Pigman
College of Engineering
Department of Mining Engineering

Steven Schafrik, Ph.D.
Associate Professor
Mining Engineering
steven.schafrik@uky.edu
859-257-8357

May 20th, 2024

RE: Written Testimony for the subcommittee of the United States Senate Committee on Health, Education, Labor and Pensions Hearing titled, Digging Deeper for Health and Safety: Examining New Standards and Practices in Mining

I'd like to thank this subcommittee of the United States Senate Committee on Health, Education, Labor and Pensions, and the Subcommittee for the opportunity to discuss this important topic of miner safety.

I am an Associate Professor and Director of Graduate Studies for Mining Engineering and a Faculty Fellow of the James B. Beam Institute for Kentucky Spirits at the University of Kentucky. I currently teach circuits, programming, mine design, ventilation, and automation at the undergraduate and graduate levels. My research is in automation, communication, ventilation, and training. I have two patents for dust filtering technologies. I am the founding Secretary/Treasurer of the Eastern Collegiate Mine Rescue Organization and the faculty advisor for the University of Kentucky RescUKats. I am very active in our professional society, the Society for Mining Metallurgy and Exploration, where I am currently the Chair of the Coal and Energy Division.

Much of this work has been developed under several CDC NIOSH contracts. The views and data are from me and in no way represent the views or opinions of the CDC, NIOSH, or any of its employees.

Much of the work described here was performed by nearly a dozen researchers at the University of Kentucky, Virginia Tech, particularly Dr. Emily Sarver; Penn State, particularly Dr. Ashish Kumar; and Missouri University of Science and Technology, particularly Dr. Guang Xu. Much of the testimony I will be describing and generalizing about mining technology, and there will always be exceptions to my comments. My comments are aimed at a general audience and not at specific mines or specific mining operations.

Sources and Characterization of Dust

There are various sources of dust in mining operations. Mining operations, by definition, extract minerals from the earth's crust for society to use. These minerals are used for anything from cosmetics to electric power to the metals that make up every piece of electronics. It is a truism that if something is not grown, then it has to be mined. Even though some of the things that are grown don't need to be mined, the tools that we use in order to harvest things that are grown are mined.

Most mining operations involve breaking stones using explosives or mechanical means to extract valuable minerals. These minerals are then used to produce items that are bought and sold every day. Mining is the beginning of the value chain for every product in society.

When a rock or any rigid body is broken, it creates dust, even if it's something that is cut. Cutting things with lasers, saws, and everything else will still create dust. The particular size and chemical makeup of the dust determine its health effects. Not all dust is created equally.

Mining operations have their own characteristics. Most of the mining operations in the United States are surface mines. Most of the mines in the United States are classified as metal/non-metal (M/NM), which means they produce a commodity other than coal. Most mines operate by what we think of as the classic mining cycle. That is, they drill holes and load those holes with explosives to provide the energy to break the rock. This leaves them with a pile of rocks that should be suitable for loading into a haulage system. They are hauled to a location and dumped in that location, and the production cycle continues. The rock is then processed. It is either sold as-is, crushed to smaller sizes, and/or processed in a mineral processing plant and then sold.

Dust from drilling is well known to the general public. Drilling was one of the most dangerous occupations when mechanization was first introduced into the mining and tunneling industries. The Hawk's Nest tunnel construction in West Virginia famously accounted for hundreds of cases of silicosis. This construction was before the adoption of the Jack Leg Drill, which was a step change in the safety of the miners. Most corporate mining operations today will use remote drilling machines that move the worker even further away from the drilling operation. The reduction of dust from drilling is a success in the mining industry, with the techniques adopted anywhere else where rock and concrete are drilled.

During loading, dust can be disturbed and created from the rocks running against each other. This process is done by machines where the operator is in the cabin and away from the digging. They are loading haul trucks, or equivalent, that are similarly operated from a cabin. Hauling can create dust from the trucks themselves or whatever haulage is used, stirring the dust up from the road or disturbing it in the loaded material. There are ways that we handle that with water sprays, and dumping creates dust, but this is also an activity where there's generally not a human being around. They will employ a negative pressure system and or water sprays in dust-related operations.

