



# Sub-standard practices: effects on safety performance in South African gold mines

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## Synopsis

Sub-standard practices and their adverse impact on safety performance remain a challenge in the South African gold mining industry. The purpose of this study was to investigate the root causes of sub-standard practices and the effect on safety performance in South African gold mines. The focus of the study was on the underground production operations at a gold mine in the Free State. The study consisted of three parts: a personal investigation into the causes of sub-standard practices at the mine, a comparison with the results of a cultural study performed at the West Wits mines, and a behavioural survey.

The studies described in this article yielded similar results in terms of the key drivers behind sub-standard practices. It was found that sub-standard practices had a number of causes, and the origin lies within the habits, attitude, and behaviour of employees. Current methods of addressing sub-standard practices and improving safety performance were found to discourage employees from performing work safely and according to procedure.

It was concluded that the lack of critical behavioural habits for the given work environment and job title could possibly be the primary reason for the occurrence of sub-standard practices.

## Keywords

sub-standard practices, safety, behaviour, habits.

## Introduction

Since the implementation of the Mine Health and Safety Act, 1996 (Act 29 of 1996) and the Mine Health and Safety Regulations, the South African mining industry has been striving to improve health and safety performance and has placed great emphasis on adherence to mine standards.

The Act requires employers in the mining industry to report accidents, incidents, and dangerous situations to the Regional Principal Inspector of Mines in their area. The data provided by employers is captured and analysed by the South African Mines Reportable Accident Statistical System (SAMRASS) and made available for public viewing (Department of Mineral Resources, 2011).

A review of the national mine-related accident statistics shows clearly that the South African gold mining industry has improved its safety performance markedly over the past decade, but is still facing major challenges

(Figure 1). These include meeting the Mine Health and Safety Milestones (Department of Mineral Resources, 2011).

Most South African mining companies have adopted a 'zero harm' policy in an effort to improve the health and safety of employees at their operations. After the 2003 Mine Health and Safety Summit, the following milestone was set with regard to the gold mining industry (Department of Mineral Resources, 2011):

*'Achieve safety performance levels equivalent to current international benchmarks for underground metalliferous mines, at the least, by 2013.'*

These milestones were revised in 2014 and new targets for 2024 were set for the South African mining industry (Association of Mine Managers of South Africa, 2014). The new milestones that were set in terms of occupational safety are listed below (Association of Mine Managers of South Africa, 2014):

- 'Every mining company must have a target of ZERO FATALITIES
- Every Fatality is one too many, we will eliminate fatalities by December 2020
- Up to December 2016, 20% reduction in Serious Injuries per year
- From January 2017, 20% reduction in Lost Time Injuries (LTI) per year.'

The 2024 targets include new milestones for the implementation of the approved culture transformation framework (CTF). These milestones included the following (Association of Mine Managers of South Africa, 2014):

- 'By December 2020 there will be 100% implementation of:

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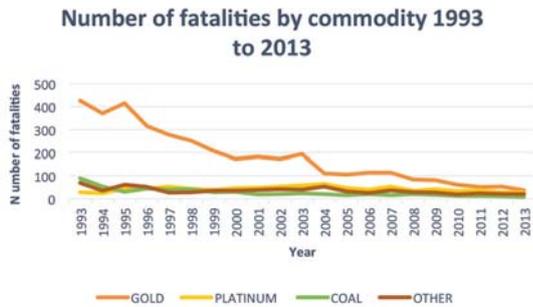


Figure 1—Fatalities per commodity sector in South Africa for the years 1993 to 2013 (Mine Health and Safety Council, 2014)

- The Leadership Pillar of the CTF
- The Risk Management Pillar of the CTF
- The Bonus and Performance Incentive Pillar of the CTF
- The Data Management Pillar of the CTF
- The Diversity Management of the CTF
- The Leading Practice pillar of the CTF
- After December 2020 the remaining pillars will be implemented:
  - The Integrated Mining Activity Pillar of the CTF
  - The Technology Pillar of the CTF
  - The Inspectorate Pillar of the CTF
  - Tripartism Pillar of the CTF
  - Regulatory Framework Pillar of the CTF'

Sub-standard practices compromise the effectiveness of any safety measures, devices, or procedures that have been put in place. They create a weak spot in the system that is bound to fail with the slightest amount of interference. Standards and safety are very closely related and standards are necessary not only to maintain the safety of underground employees, but also to improve current safety practices.

The information below represents some of the safety performance statistics at the study mine and was compiled from data obtained from the mine's safety department.

From 17 February 2009 to 22 December 2014 a total of 2042 accidents occurred on the study mine. A total of 26 of these accidents led to fatalities. Upon analysis, it was found that the mine experienced approximately 0.94 accidents per day. The accident distribution by shift is shown in Figure 2.

Figure 2 shows that the majority of accidents at the mine occurred during the morning shift. The average time of occurrence of morning shift accidents was 11:58:17 am.

Figure 3 shows that the largest number of accidents at the study mine occurred in the stopes. The second highest number occurred in development, and the third highest in tramming.

Not surprisingly, these are also the departments underground that have shown the greatest amount of sub-standard practices. It is estimated that approximately 40–50% of all accidents underground occur as the inevitable result of sub-standard acts.

