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VitalAire Healthcare/Santé

JANUARY 2008

At VitalAire we are working towards a single objective: ***To become recognized as Canada's Company of Reference for medical gases and related equipment***. We believe achieving this goal depends on three elements: providing legendary customer service, local sales support, and innovative, high quality products and services.

So in 2007 while our competitors continued to promote factory direct offers with centralized sales and minimal service support, we grew our national sales and service team, and now support our customers with specialists residing in all 5-1/2 time zones! We also added to our customer service team, and our portfolio grew with the introductions of the Integrated Outlet Flowmeter, the Alarm/Valve Combo unit, and the Air Liquide Mistral air sampling service.

And the market reaction seems to indicate we are on the right path! In 2007 VitalAire was honoured to be recognized as HealthPro's national medical gases partner, we sold and installed the most medical gas equipment in our history, and the market at large was extremely receptive to our new products and services.

On behalf of VitalAire's entire medical gas services team, thank-you for an amazing 2007! We look forward to being of service in 2008 as we continue working hard on your behalf to become recognized as **The Company of Reference.**

Tom Pike
Vice President

Congratulations to William Osler Health Centre on the opening of

The Brampton Civic Hospital

October 28, 2007 marked a new chapter in Canadian healthcare with the opening of the Brampton Civic Hospital, the country's largest acute care facility constructed under the P3 alternative financing protocol. VitalAire and GH Medical designed, supplied, and installed the medical gas systems.

FUN FACTS. BCH covers over 1.3 million square feet, and includes more than 64,000 meters of medical gas pipelines with over 8,000 medical gas outlets managed in 200 zones!

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ENGINEERING UPDATE

Do VFD's for Medical Vacuum Pumps Make Sense?

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BUSCH

The ABC of variable frequency drives

Variable frequency drives (VFD) are power conversion devices for controlling the rotational speed of electrical alternating current (AC) motors. In its most basic form, a VFD consists of:

- a rectifier that converts the input AC power into DC (direct current) power and;
- an inverter that converts the power back to AC at a modulated frequency (0 to 60Hz, and more).

Because the rotational speed of an AC motor is directly proportional to the input power frequency, a VFD is a simple way to control the speed of any AC motors.

Use of VFD with vacuum pump

The pumping speed (CFM) of a rotary claw vacuum pump is a function of its rotational speed. The faster (or slower) the motor turns, the more (or less) CFM you get from your pump. Therefore, by using a VFD, it is possible to "match" the flow (CFM) of any vacuum pump with the demand of the pipeline.
Similarly, the brake horsepower (BHP) of a vacuum pump is also a function of its rotational speed. Therefore, the faster (or slower) the motor turns, the more (less) horsepower the pump consumes.

This simple system has been used by Busch for numerous years in industrial applications where very accurate vacuum level control is required.
However, for medical vacuum, where accurate vacuum control is not of major importance, does VFD control make sense?

Vacuum level required for medical vacuum

Vacuum regulators require a minimum vacuum level of 16"Hg at the outlet. In short, this is to ensure that the flow through the regulator is sonic. Indeed, between 16 and 30"Hg, the flow through an orifice is constant and therefore, allows manufacturers to have calibrated vacuum regulators.

Thus, it is usually assumed that in order to guarantee a vacuum level of 16"Hg at the farthest vacuum outlet, the level at the central vacuum source must be at a minimum of 20"Hg. This is assuming a maximum allowable pressure drop of 4"Hg through the pipeline. These numbers are standard and are referenced in tables 2 and 5 of Z7396-1.06.

Therefore, the vacuum level in a pipeline must not be controlled precisely and accurately. All that is really required is simply to assure a minimum vacuum level of 16"Hg at the farthest outlet.

Energy losses inherent to VFD's

Since power is converted and modulated, some of the input energy is lost in the form of heat. Typical VFD internal loss is 5% of input power. That's why VFD controls are equipped with big fans and large aluminium fins!

