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ASSESSMENT OF SAFETY MANAGEMENT PRACTICES AT ANKONAM BOAFO MINE

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Abstract: Safety management practices are of profound concern in the mining industry as workers can not give out their best when their working environment is not safe. Mining companies adopt a variety of practices to avert conditions which have the potential to adversely affect the health and safety of workers. This paper assesses the safety management practices at Ankonam Boafo Mine. The safety performance in the years 2010 and 2011 were analysed to determine how effective the safety management practices adopted at the mine have been. The results show that the mine has not been very successful since there are instances where set targets of safety performance are exceeded. Infrequent safety auditing causes workers to be off guard and lose safety consciousness with time, leading to poor adherence to stipulated safety management practices. Thus, it is necessary that safety management practices are regularly and effectively reviewed and the necessary adjustments done for higher safety performance in subsequent years. Frequent and unannounced safety auditing would keep workers on their toes, and this will enhance strict compliance to safety policies for enhanced safety record.
Keywords: Safety management, health, hazard, injury, risk.

1 Introduction

Occupational health and safety (OHS) issues are very important in the mining industry as workers can not give out their best when their working environment is not safe. Consequently, production targets can not be met. Various mining companies adopt a variety of practices to avert conditions which have the potential to adversely affect the health and safety of workers.

Ankonam Boafo Mine (ABM), which is an underground mine, recognises the potential threats to the health of workers as exposure to toxic gases, dust, excessive heat and humidity, noise and vibration problems, and oxygen deficient atmospheres. In addition, the mine also recognises the potential sources of threats to workers' safety as falls of roof, face, rib or side, haulage or other machinery, explosives, ignitions of gases and dust, sudden inundations of water and gas, and mine fires.

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Safety management practices include those measures carried out by both personnel and management to safeguard the lives and properties of an establishment. These measures tend to avert injuries, damage and losses. Failure to comply to these measures mostly results in injuries, death and permanent disabilities of workers. Management of ABM has, therefore, put in place such measures to ensure safe working conditions. This work assesses the various strategies and measures ABM has adopted to ensure that workers operate in a safe and healthy atmosphere.

1.1 General Information about the Mine

ABM is a large scale gold mine which has combined proven and probable ore reserves of 79 million ounces as at 31st December, 2004 (Ayensu, 1997). The concession is in a tropical rain forest region that is characterised by long rainy periods peaking between June and July, averaging 178.5 mm. This is followed by brief periods of dryness with occasional rains from September to November. The region is associated with moderate average temperatures ranging from 25 ºC to 35 ºC.

1.2 Geological Information on the Mine

Ankonam Boafo Mine is located on the Ashanti belt which stretches from Axim to beyond Konongo in the Ashanti Region. It is part of a prominent belt of Precambrian volcano-sedimentary and igneous rocks, which extend for a distance of about 250 km long and 40 km wide, in a north-east, south-west trend. The belt consists of the Lower Birimian, the Tarkwaian and the Upper Birimian formations, which occupy the south-eastern portion of the mine. A notable feature about this portion of the belt is that the synclinal Tarkwaian rocks unconformably overlie the Birimian which is intruded by granitoids, with superficial deposits covering it (Kesse, 1985).

There are three major mineralised trends in the concession from which gold is produced. These are the Main, Gyabunsu and Binsere Trends. The zone between the Upper and the Lower Birimian constitute the Main Trend which is made up of the Obuasi fissure, the Cote d'Or shear, the Main reef and other minor shears such as the Ashanti and the 12/74 shears. The Obuasi fissure dips about 65º to a depth of about 165 m towards the west and stretches over 8 km. The Côte d'Or shear has a flatter dip relative to the Obuasi fissure and occurs to the west. In the central portion of the mine, the two shears join at about 1 300 m depth and it is predominantly quartz with massive graphitic associations. The combined Obuasi fissure and the Cote d'Or shear constitute the Main Reef (Bell and Little, 1991). Five main ore types that can be identified in the ABM concession are quartz veins, sulphide ore, transition ore, oxide ore and primary ore (Amanor and Gyapong, 1989).