From Figure 1 it is clear that safety performance in gold mining has lagged that in other sectors of the mining industry for the past 10 consecutive years, and despite the recorded improvements, further efforts are required.

### Background

Figure 4 shows the relative distribution of accidents at the study mine between the surface and underground environments. These statistics show that the underground work environment is more hazardous.

The question remains: why do employees at the mine still engage in sub-standard acts and how does this affect safety? It is this question that gave rise to this investigation into the root causes of sub-standard practices at the mine.

The hypothesis is that sub-standard practices usually have multiple causes on different organizational levels and have an adverse effect on the safety performance of South African gold mines in general.

To understand the current culture and the need to change, an investigation into what causes employees to engage in sub-standard acts and how to change the behaviour at all levels of the organization was required.

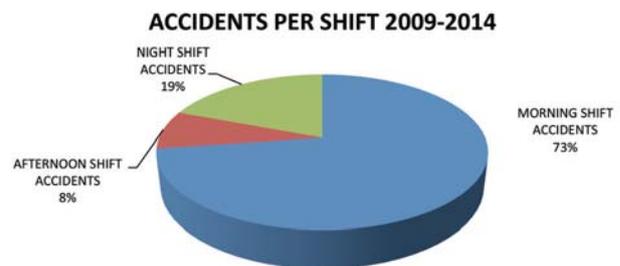


Figure 2—Gold mine accident distribution by shift

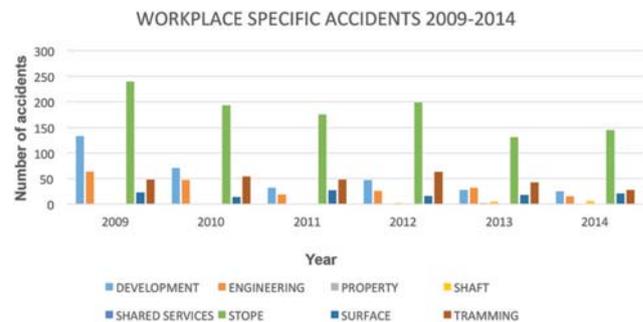


Figure 3—Accidents by workplace at the study mine 2009-2014

### Mine Accident Percentages 2009 to 2014

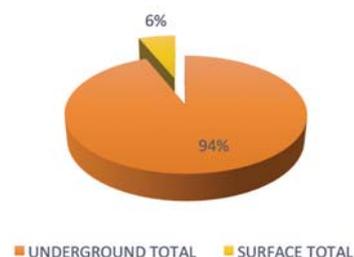


Figure 4—Surface and underground accident occurrences at the study mine

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In order to ensure compliance with regulations, the mine has implemented a full compliance policy. However, the sharp increase in sub-standard practices indicated that the policies implemented by the company have not led to the desired result.

Furthermore, a major concern is that the new generation of mine employees is adopting a culture where sub-standard practices are the norm. The language barriers that exist among the majority of the workforce raise a number of questions with regards to mine standards in terms of comprehension.

Figure 5 shows the number of accidents and fatalities recorded at the mining operation over the past 5 years. Although there was a steady decline in the number of accidents from 2009 to 2014, this is not reflected in the number of fatalities. Thus although the number of accidents has decreased, their severity has not.

Ideally, the accident statistics should show a steady decline, indicating that the 'zero harm' policy of the company is becoming a reality. Unfortunately, the fluctuations in the injury and fatality rates indicate a high probability of recurrence of accidents and fatalities. It is believed that proactive standards have a far greater impact than reactive standards.

Firstly, it was necessary to carry out research on accidents related to sub-standard work at the mine. This was done in order to identify the root causes of sub-standard practices in the underground working environment and the effects on safety performance.

The findings of the study at the mine were compared to those of a cultural study that was completed at mines in a different mining region. The last part of the study involved conducting Shadowmatch surveys on first line supervisors (shift bosses) and making recommendations for further studies.

A literature study was completed to determine what investigations have been completed in South African gold mines, and the safety performance and factors that influence it. This included a previous cultural study that was performed at mines in the West Wits region.

Personal interviews were conducted to try to determine the factors that influence sub-standard practices. Production supervisors were also interviewed in order to compare how their opinions on sub-standard practices differed from those of the underground employees. Questions were posed in such a way as to determine how the work culture (attitudes and behaviour) influences the implementation of mine standards. Towards the end of the study, a Shadowmatch survey was

conducted on shift bosses in order to determine benchmark attitudes and behaviour for this group of employees. The rest of the participants' habits were then compared to the benchmark and analysed.

The results of a cultural survey performed by Dupont were analysed in order to determine previously known causes of sub-standard practices and their relation to employee behaviour.

The Society for Mining, Metallurgy and Exploration (SME) Mining Engineering Handbook, (1973) states that all mining operations are required to adhere to local, provincial, and governmental regulations that among other things specify mine safety regulations and standards, environmental protection, and labour relations. The nature, scope, and stringency of these regulations ultimately govern the mining operation.

