ENGINEERING TOMORROW

Technical Paper | Head Pressure Control

Walk-in cold room **head pressure control**: why it's important and how to decide between **fan speed control** vs. a **head pressure valve**

The energy efficiency savings from allowing head pressure to float with ambient temperature are increasingly hard for engineers to ignore. But what's the best way to maximize the benefit without compromising refrigeration reliability?

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This is a pivotal time for walk-in cold room equipment. Rising challenges – most notably the need to become more energy efficient – mean that developers and engineers often need to go beyond swapping out individual components, and evaluate new approaches to an overall, system-wide problem.

In particular, Danfoss cold room experts have noticed that people are looking again at head pressure control – and seeing whether they could achieve greater benefits from a new, or hybrid approach.

Head pressure control: a balancing act

When ambient temperatures fall, it seems obvious that a refrigeration system should achieve energy savings – after all, the cooling demand is lower. And increasingly, seasonal energy efficiency measures like Seasonal Energy Efficiency Ratio (SEER) and Integrated Part Load Value (IPLV) reflect this requirement by combining weighted part-load figures to reflect year-round energy use.

Refrigeration equipment developers and engineers are understandably eager to maximize these substantial energy savings[1] in applications with a wide temperature variation.

Allowing head pressure – and hence condensing temperature – to fall, reduces the compressor's energy usage, while increasing its capacity. This increases longevity and reliability, while dramatically reducing running costs.

But systems need to manage head pressure carefully, in order to ensure all components – most notably the Thermostatic Expansion Valve (TXV) – keep working efficiently. Underfeeding the TXV can lead to the evaporator becoming starved, raising discharge temperatures. Meanwhile, compressor efficiencies decrease the further they depart from design conditions.

Methods for controlling head pressure

Traditionally, there are a number of methods that engineers can use – individually or in combination – to ensure head pressure remains at an appropriate level to keep the system working effectively when ambient temperatures fall. These include:

1. **Head pressure control valve (HPV):** especially in US markets, HPVs are an established way to increase head pressure. HPVs allow excess refrigerant to flood into the condenser reducing the effective surface area as ambient temperatures fall. This method offers an effective safeguard in low ambient conditions but has several significant drawbacks, notably complications with servicing and the requirement of a receiver large enough to store the additional refrigerant charge. HPVs also operate at a pre-determined head pressure setting, without the ability to float head pressure when ambient temperatures start to decline.

2. **Split condenser:** in larger systems, with multiple circuit condensers, systems might feature a solenoid valve that shuts down a proportion of the condenser circuit when pressures fall below a certain threshold.

This keeps the condensing temperature artificially high and is therefore an effective way to maintain head pressure when ambient temperature falls – however, it minimizes the opportunity for energy savings from reduced cooling demand.

3. **Fan cycling:** outside of the refrigerant line, regulating a condenser's fan performance offers another route to keep head pressure high in low ambient conditions. The simplest way to do this is to cycle fan motors on and off, using a pressure or temperature switch. Although effective, this all-or-nothing approach is extremely energy inefficient, as any savings in fan motor use are outweighed by sudden, wide swings in pressure.

4. **Fan speed control:** already proven in many markets worldwide, adjustable fan speed controllers provide much of the same simplicity of fan cycling, but with the ability to modulate fan performance – and therefore condenser capacity – more gradually, allowing head pressure to float within an acceptable range. As well as established high-performance controllers like the Danfoss RGE series, new, cost-effective options like the XGE range are making fan speed control an affordable option for a growing number of applications.

Figure 1. XGE fan speed controller.

The first choice: fan speed control

Each method has its advantages as well as its drawbacks. But for most cases, fan speed control will enable engineers to achieve the greatest efficiency benefits, with the fewest issues. There are a number of reasons suggesting this approach is increasingly the go-to choice whenever conditions allow.

Operation:

The fan speed controller keeps the condensing pressure at a steady level by regulating the speed of the fan motors. When pressure is declining, the controller decreases the output voltage, changing the speed of fan motor. The proportional band is a non-adjustable pressure difference between max. and min. pressure where the regulation occurs (fig. 2).

