Health and safety in mining: Issues for a new millennium

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Introduction

Work-related accidents and diseases continue to be serious problems throughout the world. Workers suffer about 250 million accidents a year and at least 335,000 die as a result of accidents at work. Moreover, there are about 160 million cases of occupational diseases. Taking accidents and disease together, the result is about 1 million work-related deaths each year. The consequential economic losses are enormous and the social damage to shattered families and communities is incalculable. About 4% of global GDP is spent on treatment, disability payments and survivors' benefits. This is more than the ODA to the world's developing countries. The situation is compounded in many developing countries due to material shortages and inadequate medical facilities. Unfortunately, mining takes more than its fair share of accidents and disease when the number of persons employed is taken into account.

There is a wide difference in occupational health and safety performance around the world, with fatality rates in highly industrialized countries about half those in Central and Eastern Europe, China and India. Some hazardous jobs, including in mining, can be 10-100 times riskier than the norm.

There has been a clear and steady decrease in the serious injury rate in industrialized countries as a result of changes in the nature of work and following sustained improvements in achieving a safer and healthier workplace — including the provision of first-aid and emergency care which can be crucial in saving lives after an accident. But the evolving nature of work is generating new occupational hazards — musculo-skeletal problems, stress and mental problems, asthmatic and other allergic reactions, and problems caused by exposure to hazardous and carcinogenic agents such as asbestos, chemicals and radiation.

An important starting point in improving safety performance in mining is the rejection of the notion that it is inherently dangerous and therefore work-related diseases and a certain number of mine accidents are inevitable, and that disasters are more "acts of God" which are bound to occur from time to time. Until this perception is put aside it will be difficult for those involved in mining to persevere with sustainable improvements in occupational safety and health.

A watershed in the international treatment of mine safety and health was reached in June 1995 with the adoption by the International Labour Conference of the Safety and Health in Mines Convention (No. 176) and its accompanying Recommendation (No. 183). This new standard is important for several reasons. First, because the special hazards faced by mineworkers are now dealt with in a specific instrument. Second, because the increasing importance of the mining industry in many countries is emphasizing the need to improve health and safety. Third, because earlier ILO standards on occupational safety and health, as well as existing legislation in many countries, are inadequate to deal with the specific needs of mining. The Convention has set the principle for national action on, and international monitoring of, the improvement of working conditions in the mining industry.

The Convention came into force in June 1998, one year after the first two ratifications. Fourteen countries have so far ratified the Convention; several others, including Poland and the United States, are working towards it. A widely ratified and fully implemented Convention and Recommendation will make a material contribution to achieving significant and lasting improvements in safety and health in the mining industry. The ILO is ready to assist wherever it can in the attainment of this goal. But even before the Convention is ratified, its provisions can be included in regulations or collective agreements.

Factors that affect safe behaviour include: the design of systems, machinery, equipment; the working environment; and the organization and its relationship to the individual. Any programme to promote safe behaviour must address all three.

Experience has shown that significant improvements in occupational health and safety are not just a matter of technology; they are also a matter of culture. The progressive integration of safety principles and reflexes into the workplace is a fundamental prerequisite for any improvement in the incidence of occupational accidents, injuries and disease. Unfortunately, a safety culture and an awareness of the positive values of a safe and healthy working environment in terms of economic benefits and social justice are minimal or non-existent in many countries, particularly in smaller enterprises. The socio-cultural aspects of health and safety in mines will be to the forefront in the next millennium if improvements in performance are to be sustained.

Continued need for vigilance

In some countries — India is an example — occupational safety appears to have reached a plateau. What can be done to break through this ceiling? What is being done elsewhere that might be relevant? In the Russian Federation, by contrast, the painful restructuring of the industry is now bearing fruit. In 1999 productivity increased by 16% and accident frequency declined by 23%. In the countries seeking admission to the European Union, safety and health performance will need to accord with EU norms, which in some cases means considerable improvements are required. Unfortunately, safety performance has deteriorated in a few countries. The most striking example is in Ukraine where the number of deaths per million tonnes of coal mined has risen from 2.3 to almost six in under ten years — about 60 times that in Australia. Elsewhere, despite some improvements, the situation is still grave. There were just over 300 work-related deaths in South African mines in 1999 and around 10,000 in China (said by some to be an underestimate). Moreover, the fatality rate in China's private small-scale coal mines is well above even that of the Ukraine.

