Addressing Silica

Using Real-Time Respirable Dust Monitors to Address the Silica Health Hazard in Mining.

By Justin Patts

Mining operations, by their very nature, create a lot of dust, with varying percentages of silica content. Modern mining operators are well aware of the hazard created by respirable crystalline silica dust (RCS). Operators also need to recognize that silicosis is an irreversible occupational disease with terrible consequences including lung cancer, respiratory failure and tuberculosis. And there is no cure for silicosis – the only fix is to prevent the disease by limiting worker exposure.

Based on the latest work-related lung disease surveillance report by the CDC [1], between 1990 and 1999, just over 20% of all total silica deaths occurred in the M/NM industry. And between 2000 and 2017, 12% of MSHA personal heath samples were greater than the MSHA PEL of 100 µg/m^3 and 34% of those were greater than the OSHA PEL of 50 µg/m^3.

Traditional Versus Real-Time Sampling for Silica

Sampling for silica involves the collection of personal respirable dust samples on PVC filters and subsequent analysis of the filter sample by X-ray diffraction (XRD, NIOSH method 7500). The lab reports back the mass, in mg or µg, of crystalline silica on the filter. From this value, the operator can calculate the silica concentration (mass of dust per volume of air sampled). This gives an understanding of the sampled employee's exposure over the shift.

While the traditional sampling method provides accuracy over the course of a shift, it does not allow the operator to understand *when* significant exposure occurred during the shift. By contrast, real-time monitors do offer this benefit – they continuously record in intervals, usually from 1 to 60 seconds, the real-time dust concentration.

The information gathered can be viewed directly on the device to see the time-weighted average (TWA) or it can be exported for further analysis. Because the data is recorded as a time-history, the health and safety professional can use the data to quantify where in the shift most of the exposure occurred. However, these near real-time "shift profiles" can look very different from each other.

For example, one worker could have an average exposure of 75 µg/m^3 that occurred because he or she was at a constant level for that amount all day, or it could be that just a few high spikes for a short duration caused that average level of exposure. Therefore, from the perspective of identifying the source of exposure, operators need to understand both the dust levels as recorded in a time history profile and the tasks associated with those exposures.

Understanding Limitations of Real-Time Dust Monitors

While it's very beneficial to know when high exposures occurred within a shift, operators must be aware of certain limitations with real-time dust monitors – especially in relation to accuracy. Accuracy as discussed here refers to the difference between an average concentration detected by the real-time monitor and the true concentration value as determined from a gravimetric sample. The gravimetric filter sample is always the "correct" number because the method is mass-based.

Therefore, the amount of dust that was deposited on the filter within a certain time period is literally weighed. By contrast, most real-time monitors use optical sensors and thus the results are not based on gravimetric analysis.

In a typical arrangement in a real-time monitor, dust-laden air is drawn into the instrument at some regulated flow and passes through an optical sensing chamber, where it is illuminated by a small laser. The presence of the dust causes the laser light to not pass straight through the chamber but rather to be scattered, and the amount of this scatter is captured with photometers.

The amount of scattered light is then correlated to a dust concentration. However, this correlation depends on several factors and assumptions, including the size of the dust, the index of refraction, the shape factor, the humidity, and the total concentration.

Further, most real-time dust monitors use some type of inlet size selector. This is important because health effects and the regulation PELs are based on respirable size designation (most commonly those dusts less than 10 µm), and if using an ACGIH/ISO/CEN size selector this means that the D_{50} cut point is around 4 µm. The 2016 updated OSHA PEL has resulted in an increase of dust monitors marketed as "real-time silica dust monitors," but it should be clarified that there is to date no such instrument. Currently available real-time dust monitors do not have the ability to speciate – that is, they do not determine the difference between crystalline silica or any other dust.

Finally, while real-time dust monitors are calibrated at the factory using a standardized test dust, this calibration can become less applicable the more the dust varies from the calibration aerosol. While the best practice is that these monitors be calibrated to actual field dusts on site, it's unclear how commonly this practice is followed by operators since it adds an additional step to the data collection process.

What NIOSH Is Doing to Improve How Real-Time Monitors Are Used

NIOSH is actively involved in the use and advancement of real-time dust monitors to lower exposure of mine workers to RCS. With this goal in mind NIOSH has helped to develop several products and best practices, as detailed below.

First, in cooperation with a mineral processing company, NIOSH co-developed a video exposure monitoring platform termed "Helmet-CAM." This arrangement pairs a worker-worn camera with a real-time dust monitor for simultaneous measurement of dust exposure.

To visualize and analyze this data, NIOSH further developed and maintains a free, downloadable software called EVADE [2] (Enhanced Video Analysis of Dust Exposures), which allows the user to quickly merge and analyze the video and dust data. This creates a synchronized pairing of video and exposure data that can be used to understand the magnitude of dust exposure and identify the specific tasks associated with those exposures. The EVADE software has been widely accepted and is in use in over 25 countries with more than 2,500 copied distributed since 2013.