Surface coal mines in the United States operate in much the same manner as surface M/NM mines. However, the hard rock above the coal seam requires hard digging, while the softer coal is generally not blasted but is directly dug. Underground coal mining and soft rocks, such as trona, can be mechanically mined using a continuous mining machine or, under the right circumstances, using a longwall system. In these mining methods, the rock is broken with a mechanical drum with cutting heads on it. The drilling, blasting, and loading are all done by mechanical means within the machines. The cutting heads come around, make contact with the mineral, break it away from the earth's crust, and knock it down into some form of gathering system. On a continuous mining machine, gathering arms move around and pull the broken ore into the machine's body. It's loaded onto a conveyor belt and can be loaded onto a shuttle car or similar haulage system and taken to a dump, moves the material onto a conveyor belt, and takes it outside.

In a longwall system, the conveyor belt is called a pan line, and it runs underneath the longwall shearer's head. The shearer is two drums with cutting heads that move back and forth across a face of coal. The coal face is typically between 800 and 1,500 feet wide, depending on the geologic and economic conditions. Coal and the rocks around it are cut and dropped directly onto a set of conveyor belts to take it outside. It's a very highly productive means of mining.

With all kinds of mining, we have modeled the material that we are mining, but no model is perfect. The geological conditions will dictate how much out-of-seam material will be mined. Material that is not economical to sell is not desirable to mine, although in some cases it must be mined in order to fit equipment and people into the underground opening. In surface mines, the material that overlays the ore body generally must be moved or disturbed to get to the ore body.

Focusing on underground coal, the high-quality thick seam coal deposits are being mined out. A lot of economical coal seams are thinner than in the past. Sometimes, the coal is not as thick as the cutting head, and often, especially in central Appalachian coals, the rock surrounding the coal must be taken. That rock can be the source of silica dust or the nature of how the coal was formed, which made it contain silica. What we've seen in dust characterization studies, especially those that were done at Virginia Tech under Dr. Sarver, is that it doesn't necessarily depend on how much out-of-seam material is being mined. It may just depend on the mineralogy of what is being mined. In the case of Central Appalachian coals, there's mineralogical evidence that more silicates and silicon dust are generated even when the mining height is predominantly in the coal. This same trend has not been found outside of the Central Appalachian coals. The study looked at more than 20 room and pillar coal mines both inside of Central Appalachia and outside of Central Appalachia.

Dust Exposure Reduction and Mitigation

We've been producing dust in mines for thousands of years and have determined many different ways to deal with that dust. Personal dust masks that are both passive and active will not be discussed, I will focus on engineering and administrative controls and not personal protective equipment. The first and simplest way is to inject water at the cutting or dust generation point. In the drills, dust is generated at the end of the cutting tool. There's a water stream that captures the dust. This traps the dust the second that it's made. That's been a highly effective method. In fact, that technique was the innovation in the Jack-leg drill mentioned above. This can commonly be seen on construction sites where water is injected immediately to capture the dust.

The US Bureau of Mines did a lot of work optimizing the angle of attack for mechanical breakage to reduce the amount of dust generated. Common in underground working is having a lot of airflow and keeping flow away from the workers. When the dust is created is blown away from where people are located.

In many mines, the best way to keep the workers away from the dust is to keep them in enclosed cabins. They may be in a heavily dusted machine, but they do not experience any dust because their cabin is enclosed, and these machines often have various filtering techniques for the cabin air.

There is a type of continuous miner that injects water at the point of cutting, called a wet head. In some mines, water spray bars behind the cutting head knock down the dust. Coal and clays are hydrophobic and are not as easily mixed with water. It's common in underground coal to filter or scrub the air after the mechanical cutting. These devices are called flooded bed scrubbers on continuous mining machines or scrubbers, and I'll be talking about those more later.

Another fairly new technique in the industry, but it's not uncommon is air curtains. These can generally be found on drills, such as the roof bolting machine, and haulage like shuttle cars. These are jets of filtered air blowing down around where a worker is working, keeping dust from encountering that person's work area.

This is very similar to the air curtains found in grocery stores between refrigerated sections and the rest of the store. These are needed where you cannot put that operator into an enclosed cabin because of the job's nature or the mine opening's size.

Dust is generated from explosions both on the surface and underground. Time and distance are taken away from those explosions, reducing the dust exposure for the workers. Areas that are blasted must be inspected before workers are allowed to enter them and that has kept the dust exposure down as well.

Automation as a dust control technique is gaining more acceptance and will be discussed later.

