edition:16 September 2010

ACARP MATTERS

TRAINING TO SAVE LIVES IN UNDERGROUND EMERGENCIES

An Australian coal industry research project has highlighted the need for all underground mines to develop safe self-contained self-rescuer (SCSR) changeover procedures, introduce comprehensive training programs and regularly practice the procedures during realistic emergency simulations.

Dr Jan Oberholzer
The input of former Simtars, Mining Research and Development Centre Manager, Jan Oberholzer was integral to the outcome of this project. As a dual Project Leader, he drove the development of a prototype long-term simulator that helps users become more accustomed to the feeling of a real self rescuer. Industry Monitor Jason Wagstaffe said his association with Dr Oberholzer had begun 15 years ago when he first became involved in underground mine ventilation and dust control. "Dr Oberholzer has authored or co-authored some very significant research documents that assist today's ventilation practitioners in underground mine ventilation. He was a talented academic and the worldwide mining industry is poorer for his passing," he said.

The importance of introducing these measures has been reinforced by a number of failed SCSR changeovers in Queensland underground level one emergency exercises.

Developing these procedures for an adverse environment is imperative because an SCSR may be limited to 60 minutes' oxygen supply and evacuation of the underground mine by foot generally requires much more than 60 minutes. In addition, miners need to practice donning different brands and types of SCSRs so that in an emergency they are comfortable with the variables.

The Australian coal industry has widely adopted the "3 + 3" SCSR donning sequence developed by NIOSH to ensure the proper functioning of SCSRs. However most people under-estimate the impact that emergency situations have on miners, even experienced miners. They face a dusty, toxic, dark environment; stressful psychological conditions; and an exhausting physiological situation. After walking with an SCSR unit on for an hour, it is challenging for them to put on fresh SCSR units without being exposed to the toxic environment. In the Sago investigation report to the West Virginia Governor, J Davitt McAteer said, "At that point even a veteran miner might be tempted to make the potentially fatal decision to give up on using the SCSR, hoping somehow to get along without it."

Add to this situation the fact that SCSRs have extremely high breathing resistances – up to 2.53 kPa for inhalation and 4.19 kPa for sum of inhalation and exhalation – then a reliable, fault-free device and a safe environment for changeover becomes absolutely critical.

Simtars was engaged by ACARP to:

- Identify the requirements to ensure that a changeover can occur safely despite the atmosphere;
- Identify a solution to overcome problems associated with ineffective changing of self-rescuers that may lead to personal exposure to a toxic or irrespirable atmosphere, resulting in harm or death;
- Identify what, if any, comparable equipment is currently available to replicate the use of an SCSR as a training method with the main emphasis being on the breathing characteristics of a SCSR/filter SR, including temperature, breathing resistance, humidity and air;and
- Determine what medical supervision/monitoring would be required during the testing and proving, and final use in training.

The common SCSR changeover procedure suggested by the manufacturers and NIOSH is:

- Open the case of the new unit and make it ready for use;
- Take off the neck strap of the unit in use;
- Put on the neck strap of the new unit while still breathing through the old unit;
- Activate the new unit, but do not remove the plug from the breathing tube;
- Remove the mouthpiece and nose clip while holding breath;
- Remove the plug from the new unit and put the new mouthpiece into the mouth and then apply the nose clip;
- Take one deep breath and then breathe normally;
- Undo the waist strap and discard the old unit;
- Fasten the new waist strap and adjust the new neck strap; and
- Re-apply the cap and proceed with the evacuation.

However in practice steps 5 to 7 are very difficult to achieve. According to Simtars researchers, miners find isolating the lungs from the ambient atmosphere – the most critical step in the donning procedure – to be the most difficult step to complete. Consequently the researchers assessed the performance of dockable SCSRs and hybrid SCSRs as alternative options to standard SCSRs. The dockable SCSR idea is simple and effective. The concept is to switch to a fresh canister rather than removing the SCSR mouthpiece and change the entire unit. The design minimises the chance of exposure to the external environment. With the dockable SCSR, the miner is able to extend the life of the SCSR indefinitely without being exposed to a potentially lethal gas.

Project Leader Darren Brady said despite these benefits, there were a number of practical issues regarding the deployment of this new generation of SCSR.

"These include possible difficulty with cold start, when to change, reliable docking operation in contaminated atmosphere, timeframe for the deployment (technology is still being tested), maintenance requirement, and it was reported that compressed oxygen SCSR could possibly cause hypoxia under some conditions," he said.

During the research project Simtars found that some Australian underground coal mines attempted to facilitate a "safe" changeover zone by flushing breathable air around the facial area via freestanding tubes. However, this practice is dangerous. Due to the Bernoulli Effect, a lower pressure zone created by the high speed airflow may attract the polluted air towards the mouth.