Over the past three decades, the number and extent of mining regulations and governing authorities have dramatically increased on an annual basis. The major reason behind this is a continuous effort of governments to promote health and safety standards in the global mining industry (Hansen, 1973). According to Hansen, (1973), a statistical study that was performed over a period of 50 years showed that awareness of the effects of sub-standard practices resulted in a decreased frequency of accidents. The majority of mine health and safety authorities around the world agree that the major causes of mine accidents and fatalities are unsafe conditions, poor management, and especially unsafe practices, which according to the SME, is often cited as the primary cause (Society for Mining, Metallurgy and Exploration, 2011).

Due to a combination of sub-standard practices and hazardous conditions, one must consider not only the physical causes of sub-standard practices, but also elements such as training of employees, the mental state of employees, and employee behaviour (American Institute of Mining, Metallurgical and Petroleum Engineers, 1973)

The major shortcoming of most of the approaches used to identify the causes of sub-standard practices is that the studies were usually based on hasty investigations, obvious physical factors, and common causes of sub-standard acts while neglecting the psychological, cultural, and behavioural drivers.

Poor human behaviour, however, is a known detrimental factor in mine safety. This is evident from the cyclical recurrence of repeat accidents. The key shortcoming of considering only incident and accident frequency rates as the focus of safety performance is that it neglects the root causes of the incidents (American Institute of Mining, Metallurgical and Petroleum Engineers Inc., 1973).

The Mine Health and Safety Act (MHSA) aims to enforce health and safety measures and legislation in the South African mining industry (Department of Mineral Resources, 2011). The open question remains whether the implementation of the MHSA was sufficient to create a safety-wise culture in the mining industry.

Published fatality and injury rates often reveal a false picture of what is actually occurring in the mining industry. Deep-level mining unfortunately has associated hazards and risks and requires commitment and adherence to health and safety standards (This is Gold, 2015).

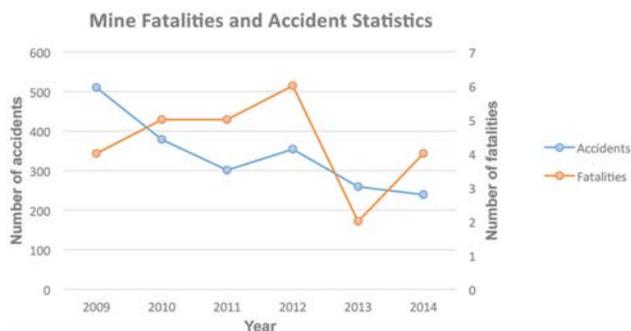


Figure 5—Mine fatalities and accidents, 2009 to 2014

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The published data on mine-related incidents and fatalities (Department of Mineral Resources, 2011) shows that conditions in the underground gold mining environment can be extremely challenging. Since most gold mines in South Africa still use conventional methods (drilling and blasting in narrow-reef stopes) it remains a highly labour-intensive industry.

The CSIR (2013) conducted a study to develop an accident investigation tool that can be used to determine the root causes of incidents and which provides better insight into the systematic factors that eventually led to the occurrence of the incident.

The CSIR was of the opinion that the injured person is not the sole cause of the accident, but that a series of events leads to such occurrences, and that supervisory and managerial aspects also contribute either directly or indirectly to such events (CSIR, 2013).

It is important to determine the human error aspect of an accident as well as the path that led to its occurrence (Society for Mining, Metallurgy and Exploration, 2011).

It must be realized that the majority of incidents generally result from at least one act and one condition. However, the majority of mine-related accidents are caused by more than one condition or act. If this is not taken into account, the opportunity to determine the real root cause(s) of the incident is lost.

An integrated diagnostic review of cultural transformation was performed at the West Wits gold mines in 2012. The purpose of the study was to determine employee attitudes and behaviour within the company and the factors that resulted in a certain attitude or behaviour (Gold Fields, 2012).

The study employed a number of different analysis tools in order to identify all the cultural issues and to ensure that all the levels of employment within the organization were covered.

An accident or fatality is usually the outcome of a number of sub-standard practices that ultimately led to the event. The probability of occurrence of the unwanted event (accident or injury) and its severity are increased by sub-standard practices. As the number of sub-standard practices increases, the probability of accidents, as well as their severity, also increases.

It is therefore important to look at accident causation theories in order to link the current situation in the South African gold mining industry to sub-standard practices and their causes.

A review of the available literature shows clearly that all accident causation theories have a number of common goals, namely:

- Identifying risks
- Identifying influencing factors
- Attempting to explain why the accident occurred
- Identifying the root causes of the accident
- Using the above knowledge to predict and prevent accidents.

The majority of authors, (*e.g.* Gutierrez, 2010; Mol, 2002; Raouf, 2011; Saari, n.d.) agree that there are several theories of accident causation, and that a single theory is often not enough to establish the true cause of the incident.

The different accident causation models often show conflicting perspectives when it comes to establishing the cause of the incident. It is important to understand that there is no single accident causation theory that is applicable to the mining industry, universally speaking. Some models, however, enjoy preference due to their simplicity and perspective on what ultimately led to the accident. (Raouf, 2011)

The theories that were investigated included:

- The Domino Theory
- Multiple Causation Theory
- The Swiss Cheese Model
- The Risk Homeostasis Theory
- Bird and Germain's Loss Causation Theory.