Novel Approaches to Dust Capture

The continuous miner scrubbers have somewhere between 60 and 90% dust reduction, although they have a maintenance issue where the impingement screen is prone to clogging. The way that these systems work is they have a shroud over the continuous mining machine that is behind the cutting head. Dust is generated by the cutting head passes over the shroud. Inside the scrubber, there's a fan pulling air into the shroud. That air is assumed to be dust-laden and goes through an impingement screen. That screen filters out the large materials. A water spray sprays water onto that screen, keeping it flooded with water. The air then enters the dust box and is treated with water. The dust box feeds into a demister device that pulls the water and dust from the air trapping it in a sump before it’s ejected from the scrubber. The demister is thought to be responsible for most of the air cleaning.

Part of my work has been improving the impingement screen to reduce the amount of maintenance necessary by the workers. That research aims to test a maintenance-free flooded bed scrubber screen that would be acceptable for use in underground coal mining applications. This research had many challenges. The first challenge was creating a maintenance-free screen that won't clog and has the same air resistance as the existing screen. This way, no modification is needed to use it. We want a worker to pull the existing screen out and put in a new screen design. Another challenge is actually measuring the effectiveness because as you can imagine, this is all taking place in a part of the mine not well disposed to sensitive scientific equipment.

It's in permissible areas, which means that you have strict restrictions on the type of electronic equipment that can be used. You also move a lot of rock, which is detrimental to scientific equipment. I'm going to be discussing work done at the University of Kentucky. Aaron Noble at Virginia Tech took another approach, funded by the Alpha Foundation.

We started with an idea, and then we did a variety of computational fluid dynamics (CFD) to test how the idea would work and optimize it as best we could in simulation. We know that there are constraints to the software. Physical prototypes were manufactured and tested in a controlled lab environment and also in a dust gallery that we have at the University of Kentucky, which lets us work in a less controlled laboratory setting. This was an iterative process of testing and CFD, we generated several different generations of these screens. We were working with the manufacturer, Komatsu, to be sure that the screens would not harm scrubbers deployed in the field.

As part of this research, we found three mines willing to test the prototype screens in various ways. It's important to note that in these tests, dust was sampled in areas, not on workers. The workers were positioned away from the machines to reduce their potential exposure to dust. Because we were testing the safety device, we needed to ensure the workers were protected.

We used the Personal Dust Monitor (CPDM), which was critically important in these tests. There are just a few minutes of delay in the dust concentration, so you can see your exposure more or less immediately. It was originally designed as a research tool by NIOSH and is now used as an enforcement tool.

The design of our maintenance-free screens creates a torturous path for the air to flow through plates. Instead of going through a mesh where it can randomly hit a mesh screen, it's forced to make sharp turns. The larger, heavier particles won't be able to take the turn, will hit the plate, and be captured because they lose their momentum.

Working with Komatsu we did a variety of different testing on our screens and compared them to the existing screens that can be purchased today. In an example test, when it's clean using the existing screen a particular scrubber is flowing about 6,500 cubic feet per minute (CFM) and when it's dirty it's flowing about 5,500 CFM. The screen that we manufactured for Mine A was able to flow a little closer to 6,500 CFM and when it was dirty it was flowing 5,900 CFM. The screen that we manufactured for Mine B was running 6500 when it was clean, and the screen that we manufactured for Mine C was running 7,800 when it was clean and 7,200 CFM when it was dirty. It's important to note that the screens that we manufactured will clean themselves, and so even though the dirty flow decreases, it will increase again while running.

The mines took their existing screen and checked the airflow through it and checked the screen that we manufactured. In all cases, we were able to meet the project's first goal, which was to have no airflow difference. In all cases, there is a 1% or less airflow difference, within the measurement error range. Mine A&B only tested the screens for one cut, but mine C tested the screen on 13 cuts, seven of them with the new screen and six with the fiber screens. They found that, when loaded, the maintenance-free screen will allow 11% more air through the scrubber than the current screen. That's consistent with the lab testing that was done at Komatsu.

They liked the improved airflow, and that improved the visibility for the continuous minor operator while he was operating the machine. They knew that more air was being pulled into the scrubber. Unfortunately, it resulted in 53% more dust being measured downwind, which means that the screen is causing a change to the scrubber system, making it less efficient overall at reducing the dust amount despite having more air going through it.

