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## CONTROLLING EMISSIONS

# Emission control

**John Chadwick looks at improving some of the fluids used in mining machines, noise reduction, gases and dust. Water is considered separately, next month**

The manufacturers of mining equipment play an important guard role against emissions, both into the mine and for the wellbeing of operators. Dust-extraction/suppression systems, electronically controlled engines, better and easier maintenance access and control of hydraulic and other machinery fluids are just some of the important areas. Enclosed cabs with sound and vibration insulation are essential for good operator wellbeing.

For example, among **Sandvik's** Environmental Health and Safety (EHS) stated objectives are "more efficient use of energy, raw material and other input materials," and to "minimise emissions to air, land and water." The company also notes:

- Maximise reuse, recycling and recovery of materials and byproducts
- Minimise EHS impact from use of hazardous substances
- Minimise the EHS impact of our products when used by our customers.

Sandvik machine cabs aim to keep the noise level below 80 dB(A). In surface drilling some of the improvements include:

- Tier 4i/Stage IIIB engines (Cummins 110/164 kW), starting Q1-Q2 / 2012
- Longer service intervals to eliminate/observe oil spillage
- The possibility of biodegradable oils in hydraulic systems
- Air-mist flushing option to reduce water consumption.

Sandvik says the DI550 series drills offer low fuel consumption through:

- Load sensing compressor pressure control
- Ambient control of oil cooler fans
- Active engine RPM control
- Optimum diesel engine RPM level (1,800 rpm).

Caterpillar says "machine functions and the cab environment can significantly impact operator performance. For example, noise and vibration can lead to operator fatigue and lower productivity. Caterpillar can isolate the source of noise and/or vibration—integrating technologies to cancel their effects in the cab environment—improving operator comfort, leading to enhanced productivity."

**Brüel & Kjaer Sound & Vibration Measurement** says monitoring noise is all well and good, but it doesn't change the noise impact to the surrounding community. If operations are creating significant noise – or worse, exceeding agreed limits – you need to know immediately so you can take action and reduce the impact.

Brüel & Kjaer's Noise Sentinel Mining can alert equipment operators or mine managers when they need to take action and reduce the noise impact:

- Monitor noise levels in real-time to see exactly what is going on – from anywhere over the internet
- Demonstrate compliance with noise limits
- Identify the source of the noise so you know what action to take
- Receive alerts while you are mobile so you can always take immediate action
- Use predictive alerts to warn of potential noise breaches before they occur
- Predict noise to feed day-to-day operational decisions in order to maximise production within noise limits.



*Dust and noise are two emissions mines must keep within limits (Main picture courtesy of Cypher Environmental)*

Noise Sentinel Mining helps manage the noise from mining operations. The company says it delivers:

- Simplicity with high quality measurement and confidence in the data
- Peace of mind, cost savings and cost certainty.

It is a collection of products based around Brüel & Kjaer's established noise management platform Noise Sentinel. It tailors solutions specifically to the mining industry for noise monitoring, noise management, noise prediction and community engagement. The company says "by including multiple elements, Noise Sentinel Mining enables you to take an innovative approach to managing mine noise, allowing you to operate your mine smarter."

Delivered as a web-based subscription service, Noise Sentinel Mining can be accessed anywhere. Brüel & Kjaer takes the responsibility for supply, installation, operation, calibration and support, freeing mines to focus on noise management and mitigation.

Vibration is another machine emission that must be managed. Companies should implement the most up-to-date safety measures to keep their workers safe from vibration injuries, rather than the bare minimum to meet regulatory guidelines. According to vibration safety expert **Reactec**, many businesses are still

choosing to simply tick boxes when it comes to meeting their safety responsibilities rather than making a firm commitment to protect people from crippling injuries such as Hand Arm Vibration Syndrome (HAVS).

