Essentials of Exposure Assessment III
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CHAPTER 1

Real-Time Detection Systems: Measuring Exposures
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Real-Time Detection Systems: Measuring Exposures

Experts discussed the use and potential limitations of real-time detection systems in measuring exposures at AIHceEXP 2018.

Dr. Emanuele Cauda, a senior service fellow at NIOSH’s Pittsburgh Mining Research Division, highlighted real-time respirable dust monitors as a tool that can be utilized in several IH/OH environments, explaining that they are extremely useful for relative measurement and before and after comparisons, as well as characterizing exposure.

“Real-time respirable dust monitors are used in any type of environment where there is respirable dust, whether construction, oil and gas, mining, and general industry,” said Cauda. “The big question has been in these cases when we used this information from real-time dust monitors, how confident are we of the accuracy of the data. We all know that humidity, particle size, particle refractive index of the dust can affect the accuracy of real time respirable dust monitors.”

Cauda went on to explain that calibration is key. “Any professional would need to do a calibration of a real-time dust monitor for each environment,” he said, “You can overestimate or underestimate greatly the concentration level using a real-time dust monitor. It’s okay if you’re aware that you have that limitation when using these gadgets.”

Cauda is also the Deputy Director for the Center for Direct Reading and Sensor Technologies. The NCDRST is a virtual center founded in 2014 and is currently focused on the NIOSH initiative known as “Right Sensors used Right.”
“The idea for the center is really to guide and create documents and information and material that can help industrial hygienists in the field to do the right thing in the right way,” said Cauda, “This is information that user should be aware of and should have to make the right decision about which monitor to pick and to select and to use in a field.”

Variability and Comprehensive Exposure Assessment

Philip Smith, PhD, CIH, FAIHA of the USDOL OSHA, Salt Lake Technical Center, Industrial Hygiene Chemistry Division, discussed the strengths and weaknesses of real-time detection to facilitate comprehensive exposure assessment and measurement of intra-sampling period variability.

“Exposures are not static. We know that they are typically not static during even a single sampling period,” said Smith. “If we look at an exposure we may just sample for a single day and hope that represents the true exposure, and in most instances it really does not. We spend a lot of time worrying about the variability inherent to a sampling and analysis procedure -maybe the variability from the lab analysis, variations in pump speed, etc. In reality, the major variability is actually true variability and not just error. It’s actually that the exposures differ from day to day, and for a period even within a day, from one brief moment to another.”

High-quality data regarding intra-day exposure concentration variability depend on the selection of sensors with adequate sensitivity and selectivity for a target airborne contaminant, and the verification that such sensors are to be used within their linear dynamic range. The use of non-dispersive infrared sensors for measuring second-to-second exposure concentrations of carbon dioxide was provided as an example where these data quality requirements may be met.

Smith concluded that intra-day exposure variability is of high importance for fast-acting stressors, that comprehensive exposure assessment should consider both day-to-day and intra-day exposure variability, and that real-time detection is the only way to assess intra-day exposure variability.

In stressing the importance of correctly-used real-time detection tools, he offered this quote attributed to G. Brennan Gisclard in closing:

“It must be remembered that when we hold an air sampling device in our hands, we may also hold the life of a fellow human being. They both deserve the best we have to offer.”
The Push & Pull of Workplace Ergonomics: “I wish as safety professionals that one day we will treat our people as good as we treat our machines.”
Chapter 2

The Push & Pull of Workplace Ergonomics: “I wish as safety professionals that one day we will treat our people as good as we treat our machines.”

At a session entitled The Snook & Ciriello Tables for Manual Material Handling Analysis at the AIHce EXP 2018 in Philadelphia, PA, Certified Professional Ergonomist (CPE) Blake McGowan explored the expensive reality of ergonomic overexertion injuries.

“I hear from a lot of safety professionals and industrial hygienist that we are the ones that are responsible for ergonomics. But we’re not really that confident that we know what ergonomics is,” shared McGowan, who is the managing consultant and research specialist for Humantech, Inc., in Ann Arbor, MI. He oversees large scale ergonomics initiatives and helps organizations to build internal ergonomics expertise.

