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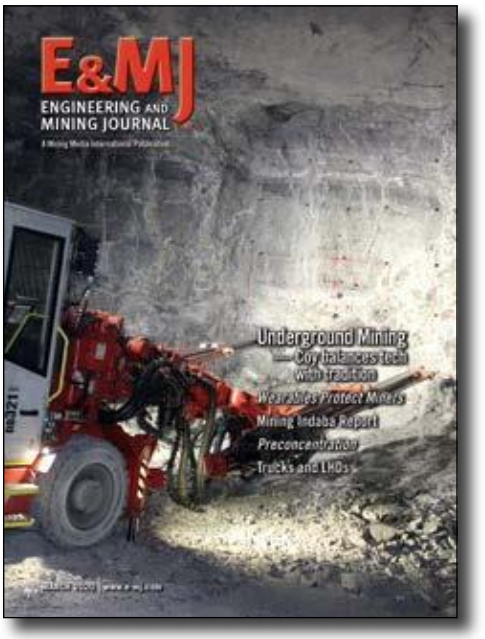

This month, E&MJ *reports on activities from the American zinc mining district in Tennessee. On the cover, new equipment allows Coy miners to drill more holes per shift accurately. (Photo: Nyrstar)*

LEADING DEVELOPMENTS

AROUND THE WORLD

DEPARTMENTS

Wearables at Work

Personal protective equipment lines draw on new technologies to get tougher and smarter

By Russell A. Carter, Contributing Editor

In today's tech-focused environment, market attention toward connecting everything to the local network or the cloud often puts a spotlight on wearable electronic gear that can report biometric and environmental data and detect safety-related trends. However, advances in familiar personal protective gear such as gloves and footwear can in many cases offer an immediate, practical approach for preventing some of the most prevalent on-the-job injuries.

For most of us, what we wear on the job is generally a matter of comfort, convenience and maybe even style. For others who routinely work around heavy machinery, high voltage or in consistently harsh environments, wearing the right gear can mean the difference between staying comfortable and finishing a shift safely, or incurring an injury that could have a major impact on a worker's quality of life and future employment options.

New products and technology, updated standards and changing corporate-culture mindsets are driving developments in Personal Protective Equipment (PPE) and other types of "wearables" that workers can choose to use or be required to wear while on the job. Suppliers of hardhats, gloves, footwear and wearable electronic devices are taking advantage of new materials and improved data collection, communication and analysis capabilities to develop products that in many cases offer much better direct-injury protection or greater situational awareness to boost worker safety and productivity.

The potential appeal of wearable electronic safety gear that can tap into emerging technologies such as Augmented Reality (AR), advanced communications and biometric monitoring is powerful and fits hand-in-glove with the industry's rising interest in digitalization, IoT and automation. It's a fertile field for innovative, fast-moving tech startup companies as well as for established industry suppliers such as Caterpillar (Smartband fatigue monitor) and Hexagon Mining (HxGN Mine Personal Alert proximity warning device), for example; along with major producers — BHP, Anglo American, Rio Tinto and others — that have the resources to tailor technology to their needs.

Hardhats are probably the most common form of PPE for miners and other mine-site personnel, and because of their familiarity and acceptance have been the focus of a number of wearable-tech initiatives. One of the earliest entries in this sector was from Smartcap Technologies, which developed a fatigue-monitoring wearable that uses brainwave monitoring technology that originated in Mining3, a cooperative research center established by the Australian government.

Smartcap's technology has been used at several large base metal and coal operations. In September 2019, BHP reported on a long-term project conducted at its Escondida copper mine in Chile. The mine's location at 3,000 m (9,850 ft) altitude poses particular problems involving worker fatigue and drowsiness, according to the company, and starting in 2017 BHP's Health, Safety and Environment team began using Smartcap technology to monitor and warn mobile equipment operators about apparent fatigue and diminished alertness. SmartCap devices were used to read wearers' brainwaves, identify micro-sleeps, alert operators and identify the hours of greatest risk. The BHP team also evaluated sleep disorders and conditions associated with working at altitude and engaged external providers to perform sleep assessments on the most vulnerable mine operators and transport providers.