Reactec, which produces the award-winning HAVmeter safety system, believes that using technology to continuously monitor employee's exposure to vibration is the only way to ensure they remain safe in the workplace – and is urging the rigid implementation of safety systems in order to meet corporate responsibility targets. Commenting on the situation in the UK, Jim O'Hagan, Managing Director of Reactec said: "The HSE introduced legislation in 2005 in the form of the Control of Vibration at Work Regulations, which clearly stipulated how much vibration is acceptable in the form of Exposure Action Values (EAVs) – the daily amount of vibration exposure above which employers are required to take action. The regulations also set out acceptable Exposure Limit Values (ELVs), the maximum amount of vibration anyone can safely be exposed to on a single day."


"The HSE's chief inspector of construction believes that companies are taking their eye off the ball when it comes to vibration safety and he is absolutely right. Hand Arm Vibration Syndrome is a huge risk for anyone who regularly uses vibrating tools and it can devastate lives – but far too many firms are failing to adequately protect their employees. The simple fact is that continuous monitoring is far and away the best way to guarantee that your workforce is protected from injury, while also adhering to restrictions. Doing the bare minimum and ticking the boxes should not be an option – and your staff should be confident that you are always putting their safety first rather than just protecting yourself from liability."

He adds that using a continuous monitoring system such as the HAVmeter will not only prevent the inaccuracies that arise from using a manual timesheet system, but will also save businesses time and money in the long run – as well as protecting them from costly compensation claims. "Manual methods of calculating vibration exposure levels have been shown to be far less reliable or accurate than an automatic system. You rely on untrustworthy timesheets and, even if your staff use a stopwatch to time their exposure, this takes a lot of wasted time and effort to do correctly. An automatic system like the HAVmeter not only provides additional safeguards for employee's occupational health, but it also gives companies a robust and foolproof way of protecting themselves against liability for injuries and to avoid compensation claims.

"With such a system, you can accurately collect detailed data of who has used which tool, for how long and when it was used. The level of reporting is so comprehensive that employers are able to determine detailed data on trigger time for the actual number of tools that are being used – and this data can assist in tool servicing intervals and optimise correct tool usage in the work place.

"The benefits and potential costs savings in tool inventory and service costs make the business case for continuous monitoring a compelling proposition. It really is the best way to improve workplace safety, save money and ensure that a business is being as responsible as possible for its staff." The HAVmeter is widely used on surface mining equipment.

## Machine fluid control

In extending service intervals, the lubricant supplier plays an important role. A leading Indian mining company that operates a range of heavy-duty equipment was using an engine

lubricant that gave a maximum oil-drain interval of 350 hours and it wanted a lubricant with a longer oil drain interval, ideally 500 hours, to increase equipment availability and production time.

The mining company worked with **Shell Lubricants** to identify a solution, and decided to change to Shell Rimula R4. The company also chose to take advantage of the Shell LubeAnalyst service to monitor the oil's condition.

After trials, it was established that the new lubricant could be used for up to 600 hours, providing the equipment was well maintained. As a result of changing to Shell Rimula R4, the mining company has increased its oil-drain interval by 70% from 350 to 600 hours. Because fewer oil changes are required, the company has reduced its lubricant consumption and extended the maintenance intervals, which has resulted in lower maintenance costs. There is also a benefit from increased production time and a lower lubricant inventory. The company recognises the value of Shell's lubricant solution and has estimated a total annual saving, across numerous machines, of $427,428.

Similarly, Norilsk Nickel's Black Swan nickel mine, an existing Shell customer, agreed to consider implementing a product rationalisation project at the mine that aimed to reduce the number of products servicing the facility while improving operational performance. This would include changing all the gearboxes on-site from a mineral oil to a fully synthetic product, Shell Omala S4 GX. The changeover to new oil also had the potential to extend oil-drain intervals and equipment life while reducing sump temperature, downtime and electricity consumption.

Using Shell LubeAdvisor, the Shell Lubricants technical team presented a report to the mine outlining the potential financial and operational benefits that could be realised by converting to Omala S4 GX. Norilsk Nickel agreed to a 14-month project: the first seven months gathering baseline data and the second seven months trialling Shell Omala S4 GX and evaluating the operational benefits.