“I wish as safety professionals, as IHs, that one day we will treat our people as good as we treat our machines. If we did, we’d have far fewer problems in the world of ergonomics,” said McGowan, “We never ask a machine to do what it’s not capable of doing. We always ask people to do things they’re not capable of doing. It still shocks me that most Fortune 1000 companies don’t have a single, dedicated person responsible for ergonomics.”
Expensive Injuries

McGowan says in the world of ergonomics overexertion injuries — injuries caused by excessive physical effort — are the biggest threat facing workers and their employers. “Overexertion injuries — related to lifting, lowering, pushing, pulling, carrying, throwing types of activities — account for about 25% of all nonfatal occupational injuries in the U.S.,” said McGowan. “That accounts for roughly $14 billion per year. That’s roughly $30 million a day. That’s how much money we invest in first hurting and then healing people with regards to these types of injuries.”

It’s a problem, says McGowan, that requires corporate focus. “Three of the top thirty global burdens of disease are soft tissue injuries that are related to occupations, yet we don’t use this data to help drive change within our organizations. We get a nickel budget to solve a billion-dollar problem. We need to start to educate people on how big of a problem this is.”

Proper Measurement to Prevent Injury

McGowan points to the simple Snook & Ciriello Tables for Manual Material Handling Analysis developed in 1991 as an excellent tool to determine maximum acceptable weights from just a handful of inputs. The capability tables are the work of Dr. Stover Snook and Dr. Vincent Ciriello of the recently sunsseted Liberty Mutual Research Institute for Safety. McGowan calls the weight limits an essential inclusion in an ergonomics professional’s toolbox. “The group of researchers who have developed these tools did a really nice job of simplifying how we can quantify the acceptability of things like lifting, lowering, pushing, pulling and carrying. The Snook and Ciriello tables are really, really simple and they are still valid. Keep using them,” said McGowan.
He shared key learnings for taking good force measurements in the work environment:

1. **Invest in Attachments** — “Any time you buy a force gauge, plan for and budget for all the attachments possible and then make a couple of good friends in your machining area and they’ll design a few others for you.”

2. **Make it Realistic** — “Understand the way that people push or pull. There’s all types of ways that people push and pull. Just make sure you’re doing it as realistically as possible.”

3. **Consider the Casters** — “Are the casters damaged, too small, or are the bearings worn out? That’s what we find in industry where we have hundreds of carts within a workplace. It’s very easy for one or two of them to become damaged and never to be maintained.”

4. **Try it Ten Times** — “Typical good practice is to push or pull something ten times over different surfaces. Casters have different characteristics depending on where they are on the floor. The floor has different characteristics: You might be going slightly uphill, slightly downhill, heat might impact it. Try it in multiple different environments just to get a broad range. We typically take the mean to extract the outliers.”

5. **Consider the Force** — McGowan says the force applied during a push or pull is most important. Make sure to measure it accurately.
CHAPTER 3

Developments in Beryllium Regulation, Sampling and Laboratory Analysis
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At AIHce2018, IHs came together to hear from regulatory and industry experts on the latest developments in beryllium regulation, sampling and laboratory analysis.

Beryllium Regulation

Maureen Ruskin, OSHA’s Deputy Director of Standards and Guidance, highlighted aspects of the agency’s new beryllium standard published in January 2017. The new standard was developed after OSHA determined the previous PELs did not adequately protect workers leaving a significant risk of material impairment of health.

“We found that there was a link between CBD (chronic beryllium disease), lung cancer and beryllium sensitization,” said Ruskin. “We have estimated that this rule would save approximately 90 lives per year and CBD is where we realize most of those benefits. We would also prevent 46 new cases of CBD per year.”

She highlighted the new “beryllium work area” created by the new standard, and indicated OSHA will be proposing modifications to the definition of the beryllium work area.

“We have a new concept called the beryllium work area and this is for employers that have processes or operations or tasks that can generate airborne beryllium. They must demarcate this beryllium work area,” said Ruskin. “One of the important things that we see about the beryllium work area is that it tells the employers that you must demarcate this area to minimize the number of employees that are in this area and potentially exposed to beryllium and also to minimize cross contamination from the beryllium work area to other areas to further reduce risk to more employees.”