Economic conditions, structural change, privatization, foreign investment (or the lack of it), new equipment (or the lack of it), new work practices (or the lack of them) and a new work culture will all have an impact on safety and health in mining. What changes to legislation might be necessary? What will be the role of the regulator as the regulations and the mining industry change? How will any changes affect the duty and liability of the employer and of workers? What emphasis should there be on human rather than technical factors? On occupational health and surveillance? On risk assessment? On social dialogue? On training? These are the questions that will need to be answered throughout the mining industry — including by governments, employers and workers' organizations — if improvements in occupational health and safety are to be sustained.

Technical change

Technical and organizational changes in mining have been marked by greater mechanization and a trend towards automation, with larger concentrations of energy in plant and equipment. Greater mechanization has resulted in a move away from individual miners, each with his own job, to a complex interaction of closely coupled, tightly paced processes involving several people. Ore treatment is also more complex, with a wider use of process chemicals that incorporate hazardous substances. More parts of the production and processing function are being contracted out, changing the employment relationship and, sometimes, making responsibility less clear-cut. Rationalization of mining activities has resulted in a high turnover of mineworkers, particularly affecting older, more experienced workers, which has led to a loss of institutional memory — how similar incidents were dealt with in the past, for example. More intensive working of capital-intensive machinery, including extended shifts, has become a prerequisite for economic survival. Unfortunately, there is sometimes a gap between design standards and the requirements of legislation, especially as far as ergonomics is concerned. A 12-hour shift increases the exposure of workers to physical stressors (noise, dust, etc.) by 50% and the cumulative or synergistic effects of multiple stressors over an extended shift render fatigue proportionally greater. Unions are concerned about possible increases in fatigue levels and the impact on accident rates. But in some countries, workers have been enthusiastic about longer shifts, ignoring potential health effects, in view of the increase in free time that arises from such working

arrangements. Some have even been able to get second jobs, the effects of which on the principal job are additional matters for study.

The impact of longer shifts underground on health and safety (exposure and fatigue) and on family life has not been widely studied and the ILO is funding a survey in Australia by ACIRRT at the University of Sydney to obtain some base-line data that we hope will lead to a better understanding and to a wider assessment of this phenomenon. A related issue is the health and safety impact of “fly in-fly out” operations where intense periods of work in remote locations are followed by substantial periods of rest at “home”. Such operations, similar to work on oil rigs, can have a significant impact on both working and personal lives. Changes in working time are being driven by the increasing competition in the mining industry, spurred by lower commodity prices. They are likely to be sustained.

Information technology (IT) is creating new opportunities for exchanging information, building data bases, analysing practices and procedures and identifying where efforts should be focussed. IT can provide quick access to current legislation, codes of practice, bulletins, accident reports, etc. In other words, possible global solutions to local problems will be increasingly available, including at the workplace, so that workers will be better able to solve problems and thus increase their “ownership” of the processes concerned and the improvements made. Virtual reality is becoming a powerful training tool, with realistic computer programmes being developed for individual mines to cover a host of different scenarios, including accident prevention and analysis through 3-D simulation.

New technology has had a positive impact on the number and severity of mining accidents and diseases — an impact that has been developed and sustained over many years. But the effects have not been uniform. Some new technologies have been accompanied by new or intensified hazards — such as dust, noise, vibration, ergonomics-related problems, and electric current — that require special attention. For example, the steady increase in the size and operating speed of earth-moving equipment at surface mines has led to them being involved in the severest of accidents at some of these mines, despite an overall reduction in the number of accidents. Half the world’s fleet of 10,000 mining trucks have a capacity exceeding 170 tonnes; 15% of loading equipment (but 30% of total capacity) exceeds 25 tonnes. In one country, which is investing heavily in large opencast mining equipment, 75% of accidents at surface coal mines are caused by dump trucks and other transport machinery. Nearly 90% of these are due to negligent or unauthorized use. In view of the human factor, the importance of education and training and of instilling a safety culture is underscored.