The trial in the gearboxes of the mine's two grinding mills showed a 2.1% decrease in the electricity consumption of the units. Omala S4 GX has the potential to last twice as long as a mineral oil and thereby to extend oil-drain intervals and reduce labour costs and downtime. Over 12 months, Norilsk Nickel estimated that changing the two grinding mills over to Omala S4 GX 220 would save $74,473 in waste disposal and electricity costs, even after the cost of the oil.

The use of biodegradable fluids has become very prevalent this century. Back in February 2005, **Houghton International** announced the approval by America's MSHA of Cosmolubric B-230, saying "this product is the first fire resistant, vegetable oil hydraulic fluid to meet Code of Federal Regulations' requirements, and is ideal for use on conveyor systems, hydraulic shovels, and a host of other mining equipment from excavators to crawler tractors.

"Cosmolubric B-230 provides an affordable means for mining organisations to eliminate the environmental concerns associated with mineral oil-based fluids. A low-cost alternative to conventional, synthetic fire-resistant fluids, Cosmolubric B-230 performs equal to or better than all other mineral-based or synthetic hydraulic fluids.

"MHSA approval follows a rigorous process of review and testing, where applicant products are measured against stringent operating parameters and transparent production procedures. They undergo ignition-temperature tests, temperature-pressure spray-ignition tests, and tests to determine the effect of evaporation on flammability, as well as reviews of the quality of material, workmanship and design. For this reason, receiving MHSA approval for a product illustrates a clear commitment to superior quality, and enhanced personnel safety.

"A vegetable oil-based fluid, Cosmolubric B-230 is formulated around naturally occurring esters, which means it is inherently biodegradable, while at the same time it possesses the lubricity associated with far more expensive synthetic polyol ester fluids. Indeed, in benchmark tests comparing Cosmolubric B-230 to premium synthetic fluids, Houghton's Cosmolubric B-230 provided comparable performance in lubrication, pump life, and oxidative stability."

**Quaker's** QUINTOLUBRIC® product line is composed of MSHA approved longwall fluids and fire-resistant hydraulic fluids. Bacteria growing in longwall hydraulic fluid can do major damage. Quaker Longwall fluids include QUINTOLUBRIC 818 and QUINTOLUBRIC 814 that protect equipment by dramatically blocking the growth of damaging bacteria. Both are high water based hydraulic fluids that are biodegradable and compatible with commonly used longwall fluids for easy conversion. As an example of providing solutions, QUINTOLUBRIC 814-01 has been running in one major US longwall mining operation since 2007. Since then solenoids and filters have remained corrosion-free and the longwall tank has remained clear and bacteria-free.

The 888 Series is designed to replace anti-wear, mineral oil-based hydraulic fluids used in fire hazardous and environmentally sensitive applications without compromising overall operations. Quaker says "these products offer extended hydraulic fluid lifetime, best in class oxidation stability and corrosion prevention that extends service and equipment life. They contain no hazardous ingredients, have excellent shear stability and reduce pump wear.

Similarly the QUINTOPLEX™ EP line of fire resistant, biodegradable greases is formulated with QUINTOLUBRIC base stocks. These greases are designed to replace extreme pressure, mineral oil-based greases in applications where fire hazards exist or in environmentally sensitive bearing applications without compromising overall equipment operation. They provide excellent low temperature performance and pumpability, and excellent extreme pressure lubrication protection. In addition the greases provide protection against shock loading and good rust and corrosion protection as well as good water resistance.

Quaker Chemical's lines of synthetic based gear oils and greases include MineTech, PROTECH EP and UNIMIST EP. MineTech™ lubricants have been specifically engineered for mining conditions. MineTech products use advanced corrosion inhibitors and lubrication additives to protect equipment and reduce wear on moving parts. The company notes that "synthetic base stocks extend drain intervals. These highly oxidation resistant base stocks incorporate premium additive packages to yield a line of EP gear oils and specialty greases that will tame even the toughest applications." The portfolio includes MineTech™ CST 100 for highly loaded enclosed gearing as well as plain and rolling element bearings. This shear stable lubricant resists damage to gear teeth caused by repeated shock loads. It is ideal for mine hoist gearboxes and crane gearing. This extended life lubricant performs well in extreme environments, has outstanding oxidation and thermal stability, high viscosity index and excellent low temperature flow characteristics. The additive system in this product protects against micropitting, has a high load carrying capability, resists sludge formation, and provides maximum protection against rust, corrosion and foaming.