Beryllium Sampling

Seuri Taruru, CIH, a beryllium sampling expert from the Nevada National Security Site (NNSS) addressed important considerations when sampling.
“Do you have natural beryllium or man-made beryllium?” asked Taruru, “Typically, natural beryllium is not considered as hazardous as man-made beryllium.”

He urged attendees to consider the pathway to the target organ, “It’s easy to get beryllium contamination from a surface and then you take it to your nose and then you get exposed, especially if you’re sensitized to beryllium,” said Taruru.

**Beryllium Laboratory Analysis**

“Laboratory selection is a key thing,” said Michael Brisson, MS, PMP, while speaking on the topic of laboratory analysis for trace-level beryllium in air, surface, and bulk samples. “Not all labs are created equal. So, you need to check with your laboratory before you use it to make sure that they can meet your needs, that they can meet data quality objectives, and find out what special requirements they might happen to have.”
Brisson encouraged attendees to consider several key questions when selecting a laboratory, “Is your laboratory accredited? That is not a requirement under the OSHA rule but it is under the Department of Energy rule,” said Brisson, adding that one should also have a good understanding of how the lab will prepare samples for analysis.

He outlined several analytical method requirements to assess before choosing a lab. “Make sure that they have done their due diligence in validating their method; that they have proper protocols for calibration, quality control, and participation in proficiency testing,” said Brisson. “AIHA PAT L.L.C. has a specific proficiency testing for beryllium that 40+ laboratories in the U.S. participate in. In my opinion, that’s the best barometer of knowing that the lab that you’re considering is going to be truly proficient.”
CHAPTER 4

Respirable Crystalline Silica: Low-Cost Controls and Respirator Fit Tests
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Natalie Fox, CIH, CSP, a Senior Managing Consultant at Ramboll, discussed effectively reducing employee exposures to respirable crystalline silica at the 2018 AIHce EXP in Philadelphia, PA.

Fox was challenged to control exposures at two glass manufacturing facilities using the most cost efficient, yet reliable, methods possible. The company that owned the facilities was seeking compliance with OSHA’s updated silica regulations, but also wanted to limit the number of employees required to wear PPE and reduce the number of similar exposure groups (SEGs) included in scheduled sampling.

To determine where controls were necessary, Fox surveyed the entire facility with a direct read instrument to create a respirable dust map, determined employee SEGs using job tasks and the map, and collected personal samples from the majority of the SEGs (based on the SEGs that had likely or potential exposures). She then implemented a variety of engineering and administrative controls, as well as improved respiratory protection.

“A lot of employee exposures can be controlled using work practice changes, housekeeping and lower-cost engineering controls,” explained Fox. “Something like a batch with sand in it, it’s really rough on the duct work and it’s hard on the conveying systems. So there were a lot of fugitive emissions coming from there. So just going around repairing the ducts, making sure everything’s tight so you’re not getting any dust out of there, really made a big difference.”

But challenges remain. “Some exposures just can’t be controlled through administrative or cost effective engineering controls. You’re going to have to spend the money,” said Fox. “Controlling specific non-routine tasks is really hard, especially maintenance activities. They do so many different things every day it’s really hard to figure out what their exposures will be and how we’re going to control those.”

She urged IH’s to never begin designing controls before conducting a thorough industrial hygiene study and cautioned against quick fixes. “Determining appropriate controls is not quick. You don’t want to rush engineering controls. You want to make sure that they’re done right, because there’s no one size fits all, even for similar facilities,” she explained.
Respiratory Protection Research Team Leader in the Technology Research Branch in the NIOSH National Personal Protective Technology Laboratory (NPPTL), talked about the role of respirators in the presence of respirable crystalline silica.

“We talk about engineering controls first, but it’s very expensive and in some cases it’s not feasible,” said Dr. Zhuang, “So we end up using the last line of defense: respirators or respiratory protection.”

