

# Improving mine operation safety performance in a developing country

K R Monro<sup>1</sup>, D W Symonds<sup>2</sup> and I P Simpson<sup>3</sup>

## ABSTRACT

Improving safety systems and day-to-day operational safety can be a challenging exercise in any first-world mining operation; however, operating a mine in a developing country introduces the additional challenges of working in a region without well-established safe work regulations, and with a workforce of relatively inexperienced, first-generation mining employees.

The Phu Kham Copper-Gold Operation (Phu Kham) is a large open pit mining operation located in the Lao People's Democratic Republic (Lao PDR or Laos). It is operated by Phu Bia Mining Limited (PBM), which is 90 per cent owned by PanAust Limited (PanAust) and ten per cent by the Government of Lao. PanAust is committed to maintaining a strong safety culture built on a philosophy of zero harm. Phu Kham commenced operations in 2008, experiencing poor safety performance particularly within mining operations. By 2013 it was evident that the safety performance of mining operations was not meeting PanAust's expectations: the total recordable injury frequency rate (TRIFR) had peaked above five, and the first-aid injury frequency rate (FAIFR) had peaked at 25. And, although there were two lost-time injuries (LTIs) in 2013, another 43 incidents occurred that had LTI potential.

This safety performance slump transpired at a time when global economic conditions were driving commodity prices down, forcing the business to increase efficiency, production and cost outcomes to remain competitive.

The Phu Kham mining operation faced a challenge: how could operational safety be improved in a developing country with a relatively inexperienced workforce, while at the same time, initiate programs for decreasing unit costs and increasing production efficiencies?

The Phu Kham management team, together with executive support from PanAust teams, developed a plan to improve the safety performance of mining operations by analysing the existing safety system; quantifying available statistics and trends; and defining and developing a system that was more aligned with the cultural requirements of the Lao national workforce.

The team introduced a series of incremental changes including: revision of the fatigue management system; streamlining of shift structures; increased assurance of contractor management; a revised procedural system; and streamlined communication tools to maximise operator learning and retention. As a result, several new initiatives were successfully introduced including: 'crew safe' and 'room controller' (behavioural-based safety programs); an electronic fatigue management assessment module monitored by the fleet management system (Jigsaw); in-cab cameras in heavy equipment; and the implementation of simple but effective multimedia communication tools including a dedicated FM radio station.

The intent of these initiatives was to challenge the prevailing safety culture, promote ownership of outcomes, open discussion of safety-related behaviours and motivate adherence to the required safe-operational behaviours.

1. MAusIMM, Mining Manager, Phu Bia Mining, Phu Kham Mine, Lao. Email: kell.monro@pbm.panaust.com

2. AAusIMM, Formerly: Mine Superintendent Trainer, Phu Bia Mining, Phu Kham Mine, Lao. Currently: Mining Manager, Newcrest Mining, Lihir Mine, Papua New Guinea. Email: dwayne.symonds@newcrest.com.au

3. Senior Safety System Advisor, Phu Bia Mining, Phu Kham Mine, Lao. Email: isaacphilip.simpson@pbm.panaust.com

The strategy was successful. By analysing the health, safety and environmental (HSE) statistical data from 2013 to 2016, it was clear that a remarkable improvement in the safety performance had occurred.

By December 2016:

- the TRIFR had reduced from 5 to 0.5 (including a ten-month period at 0 level)
- the FAIFR had reduced from 25 to 4
- total potential LTIs had decreased from 43 to seven events.

## INTRODUCTION

The Phu Kham Copper-Gold Operation (Phu Kham) is a large open pit mining operation located in the Lao People's Democratic Republic (Lao PDR). It is operated by Phu Bia Mining Limited (PBM) which is 90 per cent owned by PanAust Limited (PanAust). There are two other large-scale mining operations in Laos: PBM's second operation, the Ban Houayxai Gold-Silver Operation located approximately 30 km west of Phu Kham, and MMG Limited's Sepon mine located in southern Laos.

Since the start of production at Phu Kham in 2008, milling and concentrator capacity has been progressively upgraded from 12 Mt/a to 19 Mt/a, and the mining fleet has more than doubled in size. The mine consists of a single large open pit (450 m deep) and currently runs a fleet of 51 × 100 t haul trucks fed by 300 t and 200 t shovels. Equipment is managed via the fleet management system (Jigsaw) which assists the operation to achieve ex-pit material movements of 56 Mt/a. The mining operations workforce is 97 per cent Lao national, with 60 per cent of mine production operations personnel originating from areas surrounding the mine; the traditional primary skills base in these areas being subsistence agriculture, predominately rice farming.

Mining is supported by a range of national and local contractors undertaking a variety of tasks including public road maintenance, infrastructure support, tailings storage facility construction and equipment hire. PBM has a policy of engagement with its business partners, preferring an integrated approach using established processes and practices as opposed to reliance on contractor expertise in the areas of safety and safe work practices. This philosophy has proven to be very successful and is validated by strong contractor lag and lead safety indicators, and reliable productivity and efficiency.

Phu Kham is committed to maintaining a strong safety culture built on a philosophy of zero harm. Phu Kham commenced operations in 2008, experiencing poor safety performance particularly within mining operations. By 2013 it was evident that the safety performance of mining operations was not meeting PanAust's expectations. This paper discusses the challenges faced by the Phu Kham operation in achieving the required level of safety including those that relate to its remote location and local culture. It examines the systems that were successfully implemented that led to improvements in safety and which are expected to allow the operation to maintain a high standard of safety in the future.