PROTECH EP Series synthetic gear lubricants have excellent oxidation and thermal stability, naturally high viscosity index and excellent low temperature pumpability and fluidity. The additive system used provides increased oxidation stability, extreme pressure properties, and maximum protection against wear, rust, corrosion and foaming. They reduce friction and the input power needed to operate the equipment, and increase the available power output. The reduction of fluid friction results in lower lubricant operating temperatures, extending the life of both the lubricant and the equipment. The additive system used in this

product not only reduces frictional drag, but also protects gears against failures associated with heavy loading.

The UNIMIST EP series is blend of premium synthetic basestocks and a proprietary additive package that has been proven in the field as well as in the laboratory. The series provides superior lubrication protection over a wide range of operating temperatures and conditions.

French lubricant specialist **Condat** has developed a specific range of products for mining – all compliant with the latest safety and environmental standards. Hydraulic fluids include Condat D46 and D68 - biodegradable, fire resistant, HFDU type. They have the equivalent properties to mineral oils with which they are compatible and miscible. Condat's D46 and D68 have been approved by Factory Mutual, which is a major reference for hydraulic fluids.


For longwall mining, Condat SH4B is a concentrate hydraulic fluid micro emulsion type, and is added with the water in the hydraulic cylinders. It has good anti foam properties and great stability regardless of the hardness of the water.

For conveyor lubrication, the GR 217 range are multipurpose, biodegradable, non-toxic and fire resistant greases. They offer high resistance to water, temperature extremes and pressures and use solid lubricant additives.

## Gas control

The gases of greatest interest to miners are oxygen and carbon dioxide. An oxygen level of less than 17% is hazardous. Dilution from other gases, or by sulphide ores and carbonaceous shales which oxidise slowly, will deplete oxygen volume. Timber decay and rust on iron deplete oxygen content and can also produce carbon monoxide or carbon dioxide which may contaminate mine air.

$CO_2$ is non-explosive in air, denser than normal air and can be found at floor level. At concentrations greater than 10%, $CO_2$ causes loss of consciousness. The rate of breathing doubles at a concentration of 3%. Mine fires and slow combustion of timber, blasting, breathing, breakdown of carbonate ores and burning diesel fuel increase carbon dioxide levels in the air.

A number of contaminants need to be monitored. Airborne dust affects health and safety of underground and surface personnel and is dangerous in excessive amounts if breathed in over a sufficient length of time. The best practice is to minimise the potential for dust to become airborne, particularly when using machinery and shot-firing underground. When dust is airborne, velocity of ventilating air currents should be strong enough to dilute and remove dust and any fumes.

Carbon monoxide (CO) is a colourless, tasteless and odourless gas, lighter than air, easily absorbed into the blood stream and very toxic at low concentrations. It is explosive in air between concentrations of 12.5% and 74% and can be detected with gas detector tubes. Its main sources are diesel emissions, blasting operations, and any incomplete combustion.

Sulphur dioxide is a non-combustible, non-flammable toxic, colourless gas with a strong sulphurous suffocating odour. It is very poisonous and can irritate eyes and respiratory passages. $SO_2$ in high concentrations is

*Ventilation equipment has high noise levels. Swedvent ventilation fans and ducting introduced in 2010 (IM, September, p47) by Sweden's GIA Industries features reduced noise levels. Improved silencer design offers noise reductions of at least 3 dB(A) for the full range of fan motors rated between 10 – 500 kW to meet 75 – 85 dB(A) at 7 m. The improved sound damping has been achieved with a specially designed silencer filled with processed mineral wool to reduce high frequency sounds*

dangerous to breathe over a long time. Principal sources of $SO_2$ are fires in sulphide ore bodies, diesel engines, blasting and burning rubber. The gas may be detected by smell at concentrations of 0.003% or by gas detector tubes and gas instruments.