He outlined his respirator fit capability test for full-facepiece air-purifying respirators designed to ensure that a single-size respirator or family of respirators in multiple sizes or multiple model numbers is capable of achieving an initial fit on a specified percentage of the NIOSH bivariate test panel representing a range of face sizes. “The objective of our study was to evaluate the test methods and assess the capability of the existing respirator models to fit a 25-subject panel and then also come up with what may be a potential criterion to be used to determine whether a respirator or group of respirators would pass the test,” explained Dr. Zhuang.

His team concluded that RFC (respirator fit capability) calculated as panel passing rate is significantly different among the required fit factors and family of respirators tested. Researchers further concluded that test methods developed for half-mask respirators may also be appropriate for the respirator fit capability test of full-facepiece air-purifying respirators.
CHAPTER 5

Exposure Assessment
Challenges in Aviation and Live Weapons Training
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Exposure Assessment Challenges in Aviation and Live Weapons Training

Audience members at AIHce EXP 2018 were treated to a fascinating look at the exposure assessment challenges facing the U.S. Air Force in both during a ground and airborne operations.

“In the Air Force a lot of our assets have advanced materials in them and in the event of a mishap there are unique emissions that we have to consider for first responders, follow on support, bystanders and the general population,” said Christin Grabinski, a research chemical engineer for the U.S. Air Force School of Aerospace Medicine, 711th Human Performance Wing Air Force Research Laboratory, at Wright-Patterson Air Force Base in Ohio.

Grabinski, who currently leads the hazard detection and control engineering team with the mission to apply advanced technologies for characterizing and mitigating exposures to chemical hazards, revealed that ultrafine particles can make exposure assessment of small arms training a challenge. “The main issue is that lead ammunition was replaced with lead-free frangible ammunition quite a long time ago…but we still need to take it seriously as a potential hazard. Right away there started to be respiratory irritation complaints filed,” explained Grabinski.

“But lead-free frangible is primarily copper and copper doesn’t exceed the occupational exposure limit very often. It’s not predictive of respiratory irritation. We need to have an exposure standard and a sampling method that’s predictive of the symptoms. In the end that’s where we want to be.”

“Actual firing emissions are composed of gases, vapors and aerosols. Aerosols are primarily in the ultrafine size range, so we’re talking about very, very tiny particles that dominate the emissions from firing. So that’s what we want to make sure that we capture in our exposure assessments,” said Grabinski who investigated five small arms firing ranges, some fully
enclosed, others partially enclosed. “We know that if particles are that small — in the 16 to 28 nanometer size range — that the surface area per mass is very large. We know from toxicity studies that surface area is more often correlated with pulmonary toxicity than mass. The particles are very small. In one cell, you could have hundreds of particles enter, so we were worried about translocation issues and types of toxicity that aren’t traditionally assessed.”

Grabinski’s team found that to determine relevant exposure standards and assessment methodologies it needed to complete a follow-up research and development study including toxicity and health evaluation in small arms training instructors to identify the correlation between specific components of firing emissions and health outcomes. That comprehensive evaluation of emissions properties and health effects to support new exposure standards is currently underway and should wrap up in 2019.

The exposure assessment challenges aren’t limited to ground operations. While presenting on pilot breathing air, Daniel Mackenzie-Smith, a bioenvironmental engineer, explained that the complex environments inside aircraft often require the development of specialized monitoring equipment. “Evidence showed that engine bleed air, which can carry chemical contaminants, is getting into the supplied breathing air to the pilots. So, our short-term objective was to characterize the pilot breathing air which is supplied by the onboard oxygen generating system,” said Mackenzie-Smith, “Since there are no readily available commercial instruments or devices that are solely intended to meet this objective what we had to do is essentially engineer our own device.” The devices were affectionately nicknamed “The Slurpee Machine” — a nod to the 711th.
Sampling focused on Air Force cargo aircraft: the C-17 and C-130. The aircraft posed several challenges for the researchers and their equipment, including elevated oxygen levels and intense vibration. "We deal with a lot of unique exposure environments that require us to engineer various interfaces as well as develop correction factors and tools to help meet the objectives that we are presented with," said Mackenzie-Smith of the ongoing challenges to exposure assessment, "The key research gaps we have currently are not only finding intrinsically safe devices and instruments to use, but also ones that are safe to fly and can accommodate those unique environments."
Emergency Preparedness & Response after Crisis and Catastrophe
Responding to crises poses a wide variety of challenges for industrial hygienists. At AIHce EXP 2018, attendees were given a window into three very different crisis response situations and shared their lessons learned.

