NORTH AMERICAN
MINING

April 2025

SHAKE IT UP:
VIBRATORY SCREENS TAKE UP THE TASK

Also Inside:

- **The best in mine ventilation**
- **Heavy lifting: material handling**
- **Alternative power**
- **West Virginia Coal Show 2025 edition**

INCORPORATING
MINERS NEWS
www.northamericanmining.com

By automatically adjusting fan speed according to real-time conditions, mines can optimize the underground work environment in compliance with regulations while minimizing energy consumption. Pictured: Epiroc's Serpent Automatic module.

ACHIEVING THE BEST IN MINE VENTILATION

Ventilation is often an underground mine's most significant operating expense. It's also essential to the health and safety of personnel and equipment. Important, then, yet many take a curiously offhand approach to their ventilation systems. Experts from Chart Industries, Epiroc, Paul's Fan, and Stantec explain how to get the most from mine ventilation.

by Jonathan Rowland

The mining process is, as Todd Elswick, president of Paul's Fan Company, told North American Mining magazine, "an ever-moving target." This makes maintaining consistent airflow and climate in underground mines a challenge, as Elswick – who was "raised to build mine fans" by his late father and company founder, Paul Elswick – knows well. "The mine is continually advancing and adding to the equation of pressure and flow; the overcast and curtains required daily add to this."

Jose Pinedo, sales manager, Ventsim Control software at Howden, a Chart Industries company, agreed. "Pressure differentials drive airflow in mines. As mines expand and mine deeper, the system resistance of the mining operation increases. All other things remaining equal, an increase in system resistance will reduce volumetric flow in the mine." Operational factors also challenge consistent airflow, as Pinedo continued. "Operationally, with regards to maintaining consistent airflow, proper installation of ventilation infrastructure (fans, doors, regulators, and stoppings) is the biggest challenge. This includes duct lines being ripped, improper attachments going from fan to duct, doors with excessive leakage, and improper calibration of an actuator on a regulator."

"The presence of hazardous gases, such as methane or carbon monoxide, requires continuous monitoring and adjustment of ventilation systems to ensure safe levels and, if gases are generated from blasting, allow prompt re-entry to minimize downtime," added Kim Trapani, a ventilation engineer and project specialist at Stantec. "Additionally, the heat generated by mining equipment and the depth of the mine can significantly impact the climate, making it difficult to maintain consistent temperatures and air quality throughout the mine."

Many mining operations do not initially plan for a big enough fan to handle additional needs as the mine advances. According to Todd Elswick, a ventilation design should meet the maximum requirements and add at least 30 to 40% to account for the unknown. Photo: Paul's Fan

"If a mine is struggling to maintain airflow through its drifts and is also a hot mine, maintaining proper temperatures will be an uphill battle," continued Pinedo, picking up the theme. "It must be noted that, as mines increase in depth, the imposed heat load increases, which makes maintaining a conducive environment challenging. With low airflows in hot locations, those areas will heat up more quickly. Recirculation also plays a role in controlling a mine's climate. If there are sections of the mine that recirculate exhaust air, which is often hot, that will exacerbate thermal comfort challenges."

A complex web

Considering these challenges, the design criteria for an underground ventilation system are "numerous," said Jon Griffith, PE, product applications lead for underground at Epiroc USA. Factors include, but are not limited to, the "maximum installed horsepower of the equipment fleet, the total number of employees, environmental factors such as temperature, humidity, influx of water, corrosive or toxic rock properties, and blast gas volume."

"Determining the total fresh air requirement is often the first step in ventilation planning," said Howden's Pinedo, added to the discussion. "This is done based on the air required for the equipment fleet, whether diesel- or electric-powered, considering gas emissions, heat, and dust. It also means considering that mining projects often have extensive lifespans. The design of the ventilation network, fans, and ancillary infrastructure required to support the operation over the asset life must be carefully considered and capable of dealing with these changes."

"In my experience, mining operations do not initially plan for a big enough fan to handle all the added obstacles that come along through the process of mining, and as such, they do not account for the additional needs of ventilation through the advancement of the mine," added Elswick of Paul's Fan. "When designing a ventilation system, the design should meet the maximum requirements – and then add at least 30% to 40% to that because of the unknown. Use this number to select the fan that meets those requirements. The mine is continually advancing, and the capital expense of adding a bigger fan and reconfiguring ventilation and ductwork can be tremendous. Considering long-term mine advancement and production within initial capital investment minimizes the lifetime cost."