'Nitrous fumes' include all nitrogen oxides and in particular nitrogen dioxide, nitric oxide and nitrogen peroxide. All are toxic, having a pungent smell and an irritating effect on the air passage. Any air with sufficient nitrous fumes to cause appreciable irritation of the air passage should be regarded as dangerous. Main sources are diesel exhausts and partial detonation of explosives. Detection is by odour and should be taken as a warning not to proceed. Gas detector tubes are also available.

Undiluted exhaust gases from a diesel engine should be measured for CO and oxides of nitrogen or NO (new engines should be able to achieve about one third of the CO limit). Diesel engines should be fitted with an appropriate conditioner or scrubber. Airflows in which diesel engines operate underground should have been determined by the dilution required to achieve the atmospheric limits specified in applicable standards. This requires knowledge of the swept exhaust volume of the engine and the maximum raw exhaust gas concentrations for the duty cycle. Sufficient quantity of air for ventilation should be available when engines in one specific area of a mine are operating. Check contaminant levels are not being exceeded and appropriate monitoring methods, such as detector tubes, are in place.

Other gases which may be present in mines include methane, aldehydes and hydrogen sulphide.

In underground mines competent persons should:

- Regularly inspect, test and record atmospheric conditions
- Analyse atmospheric contaminants and air quantities and determine if they comply with appropriate standards
- Inspect, test and record wet and dry bulb temperatures at sites where temperatures are identified to have an adverse effect on safety and health
- Calibrate and maintain all metering and monitoring devices
- Select and position primary and auxiliary fans and record air levels at the parameters regularly
- Record air volume and pressure in the mine at regular intervals
- Update ventilation plans as required to ensure current information is available in cases of emergency

- Identify and deal with equipment defects or deficiencies in air volume or contaminants. In crushing and screening plants:
- Regularly inspect and test workplaces to determine and maintain atmospheric contaminants at levels as low as are reasonably possible
- Ensure dust suppression and collection systems are effective
- Operate, calibrate and maintain all metering devices
- Identify and deal with equipment defects or air contaminant levels exceeding appropriate standards.

In supplier news, **Industrial Scientific**, which claims to be the global leader in "gas detection as a service," reported in December that the Ventis MX4 multi-gas detector has received new approvals for intrinsic safety. With ANZEx approval, applicable to the Australian and New Zealand markets, the Ventis now bears marking codes Ex ia s Zone o I; Ex ia s Zone o IIC T4; and IP66 / IP67. With INMETRO approval, applicable to the Brazilian market, the monitors now bear marking codes Ex d ia IIC T4 Gb; and IP66/ IP67.

The Ventis, Industrial Scientific's newest multi-gas detector, is a lightweight, highly configurable instrument that is capable of detecting one to four gases including oxygen, combustible gases (LEL or $CH_4$) and any two of the following toxic gases: CO, $H_2S$, $NO_2$ and $SO_2$. Ideal for both confined space monitoring and continuous personal monitoring in potentially hazardous environments. In confined spaces, the Ventis can be used to draw samples from up to 30 m with its integral pump.

The Ventis is fully compatible with iNet® - the company's Gas Detection as a Service solution. iNet helps companies around the world keep their workers safe by providing visibility into gas detector alarms, exposure and usage.

**Mutech** is an electronics design and manufacturing consultancy that specialises in hazardous area equipment. Some of the areas of electronic design it has been pioneering are intrinsically safe (particularly for hazardous areas), ATEX and MSHA testing and approval processes including EN60079 and aiming for IEC61508 accreditation in 2012; RF design, GSM, CDMA, electronic security and power supply circuit design, SMPS, industrial control, PCB layout, microprocessors, embedded systems and RTOS. A key element of what the company does is conceptual design, formulating products that work in an increasingly demanding and high tech marketplace, with the ability to manufacture these designs on site.