1.3 Mine Operations

Mining operations have been going on for several years. ABM's annual production rate increased from 4 500 tonnes over the years to 880 000 tonnes in the early 1980s. In recent years, the tonnage from the underground operations has increased tremendously from 1.14 million tonnes per annum in 1994 to 2.5 million tonnes per annum in 2001 but fell to 2.2 million tonnes in 2005. Average grades, however, dropped from 10.5 g/t to 7.90 g/t over the period. Currently, the mining methods employed across the mine include mechanised open stoping (accounting for 60% of total mine ore production), mechanised cut and fill stoping (10%), sublevel retreat and reclamation (12%) and stope preparation (18%).

1.4 Materials Handling and Ore Treatment Methods

Materials handling at the mine is by both horizontal and vertical transport systems. Haulage of ore at ABM is by load haul dump (LHD) machines and dump trucks, rail transport using locomotives, and belt conveyors. Handling of ore from underground is through raises and shafts. At the Ferguson Shaft (FS), ore and waste materials from the stopes and development ends are cleaned and dumped into their respective labelled raises by means of LHDs and dump trucks. Ore collected in these orepasses is further transported by means of trolley locomotives to a main pass which is linked to the shaft. On reaching surface, the material is discharged onto a 150 m long conveyor belt which sends the material into a 1 000 tonnes capacity bin. Dump trucks then load the material from this bin to the ore treatment plant for processing.

There are two main treatment plants at ABM (*i.e.* the Sulphide and the Biological Oxidation Treatment Plants). The Sulphide Treatment Plant treats sulphide/transition ore from the open pit and underground mining operations while the biological oxidation process employs bacteria to effect enzymatic and chemical changes on sulphide minerals, concentrated from the flotation process. The bacterial action oxidizes the mineral and renders it amenable to conventional cyanide leaching and carbon adsorption. Ore treatment essentially involves crushing, milling, gravity recovery, flotation, biological oxidation (Biox), leaching with cyanide, carbon adsorption, desorption, electro winning and smelting.

2 Materials and Methods Used

Injury records for the years 2010 and 2011 were obtained from ABM. They covered the following injury categories: dressing case injuries (DCI), lost time injuries (LTI), serious injuries (SI), and fatal injuries (FI). Using the Microsoft Office Excel spreadsheet, these records were used in analysing safety performance over the aforementioned years. This was essential in determining how effective the safety management practices adopted at the mine have been.

Literature on occupational health and safety was reviewed with emphasis on objectives and general management. The various safety management practices adopted at ABM were also reviewed.

2.1 Occupational Health and Safety

Occupational health and safety (OHS) is concerned with the promotion and maintenance of the physical, mental and social well-being of workers. All OHS programmes aim at fostering safe and healthy work environments. Beyond the primary role of seeking the safety, health and welfare of workers, OHS also involves programmes for the protection of nearby communities and other members of the public who are impacted by the workplace environment (Anon., 2012a).

Occupational injuries are classified into various categories depending on the level of severity; working days or hours lost; losses in human lives and damage to equipment etc. The general categories of injuries include Dressing Case Injury (DCI), Lost Time Injury (LTI), Serious Injury (SI) and Fatal Injury (FI) (Darby, 2003).

2.2 Objectives of Occupational Health and Safety Policies

The main objectives of OHS policies are maintenance and promotion of workers' health and working capacity; improvement of working environment to make it conducive to safety and health; and development of work organisations and working cultures in a direction which supports health and safety at work (Anon., 2012a). The need for good health and safety practices can be attributed to many reasons. However, the adoption of such practices is primarily based on moral, economic and legal values.

While it is morally unacceptable for management to put the health and safety of workers at risk, as evidenced by society's attitude to moral obligations, the direct and indirect costs associated with incidents and/or unhealthy workplaces, and their impacts on the organisation are as well enough reasons to make the organisation instil effective health and safety policies. The preventive, punitive and compensatory effects of the law also ensure that mining companies adhere to the provision of OHS management systems (Anon., 2012a).

2.3 General Management of Occupational Health and Safety

Facility-specific OHS hazards have to be identified based on job safety analysis or comprehensive hazard or risk assessment using established methodologies such as a Hazard Identification Study (HAZID), Hazard and Operability Study (HAZOP) or a Quantitative Risk Assessment (QRA). As a general approach, health and safety management planning should include the adoption of a systematic and structured approach for prevention and control of physical, chemical, biological and radiological health and safety hazards. OHS issues occur during all phases of the mine cycle and can be classified into general workplace safety, chemical hazard, fires, explosions and oxygen deficient atmospheres, use of explosives, physical hazards, ionizing radiation and noise and vibration (Anon., 2007).