Research has found (De Villiers, 2009) that many individuals occupy job positions in which they are extremely unhappy. This was also the case with regard to the working environment. The associated problem lies in this: it results in negative implications not only for the individual, but also for the working environment and fellow workers.

The Shadowmatch system was developed to prevent the above-mentioned scenario by allocating individuals to environments that best suit them in order to preserve harmony between the individual and the environment. The Shadowmatch system can also be used to identify employees that best suit a specific working environment and specific job. The system possesses the capability to provide personal development programmes for individuals that require specific habits in order to be successful in their occupation (De Villiers, 2009).

This process is completed by comparing the habits of the individual concerned to the habits of employees who are deemed successful, based on the performance management system of the company, in performing a specific task within the organization

The Shadowmatch research team identified a number of aspects that ultimately define the work environment (a detailed description of each can be found in the Shadowmatch e-book available at [www.shadowmatch.com](http://www.shadowmatch.com)):

- Physical environment
- Social environment
- Emotional environment
- Operational environment.

Behaviour, being a complex field of study, can be motivated by more than one motivator, and a number of motivators may be present within a single one. Most people are uncertain of why they behave the way they do (De Villiers, 2009).

### Results

#### Personal interviews

It was found that when employees were interviewed in their specific working environment, their opinions differed greatly from when interviewed on surface. It was therefore decided to conduct all interviews in the appropriate underground working environment.

Based on the personal interviews with employees at the mine and the results of the 2012 cultural survey executed by

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Mandala Consulting, (2012), it came to light that accidents and fatalities are in the majority of cases not caused by a single event.

A total of 135 employees were interviewed during the investigation. The focus of the study was mainly on underground production personnel. The majority of the duration of the study was spent in the stopes, thus the greatest pool of information was obtained from rock-drill operators, winch drivers, team leaders, miners, and shift bosses. The previous general manager at the mine stressed that the area of concern with regard to sub-standard practices and unsafe acts was the production personnel at the mine. Figure 6 shows the distribution of employees interviewed by occupation.

The mode of the age categories was 46–55 years. The greater amount of employees interviewed were from the higher age categories, and the majority were from the morning shift. Only six employees interviewed were working the night shift.

The final parameter was the number of years' experience of employees. This is one of the most important parameters, since it is generally believed that the more experience an employee has, the less likely they are to perform an unsafe act or be involved in an accident. Table I shows that the largest category of employees that were interviewed had between 6 and 15 years' experience in the mining industry.

The behaviour of employees during interviews raised concerns in terms of the findings: if employees were too scared to disclose their occupation, how accurate and honest is the information that they have provided in the questionnaires and during personal interviews?

Honesty and fear of losing employment seemed to be a major problem at the mine. Employees were found to be extremely anxious to voice their opinions while in the presence of their colleagues. On other occasions, some of the 'new ones' (as new employees are referred to underground) were often silenced by the elder employees when an interview was conducted.

The interviewees' behaviour during interviews also opens a window for speculation that employees are hiding certain things from management as well as their supervisors. It raises the question of complete honesty – some interviewees might have lied and others were maybe too scared to answer the questions honestly. One can thus not conclude that the results of this study are absolutely complete and accurate, due to the external influencing factors in the working environment and observed differential behaviour.

Despite the occasional behavioural patterns and trust issues, it was possible to determine trends. From the data-set of interviewees it is clear that a greater number of older employees were interviewed (Table I). The data showed no correlation between age, years of experience, and the execution of sub-standard acts, which could indicate one of two possible situations:

- The mine currently has a large number of young employees who do not have many years' experience in the mining industry
- Older people have been appointed in certain occupations without a great amount of previous mining experience.

Both of these situations could have influenced the findings. After discussion with a psychologist specializing in public health, it was established that in the mining industry, the following behaviour patterns are expected with regard to age and years' experience in the mining environment (van Zyl, 2015):

- Younger employees are more likely to exhibit risk-taking behaviour such as engaging in sub-standard practices, due to the nature of younger persons' thought patterns
- Older employees are the least likely to exhibit risk-taking behaviour due to thought patterns commonly associated with age, such as being more careful in the work environment
- The less experience an employee has, the more likely they would be to engage in sub-standard practices, since they have no recollection of previously encountered dangerous situations or loss of life
- Conversely, older employees are seen as the more responsible in terms of implementing standards as opposed to risk-taking behaviour. They are more likely to be focused on issues such as health, job security, and avoiding danger.