## Dust control

Improving the application of inert rock dust to reduce the risk of coal dust explosions has become a central topic in underground mining in the last few years. The efficient reduction of

*DYWI polymer rock dust*

*This Gold Series dust collector system supplied by Camfil Farr APC to a US copper mine offers high efficiency filtration through moisture-resistant HemiPleat® filters, "which offer greatly extended service life and lower pressure drop than standard pleated filters, the company says"*

respirable dust concentrations in the mine atmosphere is another important issue, as respirable dust can cause health problems.

In order to meet these requirements, **DSI Underground Systems** USA has widened its product range by the addition of the DYWI® Polymer Rock Dust System, which has been developed by DSI and is now successfully used in underground coal mining. The performance of the new system aides customers in meeting the current MSHA requirements in terms of inert rock dust application in underground coal mining and also reducing respirable rock dust in the mine atmosphere.

This system combines wet dusting technology and polymers to ensure the effective application of inert rock dust along with reducing respirable dust. It can be applied at rock dust thicknesses in a range between about 0.5 and 40 mm and typically dries within 24 to 48 hours, depending on the mine air velocity and humidity. The compact size of the equipment ensures that it can be easily transported in underground mines using standard means of transportation such as wheel loaders or overhead monorail systems.

The DYWI Polymer Rock Dust System can be easily operated by two people and the coal surface can be sprayed during continuous shift operation. A typical batch operation provides some 75 m of roof and rib coverage, depending on mine height and width, in only 15-20 minutes. The hydraulically powered air compressor provides 30-50% more coverage per batch by improved dispersion of the product via the air assist spray nozzle. Advantages of the DYWI Polymer Rock Dust System:

- Easy to batch and spray
- Quick troubleshooting
- One stop shop service for the concentrate and application equipment (DSI is the manufacturer of the equipment)
- Operating at low pressures improves application and end user safety
- Dusting operations can be carried out while the production unit is in operation - no shutdown periods
- Cost effective and easy operation.

On surface, at one US copper mine, the use of a cartridge-style dry dust collection system from Camfil Farr APC has reduced emissions to only 0.00037 grains/dry standard cubic foot (dscf) average, just a fraction of the required limit of 0.02 grains/dscf – while delivering added benefits of energy savings, water savings and ease of maintenance. When the facility first started up, emissions were not subject to environmental monitoring. Using emission estimates extrapolated from recent data, mine officials estimate the facility potentially emitted over 15,000 t/y of PM10 (particulate emissions <10 µm in size) in its early years. The facility was later retrofitted with wet scrubber dust collectors that reduced potential PM10 by over 90%, to <500 t/y.

After the turn of the century, the facility experienced an extended shutdown due to market conditions. When the company made plans to restart the unit and expand the facility, tighter new emission regulations called for a 15-t ceiling on annual PM10 emissions for the total project.

Management learned of Camfil Farr APC's Gold Series® dry collection system, incorporating high efficiency cartridge filters rated at 99.99% efficiency on 0.3 µm particles. "The planned retrofit using this system would deliver an estimated emission rate of 0.001 grains/dscf, facilitating air quality permitting under strict project guidelines and allowing the facility to restart with emissions well within the required limit of 0.02 grains/dscf average," reports Dave Stock, Mining Market Manager at Camfil Farr APC.

In 2006, upon facility restart, potential PM10 emissions from sources controlled by the new cartridge collectors were estimated at just 4 t/y – a reduction by a factor of ten. Stack performance tests conducted in 2007 yielded a pleasant surprise: Actual PM10 emissions

*Testing of Cypher Environmental Dust Stop*

measured only 0.00037 grains/dscf average, yielding about 2 t/y of particulate or half the expected level.

Camfil Farr APC provided a system with customised wear-resistant components. It says the Gold Series collector offers "extremely rugged heavy-gauge construction, easy access and fast, trouble-free filter changeout."