2.4 Safety Management Practices at ABM

ABM realises that OHS issues occur during all stages of the mine's operations. In view of this, the mine has put in place systems that promote the health and safety of workers. These systems are implemented based on internationally recognised standards, and periodic audits are conducted to assess their effectiveness.

2.4.1 Risk Assessment

Risk assessment provides a means of identifying and assessing the level of risk of health and safety hazards. At ABM, identified risks are reduced, or where practical, eliminated. Sources of risks at the mine include falls of ground; underground and surface fires; horizontal and vertical transport; transportation, storage and handling of explosives; flooding of underground workings; and exposure to airborne pollutants and noise above the threshold limit (Anon., 2012b). ABM undertakes three types of risk assessments, namely, baseline, issue-based and continuous risk assessments.

Baseline risk assessment identifies risk exposure and determines a risk value for it. It establishes the risk register (database) for the mine, and serves to offer a pro-active direction for risk management and control. It determines the priorities on each level of the organisation in terms of risk, and also establishes the need for a more detailed risk assessment, where necessary.

Issue-based risk assessment is conducted in response to issues or circumstances that crop up. At other times, issue-based risk assessment is conducted in response to the need for a more detailed risk assessment studies already outlined by the baseline risk assessment.

Continuous risk assessment is conducted as a routine practice to address issues of extreme risk, primarily caused by rapid or continuous change. Being the most important, yet the simplest type of risk assessment, it identifies and assesses the changing level of risk at the mine. It is able to draw immediate attention to hazards of a specific area or equipment, and the necessary action effected within the shortest possible time, and in an appropriate manner. At the ABM mine, supervisors, foremen and senior operators equipped with the essential formal training are in charge of continuous risk assessment (Anon., 2012c).

In general ABM adopts the following steps to ensure that a thorough risk assessment has been carried out:

- Looking out for hazards;
- Deciding who might be harmed and how, and determining who might be particularly at risk;
- Calculating whether there have been enough precautions put in place to counter the hazard;
- Recording findings. This includes a risk assessment check showing that all obvious hazard areas have been dealt with, and that employees who might be affected have been accordingly attended to;
- Reviewing the risk assessment procedures and making revisions where necessary.

2.4.2 Job Safety Analysis

Job safety analysis is effective in identifying, analysing and recording the steps involved in performing a specific job, the existing or potential safety and health hazards associated with each step, and the recommended procedure(s) that will eliminate or reduce these hazards and the risk of a workplace injury or illness.

The primary role of job safety analysis is to focus on job tasks as a way to identify hazards before they occur. It focuses on the relationship between the worker, the task, the tools and the work environment. Ideally, after uncontrolled hazards have been identified, it is required that the necessary steps are taken to eliminate or reduce them to an acceptable risk level (Anon., 2012d). The results of the analysis serve as a valuable tool for training new employees in the steps required to perform their jobs safely.

2.4.3 Planned Task Observation

ABM has in place the necessary techniques for observing critical tasks and determining the degree of compliance with standard operating procedures. The process involves the observation of all steps of a task as it is being carried out to ensure that the procedures are accurate and being followed. The process of planned task observation helps the supervisor to come to a conclusion as to whether a given task could be safely executed by subordinates, or otherwise. Planned task observation is associated with feedback that serves as a tool for positive reinforcement and corrective actions such as further training and modification of job procedures.

2.4.4 Hazard Management

OHS officials in the mine regularly undertake planned workplace inspections to help identify hazards, assessing any risk associated with them and adopting the necessary measures of control and regularly reviewing controls to ensure they remain effective. There are situations where a combination of control measures will need to be used to control hazards and risks. The mine generally adopts a hierarchy of controls. In other words, this is a priority order of control measures ranging from elimination of the hazards and associated risks to providing people with protective equipment. It is better to eliminate the hazard if possible. It is important to note that the lower the level of control implemented, the higher the level of risk accepted (Anon., 2012e).

2.4.5 Toolbox Meetings

At ABM, toolbox meetings are observed before the start of the shift to help the workers know what needs to be done in the course of the shift, why it must be done and how it can safely be executed. Though short in duration, these meetings are very important to management of the mine since they provide workers with clarity on the task that lies ahead (Anon., 2012f).

2.4.6 Safety Committee

Generally, the purpose of a safety committee in an organisation is to identify hazards in the workplace through regular inspections, and make recommendations regarding corrections of the hazards. Furthermore, the safety committee is tasked with a duty to establish procedures for investigating all safety-related incidents.