Secondly, because of the technical limitations of real-time light scattering dust monitors discussed earlier, NIOSH has conducted and published research on the performance of light scattering monitors in response to several dusts commonly encountered in the M/NM industry, including limestone, sand, and high purity silica [3].

The results of this study showed that in a highly controlled aerosol chamber environment, the monitors required correction factors of between 0.8 and 1.6 relative to the standardized test dust. This means that to match a gravimetric sample on these dusts, a mine operator would need to take the real-time dust monitor data collected and multiply it by the appropriate factor. These factors can serve as a starting point for mine operators, but for the most accurate sampling a site-specific correction factor would still be recommended. Finally, NIOSH has developed a field-based technique for end-of-shift (EoS) analysis. As discussed earlier, to quantify the actual silica exposure, the mining operator needs to have the filter sample analyzed according to NIOSH 7500.

After sending these filters off for analysis and receiving the results back, it is then possible to correlate the real-time dust monitor's output to the real-time silica concentration. For example, if a real-time dust monitor reported an average respirable dust concentration of 175 $\mu g/m^3$ and the lab results for that filter revealed 15% silica content, then the silica exposure for that shift would be 0.15 X 175 $\mu g/m^3$ = 26.25 $\mu g/m^3$, or roughly one-half of the OSHA PEL or one-fourth of the MSHA PEL.

The NIOSH-developed EoS analysis technique shortens this time between sample collection, lab analysis, and silica exposure estimations. By using a field-portable Fourier transform infrared (FTIR) instrument, NIOSH has developed a methodology to improve the response time between sample collection and silica estimation. While the method is not a direct replacement for the approved NIOSH method 7500, research has shown good correlations and many mines have either trialed the technology or purchased a field-portable unit themselves to better estimate silica exposures during their routine internal health audits.

To support this EoS analysis, NIOSH has developed freely available software, called FAST (Field Analysis of Silica Tool) [4], which takes the output of the FTIR instrument and creates a silica estimation based on databases and algorithms developed through research. By combining Helmet-CAM and this EoS technique, mines can better estimate their employees' silica exposures by correcting real-time respirable dust measurements to the actual silica content.

The Future of Low-Cost Sensors

The benefit of real-time dust sensing lies in the ability to help the operator understand when certain exposures occurred. Pairing real-time sensing with Helmet-CAM technology, mine operators can also understand the specific tasks that led to those exposures. Further adding the use of an FTIR instrument and end-of-shift analysis can effectively yield silica estimation. All three of these approaches can be combined to estimate real-time silica concentrations.

Importantly, to quantify worker exposure, there is no substitute for personal sampling. Complementary to personal sampling is area sampling, and when area sampling is conducted in real time then the dust levels present at mines in key areas can be quantified on a continuous, long-term basis. NIOSH has conducted many years of engineering control research and has published extensively on the topic [5]. While the commonly used hierarchy of controls puts substitution as the best method for reducing worker exposures, often in mining the best controls are engineering-based, such as exhaust ventilation, dust capture systems, and total structure ventilation.

Fueled by a growing global desire to understand indoor and outdoor air quality (most commonly combustion aerosols in the atmosphere), numerous "low-cost" particulate sensors have been developed and marketed to those interested in quantifying their local air quality. Further, studies have compared these sensors to research-grade federal environmental monitoring devices and, after some appropriate scaling factor is applied, the agreement can be quite good.

NIOSH recently began a new research effort in the fall of 2019 which aims to evaluate the applicability of these sensors not to ambient aerosols, but to the perhaps more challenging role of measuring real-time mining dust levels [6]. This work poses many challenges – larger and more varied dusts, higher dust concentrations, and harsh environments – but the potential to inexpensively quantify mining dust levels in real time is intriguing. If low-cost area dust sensing for mining becomes a reality, it's possible that plant operators could apply engineering controls more widely by justifying installations that would most efficiently reduce both area exposures and individual worker exposures, providing a significant health benefit. ▲