## CULTURAL CHALLENGES AND LEARNING

Laos is a developing country which is heavily reliant on subsistence farming and other primary industries such as wood processing, tourism and artisanal mining. The country has two primary natural resource industries: base and precious metals mining and hydroelectric power generation.

The introduction of modern mining operations in Laos, post-2000, identified a key need to progress local business capability and employee development via improved training and education standards. In other sectors, lack of skilled workers has held back the development of industry but early recognition of these challenges has addressed, at least in part, this constraint. As stated by Milnes *et al* (2010), occupational health and safety processes often contain assumptions of cultural understanding that may not be shared or understood by non-indigenous mining employees. There are potentially dangerous and costly implications of cultural differences in the mining environment.

Phu Kham faced many challenges when operations commenced. One of the greatest challenges was to deliver a coherent and meaningful safety message to the Lao national workforce. It was critical that our Lao employees understood the importance of safe operations and accepted

responsibility for individual behaviours. This seemingly simple philosophy had little, if any, meaning to the local population, where safety messaging had not penetrated the lexicon as it has in Australia over the last 30 years.

Our Lao national employees seemed unaware of the potential long-term benefits that could be gained via compliance with Phu Kham's safety and production requirements. The concept of mass production via mechanised mining and the associated requirement to work within a significant safety framework was simply alien to the traditional subsistence agricultural practices that typified the local area.

Employee education and training systems were implemented prior to the commencement of operations at Phu Kham but the results were lacklustre. For every training success we experienced a training setback or outright failure. The Lao people in the region surrounding the operation were subsistence farmers and had been for generations; suddenly they were employed by a mechanised 21st century mining company with an entirely different world view, required skills and operating philosophy. Their workplace literally shifted from the rice field to the air-conditioned cabin of a haul truck.

At the time, we implemented a strategy of combating poor behaviours with disciplinary action. Although this did reap some rewards, the workforce simply struggled to adjust from the agrarian lifestyle to working 12 hour days over prolonged rosters. As a result, many employees did not meet the company's expectations or chose to depart the company within their first year of employment, which led to repeated recruitment.

Over the next several years, the Phu Kham management team developed an improved understanding of the local culture and our Lao employees developed a better understanding of their employer's requirements. This mutual learning, understanding and adaptation provided significant benefits and improvements on the early approaches.

The Lao employees began demonstrating behaviours which indicated a growing appreciation of modernised safe work methods and an understanding of the high-value with which Phu Kham regarded its compliant mine operations staff. Equally, Phu Kham developed a much deeper appreciation for the varying cultural stimuli and different work methods required to manage and motivate its Lao employees. A meeting of minds, permeated through cultural exposure, began to show positive results.

## **HISTORICAL DATA COLLECTION AND ANALYSIS**

To define the root causes of individual safety events which led to the poor safety performance of the mining operation, four years (2012 to 2015) of data captured in the safety incident reporting system (INX) was analysed. Data for safety events before 2012 was excluded from the analysis as it contained too many information gaps and inconclusive investigations for proper analysis.

Through the analysis of available metrics for the four-year period the following information was identified:

- 48 vehicle to equipment, or equipment to equipment, contact events (average 12 incidents per annum – causes indeterminate due to lost knowledge and minimal INX information)
- 38 equipment to environment or infrastructure contact events (average 9.5 incidents per annum – causes indeterminate due to lost knowledge and minimal INX information).

The above total of 86 events formed the basis for the statistical evaluation and was further analysed to determine basic underlying and immediate root causes:

- 16 of the 86 events were due to poor communication practices
- 26 of the 86 events were directly attributable to fatigue
- the remaining 44 events were directly attributable to procedural and behavioural non-conformance, including ten events linked to the use of mobile phones while operating machinery.

Although training and competency records and a basic paper-based fatigue management system were in place for equipment operators, evidence from various sources indicated that complacency had set in. Training records were incomplete; trainers had different opinions about training requirements; systems were fragmented and did not communicate with each other; different revisions of procedures were available; and, witness statements indicated a general lack of process

awareness. From the analysis and subsequent conclusions, it was decided that multiple areas of the operation required immediate attention. This included:

- procedural system review and update
- training system revision and realignment
- refresher training aimed at operators and designed to redefine expectations and restore workplace compliance
- a realignment to satisfy the requirements of Occupational Health and Safety Management System (OHSMS) 18001 and AS/NZS 4801 via the development of standards and a more rigorous, cascading documentation system
- fatigue management system review and update
- a communications regime to remind all personnel of Phu Kham's behaviour-based safety system.

### **Procedures and training**

Evaluation of the electronic document management system indicated that procedures were out of date, training records had not been appropriately updated and refresher training was inadequate including an underlying lack of stakeholder communication.

To achieve procedural compliance, existing procedures would require updating. Procedural structure and content would need to be revised to maximise learning potential for the Lao audience and the new suite of procedures rolled out via a rigorous and well documented training regime to ensure that expectations were well understood. Revisions to policies would be required including changes to the policy covering the use of mobile phones in mining equipment.

### **Fatigue management system**

Examination of the fatigue management system soon determined that trend mapping was impossible. Literally thousands of fatigue records (hard copies) would have to be evaluated and cross-referenced by operator number to determine who was occasionally fatigued and who was not complying with duty of care by consistently arriving at work fatigued. The examination also discovered that most operators, regardless of their fitness for work, were selecting 'tired' from the available options (alert/tired/fatigued).