We decided to take the prototypes and bring them back to the lab. While we were doing the work in the field, the NIOSH Pittsburgh Mine Research Division built a scrubber set up with the help of Komatsu. They have started instrumenting it so that they can do much more detailed work on the internal workings of the scrubber system. It had previously been thought that most of the dust collection was being done inside of the demister and not at the impingement screen. But our results show that that may not be the case. The NIOSH setup has already been used to test the Virginia Tech vibrating screen from Dr. Noble's research, which will require a major change to the scrubber design.

Dr. Sarver's Virginia Tech research group is using NIOSH's lab to investigate our maintenance-free screen. Their preliminary results have shown similar results to our lab results. It's important to note that our lab results and their preliminary results are currently at lower air flows than scrubbers at the mines. This work is ongoing and is difficult because of the nature of the measurement devices. They are not designed to work at the high flows that are seen in mining machines and in most underground coal mines. Instrumentation work is ongoing to find the point that the maintenance-free screen changes the effectiveness of the scrubber. My hypothesis is that the maintenance-free screen is capturing the water from the water spray and choking the demister. We may need to change the spray nozzle to one that is emitting smaller water particles. All of this is being investigated right now and we just don't have, we just don't have results on it at this time.

Scrubber systems are not the only and best solution. Also, running more air through the scrubber is not always the best solution if the air is dirty. In previous work, we've seen that the running air through the scrubber can actually cause other problems because what it can tend to do is it can pull the fresh air coming in that is intended to, you know, get the dust and gas away from the continuous mining machine and pull it into the scrubber. Because the scrubber is creating so much negative pressure, it's pulling the clean air through before it can get dirty or mix with the gases being emitted.

Potentially, flooded bed scrubbers are not the best technology. Researchers prior to me at the University of Kentucky looked at a machine called the Vortecone. Most notably it's used in paint spray booths in auto automobile manufacturing in order to capture the spray particles out of the air. In the Vortecone, air is drawn through the system, accelerated, and spun. The heavier particles tend to move closer to the wall of the Vortecone. When they make contact with the wall, they become captured because there's also a water jacket that is introduced, creating a thin film of water all along the wall of these types of filters. Effectively, dirty air and clean water enter with air, and dirty water leaves with a very high cleaning efficiency. The Vortecone has a high resistance to airflow and will take a lot of energy to achieve the airflows that are necessary in mining conditions. More power is not always available for airflow because the motors on the fans and the fans themselves can be loud.

This device is good at cleaning but not ideal for underground mining conditions or machines. We performed CFD development on these devices and physical testing to understand the cleaning mechanism and to adopt it to a horizontal orientation. We created a physical prototype and tested it in our lab and found that we were able to get better cleaning efficiency than the original as well as were able to drop the resistance to flow to approximately 10% of the Vortecone resistance. This allows the horizontal version, the Hortecone, to achieve the airflows necessary in mining conditions. We are investigating developing a standalone version of the Horticone specifically for mines in South Africa.

There are trade-offs in all the mitigation work. You want to clear all of the air in the area, but you don't want the maintenance of the filters to be constant. If it's too much, it won't be done.

The only way to find the balance, which will be site-specific, is to deploy good monitoring technology. There's a lot of monitor monitoring technology that has been developed. Much of the work that has been described thus far, all of the in mine testing and dust gallery testing, was done with real time dust accumulation that's reported by the CPDM.

Dust Monitoring

In laboratory testing, we use devices such as the TSI DustTrak™ that give excellent repeatable results. Those and others like it are excellent devices, but they can only work on extremely low flows of air compared to what we need in the mining industry. That is why we must do area sampling when developing dust mitigation technologies. Doing direct sampling of the air stream is difficult and introduces errors with the machines that are available to us to use. We cannot sample the air while it's not flowing, the point of the sample is to see how much and the size of the dust in the air.

Especially in coal mining operations, mines move a tremendous amount of air. It is not uncommon for a coal mine to move more than a million CFM of air at the main fan. To put that in perspective, a typical bathroom fan and a house is somewhere around 200 to 800 CFM and a typical 2,000 square foot house will have an air conditioner fan on it that runs somewhere between 4,000 to 6,000 CFM.