Since the program's inception, 739 employees have been evaluated and 178 have received specialized treatment for associated sleep disorders, according to the company. Smartcap said that over the course of two years during which Smartcap was used by employees at the Escondida site and another BHP operation in Australia, zero fatigue incidents were recorded.

Smartcap technology has evolved to its most current product, the LifeBand, which as its name implies is a flexible band that can be worn inside a variety of headwear or by itself. A dedicated smartphone app allows users to monitor their fatigue levels whenever desired via Bluetooth connectivity.

Another wearables developer, Guardhat, offers "smart" helmets and proprietary software designed to actively monitor a user's location, pulse, body temperature and work environment. This, according to the company, provides a holistic view of each user's work environment and instant alerts in the event of a fall, exposure to toxic gases, lockout zones and proximity to moving equipment. Guardhat claims its helmets are particularly effective in minimizing the risks of falls. They can detect whether someone is wearing appropriate safety gear for work off the ground and thus help to prevent them from working at height if they are unequipped for the job. Also, the hat's communications system immediately notifies safety operators and emergency services if a worker falls from a considerable height. Guardhat is collaborating with IBM to integrate its KYRA IoT platform with IBM's Maximo Worker Insights solution to provide what it describes as near real-time situational awareness.

Safeguard Equipment, a relative newcomer to the sector, has developed a wearable PVCD (personal voltage and current detector) that clips to the brim of a hardhat. The Compass PVCD, according to Safeguard, detects electrical and magnetic fields emanating from sources anywhere in a 360° zone around the wearer. LED proximity alerts are triggered well before the wearer comes into contact with an energized source, and after the initial proximity alert is shown the device displays the approximate direction of the detected source.

An auto-sensitivity feature allows users to silence redundant alerts by pressing the center button on the device. Alerts are reactivated if the user moves closer to the source.

The IP6X-rated Compass PVCD is powered by a lithium-ion battery that is rechargeable via the unit's 5-v USB 2.0 Micro B port. According to the company, it has a 10-day battery life with non-frequent alert intervals, or five hours during rigorous activity with frequent alerts. Recharge time is 1.5 hours and depending on use, the battery has a typical life of three to five years before charge capacity begins to degrade. Power-saving features include automatic shutoff if the unit remains motionless for five minutes and ability to extend battery life by reducing power functions when energized sources aren't present. The company also offers the Compass LV, a lower-voltage detector claimed to be ideal for workers in environments where operating voltages are in the 120- to 600-v range.

Although personal safety is a primary design objective for many wearables, their scope of usefulness has quickly expanded to include facility access control and productivity enhancements such as on-the-job training and task guidance. For example, iMotion, a Montreal, Quebec-based IP security integrator, designs tailored safety and risk management systems for the mining industry using technology and equipment from a variety of suppliers and running on a unified platform such as Gallagher Security's Comment Center.

The Gallagher Command Center integrates Physical Access Control Systems (PACS); fatigue management; biometrics; perimeter security; staff and visitor flow management and locker management. The Gallagher solution can also integrate into a company's human resources management system, where it can be customized for each mine according to specific challenges and type of activities. Wearable items employing either contact (magnetic or chip cards) or non-contact (RFID chips embedded in badges, objects such as key rings, etc.) technologies can be incorporated into an overall security system that suits the clients specific requirements.

RealWear specializes in developing hands-free, rugged, wearable Android tablets. The company said its Head-mounted Tablet models HMT-1 and HMT-1Z1 (ATEX + IECEx Zone 1 certified) are designed for hot, rugged, dusty, physical, PPE-mandated environments and facilitate the real-time flow of data and information over vast distances as part of expert-to-trainee, worker to IIoT sensor-cloud and DCS, ERP-to-worker and many other operational conversations, without reducing the situational awareness of that worker around heavy machinery and potential danger. The HMT can easily be moved out of the way when not needed, and its hot-swappable batteries can provide up to nine hours of service on a full charge.

Benefits and Challenges

Consulting, advisory and analytics company Deloitte and the Northern Center for Advanced Technology (NORCAT), a nonprofit tech and innovation center in Sudbury, Ontario, have collaborated since 2017 on a strategic partnership aimed at helping the global mining industry better understand the latest mining technology and innovation trends. NORCAT has an operating mine on site that enables various organizations and commercial clients to develop, test, and exhibit innovative technologies in an operating underground environment.