### **Behavioural-based safety**

During examination of the behavioural based safety system it became apparent that operators, post-incident, appeared to lack understanding of how their behaviour had directly contributed to the incident.

Where the incident investigation showed that the operator was at fault, either through lack of consistent and adequate sleep or failure to observe procedural or behavioural requirements, the operator indicated a lack of willingness to admit to the fault. Post-incident, operator concern was not focused on recognising the seriousness of breaching safety requirements, but rather on retaining employment.

Our immediate challenge was to get the workforce to understand that compliance to safety should be of equal concern as retaining employment. We also needed to ensure that crews understood duty of care requirements and would be responsible for championing and owning their own workplace safety.

Several initiatives were subsequently introduced to bolster our existing behavioural based safety tools. These initiatives included crew safe, a dedicated mining operations safe behaviours program which was designed to be driven and owned at the operator level. The management team used a wide variety of media to ensure that the initiative was communicated effectively including print media, visual media, presentations and a new FM radio station.

## **INITIATING CHANGE**

From the safety event analysis, management determined that immediate changes were required. Firstly, an electronic fatigue management system, with the ability to map trends and determine which operators were consistently arriving at work fatigued, was required. This would allow trends to be mapped and problematic operators to be removed from the mining operation.

Secondly, step changes were made in late 2014 to improve safety performance. This involved the introduction of new initiatives and programs as well as a renewed focus on improving personal behaviours to improve safe operations:

- *Initiative 1* – developing new systems. By auditing previous systems and working on tangible improvements, the team introduced the revised fatigue management system. Creative and cost-effective ways were also sought to improve sustainable operations and reduce incidents.
- *Initiative 2* – improving communication. Working together at the leadership level of the workforce to create unified expectations, develop, deliver and facilitate new safety programs. Working closely with mine training, HSE and operators to determine the best approach to move forward as a unified business. Engaging the various functions within the business to ensure vision and goals were aligned.
- *Initiative 3* – encouragement. Encouraging the workforce to become more engaged as responsible members of the organisation, to own safety and operate sustainably and to lead the way within their peer group.
- *Initiative 4* – empowerment. Providing the tools, with input from all levels within the operation, to empower the workforce to be responsible for fatigue management, safe behaviours and consistent and safe operations. Implementation of the ‘crew safe’ and ‘room controller’ initiatives to improve communication and promote grass roots safety engagement and accountability.
- *Initiative 5* – behavioural reinforcement. Making necessary changes to the documentation and procedural system to reinforce safe operating behaviour. Modifying the mobile phone policy to reduce possible distractions. Introducing in-cab cameras to understand operator actions leading up to an incident, and using the Caterpillar Inc haul truck vital information management system (VIMS) to understand operator competence for triggering of retraining and performance management.
- *Initiative 6* – diligence: Maintaining forward momentum to deliver the vision of a safer working environment. Working through problems and finding solutions with minimal cost. Continuing to evolve systems, communication processes and tools to fulfil that vision.

As shown in Figure 1, there has been a remarkable year-on-year reduction across all injury frequency rate measures. This includes the TRIFR, which reduced from a high of 5.1 in January 2013 to 0.5 by