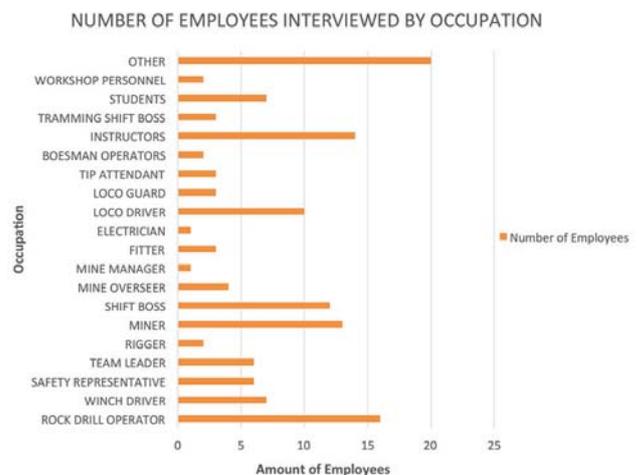


Figure 6—Distribution of employees interviewed by occupation

Table I

### Number of employees by years' experience in the mining industry

Years of experience	Number of employees
Less than 3	13
3-5	17
6-10	38
11-15	31
16-20	18
21-25	13
26-30	4
31-35	1
More than 35	0
Overall total	135

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There are, however, a great number of factors that could influence any employee, irrespective of age category and level of experience. These factors include mental health, job satisfaction, remuneration, stress, and education, to mention just a few.

In order to establish and analyse certain trends in employee behaviour with regard to sub-standard practices, some of the questions in the questionnaire were grouped together in order to analyse them for similarities and conflicting answers.

### Discussion of interview results

One group of questions dealt with whether employees had encountered sub-standard practices, and the other group dealt with whether employees understood what standards were and the necessity for them.

More than 80% of the interviewees indicated that they were aware of sub-standard practices in the workplace. This might show that employees were very aware of what sub-standard practices meant in terms of their occupations.

More than 91% of employees that were interviewed felt that they were trained to understand why standards were required and needed to be upheld. The result is somewhat contradictory, since personal experience and discussions with management indicated that employees often do not understand the implementation of standards.

It was found that 89% of the interviewees had a good understanding of standards and their importance. The correlation between understanding standards and implementation is that if employees understand what standards are and why they are important in the working environment, they should also be able to identify sub-standard practices without difficulty.

The 22% of employees that said they were not aware of any sub-standard practices could have felt this way due to:

- Fear of losing their job
- Not understanding the questions
- Not understanding what the standards at the mine are

A fairly high percentage (11%) of the interviewees were of the opinion that they were not adequately trained in understanding the standards. This shows a strong feeling among employees that a lack of training and education on standards is a root cause of sub-standard practices. It is clear that an employee who does not understand a standard would be highly likely to implement the standard incorrectly, not be able to identify sub-standard practices due to a lack of understanding of the standard itself.

14% of the interviewees claimed that they did not understand the consequences of sub-standard practices. During the interviews, a number of employees often apportioned blame on the 'new ones' for performing sub-standard acts. The problem here might lie in lack of underground experience. The majority of interviewees were concerned about the consequences of sub-standard acts since they had experienced consequences themselves, witnessed them, or heard accounts of serious injuries from colleagues.

Although 86% of employees claimed to understand the consequences of sub-standard practices, a shocking 46% of them were still prepared to perform sub-standard acts if the opportunity was presented.

These results prompt the question as to why would employees be willing to take the risk of incurring a loss, if they understood the probability and severity of the loss? The answer lies in the behaviour and mind-set of underground production personnel.

Supervisory skills seemed to be lacking in the majority of workplaces that were visited. Due to a lack of respect and no fixed structure of authority, there was no control over employees' behaviour. It was also found that teamwork skills were not favoured underground. Every employee had the mind-set of 'I'm here only to do my job'. Sub-standard practices were therefore closely related with communication gaps, lack of teamwork, and apportioning blame to younger employees, instead of accepting fault.

It was found that approximately 56% of employees, at some point in their careers, had performed sub-standard work and approximately 33% of employees also instructed other employees to do so.

Most of the employees who were interviewed encountered some form of sub-standard practice on a weekly basis. Surprisingly, some employees felt that they encountered sub-standard practices only on a yearly basis, which is hard to believe based on the author's personal experience at the mine.

Figure 7 shows that 39% of employees said that their work was always up to standard, while only 5% said that their work was completely sub-standard. This is, however, a misleading result according to personal investigation. If the majority of employees feel that their work is always up to standard, then why is there a problem with sub-standard practices?

According to the results, the sub-standard acts that were encountered varied widely, with some types of sub-standard practices mentioned more frequently than others. The general types of sub-standard work that were encountered included, but were not limited to, the following:

- Incorrect procedures when entering and exiting man carriages
- Incorrect tramming procedures (speeding, leaving locos running without an operator inside, attaching too many hoppers *etc.*)
- T-sprags almost never in place and ventilation doors always open, since it interferes with tramming according to loco guards
- Unequipped travelling ways (no steps, footwall not cleaned, no handrails or rope guides, sometimes not sufficient support)

DISTRIBUTION OF SUB-STANDARD WORK RATING

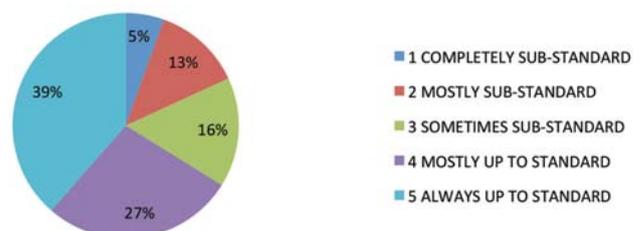


Figure 7—Sub-standard work ratings

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- Incorrect explosive storage, transport, and handling procedures
- Incorrect rigging practices
- No supervision

The abovementioned examples of sub-standard acts, procedures, and installation are but a few compared to the great number of sub-standard practices that were encountered during the investigation.