At ABM, there are health and safety committees in the various sections of the mine. These committees comprise management (40%), as well as union and employee representatives (60%) who meet every month. It is the duty of the representatives to investigate any health and safety deficiencies that are reported to them, as well as assist in investigating and determining the cause of any incidents or near-misses; make periodic inspection tours to assess whether rules are being observed; whether any dangerous conditions exist; to ensure that protective devices and equipment are used when required; and that hazardous areas are properly identified. Findings are reported to supervisors. Monthly inspections are also conducted using a checklist, and the results forwarded for discussion at the safety committee meetings (Anon., 2012b).

2.4.7 Employee Training, Involvement and Awareness

Management of the mine ensures that all new employees and contractors go through a safety induction process before they start work, and those returning from leave are given refresher training. The training programme focuses on workplace hazard identification, how to run a risk assessment on a particular task to be performed, and fall of ground management.

2.4.8 Auditing

Health and safety audits are performed to determine whether health and safety regulations and company policies are being adequately implemented and complied with. They determine the effectiveness of management systems and identify the strengths and opportunities for improvement. A health and safety audit is usually performed using a standardised checklist, and it may have a very specific objective such as reducing the number of injuries or it may be a compliance audit.

ABM implements safety management systems based on internationally recognised standards and assesses their effectiveness through periodic audits. Performance, in terms of safety and health objectives, is measured and the effects on the mine’s operations monitored on a regular basis. The mine is progressing with the implementation of Occupational Health and Safety Assessment Series (OHSAS) 18001 in its operations. The series provides both a framework for identifying business risks associated with safety and health, and guidelines for implementation and achieving certification. The series has international acceptability which facilitates benchmarking.

Internal and external audits are performed alongside ongoing monitoring procedures. For instance, in the course of time, the mine endeavours to perform both ISO 14001 internal and external audits as a form of review and system analysis (Anon., 2012b).

2.5 Safety Performance

While management strives hard to improve the mine’s safety performance every year, the mine has had to deal with varying degrees of injuries in the course of its operations, with greater chunk of injuries being attributed to materials handling and machinery. Injuries recorded at the mine are classified as dressing case injuries, lost time injuries, serious injuries and fatal injuries (Anon., 2012g).

This report captures the monthly safety performance of the mine in 2010 and 2011. Various OHS terms are used in the assessment of the types of injuries. For example, Frequency Rate is a measure of safety performance over a period of time. Mathematically, this is expressed as:

$$\text{Frequency Rate (FR)} = \frac{\text{Number of injuries}}{\text{Manhours}} \times 1\,000\,000 \qquad (1)$$

Also equation (2) is used to calculate the Lost Time Injuries Frequency Rate (LTIFR) for any given month:

$$\text{LTIFR} = \frac{\text{Number of lost time injuries recorded during the month}}{\text{Manhours recorded during the month}} \times 1\,000\,000 \qquad (2)$$

In any given month, the same approach is used to calculate other injury frequency rates such as Dressing Case Injury Frequency Rate (DCIFR), Serious Injury Frequency Rate (SIFR) and Fatal Injury Frequency Rate (FIFR). Figs. 1 to 7 show the monthly safety performance of the mine in 2010 and 2011.