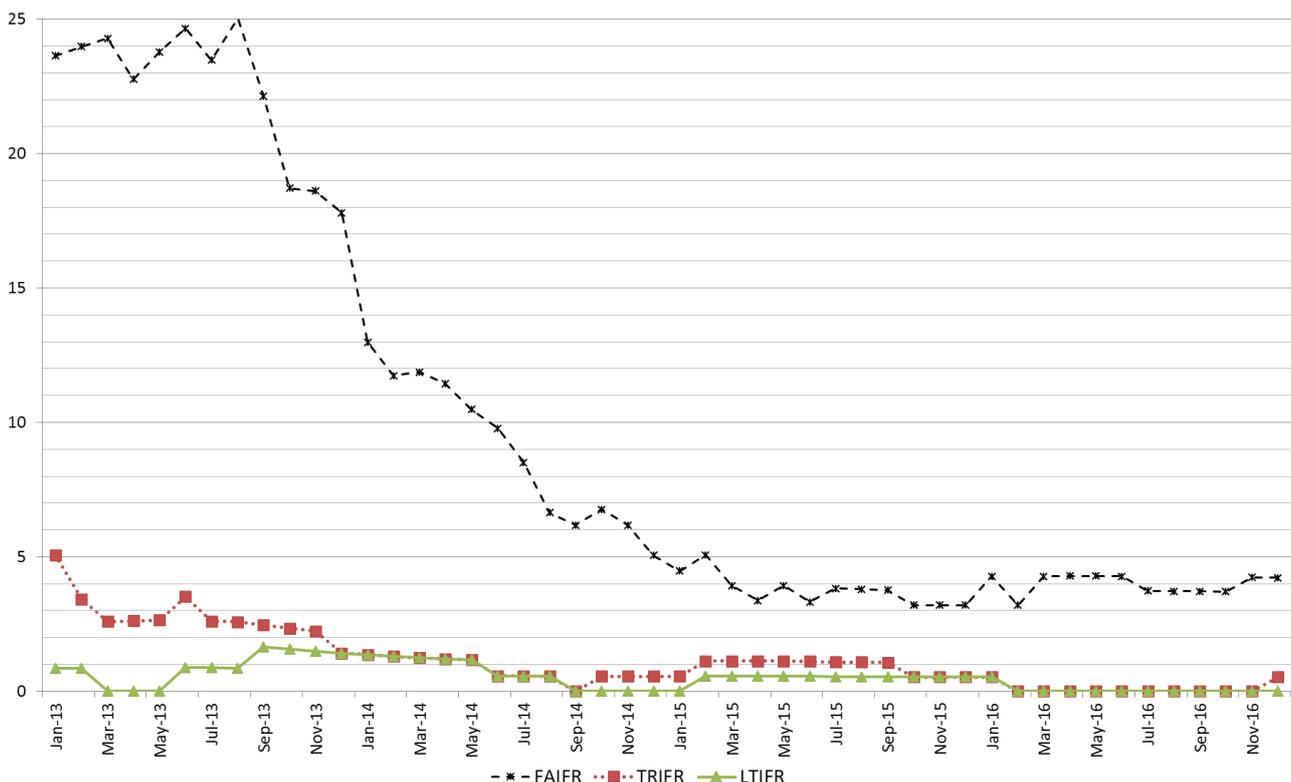


FIG 1 – Phu Kham mining operations – safety event (injury) frequency rates, January 2013 to December 2016.

December 2016 (including a ten-month period in 2016 at a zero TRIFR level). As shown in Figure 2, the number of potential LTI events reduced from a high of 43 in 2013, to 35 in 2014, 25 in 2015 and 7 in 2016.

And, these improvements were not just restricted to mining. Our Senior Executive Incident Taskforce lead the evaluation of significant incidents, hot spots and trends at all levels of the organisation. This environment of support ensured lessons learnt at Phu Kham were also applied across the company. The data generated at Phu Kham was fed into vehicle incident analysis, considered all our drive-in-drive-out, transportation and logistics functions as well. As a result of this data, and other shared initiatives, we witnessed a dramatic reduction in potential LTI vehicle related incidents (198 in 2012 reducing to 18 in 2016).

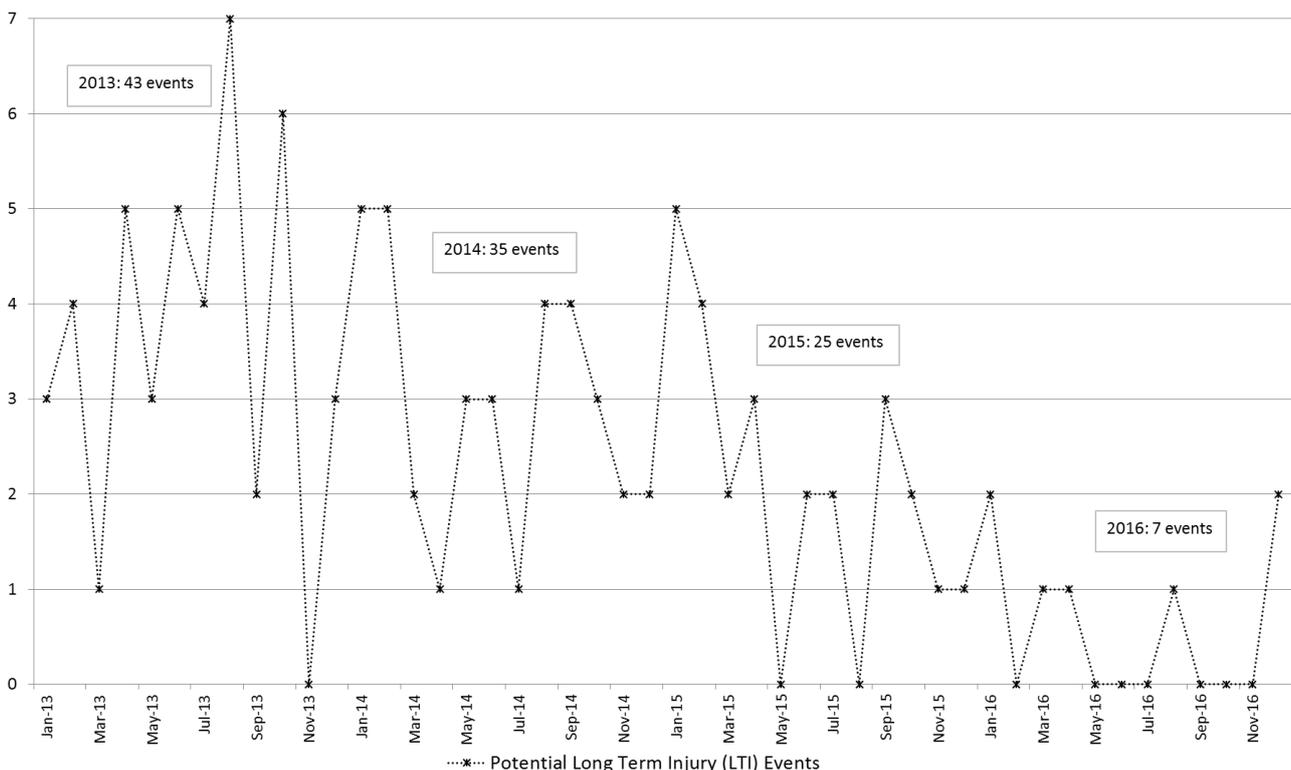
**MOBILE PHONE POLICY**

Many safety learnings take time to implement as they do not easily bridge the cultural divide in developing countries. The banning of all mobile phones in heavy vehicles in early 2015 is an example. Through the analysis of safety incidents that occurred between 2012 and 2015, it was established that some incidents were directly related to inattentiveness caused by the use of mobile phones while operating vehicles. PBM respects the right of its employees to have access to communication for non-work related activities given restrictions to individuals’ movements after work hours and the remote locations of its operations. For this reason, it was challenging to make the radical but necessary changes required to reduce the risk for all employees.