"While the mine's first dust collection priority is to ensure compliance with permitting conditions, an important secondary goal is conservation of resources," notes Stock. "Here, again, Gold Series technology has proved beneficial." In the fine ore crushing application, the previous 22 wet scrubbers, which used a total of 1,740 hp, have been replaced with 52 cartridge filter units that use 1,030 hp, for a savings of 710 hp. Electrical energy savings are estimated at approximately $400,000 annually.

The wet scrubbers required pumping and re-pumping of water with periodic addition of make-up water, costing about $700,000 annually. The dry collection system has eliminated this cost while conserving a precious resource.

"The HemiPleat cartridge filters in this application carry a normal-use replacement cost of about $200,000 per year based on annual changeout. Subtracting this amount, we calculate the mine is saving about $900,000 a year through reduced water and energy use," says Stock, adding: "In reality, most of the filters have gone more than three years without needing replacement, so the true operational savings may be upwards of $1 million a year."

**Cypher Environmental** recently shipped Dust Stop to a mine in Africa to alleviate hazardous dust problems both on the haul roads and within the mine. It was the suppressant of choice due to many factors and the ability to seal and stabilise the dust from haul roads. Dust Stop absorbs moisture from the atmosphere as well as repels the damaging UV rays from the sun and after application it totally seals the dusty roads for an extended period of time without the constant use of depleted water supplies. Dust Stop is certified 100% Environmentally Friendly and this is highly valued by mine workers, health and safety departments, environmental inspectors and maintenance personnel since dust causes extreme down time due to health problems and also due to the fact that hazardous dust is highly destructive to all equipment.

Todd Burns, President Cypher Environmental, explains that "Dust Stop is used primarily as a dust control product on roads, but is also used as a dust suppressant in mining environments for stockpiles/tailings, open haulage situations and any other erosion/dust control requirements. Some interesting upcoming applications are for covering open rail cars at a bauxite mine in Guinea where the trains run 24 hours a day through Conakry, and a large copper mine in Chile where three separate tailings sites of approximately 350 ha each will eventually be capped with Dust Stop.

"Some Canadian mines have also used the product on their haul roads and our soil stabiliser is used on a large scale basis at one of the major oil sands facilities here in Canada."

Cypher Environmental explains that Dust Stop effectively eliminates unwanted fugitive dust from dirt roads or unpaved roads consisting of any soil type. It is unaffected by rain or water run-off. The product is very resistant to breakdown by both enzymes and UV rays. It has the ability to withstand heavy haul truck traffic and is applicable on any soil type. Another benefit is Dust Stop is available in powder form, allowing for easier transport and storage compared to traditional liquid dust suppressant products. "The concentrated form of Dust Stop allows for easier mixing and application than any other powder dust suppressant on the market," the company claims.

Dust Stop is mixed with water and is applied topically to the road or soil. Once the film dries on the road it will eliminate the dust and will provide soil stabilisation properties while the film remains intact. It can also be used in dry applications. It is a non-corrosive product.

Dust Control Technologies manufactures fog-type dust control equipment that uses compressed air and water to produce water droplet sizes of 1-100 µm for PM10 and larger dust particle capture. This technology meets US EPA clean air requirements. Typical applications include material transfer points, crushers, belt feeder tunnels, and truck/railcar dump points.

Quaker Chemical has developed an innovative, effective dust suppression system. DUSTGRIP™ TURBO is a proprietary blend of wetting agents designed to accelerate water penetration in areas where dust is a hazard. It is designed for multiple applications including mine haul roads, stockpiles and longwall mining. The product mixes easily with water and can be used with a mine's existing equipment. No post-application rinsing of equipment is needed.

Quaker says it "reduces the total water volume consumed for dust suppression purposes. Repeated applications have a cumulative effect, thereby maintaining subsoil moisture content for long periods (depending on soil types, traffic and weather conditions).