Health as well as safety

Workers’ health has often received less attention than their safety. Moreover, there is little awareness of the enormous cost of occupational health to much of the mining industry and to the general public. Regular health surveillance of mineworkers is by no means universal, and extreme care is needed in selecting, developing and implementing a surveillance programme. Occupational diseases (noise-induced hearing loss, vibration white finger, silicosis and pneumoconiosis) are becoming more pervasive with increased mechanization. Nowadays, noise and vibration are major causes of sickness. The increasing use of VDUs is also having an impact on workers’ health. These phenomena are by-products of more intensive working, particularly underground. But unlike silicosis or pneumoconiosis, they manifest themselves after relatively short exposure times. Stress-related illnesses are being increasingly recognized as being valid for compensation if they are proved to be work-induced. Increased work-shifts might have implications for occupational health. There have been several well-publicized court cases in which large amounts of compensation have been awarded to those suffering from the “new” diseases. An ILO code of practice on ambient factors at the workplace was published in 1999. It provides guidance on the roles and obligations of all those involved with regard to hazardous ambient factors. Moreover, infectious diseases, such as HIV/AIDS, TB, cholera, malaria and typhoid, are still rife in many mining regions and have a severe impact on life expectancy and therefore all aspects of work. A recent article in *The Economist* referred to a “Disability adjusted life expectancy index” that has been developed by the WHO. It takes these diseases and other factors into account and shows that Australians can expect a life expectancy of 73 years, compared with 40 in South Africa and less than 35 in Zambia.

HIV/AIDS

In some important mining countries in sub-Saharan Africa, the incidence of HIV in the adult population is over 10%. In some mining workforces in South Africa it is 20%. This has enormous implications for the composition and quality of the workforce and on costs and revenues of enterprises. HIV/AIDS will decrease the labour force in Zimbabwe by 17.5% in 15 years. The impact of HIV/AIDS will require more spending by employers for health care, burial, training and recruitment of replacement employees. In addition, there will be a reduction in revenue due to absenteeism caused by illness or attendance at funerals, as well as time spent caring for persons with HIV/AIDS, or training people to replace those who have become weak or have died. Anglo American was reported in the *Financial Times* as stating that 40% of lost time in its Zimbabwe mines is due to HIV/AIDS, as were 60% of all deaths in the last four years. Some companies have already begun to hire or train two or three employees for the same position. The increased use of migrant labour, which is common in some mining countries in Africa and elsewhere, can also risk creating a larger group that is often more vulnerable to HIV infection. The ILO has joined with UNAIDS to tackle this pandemic in the workplace. There is much to be done and a key feature of prevention policy is non-discrimination. Despite 39% of working age people in Gabarone, Botswana being infected, there is a resistance among construction and engineering workers there to undertaking HIV prevention measures.

What to do

The three key areas of occupational health — testing, diagnosis and control — are being approached differently in different countries. At the national level, an approach that is fair to all is necessary; one that is practical, cost-effective and sustainable; and one that is philosophically, legally and morally acceptable and is effective in reducing exposure and mitigating the effects.

There is a shortage of trained occupational health professionals in the mining industry, particularly in developing countries. Even those that are available sometimes have problems in applying their knowledge — because of a lack of resources and/or motivation. Getting access to current occupational health information is still a problem in many areas, but there is growing international cooperation. One example is the ILO/WHO International Programme on the Global Elimination of Silicosis. International collaboration can contribute significantly to the development and strengthening of national capacities. Industry must play its part too, by collaborating with unions and other organizations, and in helping to set up and participating in occupational health and safety organizations that work to enhance occupational health and hygiene skills. As strengths are shared, weaknesses will be overcome and resources optimized. The ILO's International Programme on Chemical Safety develops, translates and disseminates clear and standardized information on the properties of chemical substances in the workplace. The recently published *ILO Encyclopaedia of Occupational Health and Safety* — in paper and CD-ROM versions — is a major source of reference for the mining and other industries.