Initial efforts to address this risk focused on routine education and post-incident investigation. This had little effect on the workforce with incidents related to mobile phone use still occurring. Given that the requirement had been well communicated, that personnel understood the instruction, and that penalties were severe, it appeared reasonable to expect compliance.

However, this was not the case, sparking discussion on how to manage mobile phone use at all levels within the business. Western values in relation to mobile phone etiquette and appropriate use proved to be a hindrance in resolving the issues as it was assumed national employees shared these values. Mobile phones are a new phenomenon in Laos and mobile phone etiquette, as generally accepted, has no basis.

Not answering the phone when it rang was considered rude, regardless of activity or location of the individual. For this reason, the decision to ban the possession of mobile phones within



**FIG 2 – Phu Kham mining operations – potential long-term injury events, January 2013 to December 2016.**

mining equipment was adopted and strictly enforced. No amount of education or disciplinary sanction could otherwise manage this risk. As a result, there has been a significant reduction in heavy equipment incidents related to inattentiveness and the workforce has slowly accepted the restrictions. Personal lockers were provided to each employee and random searches of employees getting into and out of equipment were, and continue to be. The learnings lay in the time taken to reach the decision to ban mobile phones in mine equipment. The responsibility to keep employees safe must not be swayed by cultural or personal belief.

## SHARING OF KEY LEARNINGS

Analysing operator's responses post-incident uncovered a trend whereby operators appeared to lack understanding of why a particular incident occurred. This occurred even when the operator had been at fault, either through lack of diligence applied to adequate sleep requirements or procedural breaches, some of which were blatant. Primarily, the individuals were concerned about retaining employment, but lacked the same level of concern for duty of care and safe work behaviours. Simple and visual lessons learnt presentations were introduced for crews, outlining the key learnings after incidents were risk ranked and investigated. This also included a summary of such lessons learnt which was communicated to incoming crews that were previously on break. This ensured that incidents were communicated to every operator.

## REVISION OF PROCEDURES

Phu Kham engaged an expert in the field of procedural development to assist with the audit and revision of safety procedures. From the existing database of procedures, many were found to be redundant, out of date, repetitious, or simply unnecessary, and it was identified that procedures could be streamlined to generate a maximum of 300 procedures.

These procedures were mapped to new safety standards and OHSMS standards, particularly ISO 18001 and AS/NZS 4801, to identify holes in the structure, and to ensure compliance cascaded from policy, to standard, to plan and finally, to procedure.

The procedures were developed in conjunction with mine training using a combination of resources including: existing data; the technical writer's mining expertise; subject matter expert interviews and field observations; and were communicated across the mining operations group. Procedures became a lot more visually focused. New photos and graphics were inserted and updated and, where possible, content was simplified. 'One sheets' were developed that could be laminated and retained in the cabins of mobile equipment. These one-page summaries provided operators with a refresher sheet that they could refer to prior to start-up or during downtime periods on shift. These sheets included:

- minimum compliance standards (ie speed limits and separation distances)
- required safe behaviours (ie no use of mobile phones, the use of positive communications and sound fatigue management practices)
- highest risks (ie managing speed in the wet season and during periods of low visibility).

All one sheets were available in both English and Lao language versions.

The new procedures and one sheets were rolled out and timelines developed for all operator training and refresher training requirements. Oversight of the training department was improved while working closer with trainers to develop capability and improve systems. Almost immediately, there was a reduction in incidents associated with procedural non-compliance and training system failures.

## IMPROVED FATIGUE MANAGEMENT

### Night shift fatigue breaks

Mandatory fatigue breaks were introduced as a response to another cultural issue: Lao national operators did not feel comfortable admitting they were fatigued. There were two primary reasons for this: firstly, the Lao saw it as a potential 'loss of face' situation to admit they could not continue operating; and secondly, in Lao culture conflict is generally avoided and many of the Lao thought that admitting to being fatigued might bring them into conflict with the mining operations leadership team.

This introduction of mandatory fatigue breaks was focused on night shift operations during the 01:00 to 06:00 period, where 95 per cent of all fatigue related incidents were occurring.

Under the new system, it was no longer permissible for an operator to operate machinery for more than two hours, without a 15-minute break, between 01:00 and shift change at 06:00. The 15-minute break included 'hot seating' (operators being swapped out at equipment boarding ramps without requiring equipment downtime) at the 'go-line' (the area where operators embark/disembark mobile equipment). The go-line facilities were reviewed to ensure that the facilities were equipped with suitable lighting, tea and coffee facilities and large-supplies of fresh water as well as games to help keep the operators stimulated and installed televisions to display safety messaging and reinforce safe behaviours. These mandatory fatigue breaks assisted in reducing fatigue related incidents by 50 per cent when introduced in the fourth quarter of 2014.

### **FM radio broadcasts**

In a bid to help manage fatigue and provide additional stimulation to equipment operators, an FM radio broadcast was launched (there are no local radio stations in this remote region of Laos). This included the purchase and installation of simple FM radio receivers and speakers for mobile equipment. The radio station fulfils an important function in helping to provide mental stimulation to equipment operators, especially those on night shift.