John Archer, MS, CIH, with the U.S. EPA Office of Research and Development’s National Homeland Security Research Center, explored chlorine exposure during a biological decontamination study. "Essentially what we were doing is looking at a mock subway system and our intent was to figure out how we can potentially decontaminate the subway system after an intentional biological release," said Archer, "This whole multi-year project looked at if there is a potential biological release to a subway system how do we get that subway system back in operation? How do we minimize the damage, minimize exposure or minimize the cost?" The study was conducted at the U.S. Army’s Fort A.P. Hill using a non-pathogenic bacterial spore surrogate that behaves similarly to bacillus anthracis.

"Essentially we looked at sampling. So, if there's a biological release how do you sample the surface? How do you sample the air? How do you characterize it? How do you determine what's contaminated, what's not contaminated, and then, obviously, one of our big focuses is on decon."
Archer served as site safety officer and collecting chlorine exposure data on decontamination workers. “Health and safety is integral and in a situation like this. We had extreme hazards. So, we wanted to make sure that people were protected properly and that this wasn’t something that we could engineer out. The pH-amended bleach (PAB) presents a high hazard with the chlorine vapor,” said Archer. “I think automation is something that we’re going to look at in the future. There’s things like orchard sprayers which have a radial spray pattern that you can load decontamination solution, put on the rail cart and move through the subway and actually decontaminate it without people being in there.”
Flint Water Crisis

Steve Neilson, MS, CIH, with the U.S. Department of Energy, was born in Flint, Michigan, and had family living there when changes were made to the drinking water supply in 2014, triggering contamination issues for consumers.

“The big consequences of the Flint Water Crisis are going to be long lasting in terms of the public health consequences as well as the loss of public confidence,” explained Neilson, “As tragic as this event is, it would be an additional tragedy if we don't attempt to have some lessons learned that we can apply to our own organizations.”

Neilson offered the following lessons learned from the Flint Water Crisis:

1. Always presume your customer complaints are legitimate.
2. Your ethical convictions may be tested the most when you’re contending with other crises.
3. Don't rely on regulatory actions or inactions as your barometer of performance.
4. Your internal audit program should include some deep-dive analysis to spot check raw data.
5. Community relations must be based on open communications and not selective communications.
6. Be mindful of both real and perceived conflicts of interest in your organization’s management structure.
7. Confirm your organization's mission is understood and that it flows down to your implementing policies and procedures.
8. Trying to recover public trust should include additional and sustained transparency.

First, Do No Harm: Crisis Response in the Wake of an Explosion

“As industrial hygienists we get to go to unpleasant places where unpleasant things have recently happened,” said Andy Rowland, CIH, referring to being called to the site of a massive explosion at a natural gas plant in Mississippi in June of 2016, “We were there just a couple of days after the explosion occurred. Our job was to see to it that these guys [the chemical safety board] were not harmed while they tried to do their job, which was to find out why we had the explosion and how to prevent in the future. We had no fatalities during the event or after the event.”
The field of debris from the blast extended to a 100-yard radius. Rowland encouraged IH’s to consider all of the potential hazards created by a catastrophe before approaching the scene, “First do no harm. Not only must you think in positive proactive terms, but you have to also consciously plan to make sure that bad things don’t happen,” said Rowland, “Might there be lead or silica exposure potential? Are there ergonomic hazards? Yes. We absolutely have the potential for an injury here as well.”

Based on the Mississippi crisis response, Rowland had this advice in the wake of a catastrophe, “My recommendation to you, if you get a case like this, get a CIH, get a CSP, and get a structural engineer who has a strong basis in life safety issues. That’s your combination for a safe project where everybody gets to go home at the end of the day.”