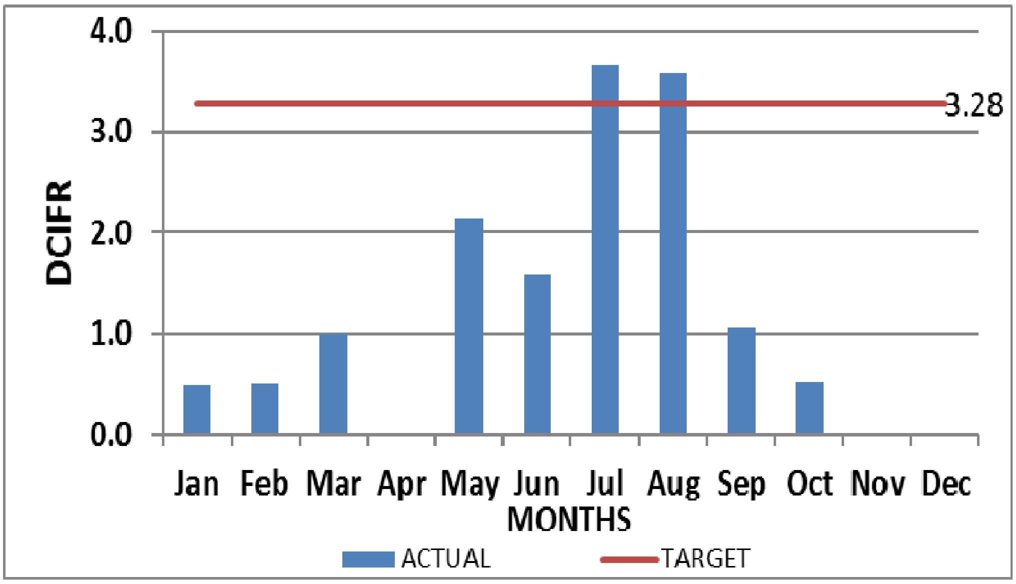

Fig. 1 Monthly Dressing Case Injury Frequency Rates (DCIFR) in 2010 (Source: Anon., 2012g)

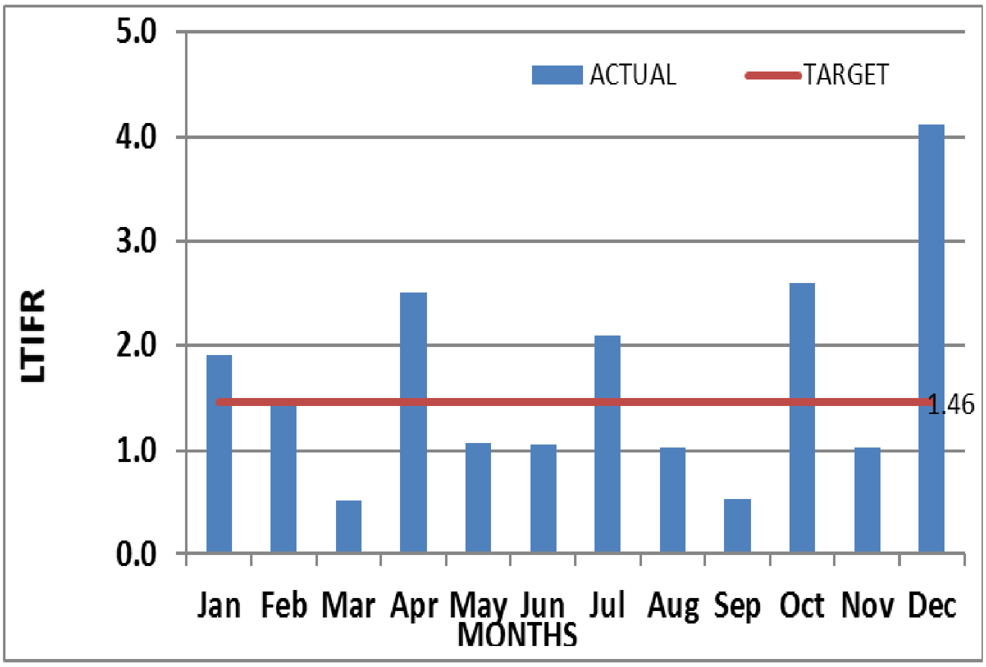

Fig. 2 Monthly Lost Time Injury Frequency Rates (LTIFR) in 2010 (Source: Anon., 2012g)