In terms of a safe changeover environment for SCSR, researchers found that refuge chambers and specially designed changeover stations, once properly deployed, were also beneficial. However, in an emergency a drawback might be that they could create an illusion of safety. Miners might be tempted to remain underground when escape might be the better option.

Personal Changeover Enclosures

To provide a safe, easy and reliable SCSR replacing environment, researchers designed, modelled and tested two personal changeover enclosure prototypes: an open bottom design and an airtight design. They found that the open bottom design, even with the advantage of having a small purging volume and easy access, could not control pollutant ingression. Even with a modest breeze, only half the contaminant was purged out after a long period of flushing. The airtight design provided more efficient purging. Even with a limited fresh air supply and full of pollutant, the enclosure could be cleared within a few minutes. The enclosure also showed a good control over the ingress of pollutant. The safe environment was well maintained during the changeover.

Efficiency of purging was improved greatly by a properly designed breathable air supply loop. Researchers tested a plunger pushing system where breathable air was introduced to the top of the enclosure. The breathable air worked like a piston pushing the pollutant out of the enclosure. This resulted in a more efficient purging system.

Darren said the advantage of the personal enclosure was evident.

"While a well designed personal changeover enclosure will have the potential to provide a safe atmosphere for changing the SCSR unit, it would not give any illusion of prolonged safety during the mine evacuation. Only minimal fresh air is required to secure the safe changeover environment. The requirements for the air source are flexible – stored cylinders are preferred but a surface borehole compressor on a mine air supply line can be used as the air source for a safe changeover," he said.

"The enclosures are light and portable, and can be easily carried or stored. They are a cost effective solution and can be readily deployed in an underground coal mine.

"The purging efficiency of the prototype was also confirmed during the field testing. The personal enclosure, in a training smoke room containing smoke and 380 ppm of carbon monoxide, was purged in a few minutes."

Feedback from miners during the project suggested that the ergonomics of the personal changeover enclosure needed to be improved by providing extra space and improving visibility. The design of overhead storage to accommodate these enclosures was also suggested. In a mine emergency, the enclosures could fall down from the overhead storage, just like the oxygen masks in an aircraft cabin, providing easier access during changeover.

Industry Monitor Jason Wagstaffe said the project supplied mines that use SCSRs as their primary self-escape device with valuable information with respect to training and what devices were currently available.

"It is very common for mines not to train 'realistically' when using SCSRs as they are a one-time unit. Knowing that there are training simulators available means that we have the ability to progress more realistic training with respect to what these units feel like when used 'in anger'," he said.

"Darren Brady also examined a simple form of fresh air changeover station which, with a little more research, could prove to be a cheap and simple device carried by miners to assist with SCSR changeover."

Training

To help underground mines prepare for effective SCSR changeover during an emergency, Simtars recommends:
A means be provided to ensure that effecting the changeover isolates miners' lungs from what could be a toxic environment.

Potential SCSR users should all experience the sensation of using a rescuer so they do not confuse the normal characteristics with malfunction.

The use of simulators be included in training unit No. MNCU1037A, which sets out the training requirements for escape from a hazardous situation unaided.

Darren Brady said chemical oxygen self rescuers produced oxygen independently of the surrounding atmosphere through a chemical reaction which, in turn, gave off heat.

"This leads to a feeling of dryness in the respiratory tract. The chemical process also produces water vapour which, coupled with the heat, increases the relative humidity and could cause a sensation of suffocation in the user," he said.

"These sensations are experienced in different ways by users and can also be dependent on the type and model of self rescuer being used. Using a nose clip to prevent air entering the nostrils places a further burden on users.

"If they have not previously experienced these sensations in a safe, controlled environment, SCSR users may, in the event of an emergency, attribute them to equipment malfunction and remove the SCSR.

"The need for realistic simulation of these sensations during training has been identified as essential to a successful self-escape subsequent to an emergency. Simulators enable users to become accustomed to these sensations.

"However long-term simulators only simulate the heat, humidity and resistance that would be felt by the user. Another equally important aspect is the way that the chemical self-rescuer's air supply rate changes over the period of use. Short duration sets, such as the CSE SR-T, enable users to experience this change."

Simtars says as important as training is in an effective changeover, evidence has shown that it is not a guaranteed control. Results of its prototype simulator trials in Queensland and New South Wales were mixed. In general, the response from users who were relatively fit was very positive. Some others found the trials too demanding and, in their opinion, unrealistic. Simtars formed the opinion that the issue of worker fitness was critical to the successful use of oxygen self-rescue equipment.

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