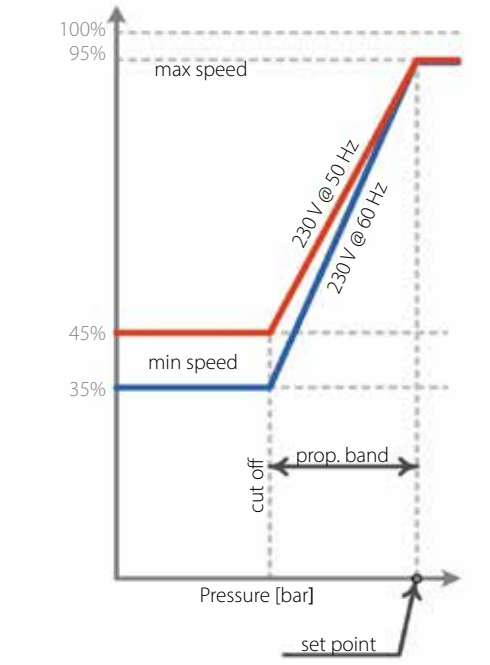

Figure 2. Fan speed controller operation.

Easy installation, retrofitting and servicing:

A fan speed controller doesn't need any of the additional piping required for an HPV, and there's no need to keep a reserve of refrigerant charge in a receiver – or to perform the associated calculations. It's an excellent choice where an existing system needs additional head pressure control, as it does not need refrigerant to be pumped down – which also makes it easy to service, troubleshoot and replace.

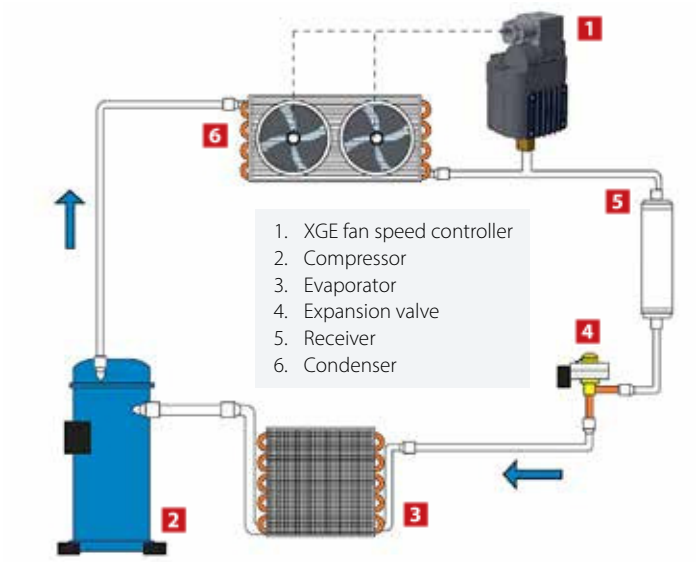

Figure 3. Fan speed controller installation.

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Compressor and fan motor efficiency savings:

Compared to other methods, a fan speed controller can operate across a wide proportional band, meaning it allows head pressure to float within a broad, user-defined range. So, energy savings from the fan motor are complemented by further efficiencies from the increased compressor capacity. In short, it maximizes the opportunity to reduce running costs when ambient temperatures decrease.

Simple adjustment when conditions change:

Typically, an HPV's operating pressures are fixed at the time they're purchased and installed. Calculating the most appropriate setup takes experience – and unless the installation is made when the weather is at its coldest level, it's difficult to confirm the settings are correct. By contrast, a fan speed controller can be adjusted with minimal training – for example, the Danfoss XGE is calibrated by turning a single screw, allowing the fan speed to be fine-tuned to achieve the greatest possible energy saving without compromising reliability.

*Figure 4. To set pressure for maximum speed of the fan, use **Adjusting screw** (located at the top of the controller)*

Noise reduction at night:

In most applications, a fan speed controller will automatically slow the fan when temperatures drop at night. As well as providing energy savings, this also makes the approach especially suitable for residential environments, and other applications where it's clearly beneficial for the system to run more quietly after dark.

Suitable for new refrigerants:

Danfoss is committed to supporting the transition to new, low-GWP refrigerants, and fan speed controllers are no exception. Both the RGE and XGE controllers are already qualified for use with popular options like R407A/F, R452A, R448A and R449A. Danfoss will continue to test and qualify with promising new refrigerants as they emerge – and because a fan speed controller doesn't deal directly with refrigerant flow, it's likely to be a future-proof choice as the refrigerant picture changes in years to come.