The Phu Kham FM radio station was launched in September 2015. The broadcast volume is set at a level that does not interfere with or overpower the UHF dispatch. The station broadcasts a mix of Lao, Thai and western music from a standalone computer in the central control room.

In the first quarter of 2016, the function of the playlist was extended to include prerecorded safety and motivational messages, and the playlist was modified to include more upbeat music during the fatigue hot spot time after 01:00. Feedback from the operators has been positive, with many reporting Phu Kham FM radio is making work more enjoyable and helping them to stay alert.

### **Fleet dispatch automated fatigue system**

Management of mining employee fatigue developed sporadically over several years, predominantly in response to incidents and the need to implement meaningful actions. By 2014, a manual system (tracking employee operating time) was being run by crew fatigue coordinators based at the mining go-line. The fatigue coordinators were tasked with manually collecting hardcopy fatigue questionnaires and assisting supervisors manage truck operator rotation. Operator rotation was driven by truck utilisation requirements rather than employee fitness for work but served the dual purpose well given regular shift breaks and dedicated fatigue breaks for night shift.

Despite reductions in fatigue related heavy incidents as a result of mandatory night shift fatigue breaks, management dissatisfaction with ongoing fatigue related incidents triggered an investigation into the existing system in mid-2015. On completion of the investigation, the current system was deemed inappropriate for the level of risk to the business. This was largely due to the fact that it was paper based, that metrics could not be evaluated, and that it relied on a series of coordinators to manually attempt to analyse the operator hand written responses and provide follow up communications, which was proving ineffective. A small team was assembled to investigate alternatives and propose an appropriate replacement system for review and approval by management.

Following extensive research into existing automated systems, a decision was made to work in consultation with the existing fleet management system (Jigsaw) provider to develop a fully integrated fatigue management system which would be managed by mine dispatchers.

The new system, which was rolled out in early 2016, could be best described as a hybrid, based on existing off-the-shelf supplier software upgrades and site-specific tracking and operation requirements. The system tracks an employee's equipment operating time and provides a series of warnings to both the employee and dispatcher when the recommended operating time is exceeded. This allows dispatchers to manage truck rotation in a systematic fashion and ensures human error is removed from the decision-making process. Of further value in the fight against fatigue was the implementation of automated self-assessment tools which, through the fatigue management system in-cab display asks the operator a series of questions specific to fatigue level. The responses are then transmitted for immediate analysis and action by dispatchers and supervisors.

The data collection and analysis potential for the system has proven significant. Several educational programs have already been launched based purely on historical data collected by the system. Non-

compliance to in-cab fatigue assessment is now easily managed on a daily or weekly basis ensuring a very high level of compliance amongst operators. This, along with post-incident data analysis, is proving a powerful tool in the fight to manage operator fatigue. Longer term trend data will be used to modify existing system parameters to better target high risk times and allow for more flexibility during high alert periods (between 01:00 and shift change at 06:00).

The system has proven reliable and simple to use at all levels and it is expected that upgrades will be added periodically to provide even more data and safeguards.

## **EMPOWERMENT INITIATIVES**

Early 2015 saw a re-focus on individual accountability, primarily addressing ongoing serious vehicular related incidents and poor levels of employee culpability. A philosophy of training for competency and coaching for performance and empowerment was adopted to bring ownership back to the right levels. Strict accountability enforcement led to two key developments. The frequency of heavy equipment collisions dramatically decreased with residual events resulting in less damage and associated downtime and, there was a sustained improvement in truck cycle times and overall productivity. This single initiative demonstrates the symbiotic relationship between safety and productivity.

Before the initiative was implemented, Phu Kham mining operational safety had declined to the point where employees no longer felt empowered or engaged by safety systems and became disengaged which lead to lower levels of attentiveness. Empowering employees to operate to their ability energised many who had previously done little more than try to keep out of trouble. Now they were free to participate in the business, make decisions and impact on outcomes making the operation safer and demonstrating their own value, lifting self-esteem amongst many of the employees.

### **Crew safe**

The crew safe initiative was designed to encourage the workforce to 'own' safety management at the peer level. Previously, Phu Kham had a culture whereby safety management was not penetrating down to the workforce. A change was needed to help the Lao employees understand that safety was a top-down/bottom-up culture, where all employees had a duty of care to each other.

Crew safe is a relatively simple initiative. Representatives from each crew were selected and attended workshops chaired by area supervisors. Together, the representatives discussed and prioritised safety issues that they believed were important.

After these discussions, ten crew safe rules were determined. Of these ten rules, at least three had to relate directly to fatigue management. This included, for example:

- be 100 per cent fit for work every day – not under the influence of drugs, alcohol or fatigue
- follow fatigue management procedures and, if fatigued, stop and have a break
- follow camp rules and the advice of room controllers – get at least seven hours' sleep.

After the ten rules were finalised, the crew safe initiative was rolled out to the crews by their representatives. A key part of this rollout was the understanding that these rules were decided upon by contemporaries, not Phu Kham management. To acknowledge this roll out, and to signify their commitment to follow the ten rules, each crew member signed onto a large printed crew safe banner which was put on display at the mining go-line.

### **Room controllers**

Processes to control behaviour in the accommodation camp environment were initiated to combat fatigue related to insufficient quality sleep for night shift employees. The practice of housing local employees was instigated in the early years of the operation to allow employees a more controlled environment for night shift duties. Village life is largely driven by the cycle of day and night and not necessarily conducive to sleep. As a result, employees have little understanding of night shift personal obligations or indeed, the ability to control their environment in the village. As such the responsibilities for ensuring employees are fit for night shift duty fell to the operation.