The alliance has produced a series of reports focusing on key trends in the mining industry, including one published a year ago titled the *Future of Mining with Wearables: Harnessing the Hype to Improve Safety*, which pointed out that implementation of wearables across the industry offers potential gains in personal safety and productivity, but also brings a handful of major issues to the table. These include personal and union concerns about data privacy, challenges in getting workers to accept new approaches to on-the-job safety, and implementing sophisticated systems that require unprecedented levels of interconnection in an environment that is typically hostile to communication technology in general.

There are strong incentives to consider wearables for the mining workforce, according to the report. These include:

- Environmental monitoring—remote sensing technologies can help frontline workers anticipate and companies respond to risks of overheating.
- Focus on workers' health—biometric devices can provide real-time alerts of physically stressed operators who are at risk of injury or causing accidents.
- Training with new technology adoption—real-time virtual and augmented reality training applications can accelerate skills and knowledge development.
- Incident rates at new or exploratory mine sites—tracking and communication technologies can bolster overall response capability.

However, companies still face the challenges that typically accompany the introduction of new and potentially intrusive technology to an industry sector. The report lists some of the main issues and primary objections or concerns from affected stakeholders:

- Being on-point regarding privacy – Lack of data privacy for both workers on site

Safeguard Equipment's Compass and Compass LV clip-on voltage/current detectors visibly alert users to potentially hazardous nearby electrical sources in a 360° zone around the wearer.

and the industry in general. "Unions often take the perspective that, contrary to monitoring the environment, wearables do monitor the worker, including management monitoring confidential health data that a frontline worker may not be comfortable sharing."

- Driving leadership buy-in – Leadership stalling the implementation of wearables within existing operations. "A common challenge in technology implementations is leadership slowing down the process by seeking full-blown solutions, while also following conservative protocols for IT/ERP implementation."
- Developing workplace culture and adoption – Workplace culture and lack of engagement with frontline workers. "A common view held by frontline workers is that wearables are intrusive, lack clear benefits at best and at worst, undermine workers' rights, while shifting the relationship between employee and employer."
- Designing for the human interface – Wearables designed to gather data, but not with the user or worker in mind. "Aimed primarily at gathering data as opposed to meeting end-user needs, wearables are often seen by frontline workers as bulky and an unnecessary add-on to existing encumbrances of everyday gear."
- Connecting to the technical infrastructure – Availability of reliable technical infrastructure, including strong connectivity. "Successful implementation of wearables in mining requires reliable technical infrastructure, including strong network connectivity to ensure that — where appropriate and secure — data can generate actionable insights in real time."

Balancing Design: Productivity vs. Privacy

In addition to smart hardhats and other types of headwear, wearables developers are pursuing a variety of device designs that can be integrated into various industrial applications, offering built-in capabilities to monitor a range of environmental parameters that can enhance safety performance and trend analysis. As with any device which may be perceived by workers as capable of collecting personal data, developers must navigate a course through the choppy waters of data collection, processing, dissemination and privacy issues to reach a safe design haven that satisfies most of these concerns for companies, workers and other interested parties.

MākuSafe says its patented system combines a robust safety management software platform with innovative wearable technology that provides immediate access to real-time EHS data with predictive value.

E&MJ spoke with Mark Frederick, chief technology officer and co-founder, and Thomas West, strategic relationships manager of MākuSafe, an Iowa, USA-based safety analytics company that is preparing to introduce its wearable device and software platform to the market in 2020. The MākuSafe wearable is a small device attached to an armband worn outside a worker's clothing. A built-in CPU and sensor array gather a range of environmental data in real time to provide indicators of current conditions, potentially hazardous motion data, and facilitate voice-recorded near-miss and other observations from workers as well as location of occurrences at a work site.

Frederick said the company's platform objectives were guided by the realization that safety managers often function in reactive mode, where actions come mostly in response to actual safety incidents and injuries. Their plan was to devise a system that monitored a worker's real-time experience, collecting environmental and movement data and using predictive analytics to guide safety managers toward discovering problems before they resulted in incidents.