Pump efficiency vs rotational speed

Pump volumetric efficiency varies with rotational speed. To illustrate this, we can use the concept of relative pump efficiency. Relative pump efficiency is simply the ratio of the efficiency at modulated speed (VFD operation) to the efficiency at full motor speed.

$$\text{Relative eff.}_{\text{at 20"Hg}} = \frac{(\text{SCFM} / \text{BHP})_{\text{at modulated speed, 20"Hg and 60Hz}}}{(\text{SCFM} / \text{BHP})_{\text{at 60Hz and 20"Hg}}}$$

Where
SCFM = Standard Cubic Feet per Minute at the given motor speed and at the given vacuum level (20"Hg).
BHP = true horsepower consumption of the pump at the given motor speed and at the given vacuum level (20"Hg).

Table below shows typical rotary claw vacuum pump relative efficiency at different motor speeds (20 "Hg).

Pump size	**Motor speed**				
	20 Hz	30 Hz	40 Hz	50 Hz	60 Hz
	% of full motor speed				
	33%	50%	66%	83%	100%
	Pump relative efficiency				
5 HP	0.27	0.70	0.81	0.94	1.0
7.5 HP	0.51	0.81	0.97	0.99	1.0
10 HP	0.64	0.91	1.0	1.0	1.0

Data clearly show that pumps are most efficient at full motor speed and that pump efficiency decreases as motor speed decreases.
This efficiency loss can be explained by the fact that clearances inside all vacuum pumps are optimized for operation at 50-60 Hz at which heat generation, and hence thermal expansion of internal rotating parts, is maximum. At lower speeds, because heat generation is reduced, the clearances are larger and backflow of air between discharge (higher pressure) and inlet (lower pressure) increases. As backflow increases, the volumetric efficiency decreases.

Therefore, although both pumping speed and power consumption are a function of the motor speed, this function is not linear (i.e. not directly proportional). As the rotational speed reduces, the loss in pumping speed is proportionally more important than the reduction in consumed horsepower.

Stop-start control and multiplexing

Stop-start control consists of turning "on" and "off" pumps based on vacuum level (demand). The simple and basic control scheme allows the pumps to run in their most efficient way: "full-on" or "full-off".

With stop-start control, the vacuum level does fluctuate more than with VFD control and is usually kept at a higher level than what is minimally required. However, the energy spent for keeping the vacuum level higher is not wasted energy, but rather energy stored inside the pipeline as

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vacuum reserve. The stored energy is then used between cycles, while the pumps are turned off.

When using the stop-start control scheme, multiplexing can also be used to optimize energy consumption. Multiplexing consists of using three, four, five and even six pumps instead of just two pumps. This allows the system to start and stop multiple pumps to modulate the pumping capacity to match pipeline demand. In lower demand periods, fewer pumps (hence less horsepower) will be used. However, there is a major difference between this type of modulation and VFD modulation; with this control scheme, pumps are always at full speed and therefore, at full volumetric efficiency.

Differentiating between energy consumption rate and total energy consumption

Vacuum pumps are usually selected according to worst case scenarios and hence, oversized. With VFD control, because most of the time, pump speed is reduced, the energy consumption rate is reduced. However, pumps run almost all the time and less efficiently! Therefore, energy consumption rate (energy consumption at any given time) may be reduced, but the total hourly energy consumption is actually increased.

In short, there is a certain amount of cubic feet of air the pump needs to pump out of the pipeline over time (i.e. hospital average demand). The pump can run either slowly for a long time or run faster for short amount of time at a time. Over time, what really counts is that, when the pump runs, it should run efficiently. Pumps run most efficiently at full, non-modulated speed.

Figures 1 and 2 show typical results that can be obtained using either a multiplex start-stop system or a VFD controlled system operating at 30 Hz.

- For the VFD system, although the speed of the pump is reduced at 50% (i.e. 30 Hz), the pump delivers only 40% of the full speed flow and still consumes 45% of the full speed energy. This clearly highlights the volumetric efficiency loss at lower speeds (or how flow drops faster than the energy consumption at lower speeds).

- During an hour of operation of the system, the energy consumptions will be:

Typical multiplex start-stop operation, dry claw system
1 unit kW x 6 cycles x 4 min / 60 min = 0.4 unit kW-h

Typical VFD operation, dry claw system
0.45 unit kW x 1 cycle x 60 min / 60 min = 0.45 unit kW-h
(10% more than with a multiplex start-stop system)

Figure 1
Typical SCFM curve at 20"Hg for a dry claw vacuum pump operating either with start-stop or VFD control.