Some negative aspects of this practice, including the night shift crews being disturbed by other individuals, required the implementation of room controllers whose duty it is to manage their area and to ensure employees have adequate opportunity to rest and sleep prior to undertaking night

shift. The position also represents the group in taking concerns and complaints to toolbox meetings, supervisors, HSE representatives and management to ensure that timely solutions are implemented.

The implementation has been very successful with both employees and management deriving benefits from the experience. The program is 100 per cent run by Lao national employees to ensure concerns are properly understood and addressed.

### **Camp accommodation sleeping conditions**

A sleep study was performed in 2015 utilising information collected from a program that involved operators wearing sleep tracking bands on their wrists to measure the number of hours of sleep per night. This identified that both day and night shift operators were not receiving adequate sleep to help prevent fatigue issues from occurring. Given that the operators sleep in shared rooms of up to four occupants, behaviours within the rooms was identified as a factor and the reason why the room controller initiative was put in place. It was identified that the location of the rooms was not conducive to maximising sleep performance due to the wet mess and sporting facilities being located within the vicinity. This meant that there was a higher volume of personnel walking past these rooms. The decision was made to relocate the mining operators to a different section of the camp where there were fewer external influences which would negatively affect sleeping patterns.

### **RECOGNITION OF SAFE WORKING**

Recognition of outstanding achievements by groups and individuals has taken many forms since operations commenced. In March 2015, Phu Kham mining department set about formalising the recognition processes and ensuring long-term sustainability. This involved the development of crew key performance indicators, dependable and transparent tracking systems and individual recognition processes supplemented by one-off awards for outstanding achievement.

Monthly 'best crew' awards were developed and rolled out based on a range of safety and productivity criteria. Each crew is scored on their monthly performance using a widely publicised and transparent set of criteria. The awarded best crew enjoy a shift change celebration where soft drink and musical entertainment is provided, with the honour of holding the title for one month. The aim was to build team camaraderie encouraging greater participation by all employees. Records to date indicate no single crew has dominated the awards, ensuring the ongoing success of this program.

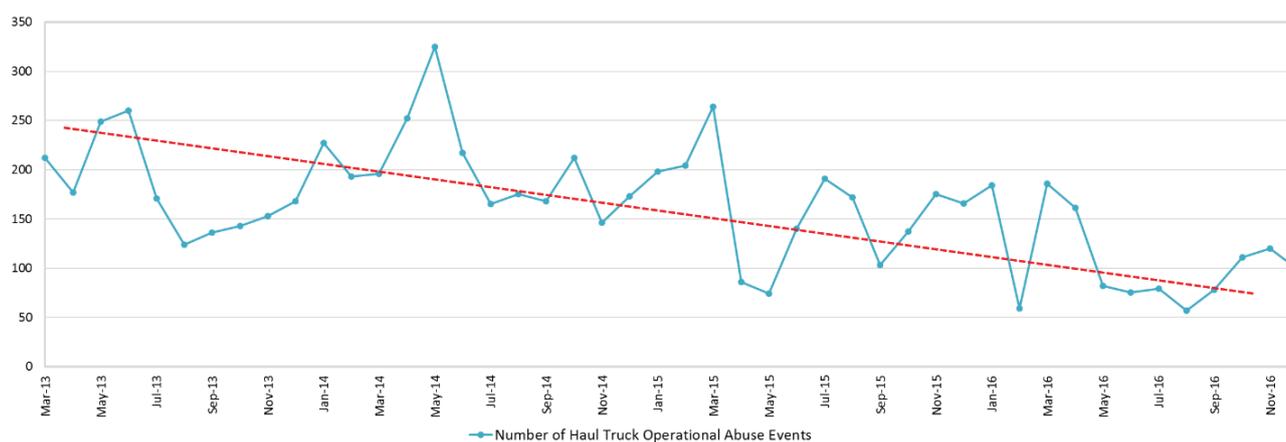
Annual employee awards were implemented recognising exceptional individual performance in various categories. The awards are targeted at operators with recognition for outstanding achievement across a range of machines and duties. An awards event is held which allows maximum employee participation and includes live music, food and a range of other entertainment. The inaugural awards event, hosted in April 2016, was a success, with the Lao operators responding with pride and increased diligence in their roles when they were nominated and/or rewarded in front of their peers.

### **USING MACHINE DATA TO IDENTIFY UNDESIRABLE OPERATOR BEHAVIOUR**

As well as formal recognition programs for machine operators, the use of machine data to identify undesirable operator behaviour was considered equally important – an operator that abuses equipment would be highly likely to cause a safety incident as a result of non-compliant behaviour. The haul truck VIMS provides data highlighting undesirable operator practices including excessive braking, engine over speed and harsh gear selection. Multiple VIMS abuse reports triggers operator retraining with the mine training group. Initially, the retraining would not trigger other consequences, however beginning the first quarter of 2015 multiple retraining events led to performance management which includes disciplinary processes as required. As can be seen in Figure 3, the declining trend in abuse events mirrors the improving safety statistics shown in Figures 1 and 2.

### **IMPROVING PRODUCTION EFFICIENCIES TOGETHER WITH SAFETY**

During this period of operational and cultural safety improvement the business also remained focused on improving operational productivity and efficiency. Similarities were found in key elements: simply, a symbiotic relationship existed between both safety and production: what we changed with one functional discipline affected the other.