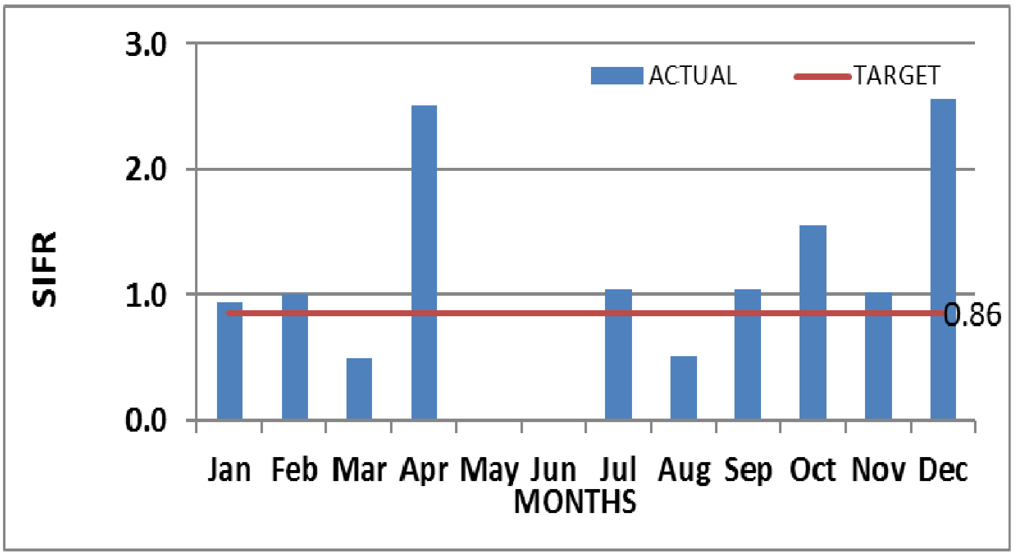

Fig. 3 Monthly Serious Injury Frequency Rates (SIFR) in 2010 (Source: Anon., 2012g)

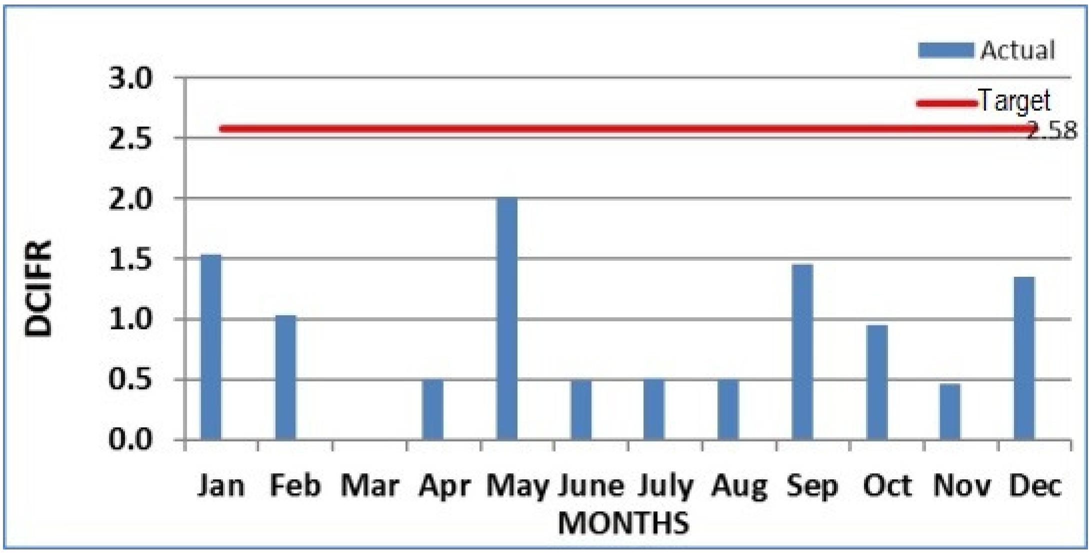

Fig. 4 Monthly Dressing Case Injury Frequency Rates (DCIFR) in 2011 (Source: Anon., 2012g)