Underground M/NM can be running very significant CFM at their main fan, but because these openings are so large, it can appear underground as if it is stagnant or quiescent flow. To put that in perspective, the average coal mine opening cannot exceed 20 feet wide and 3-8 feet high. In the United States, a 10-foot-high coal seam is very high and very unusual in modern times. At 10 feet of height and 20 feet wide the area is 200 square feet. In stone operations, they can be anywhere from 20 to 80 feet wide in their opening and 20 to 120 feet tall. At 40 feet wide and 60 feet high, the cross-sectional area is 2,400 square feet, or 12 times more than the coal mine. An order of magnitude larger areas inside of stone operations and although they can have a good amount of air going through them, you won't notice it because the cross-sectional area is so much bigger.

It's also important to note that dust isn't only present underground, it is also present in surface mines and it's also present in the plant. When we're talking about dust and dust mitigation, we need to make sure that we are looking beyond just what is going on in underground coal mines and looking at the surface and plant operators.

There has been a lot of research and evaluations of enclosed cabins and clean areas of plants. There are different air intake systems that are available on drill rigs and other places where lots of dust is being generated. We have water trucks in order to reduce dust along hall roads. There has been a lot of work and also a lot of things with the air curtains in the surface operations and plant operations that have dramatically decreased dust exposure outside of the underground environment.

For silica in particular, it's important that the silica risk for a site be evaluated because this risk is going to be site-specific. Rocks in the Earth's crust are not homogeneous, they are not the same everywhere. A particular kind of deposit or mineral mineralogy in one location will have big differences from another. Those differences can be from the way that it was deposited or what rocks are around it. The dust constituency must be present in the rock to be present in the air.

There are a lot of current silica measuring technologies, such as the Field Analysis of Silica Tool (FAST) from NIOSH, which is fast and accurate. They tell you about the worker's exposure, but it's after the fact. Many of these systems have been developed for specific mineralogy and dust constituencies and should not be universal. Many methods rely on personal dust pumps that are widely available and used in dust sampling for M/NM mines. However, in coal mines the CPDM has mainly been used in place of the pumps.

Several projects, such as NIOSH's Helmet-Cam project, can be used in surface operations and mostly in M/NM operations. The Helmet-Cam monitors what the person is doing and monitors their dust and noise exposure. When the dust is post-processed and contains higher exposure than expected the video can be investigated to determine the source. That project has been popular with several different M/NM operations, but it is not widely used and can't be used underground or in underground coal. It would be much more valuable if it gave real-time data to the worker.

For at least the past four years, NIOSH's Broad Agency Announcements have been soliciting proposals to develop something that is similar to the CPDM but for silica dust. That effort has had some promising results and some difficulties. In my understanding of that effort, I think these difficulties can be engineered out, but it will require more than the NIOSH can do with that funding mechanism. I was very involved in the development and deployment of the communication and tracking systems that were required by the MINER Act. That effort was a huge effort for the industry, pulling in many new people and technologies into the coal mines and resulting in some very successful communication and tracking equipment. I think that the difficulties, as I understand them, encountered by NIOSH in the FAST and vendors such as Ring IR and ThermoFisher can be engineered out if they have sufficient funding and backing.

Automation

I consider automation a means of dust mitigation and reduces dust exposure for workers. Modern mines, right now today are highly automated operations. Most of the mining machines that you see in operation, especially in production operations, resemble robots more than they resemble shovels and picks. These systems have a tremendous amount of data logging on them for maintenance purposes and for efficient use. A major component of efficient use is safe use. Reducing dust improves the life of the machine and even highly automated machines need to be run efficiently. Off-Earth mining operations are projected to be highly automated and will encounter tremendous dust issues. A lot of the lessons learned in terrestrial mines have immediate relevance to NASA's moon missions and any mission to mine asteroids.

We are at a point in the industry, underground, where we have a fleet of highly automatable machines that are being operated by humans. We have reliable communication and tracking information, and that's the opportunity to automate those machines and turn them into remote control or completely autonomous machines. One of the solutions we've discussed is reducing workers' dust exposures to get them away from where the dust is being generated. If you can make all the machines so that they are or they can mostly work by themselves with a human supervising them, then you can put that human into a place where they'll be able to work in a protected environment. They would be more readily able to work in a closed cab or away from where dust is being generated or you know, anywhere. It's not uncommon for a mining machine in Kalgoorlie, Australia, to be operated by a human in Perth.