When to consider adding an HPV

While a fan speed controller is an excellent first choice for head pressure control, it is not suitable for all applications – at least, not in isolation. HPVs still have an important role to play.

For example, where the ambient temperature reaches the bottom of the controller's operating band, the fan is either running at minimum speed or shut off entirely. If the ambient temperature falls further, there is nothing more the controller can do to prevent head pressure from falling below an acceptable level.

Figure 5. KVR valves.

So, in applications with an especially wide ambient temperature differential – whether seasonally, or between night and day – the best approach is often to use a fan speed controller in conjunction with an appropriately-specified HPV, like the Danfoss KV regulating valve.

This combined method gives the efficiency benefits of fan speed control, while also protecting the system from extremes of low ambient temperature.

In summary: navigating the changing cold room landscape

Right now, cold room technology is evolving – perhaps more quickly than ever before. Energy efficiency demands are rising, refrigerants are changing fast, and everything needs to be packaged in a smaller, more compact unit.

Cold room equipment developers and engineers face significant, system-level challenges and there is no single right answer. It is therefore important to have the widest possible view of the solutions available – often, there are more options than seem immediately obvious.

Fan speed control is one such option. It is not suitable for every application, but where a system would benefit from maximizing head pressure energy savings, or cutting noise at night – in a format that's easy to install, adjust and service in the field – it's likely to be a very good fit.

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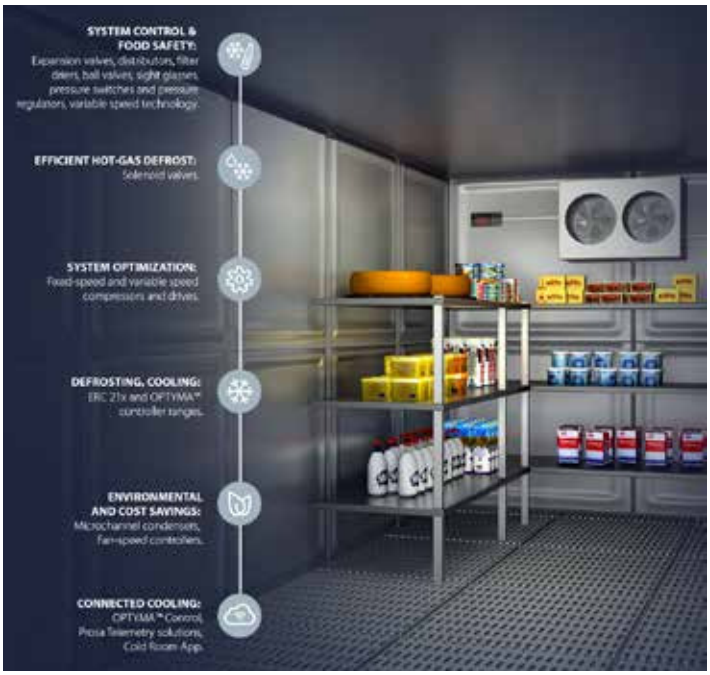

Figure 6. Danfoss solutions for cold rooms.

As with any engineering challenge, it is important not just to consider the component, but the goal you're trying to achieve across the system as a whole. At Danfoss, we have a broad portfolio of solutions for cold rooms, including:

- **Variable speed compressors and condensing units** which give precise cooling and enhance part-load efficiency
- **Thermostatic and electric expansion valves** offering minimal energy use and making the system reliable
- **Microchannel condensers** to dramatically enhance heat exchange and reduce refrigerant charge
- **Advanced logic controllers** that optimize performance and efficiency at every stage

But most importantly, we have the experienced, friendly cold room experts who'll listen to your challenge, and help you find the best possible way to achieve your goal. And because we have the widest possible portfolio of cold room technology, we're free to keep an open mind – and perhaps suggest a solution you haven't tried.

If you're looking again at head pressure control, we'll be happy to help you find the right answer.

For more information about fan speed control and solutions for cold rooms, visit **www.coldroom.danfoss.com**.

[1] *Refrigeration Control with Varying Condensing Pressures* by Green, Vinnicombe & Ibrahim: Kings College London and EA Technology, UK

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