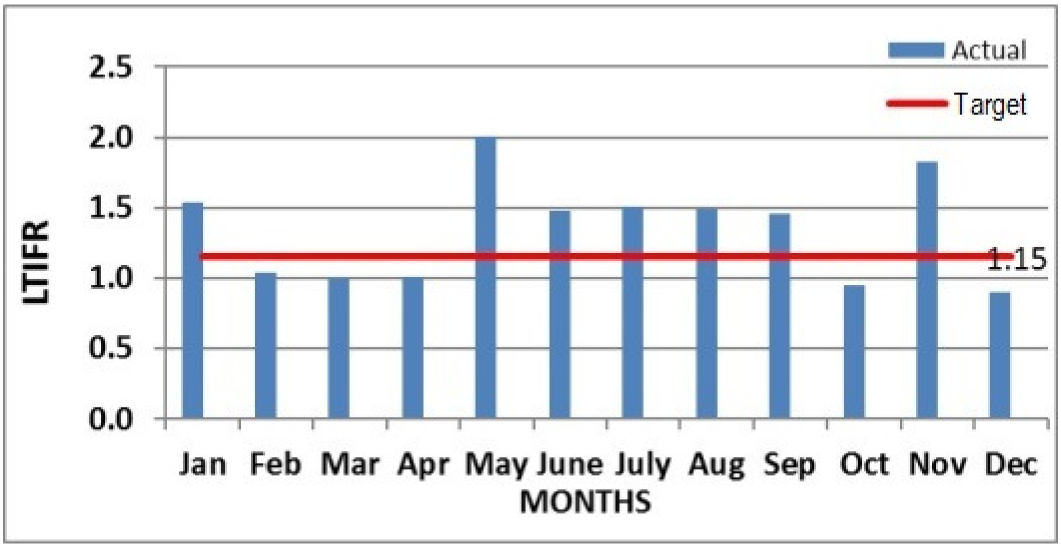

Fig. 5 Monthly Lost Time Injury Frequency Rates (LTIFR) in 2011 (Source Anon., 2012g)

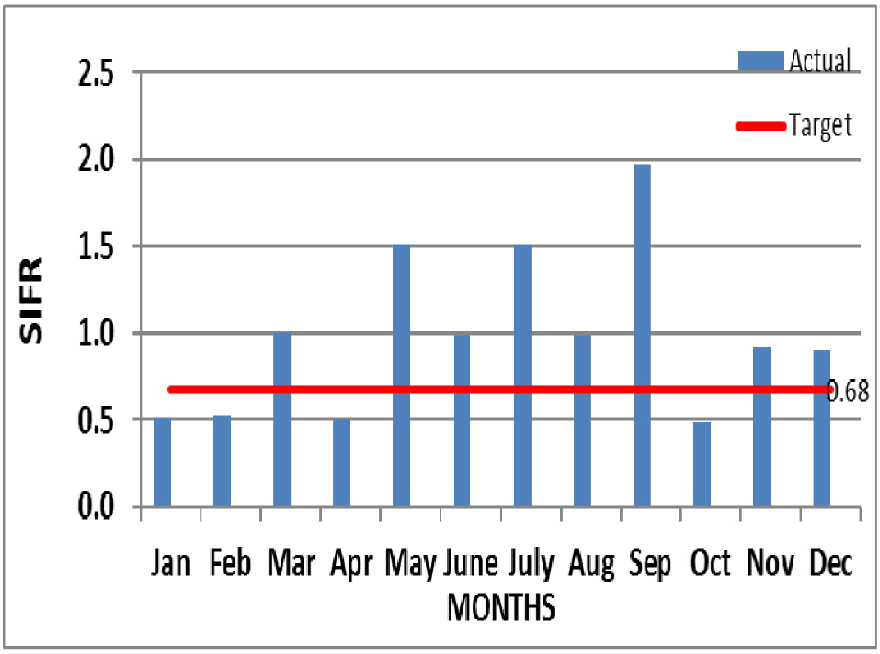

Fig. 6 Monthly Serious Injury Frequency Rates (SIFR) in 2011 (Source: Anon., 2012g)

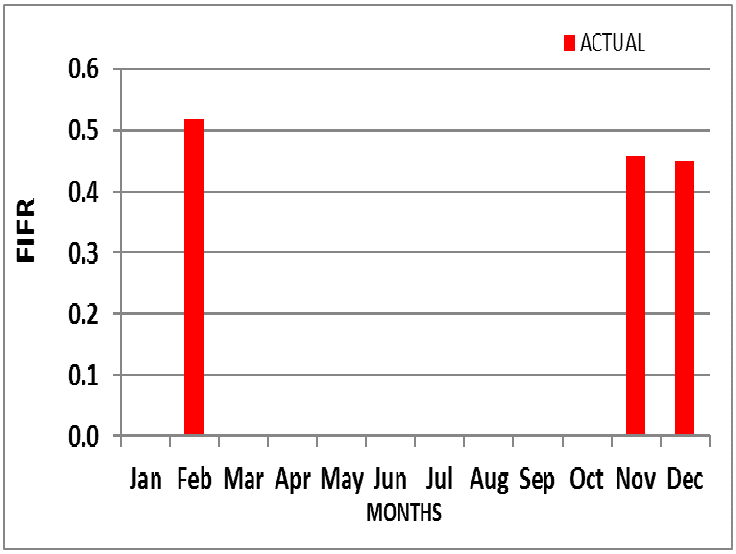

Fig. 7 Monthly Fatal Injury Frequency Rates (FIFR) in 2011 (Source: Anon., 2012g)

3 Results and Discussions

In 2010, the monthly targets were 3.28 for DCIFR, 1.46 for LTIFR, 0.86 for SIFR and zero for FIFR (see Figs. 1 to 3). No fatalities were recorded in 2010. Hence, there is no corresponding chart on fatalities for that year. In 2011, a monthly target of 2.58 was set for DCIFR, 1.15 for LTIFR, 0.68 for SIFR and zero for FIFR (see Figs. 4 to 7).

