sealed with check balls or rubber flaps when the vacuum pump is running. However, over time these seals degrade and need to be replaced. If a drain is leaking when using a VS vacuum pump, the pump runs at a higher speed than if the drain is sealed properly, using additional electrical power and reducing potential savings.

Table 1. General economic guidelines for variable speed vacuum pumps

Vacuum pump (HP)	Phase power	Hrs/day of operation for 4 year payback*
5	1	15
7.5	1 or 3	11
10	1 or 3	8
15	3	6
20 or higher	1 or 3	4

* based on \$0.085/kWh, 65% energy savings

For more information

Information on different technologies and energy conservation opportunities are contained in the *Energy Conservation in Agriculture* publication series, available from Cooperative Extension Publications at <http://cecommerce.uwex.edu>.



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This publication is funded in part by the *Wisconsin Focus on Energy* Program.

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