Employees' reasons for performing sub-standard work or instructing someone else to do so indicated clearly that engagement in sub-standard practices is a behaviour-based issue. The majority of employees showed an inclination towards taking matters into their own hands when events did not go according to their personal plan. It was observed that everyone wanted to be leaders, and seldom followers, even when it was necessary.

Many experienced employees were extremely set on respect. If they felt that they were not respected, they would not assist in the task or deliberately work slowly in order to annoy the person who had assumed seniority in the situation. A lack of 'soft' skills is definitely a major cause of sub-standard practices. Teamwork is essential in the mining industry and interpersonal skills are vital; this is an area that employees at the mine need to be trained in.

Ignorance was found to be a major driving force behind sub-standard acts. Employees believed that because they have never been involved in an accident, it will never happen to them. They have been involved in sub-standard acts for so long that they are now accepting them as the norm. It was clear that revenge also played a major role in sub-standard procedures and acts. The belief amongst interviewees was that if a colleague has done them wrong, he must pay for it. Sub-standard acts are often the result of payback to try and regain status by being rebellious.

The results confirmed that production supervisors were often seen as lead agents by not adhering to safe practices as they have instructed to their gangs to do. This behaviour results in a shared anger by production personnel, which engenders a less motivated work culture. Employees feel that they can do as they please, since production supervisors do not care.

Although one might not have expected the physical location and working conditions of stopes to be a leading factor driving sub-standard practices, the results clearly showed the opposite.

Many employees complained about the travel distances on foot in order to reach the workplace early enough so that there was still adequate time available for completing mining activities. Associated fatigue resulted in employees performing work that was of poor quality, as they claimed a lack of energy to perform the tasks correctly.

Other employees were of the opinion that they did not have the correct tools to perform the given tasks to standard. A combination of fatigue, incorrect tools, and limited time resulted in sub-standard acts.

The responses to a question on what employees felt had to be done to remedy the problem showed a number of general ideas to remedy sub-standard practices. The suggested actions to take control of the situation can be summarized as follows:

- Improve training
- Reward implementation of standards
- Address mental wellbeing of employees
- Address attitude-related issues
- Provide education on standards and their importance

A factor that stood out was that employees at the mine seemed to lack motivation in performing their jobs. They want to feel part of something larger than themselves and be rewarded for performing a good job.

The level of education of employees influences the training methods to a great extent. Interviewees felt that on-the-job training in the underground environment would be more suited to their level of education than theoretical training in a training centre. The general feeling was that there is a major difference between executing tasks in the training centre and executing the same task a few hundred metres underground.

Great variation in the origin of sub-standard practices was observed. Some employees believe that this is more of a psychological and behavioural problem, while others tend to blame management and direct supervisors for the issue.

The investigation at the mine indicated a number of potential issues that can be further investigated to determine the root causes of sub-standard acts and their effects on safety. Perhaps the most interesting question yet to be answered is if sub-standard acts are largely a result of human behaviour and individual mentality. This question will be addressed in the analysis of the results from the Shadowmatch survey.

### Comparison between West Wits cultural transformation and this study

A number of responses to questions in the gold mine study revealed that employees were often just there to get the job done, not willing to go the extra mile with regard to their job descriptions, lacked a feeling of corporate ownership, and often did not take control of conflict situations.

The cultural transformation study at the West Wits gold mines yielded the same results. About a quarter of the employees that took part in the study were not interested in doing more than what was expected of them. About 70% of employees did not want to take control of situations that resulted in conflict. This showed that conflict resolution skills were lacking with most employees.

It was found that employees that took part in the cultural study at West Wits also did not feel competent to perform all work tasks all of the time. The results also showed that adaptability, tenacity, and resilience were often a problem for employees. These findings strongly agree with the results obtained at the study mine.

The results indicated a strong similarity in the safety culture at the study mine and in the West Wits mines. Employees did not understand the safety vision clearly and did not always follow standard procedures. It can therefore be postulated that employees in the gold sector show a general disregard for safety and standards in the underground working environment.

Acceptance of teamwork as an inevitable factor in mining and safety showed exactly the same trend at the West Wits gold mines and the study mine. Almost half of the employees

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believed that interdependence during teamwork played no role in the quality of work and relationships. Employees preferred working individually, although this is almost impossible in the production environment.

When performing teamwork, employees had great difficulty in trusting each other. This was the case at both the study mine and in the West Wits study. However, trust was not the only underlying issue. Many employees also felt that they were not fully equipped for performing teamwork and that they were often not informed on their specific role within the team.

From the results obtained in the West Wits study, it was evident that the study mine was not the only operation that indicated quality of supervision as a major problem. It was shown that employees did not possess proper supervisory skills, nor did the supervisors themselves. A lack of on-the-job coaching, lack of motivation and acknowledgement, and relationships with supervisors again came up as causes of sub-standard practices.