**Dust Control Technology** has introduced an innovative dust suppression device specifically for use at conveyor discharge points, designed to create a virtual curtain around the material flow for outstanding particle containment. The DustBoss® DB-R™ Ring has a high-quality stainless steel ring outfitted with a network of atomising nozzles that deliver millions of 50-200 µm droplets per minute. By surrounding the discharge flow on all sides, the DustBoss Ring provides simple, focused dust management that's well suited to continuous duty.

*The number and size of the dust suppression spray nozzles vary by model of DustBoss DB-R. The smallest model features 30 brass nozzles that produce 12.3 litres/min of water flow. The 648 mm unit is designed with 18 medium-flow nozzles, with a water usage of 42.9 litres/min. The 648 mm and 1,067 mm models feature 30 high-flow nozzles that deliver litres/min, and the 2,540 mm diameter size employs 84 nozzles for 200.3 litres/min of water delivery*

"This design was first developed for a coal application," explains DCT CEO Edwin Peterson. "The momentum created while discharging dry coal was propelling large amounts of dust into the air, and the customer was looking for a way to specifically address the material as it came off the conveyor. The solution was simple but effective, and we're finding that it's well suited to conveyor discharge of traditionally dusty materials."

The DustBoss DB-R is available in five standard sizes, from 432 to 2,540 mm in diameter. All five can be customized with DCT's Variable Particle Sizing™ technology, allowing customers to specify different droplet size ranges to match specific materials.

"The greatest chance of a collision between a dust particle and a droplet is present when the droplet and dust are roughly the same size, avoiding the slipstream effect," Peterson notes. "If we can increase the chances of collision with a given particle size, we improve the effectiveness of the suppression."

Designed without any moving parts, the intrinsically safe DB-R is intended for elevated mounting. It requires no electrical power or compressed air. The water supply hose is connected directly to male pipe threads on the ring. Available options include a booster pump to elevate low water pressures, a variety of nozzle sizes and configurations, and a water filter. Customers can also order the units with a two-way valve and/or hose included.

## Hidden resources

Dust can also be controlled by containing the source. **Geometrica** and Carlos Caballero have created a rugged solution high in the Bolivian Altiplano. Located at over 4,000 m above sea level, San Cristobal is the largest mine in Bolivia. The open-pit silver, lead and zinc mine moves 150,000 t/d of rock, and processes 40,000 t/d of ore. The dome protects workers, the environment and neighbouring communities from the release of dust from its stockpile, and protects the material awaiting transport to the ore processing facility. In early 2010, Bolivian contractor Carlos Caballero responded to a bid request for a stockpile containment solution and teamed with global storage company Geometrica to propose a customised containment solution for the mine. Caballero served as the main contractor and installer of the dome, while Geometrica, as a subcontractor, engineered, manufactured and supplied the dome. Key factors in the decision to employ a Geometrica dome solution for the site included the team's extensive experience, the capability to build around an operating stockpile, and the capability to follow an irregular shape for the supports, the company reported.

The finished stockpile containment structure is a Geometrica dome 140 m in diameter and 59 m in height anchored by concrete foundation — the largest dome of its kind in South America, the companies report. The foundation, which accommodates a 9 m change in elevation over 140 m, is fitted to the terrain. The dome is designed to withstand wind speeds of up to 150 km/h and an ice load of 110 kg/m².

A ventilation lantern is located at the top of the dome and the side of the dome can support dust removal equipment. The interior includes a system for lowering the material-conveyor pulley for maintenance, and a catwalk circling the dome interior. Three 13 m x 10 m doors allow simultaneous access by up to two off-road vehicles to the interior of the dome. Material is transported from the dome to the ore processing plant via an existing underground tunnel.

- Covered area 15,493 m²
- Surface area 25,340 m²
- Base diameter 143 m
- Height from base to apex of dome 59 m
- Weight of structural dome elements 523,400 kg
- Structural material - galvanised steel and aluminium
- Number of tubes - 88,329 pieces
- Number of connectors - 25,295 pieces
- Cladding - galvanised steel, painted steel and translucent panels. ***IM***