The size and layout of the mine are crucial, as they determine the airflow needed to reach all areas, noted Stantec's Trapani. "The mining method and the equipment used also impact, as different activities and machinery produce varying amounts of heat and contaminants. In addition, worker safety regulations must be met, often involving specific ventilation and air quality standards." These are becoming "more stringent with regard to airborne pollutants while rising energy costs and ESG commitments are forcing mine planners and engineers to design ever-more optimized solutions," noted Pinedo.

Last, there is the placement and size of ventilation shafts. Here, more than anywhere, the need to take a whole-of-life approach is critical, concluded the Howden engineer. "A ventilation shaft cannot be made more prominent once it is excavated, while a mine's ability to have multiple shafts may be limited, even when site conditions allow it, due to the cost implications associated with shaft sinking." In addition,

Mining operations present a moving target, challenging ventilation system design and operation. Photo: Paul's Fan

"if it is possible to take advantage of any elevation difference between intake and exhaust shafts, this helps the mine to ventilate naturally," added Griffith.

Not too hot; not too cold

Climate control is a "significant factor in mine ventilation, as it requires additional energy to heat or cool the air," said Stantec's Trapani. "In deeper mines, the need for cooling increases due to the higher temperatures from the ventilation auto-compression and strata heat, exacerbated by the heat generated by mining equipment."

Conversely, heating is necessary in colder climates to prevent ice buildup and maintain safe working conditions. However, "heating is much simpler approach," added Pinedo, "as management mostly ensures the air is heated above freezing (39°F/4°C)".

The best way to cool a mine is always a trade-off. "From a capital expenditure perspective, increasing airflow might be less costly than installing a refrigeration plant," explained Pinedo. "From the operating cost perspective, increasing airflow will always be more expensive given the relationship between airflow and power to the cube. In addition, mine cooling installations can be manipulated with changes in ambient conditions, [such as] to reduce cooling on colder days and months, allowing further operating cost savings. It ultimately comes down to how much cooling is needed and the optimum airflow to achieve that."

Both heating and cooling add to the overall energy consumption of the ventilation system, making it essential to find efficient ways to manage these needs, concluded Trapani. "For example, some mines use heat recovery from available heating/cooling sources to reduce the energy consumption from the heating/cooling."

Hazardous gases

Hazardous gases such as methane, carbon monoxide, and radon, and particulate matter (diesel, silica, and other dust) pose significant risks in underground mines. In most metal and nonmetal mines, "the highest concentration of these gases comes from blasting," noted Tomas Otterberg, global portfolio manager, Tunnelling and Infrastructure, at Epiroc's Underground Division. "Underground coal applications present other challenges and require specialized design criteria to prevent a fire, while using BEV technology can reduce gaseous engine emissions and heat in the mine, reducing ventilation requirements."

As there is "not a good way to neutralize these gases other than to keep them moving through the mine and out the shaft, ventilation is the only way to achieve safety for the mine and the miners," said Elswick of Paul's Fan. This may mean that the "total ventilation in mines where hazardous gases are present is significantly higher than that of a similar mine without hazardous gases," added Trapani. "They also require robust monitoring systems to detect gas concentrations and the ability to adjust airflow dynamically. Emergency ventilation plans are necessary to quickly address any sudden release of hazardous gases, ensuring the safety of workers. This could include fire doors in strategic locations and reversible fans."

A good part of this challenge goes back to the dynamic mining environment.

"It is hard to see the future other than comparing different mines and seams that have been mined before," continued Elswick. "Monitoring and predicting these gases is a big deal, although needs may vary depending on the mine type.

For example, methane will leak in coal mines after production stops, so most coal mines always require monitoring and an operable fan. When the equipment is shut down in aggregate and hard rock mining, particulate matter mostly settles, so there is less need for continuous monitoring and ventilation."

Energy efficient ventilation: ventilation on demand

"If you look at all the factors, you ultimately want a system adaptable to changing conditions within the mine," concluded Trapani. "This adaptable ventilation system can be applied through a ventilation-on-demand (VOD) system, which allows control of key ventilation infrastructure based on the presence of personnel and equipment, monitored air quality, and scheduled events in the mine."

"I 100% recommend using a VFD or comparable product, or as an alternative, a secondary fan, to reduce airflow to a minimum in downtime or to unoccupied areas," said Elswick. "Airflow/pressure or quantity is directly linked to horsepower, and horsepower is directly related to energy consumption. From my experience, the standard is 1000 horsepower, which equals $100,000 a month in electricity costs. So, anytime you can reduce the flow, you reduce the horsepower, the electricity usage, and therefore the costs."