The studies performed at the study mine and the West Wits study showed that there were almost no differences in the cultures with regard to safety and sub-standard practices. In fact, most of the influencing factors that were investigated were similar, and it can be concluded that the findings may be applicable to the entire gold mining industry of South Africa.

### Results of the Shadowmatch survey

A total of 88 shift bosses were selected by senior management of the company to participate in the Shadowmatch survey. Included in this number was a benchmark study group of 10 shift bosses, who were selected based on their performance in terms of safety and production. The purpose of the benchmark group was to determine the habits exhibited by successful shift bosses and enable the profiles of the other shift bosses to be compared with those of the benchmark group. This was done to determine poor habits that may result in sub-standard practices and a poor safety record.

The majority of participants were day-shift stoping shift bosses. The day-shift vamping shift bosses were the smallest group within the data-set.

### Benchmark group analysis

The Shadowmatch results that were obtained from the benchmark group showing the most embedded or critical habits exhibited by successful shift bosses, were identified and are listed below:

1. Team inclination
2. Conflict handling
3. Discipline
4. Resilience
5. Altruism

These critical habits correlate well with the problematic areas identified at the mine, indicating that the study delivered accurate results with regard to the identification of the root causes of sub-standard practices.

The benchmark group showed relatively low scores in the following habits:

1. Individual inclination
2. Innovation
3. Propensity to delegate
4. Propensity to change

Successful shift bosses definitely preferred to work in teams, as indicated by the low score for individual inclination.

Based on the results obtained from the behavioural study performed at the mine, it was anticipated that employees would obtain a low score for innovation in a Shadowmatch survey. The reason behind this is that employees showed a strong inclination towards performing tasks the way they were used to, and not to embrace new technology or innovative solutions to problems. The group showed a thinking style opposite to an out-of-the-box thinking style. As mentioned previously, this type of behaviour could hamper safety performance due to the fact that new ways of performing tasks were often deemed as additional work or unnecessary change.

The score for propensity to delegate is lower than that for propensity to own. The benchmark group of shift bosses showed that they preferred to take ownership of problems and handle challenges themselves as opposed to getting another individual to deal with the problem. This habit, in the opinion of the author, should actually be much more prevalent, since it reflects the shift bosses' ability to take control of a situation.

The Shadowmatch results with regard to propensity to change confirmed the findings from the study mine as well as the West Wits study. In both of the studies, shift bosses found it difficult to adapt to change in their working environment. They were not comfortable with new methods of performing work, new environments, and new technologies.

### Attitude analysis

The Shadowmatch attitude analysis delivered results that strongly correspond to the critical habits that were identified within the benchmark group. The majority of participants in the benchmark group formed part of categories 1 and 2, while equal numbers of participants formed part of category 3 and 4. The significance of the attitude distribution is as follows:

- Categories 1 and 2 exhibit a shared habit of involvement.
- Categories 2 and 3 share habits of assertiveness and, sometimes, unaggressive behaviour.
- Categories 3 and 4 exhibit a habit of less involvement or complete uninvolved attitude.
- Categories 1 and 4 represent a shared attitude of unaggressive behaviour

Figure 8 shows the attitude distribution of the benchmark group.

As shown in Figure 8, the benchmark group displays a strong attitude of involved, unaggressive behaviour. This group showed positive involvement in their work environment. They found it easy to get involved and this formed part of their natural behaviour. The group thus showed positivity when working with people and exhibited optimism.

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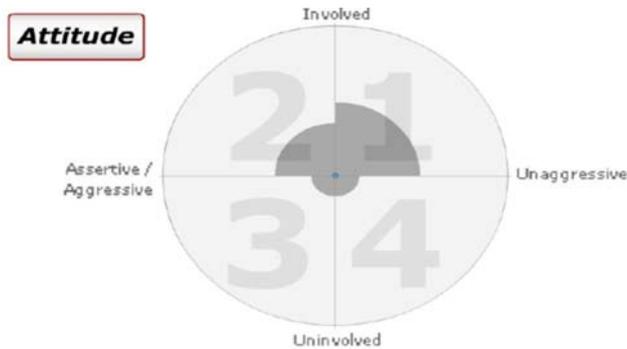


Figure 8—Attitude distribution of the benchmark group

The attitude is associated with altruism since the group proved to be unconditional in their actions and willing to make the necessary sacrifices to achieve a greater goal. Importantly, the benchmark group may be seen as materialistic, but emphasizing the value of all life. The way they perform work is not to serve others, but to drive a certain principle.

With regards to conflict handling, the benchmark group resolved conflict in a mature way without feeling compelled to become aggressive. This type of attitude does not seek revenge or personal gain.

### Comparison between benchmark group and study group results

The purpose of the comparison was to establish any differences and correlations between the habits and behaviours exhibited by the two groups.

It was decided to compare the 'worst' and 'best' performers in terms of the Shadowmatch study to the data obtained from the benchmark group in order to determine any similarities or differences.

First, the results of the best and worst performers were compared to the results of the benchmark group. The best performer's scores with regards to the critical habits showed a high correlation with the scores of the benchmark group. The comparison of the scores is shown in Table II.

The worst performer scored significantly lower in all the critical habits of the benchmark group. This individual had a high likelihood of being extremely problematic in the working environment due to his/her habits.