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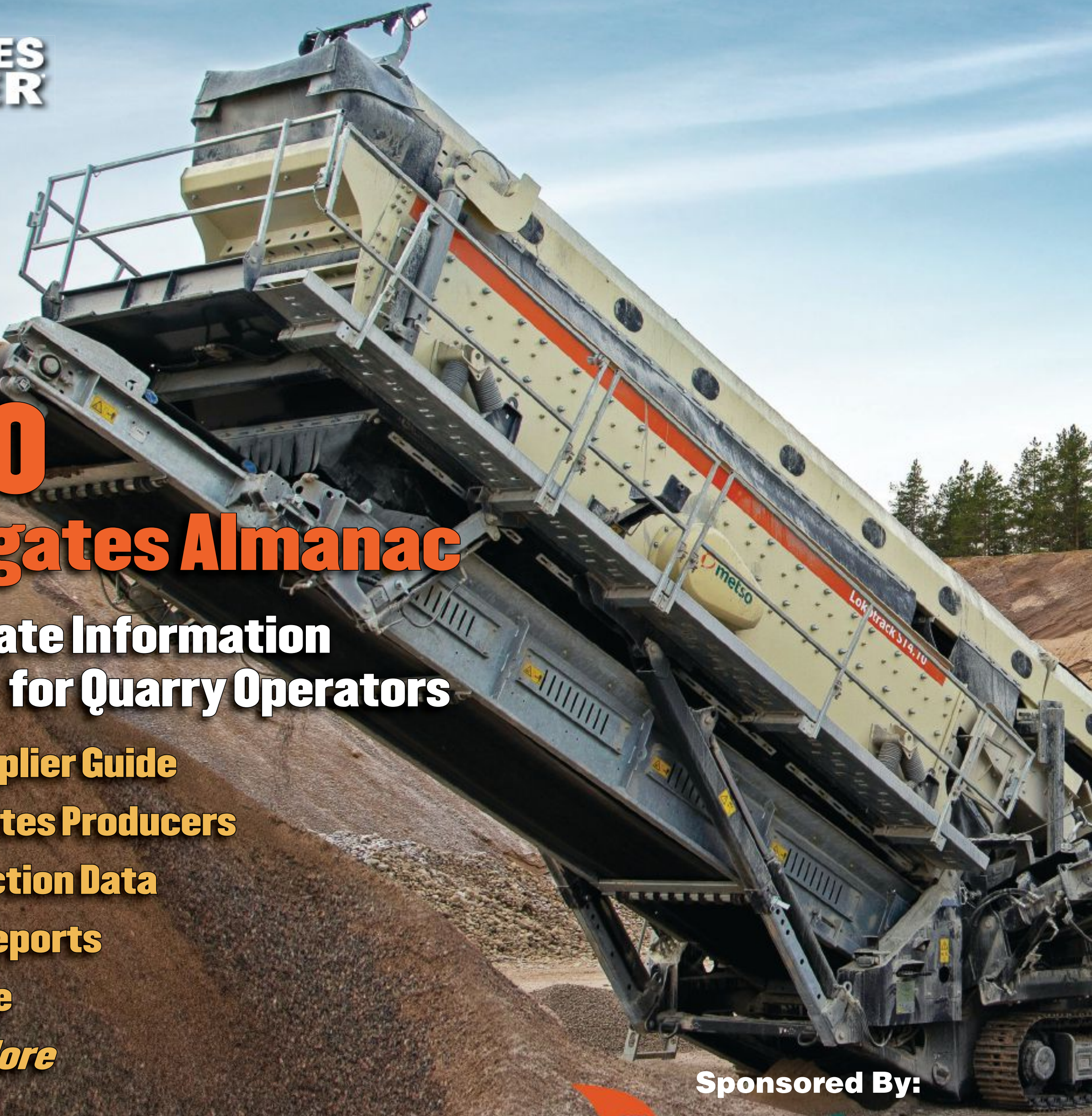

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ON THE MARK

The Aggregates Almanac Is Back

Welcome to the 2020 edition of the "Aggregates Almanac: The Ultimate Information Resource for Quarry Operators." Published now for the fourth year in a row, feedback from our readers indicates that this publication is widely used and valued; and retained as a go-to information source.

Rock Products' Benchmark 2020 survey indicated that aggregates operators are interested in New Equipment, Equipment Upgrades, Mine Development and Plant Additions.

Over and above consumables, producers are most interested in purchasing screening/sizing equipment, material handling/conveying equipment, and excavators/loaders and dredges. Motors and pumps also ranked high.

Our updated and improved North American Buyers' Guide gives producers all of the information they need to contact manufacturers and suppliers to make these important purchases.

Our Legislative Report just may give producers the best reason they have had in a long time to initiate those purchases: The "Investing in a New Vision for the Environment and Surface Transportation in America Act (INVEST in America Act).

The INVEST in America Act authorizes nearly $500 billion over five years to address some of the country's most urgent infrastructure needs. The bill has moved out of the House Committee on Transportation and Infrastructure and is headed for a vote of the full House of Representatives.

With the FAST Act due to expire in September, and with additional economic stimulus needed to inject some additional life into our COVID-19-ravaged economy, there is no better time to get a new infrastructure bill passed.

The other data, statistics and features in the Aggregates Almanac are meant to create a snapshot of an industry poised to move boldly in to the 2020s and address our nation's urgent infrastructure concerns.

There is something for everyone in the Aggregates Almanac. We hope you find this edition useful. Is there anything you would like to see in future editions of the Aggregates Almanac? Let me know about it at mkuhar@rockproducts.com.

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