**FIG 3** – Phu Kham mining operations – haul truck operational abuse events, March 2013 to December 2016.

As stated by Monro and Young (2016), commencing in late 2014, a range of initiatives were implemented to improve the production efficiency of the mine haulage fleet. These initiatives increased mine haulage fleet utilisation of availability from 85 per cent to 97 per cent and productive operating time from 73 per cent to 84 per cent, both of which could be considered best practice levels of efficiency.

## NEXT STEPS – THE USE OF TECHNOLOGY

### In-cab cameras

The decision to implement passive levels of supervision into mining equipment was largely the result of experience gained from the logistics department in managing its fleet of on-road trucks, and the inability to reliably define root causes for incidents, which led to inadequate or inappropriate post-incident controls being implemented. Technologies advanced in the area of in-cab monitoring with camera systems capable of both in-cab and outwards recording in all conditions. After various trials a suitable in-cab monitoring system was installed in December 2016 which allows for both real-time monitoring of equipment cabins and post-incident review of video footage to assist in determining the root cause of an incident or equipment damage.

It was anticipated that there would be employee uncertainty to the implementation of in-cab monitoring with some viewing it as an unwelcome invasion of privacy. Education campaigns that focused on the positive aspects of the introduction stemmed this resistance. The positive aspects include the opportunity for employees to prove they performed their duties without negligence prior to any incident or were unable to avoid situations.

The revision of systems and the realignment of a workforce is not an overnight change. There are implications including time take to re-adjust to required behaviours, the improvement of stakeholder relationships and methods of communication, and the realignment of the workforce towards unification. There will, for a period, be a reluctance to change, followed by a tolerance period and finally then acceptance, which, in the best-case scenario is not simply acceptable. Success requires the full-embrace of the system so that champions within the system can be created who genuinely promote and believe in the revised safety system.

Other, less tangible benefit of the in-cab system relate to an expected reduction in non-compliant operator behaviour. A minority of employees lack commitment to mine operational procedures and practices. The reasons vary from case to case but the resultant inappropriate behaviour sits at unacceptable levels requiring management. This system is expected to go a long way towards modifying or reducing inappropriate behaviour while in control of heavy equipment.

### Real-time fatigue detection

Evidence suggests that even when a company provides a safe environment that allows an employee to put up their hand and stand down when feeling fatigued, individuals will still make poor choices. Evidence suggests that employees will ignore signs of fatigue and this becomes even more evident the more fatigued they become. It is planned to trial various real-time fatigue detection technologies currently on the market that provide data to a central location where the

decision to stand an employee down due to possible fatigue is taken out of the employees hands and decided by a central control centre that identifies where an employee is behaving erratically and outside normal parameters. However, given the dramatic reduction in fatigue related events occurring as a result of the current improvement initiatives and programs any use of these systems would be implemented as a last effort solution.

## CONCLUSIONS

The key to continually improving safety performance for mining operations includes a combination of education, empowerment, effective communication and robust processes accompanied by systematic review and unwavering enthusiasm. Creation of a positive culture that permeates throughout the organisation and provides the necessary environment to support initiatives to continually improve safety performance requires focus and engagement from the executive team through to the heavy equipment operator.

Engagement and empowerment of employees to drive performance improvement from the lowest employee grade upward is a challenge, but is not insurmountable. Cultural obstacles continue to challenge sustainable progress but the management team have the advantage of experience and a deep desire for success.

Enhanced measurement and modelling tools will continue to provide improvement opportunities and driver fleet efficiency. Phu Kham's management team believe the relationship between safe work practices and improved productivity goes hand in hand and provides an excellent platform for improvements in both areas. Safety is no longer treated in isolation rather considered as part of the overall continuous improvement cycle ensuring any productivity improvement program supports safe operations at its core. Likewise, all safety initiatives must allow the company and employees the opportunity to improve a process not hinder it.

As operations continue in the Lao PDR, the ability to communicate and continue to empower its employees will become even more critical to guard against complacency in all its forms. The journey to a safer operation as well as more productive and efficient operation is never complete, it simply morphs to meet new challenges. Phu Kham and all its employees are better armed to tackle the future largely due to the range of initiatives undertaken in the last two years and the real enthusiasm displayed by each employee.

## ACKNOWLEDGEMENTS

The authors would like to acknowledge the following individuals and groups for their support and assistance in the preparation of this paper, and whose efforts were pivotal in achieving the safe operations improvements outlined:

- David Reid, General Manager Operations, Phu Bia Mining Ltd
- Richard Taylor, General Manager External Affairs, Phu Bia Mining Ltd
- Adrian Bell, General Manager Human Resources and Risk Management, PanAust Limited
- Simon Young, Operations Improvement Manager, Phu Bia Mining Ltd
- Mining Department, Phu Kham Operations.

## REFERENCES

- Milnes**, P, Melkounian, N S, Mather, D, Milnes, T, Stewart, A and Tan, L, 2010. 'She'll be right mate' - culture and safety, in *Proceedings Mine Planning and Equipment Selection Conference (MPES)*, pp 427-439 (The Australasian Institute of Mining and Metallurgy: Melbourne).
- Monro**, K and Young, S, 2016. Truck haulage improvements at the Phu Kham Mine - the journey to 97% utilisation of availability, in *Proceedings International Mine Management Conference 2016*, pp 339-346 (The Australasian Institute of Mining and Metallurgy: Melbourne).