The best performer showed significantly stronger habits than the benchmark group in conflict handling, discipline, and altruism. For this specific individual, it could be said that these three habits are ultimately the drivers behind success. The worst performer scored higher than the benchmark group in only two habits, namely propensity to delegate and individual inclination. However, it is necessary to discuss the possible reasons for these two higher scores. Propensity to delegate is almost self-explanatory. This individual's critical habits showed very low scores. It may be speculated that he/she would be the type of person who is not involved at all, has no confidence in what he does, showed no altruism, and prefers to give the task at hand to someone else to complete.

The attitude scores in the results of the best performer are of particular interest. Although there is a strong correlation with the benchmark group in category 1 and 2 attitudes, the individual showed a significantly stronger category 4 attitude than the benchmark group. As opposed to the best performer, the worst performer showed strong category 2 and 3 attitudes and a low category 1 attitude.

The recommended personal development programme (PDP) for the worst performer was problem-solving. As described earlier, the fact that this individual has none of the critical habits of the benchmark group indicates that he/she would be likely to see all aspects of the job as a major challenge.

A number of different PDPs were recommended for the study group, based on the habits that were determined as critical habits of the benchmark group. The recommended PDP addresses the habit that needs development.

Based on the results of the benchmark group, the Shadowmatch system recommended the following PDPs for shift bosses that were not part of the benchmark group (ranked in terms of number of recommendations from high to low):

1. Handling frustration
2. Routine
3. Problem solving
4. Propensity to delegate
5. Individual inclination
6. Team inclination

Table II

### Comparison between critical habit scores of benchmark group and the best and worst performing individuals

Habit	Benchmark	Best performer	Worst performer
Team inclination	63	61	46
Conflict handling	59	67	38
Discipline	58	65	39
Resilience	57	57	32
Altruism	57	64	43

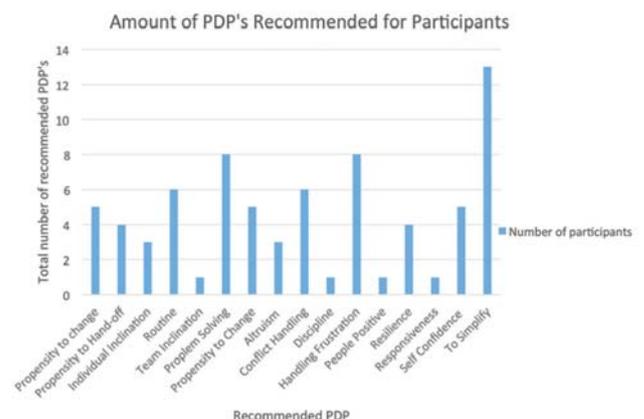


Figure 9 – Number of different PDPs recommended for the study group

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Again, the set of PDPs that were recommended by the system fits the results obtained from the study mine and the cultural study extremely well. It further emphasizes the habits and behavioural patterns that were identified that could lead to sub-standard practices in the working environment with adverse effects on safety.

Figure 9 shows the different PDPs that were recommended for the study group as well as the number of each recommended PDP. It is clear from the figure that the habit of being able to simplify problems is a major concern. This habit is closely related to the habit of problem-solving which was recommended for eight individuals. Frustration handling is the third habit that requires intervention. The underground working environment is full of challenges and definitely requires a radical habit of frustration handling.

### Conclusion

Sub-standard practices and their adverse effects on safety remains a challenge in the South African gold mining industry. Although a number of previous efforts have been made to determine the root causes of sub-standard practices, the results were inconclusive or addressed the same technical issues that have long been present in the mining industry.

The origin of sub-standard practices in the underground working environment was found to be in the habits, attitudes, and behaviour of employees. However, it is important to realize that habits and attitude are not fixed characteristics like personality. Habits and attitude can be changed and developed with the correct instruments.

The research described in this paper (the study performed at a gold mine in the Free State, the cultural survey conducted at West Wits, and the Shadowmatch survey) all highlighted correlating causes of sub-standard practices which had their roots in the habits and behaviour of employees. The absence of certain radical habits (such as team inclination, conflict handling, leadership, altruism, discipline, and resilience) for a specific working environment and a specific job title (in this case underground production employees with the focus on shift bosses) could be the primary reason behind sub-standard practices.

Aspects such as a lack of education, inappropriate on-the-job training, and shortcomings in managerial style were found to increase the occurrence of sub-standard practices, which in turn had adverse effects on the safety culture at the gold mine.

The problem extends beyond a specific section at one mine or a specific shaft, and is most likely an industry-wide issue that needs to be addressed. The best solution would be to determine whether the habits and attitude of an individual are suited for a specific job position and working environment before employing that person. This would avoid the need for subsequent remedial action on sub-standard practices.

However, there is no single solution that would alleviate the current problem. In order to address the different aspects of the problem, a number of solutions such as a Shadowmatch survey, improved training, basic education, revision of risk control programs, are suggested.

Finally, the gold mining environment in South Africa poses some of the most extreme challenges with regards to working conditions. Looking forward, it would be impossible

to improve on the current situation if the necessary habits such as propensity to change, simplification of problems, self-motivation, and team inclination are not addressed.

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