VOD systems can be further optimized "by using geo-fencing to detect the total number of miners and machines in a particular work area, which will prompt the VFDs to increase or decrease air volumes as needed," added Jon Griffith of Epiroc US. "Real-time monitoring of gaseous and particulate contaminants is also an excellent addition to the mine's VOD system, helping provide the high-quality, real-time data needed to optimize the system."

The more information that can be fed into a mine's control system, the broader range of possibilities of control strategies

Each mine's ventilation needs vary depending on their unique processes. Photo: Epiroc

that can be implemented, agreed Howden's Pinedo. "For example, knowing where vehicles and personnel are allows us to turn fans on and off based on their positioning. Taking that a bit further, if a fan with a VFD monitors airflow in that location, we could vary the speed to supply the required amount of air for that specific heading."

"These technologies can also detect potential issues early, allowing for proactive maintenance and reducing the risk of system failures," noted Trapani. "However, the challenge is ensuring that the monitoring stations are maintained well and calibrated to ensure that the data provided are useful and reflective of site conditions."

"It goes back to the principle of only using what is required," Pinedo continued. "Activities conducted at a heading require different amounts of airflow. Supplying the right amount of air depending on the activity can generate energy savings of over 50%. This can be done at a small scale and specific levels or on a mine-wide scale by incorporating the main fans."

Mines also don't require high-end automated systems to begin to improve efficiency, added Pinedo. "Something as simple as timers on fan starters can ensure that, even if a fan is left turned on by mistake, it shuts down eventually." It is also about doing the fundamentals right, like regularly inspecting rigid ducting and vent bags to ensure they are "kept in good order to prevent leakage," said Griffith. "Ducting should also be sized appropriately to optimize airflow.

Computational modeling and simulation: Helpful, but don't forget the human factor

Digital technologies "allow engineers to create detailed models of the mine and simulate various ventilation scenarios," explained Stantec's Trapani. "Howden's Ventsim, SRK's VNetPC, and VUMA are the three most common tools. These help identify the most efficient and effective ventilation strategies, predict the impact of changes, and optimize system design and operation. These tools can also test emergency ventilation plans and ensure the system can handle unexpected events."

"Ventilation modelling software is extremely useful in prefeasibility ventilation design and day-to-day operations management," added Epiroc's Otterberg. "As mine workings expand and grow, the ventilation system will have to grow with the mine. A well-maintained ventilation model will enable the mine to perform sensitivity analyses and quickly decide on upcoming ventilation needs."

However, according to Elswick of Paul's Fan, humans still have a place in monitoring and understanding the mine and its environment. "Nothing replaces the human ability to take a handheld monitor and go to that working position and make sure. Double-check! Do not rely completely on the computer or the machine. There's no substitute for checking with handheld equipment."

Integrating mine ventilation and production planning

"Best practices for integrating mine ventilation with overall mine production planning include early collaboration between ventilation engineers and production planners, continuous monitoring and adjustment of ventilation systems, and incorporating ventilation considerations into the overall mine design," said Trapani. "Regular reviews and updates to the ventilation plan based on production changes are also essential. This ensures that ventilation systems align with production activities and adapt to changing conditions."

As Venstim Sales Manager Jose Pinada explained, models and simulation software play a part in this. "Using a tool like Ventsim that allows users to import their mine plan schedule from mine planning software enables your ventilation planning to inherit all the mine's attributes already configured in the planning software."

"In my experience, involving all departments in the decision-making process is also good practice," said Elswick. "Often, our mining folks get involved with engineering and accounting while the maintenance and productivity team is left out. But talking to the people who use fans and know their advantages and disadvantages can help determine whether a particular fan will be a viable unit for long-term production."

Measuring capital investment against long-term operating expenses can be overlooked.

"Pulling a smaller, older fan out of storage for a start-up or temporary situation is not necessarily the cheapest option," continued Elswick.

"You only end up changing it later, and that cost is multiplied more ways than double because a shutdown is required to make the upgrade, plus the additional work taking the old unit out and back to storage while putting in the proper unit. If the mining company properly integrated their ventilation and production planning first, there would be no downtime, upfitting, or wasted time and costs, just optimal use, energy flow, and all that good stuff."

Set and forget?

According to Epiroc's Otterberg, many mines treat ventilation with a "set it and forget it" attitude, receiving little special thought. Yet, ventilation is often among a mine's highest daily expenses. For example, "main fans are typically set at the maximum airflow, which is a significant waste of resources." Tailoring the mine's underground ventilation system for real-time conditions will reduce operating costs, ensure a safe and comfortable working environment, and help reduce a mine's carbon footprint." Far from setting and forgetting, then, mines have much to gain from giving their ventilation systems the attention they deserve.