At the University of Kentucky, my research group has been doing extensive work in automating underground coal mining machines. In our work, we are moving the machine operator from being on the machine to supervising it. The American coal miner's expertise is necessary for the successful conduct of a mining operation. The expertise of America's coal miners is the best in the world, and they are needed to spot issues and keep everyone safe and working together.

In M/NM, the automation constraints are different. They don't have the permissibility issues amongst other things. Also, coal mines are constantly moving the area of the coal mine where the mine face is located. In some mining techniques, you can keep the mine equipment in place for a relatively long time. In a mining technique called block caving, the draw points underneath the block cave will stay there for months. Setting up autonomous pathways underneath the ore body is much more like setting up a factory than setting up a mine. In those cases where you have a fairly static mine opening and so you don't need people working in that area.

You can travel around the world today and visit underground autonomous mines where pretty much nobody is working underground. There's definitely nobody working around the equipment except for during maintenance or if there are any issues. But this is very expensive, and it's really just for particular types of mine methods and particular types of ore bodies. I don't think that these kinds of completely automated operations will be widely distributed inside of the industry.

I think that more we need to be looking at automation as being a collaboration between humans and the mining machine robot.

Conclusion

In conclusion, we know that dust is generated at mining operations, and it needs to be managed. Especially if the dust particle size is small and the constituents of the dust are potentially harmful to worker health. We don't have a good model for where the dust will go or how far it will run in the airstream. Especially in the high-flow airstreams that we have in various parts of the minerals industry. Monitoring does exist, but the issue is when it comes to dust, not very much dust monitoring is available in real-time. This is necessary to give the worker the tools they need to make their own decisions about their health.

Dust mitigation technologies exist and are always evolving. No dust mitigation is perfect, especially when we generate a lot of dust at scale. We've worked to reduce the maintenance for dust mitigation technologies because that will keep them running as efficiently as possible for as long as possible.

Using automated machines or more automated machines can reduce exposure to dust, noise, and vibration. But automation can’t always be implemented; the skills and knowledge of the mine worker must still be present in the system. Today, most mining machines are customized to their locations, so particular autonomous machines are a lot more expensive because they need additional engineering work before they can be deployed.

Current Needs

The issues discussed highlight the current needs of the minerals industry. It's clear, and it's been well documented several different ways, that we don't have enough engineers going into the mines. This is the fundamental problem that is shared by industry, academia, and society as a whole. The products of the mines are the basis of the economic activity because it’s the beginning of the production chain. Technology developed or adapted to the mines is important to many other industries. The less that we are mining in the United States, the more that we have to transport materials around the world, and the more that material is produced in locations without our environmental, health, and safety standards.

We have the mineral resources and education expertise, but we lack the public will to encourage highly talented engineering students to pursue a career in the mining industry. I meet with the parents and with students to do quite a lot of recruiting into our discipline. I teach an introductory freshman engineering class with approximately 150 students in two sections every fall. What I see in the incoming engineering students is they want to solve the big problems. This is what engineering students do, they want big problems.

They are directed to other engineering disciplines in other industries. A lot of it's because of the rhetoric around the mining industry. The number one question I get from parents of prospective engineering students is, “Will we still have mines in five years?” There's a fundamental misunderstanding of the importance of the minerals industry. I think it has been an issue that we, as leaders in society, can address. I’ve been addressing it by bringing mining technology to other industries.

The mines and their conditions are as difficult and varied as the Earth's crust. That level of challenge is the sort of thing that should be attracting the top engineering talent. We should be saying you're really smart, you need to go work in the mines. There is tremendous opportunity for engineers in the mining industry. Everything in this discussion around the dust problems is rife for engineering solutions. We just need engineers to put existing solutions together in the right way.

In terms of what needs to be done in the future, we need to have more engineers working together on the dust problems. Those engineers need to have a deep understanding of the processes from the mine face to the load out, where customers' materials are loaded, and the particular needs in each of those places. They need to take a risk-based approach to all of the health and safety issues in that area and make tools that match the problem so that we can solve these things as efficiently as possible. Inefficiencies at the beginning of the production chain go all the way through to everyone in society.

The solutions to dust problems in the mines will be direct and immediate solutions in other industries. We are not the only industry that turns big things into little things and creates dust. Our solutions are the basis for others to learn from because we solve big problems in this industry.