Comparing these sets of values, it is found that apart from FIFR, the monthly target for each category of injury followed a decreasing trend from 2010 to 2011. Management has a tradition of reducing injury targets year after year in their quest to seek an improved safety performance by having to deal with a new challenge.

In the case of DCIs, in July and August 2010, the recorded values exceeded the DCIFR target of 3.28 (see Fig. 1) while the recorded values in all the other months were below the target. In Fig. 1, zero DCIFR was recorded in April, November and December 2010. On the whole, the average monthly DCIFR in 2010 was 1.21, which was lower than the target of 3.28. In 2011, a DCIFR target of 2.58 for DCIs was set and this value was never exceeded in any of the months (see Fig. 4). The monthly average of 0.91 shows that the DCIFR values were very low compared to the target of 2.58. Thus, there was a 24.79% decrease in average DCIFR from 2010 to 2011.

The mine is very particular about the LTI statistics since it directly affects production. Whenever the mine realises an increase in LTIFR, there is a corresponding decrease in production, and vice versa. In 2010, the monthly target of 1.46 for LTIFR was exceeded in the months of January, February, April, July, October and December (see Fig. 2). December had a very high value of 4.12 as against a target of 1.46. On the average, the monthly LTIFR was 1.79 which was above the target of 1.46. However, in 2011, the LTIFR target of 1.15 was exceeded in seven months (see Fig. 5). The average monthly LTIFR was 1.62 which also was higher than the target of 1.15. However, the average LTIFR dropped from 1.79 in 2010 to 1.62 in 2011, representing a 9.50% decrease.

In the year 2010, a SIFR target of 0.86 was set (see Fig. 3). No serious injuries were recorded in May and June 2010. The serious injuries recorded in March and August, 2010 were below the SIFR target of 0.86. On the whole, the average monthly SIFR in 2010 was 1.06 which was higher than the set target. The SIFR target in 2011 was 0.68 (see Fig. 6) and this was exceeded in eight months in 2011. The average monthly SIFR was 0.87 which was above the target of 0.68. However, the average SIFR decreased from 1.06 in 2010 to 0.87 in 2011, signifying a 17.92% decrease.

Throughout 2010, no fatal injuries were recorded. Hence, the target of zero FIFR was not exceeded. However, in 2011, three cases of fatal injuries were recorded in the months of February, November and December, yielding an average FIFR of 0.48, which exceeded the target of zero.

Fig. 1 is a typical case of loss of safety consciousness with time. Safety performance was good during the early part of the year but deteriorated drastically by mid-2010 when frequency rates exceeded the indicated targets. After management intervened with strict safety auditing, there was an increased level of safety consciousness among the workers, and there was a steady fall in frequency rates to zero in November and December 2010 (see Fig. 1).

4 Conclusions

From the analysis in this work it is concluded that:

- The mine has not been fully successful with its health and safety practices since set targets were exceeded in some cases. However, the health and safety practices in place led to a general improvement in safety performance over the period under review, in the areas of DCIs, LTIs and SIs. The average monthly Frequency Rate (FR) of each of the classes of injuries in 2010 was found to have decreased between January 2010 and December 2011;
- In the case of FIs, the mine failed to maintain its good performance standard in 2010 as it recorded a number of fatalities in 2011. The safety performance was therefore poor;
- LTIs are directly related to production. Records on this category of injuries were not satisfactory as the LTIFR targets were exceeded in six and eight months in 2010 and 2011 respectively. Thus, the mine needs to take steps to ensure strict adherence to safety and health practices to attain an improved level of productivity;
- Infrequent safety auditing causes workers to be off guard as they lose safety consciousness in the course of time, leading to poor adherence to stipulated health and safety practices. Frequent and unannounced safety auditing is thus advised. This would keep workers on their toes, thereby ensuring strict compliance to safety policies for enhanced safety record;
- Workers, especially those in charge of materials handling and machinery, are very susceptible to injuries when they fail to undergo intensive regular training to make them abreast with changing trends in their areas of work. The situation is worsened when they have to handle newly introduced equipment and machinery which they have had inadequate or no prior training on.

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