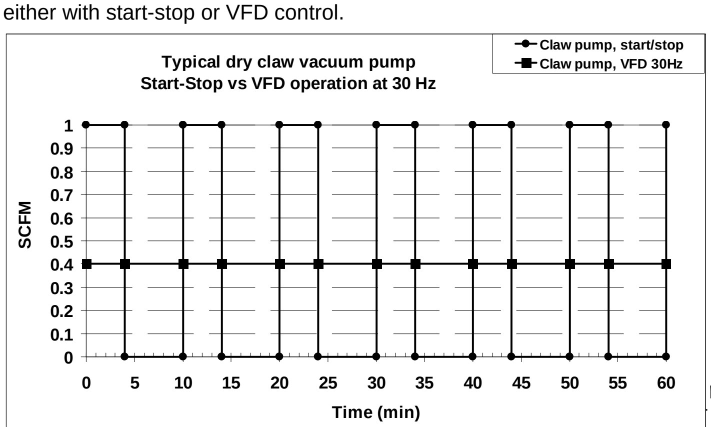
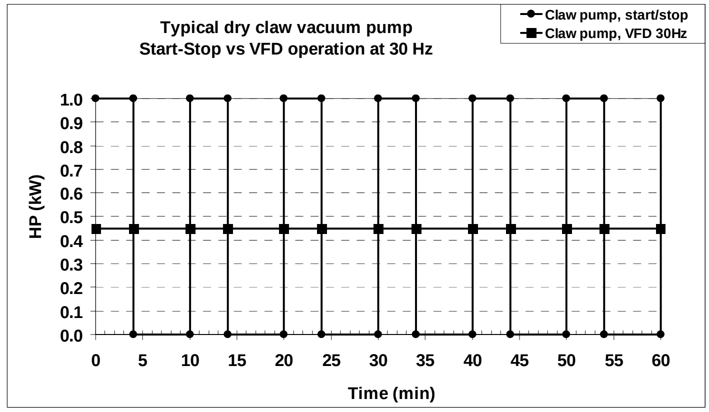


Figure 2
Typical HP (or kW) curve at 20"Hg for a dry claw vacuum pump operating either with start-stop control or VFD control.



Motor efficiency

After multiplexing, specifying high efficiency motors is probably the second most effective way reducing energy consumption. The more efficient a motor is, the less heat loss there is inside the motor and the more efficient the motor is at transforming input electrical power (amperage draw) into output mechanical power.

Maintenance costs

Because vacuum pump preventative maintenance is mainly based on run time, VFD control of vacuum pumps increases maintenance costs.

Conclusion

Busch has used VFD control for years on applications where accurate vacuum level control is critical. In these applications, the accurate vacuum control advantage outweighs the disadvantage of volumetric efficiency loss. **However, for applications where vacuum control is not critical (like medical vacuum), stop-start control combined with multiplexing, remains the most efficient and simple control method.**

Pros and Cons of VFD with vacuum pump

PROS
a) Precise vacuum control
b) Reduces frequency of motor stops and starts
c) Allows operation at over 60Hz to increase flow for short time
d) Reduces noise level
e) Reduces inrush starting amp draw

CONS
a) Initial cost (10% to 20% adder on total system value)
b) Decreases volumetric efficiency of pumps
c) Energy losses involved in power modulation (inherent to VFD's)
d) Increases energy cost when compared to properly designed multiplexed system
e) Largely increases run time and hence, maintenance costs

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Welcome aboard **Eric Champion**!

VitalAire's medical gas services unit is pleased to welcome Eric Champion to the team. Eric brings years of medical gas systems design and sales experience, most recently covering the western U.S. on behalf of Amico Corporation, VitalAire's primary pipeline manufacturer.

With the addition of Eric, our Brampton based team continues to offer our Ontario customers an unparalleled level of expertise in the design, supply, installation, and maintenance of medical gas piping systems.

2008 Trade Shows & Conferences

You're invited! We look forward to seeing you at these trade shows & conferences in 2008:

CHES Manitoba – Education Day	March 26	Portage La Prairie
CHES National	September 14-16	Toronto
CHES Atlantic	May 7-9	Moncton
ISBER	May 18-21	Bethesda, Maryland
CHES B.C.	June 1-3	Penticton
AABB	October 4-7	Montreal
Clarence White Conference	November (dates TBC)	Red Deer
CFAS	November 26-29	Calgary

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