"We use a small wearable device to collect a lot of data about the worker's environment and experience — air temperature and pressure, lighting level, motions that might indicate a slip, trip or fall, location — and the worker also can press a button on the device to record a short voice memo that is converted to text and sent to the safety manager," Frederick explained. The company's MākuSmart cloud platform receives the data from the wearable devices, along with data gathered from additional IoT sources, and uses machine learning to identify high-risk trends at a work site. The wearable "core" devices currently communicate with a base station over a WiFi network; however, Frederick said the company's product roadmap includes a future transition to Bluetooth mesh networks.

West noted that the wearable device doesn't collect data considered to be personally identifiable information, such as biometrics. "And, we're not continuously tracking the worker. We're looking for potentially hazardous environmental conditions as well as possibly hazardous worker motion coupled with force and using our machine-learning capability to identify patterns in motion that could indicate a slip or fall, for example. When a pattern emerges we call attention to the location of the activity so management can be guided towards correction action."

Workers are given an armband holster that holds the core device, which is stored in a slot at a small, kiosk-type station; after checking-in the device they insert it in the holster and return it to a kiosk slot at the end of the shift. The device's single push-to-talk button is designed for use by workers wearing heavy gloves, provides a tactile response when pushed and is recessed to avoid accidental activation. In line with the design intent of being a device that is 'outward looking' to sense environmental conditions around the worker, the holster is made to be worn outside a person's outer layer of clothing. Frederick said it had been pilot tested for several months by foundry workers exposed to high heat and dusty conditions, with good results.

Users access the data through an app that runs on a wide range of handheld devices, and receive notice within 30-40 seconds after the core device detects an environmental condition that exceeds a preset threshold. The app dashboard is customizable to provide updated graphs, tables or other formatted data objects for specific needs.

Data security, said Frederick, is ensured because the system never "pushes" personal identification out from the cloud. A wearer is identified only by a unique de-

vice identifier assigned to their device, and the wearer/device identifier data remains within the cloud, which in turn is protected by the security measures put in place by MākuSafe's cloud hosting service.

New Standard for Gloves

In today's tech-focused environment, market attention toward connecting everything to the local network or the cloud often puts a spotlight on wearable electronic gear, but notable advances in hand protection and footwear can in many cases offer a more immediate and practical approach for preventing common injuries. For example, a number of studies indicate that injuries incurred while handling material are the most prevalent type of safety incident in both surface and underground mining, with slips and falls following closely behind.

While biometric sensing devices and apps often can identify trends pointing to where and when these types of injuries occur, the right glove, boot or hardhat can provide direct protection against injury — and go a long way toward keeping injury-associated costs under control. A white paper released by industrial PPE provider HexArmor claims that treatment and handling for a cut on a worker's finger that would have been preventable with the proper glove can often mushroom to a total cost of $40,000, with an estimated $400,000 in future sales needed to pay for it. Other estimates pin the average cost of general hand injuries at around $20,000.

One of the difficult tasks facing corporate safety and purchasing departments is choosing the most cost-effective glove for specific job requirements. In recent years, industrial glove suppliers have started offering styles with better cut resistance, improved visibility, fingertip touchscreen compatibility, palm coatings that provide better grip and other options to meet specific safety needs. Yet, until early last year the existing glove standard in North America was ANSI/ISEA 105, which addressed cut, abrasion, tear and puncture performance, but didn't consider impact (back of hand) protection, which is a major concern for workers handling heavy, awkward items such as drill rods, GET parts or giant tires. Suppliers could advertise that their gloves were effective against crushing and pinching injuries, but there was no standard by which to measure or validate such claims. That changed in 2019 when ANSI/ISEA 138 took effect: the standard, which is voluntary, describes an agreed-upon testing method for glove impact protection, includes three well-defined performance levels and pictogram marks for each level, and mandates that products be tested in a certified accredited laboratory that meets ISO/IEC 17025:2017 requirements.

The new ANSI standard resembles the 2016 European Union EN388 standard in certain respects, the main difference being that EN388 applies just to knuckle protection, not knuckles and fingers. The International Safety Equipment Association notes that ANSI 138-compliant gloves are evaluated for their capability to dissipate impact forces on the knuckles and fingers and are classified accordingly. The resulting classifications, said the ISEA, can now be used by employers as a reliable means of comparing different products on an equal basis when selecting hand protection relative to the tasks being performed.