Systems must be put in place that will identify the health problems due to, or made worse by, work activities, and establish priorities for addressing them. Relevant information should be collected and used as the basis for managing ill health. The workforce must be advised of the specific health risks they face and what to do about them. Staff should be trained to target ill health continually and apply their skills better to protect themselves. The effectiveness of actions taken should be monitored — feedback — and outputs and inputs measured. The commitment of those involved must be gained and held.

The importance of managing health risks has often been understated. In some cases the problem has been ignored because the relevant information that can be analysed is difficult to collect. This makes proper health management extremely hard. Ill health costs money, big money over many years, so there are plenty of economic, let alone humanitarian, incentives to do something about it now so that improvements in both health and safety in mines can proceed in step.

Legislation and the role of the regulator

Legislation should provide an effective framework of standards and direction, and the regulatory authority charged with administering that legislation needs to do so in a professional, constructive and

consistent manner. Effective administration by the regulator is best achieved using a combination of processes which create an interactive relationship with enterprises and their workforce, and with industry representative groups, so that enforcement sanctions rarely need to be invoked. But a de facto policy of non-prosecution can arise when the inspectorate is part of a ministry whose primary function is to assist companies to develop mineral resources. Moving the inspectorate to a safety body with a strong prosecution policy could ensure that offences under occupational health and safety regulations are dealt with as the regulators intended.

Prescriptive regulations are being reduced. New regulations are highlighting the responsibility and liability of mine managers and make it a regulatory requirement that they develop a variety of policies and procedures to manage health and safety and to provide a safe place to work. Voluntary initiatives on occupational health and safety are being developed in several industries and are quickly gaining acceptance.

Enforcement is not an end in itself; it must be matched by a continuing decline in preventable harm to miners. The long-term goal should be to ensure that, without exception, an individual can devote a lifetime to a mining career and emerge healthy and unharmed. As one safety slogan has it: “The most important thing to come out of a mine is the miner”.

The regulator’s basic objective is to ensure that the risks to the safety and health of the workforce from workplace activities are eliminated or effectively controlled. His task is to influence and advise on the achievement of minimum health and safety standards that are contained in legislation. The regulator’s statutory powers mean that its advice should not be taken lightly. When a mine inspector calls, he should be regarded by the mine management not as merely an enforcer of regulations but as someone who is able to contribute to its thinking, able to interpret legislation and formal guidance sensibly and reasonably, in the particular situation and backed by scientific and technical resources that command respect. This will be increasingly important when foreign capital and highly experienced operators become increasingly used in a fast-globalizing mining industry. Thus, if the power of the inspectorate is to be sensibly deployed and effective, the quality of staff must be high and no compromises made. Regulators will continue to need a high level of technical and professional expertise but they will also need to be well equipped to deal with the increasingly important human and organizational factors of mining. The educational and advisory role of the regulator is growing as enterprises realize they can benefit from the regulator’s overview of the industry and access to data. The regulator can also give advice on good or best practice.

The historical perception of the regulator managing safety at the mine has been put to rest with the recognition that the regulator’s purpose is to be achieved largely through others — industry management, the workforce, and a range of intermediary groups such as industry associations, trade unions and suppliers.

ILO Convention 176

Mining is of major economic importance in many countries, but it is often dangerous. Yet, before 1995, the existing ILO standards on occupational safety and health, as well as the legislation in a good number of countries, were inadequate to deal with the specific needs of mining for the prevention of occupational accidents and diseases. An important landmark in the ILO’s continuing work on protecting workers against sickness, disease and injury arising out of their employment was therefore the adoption in June 1995 of the Safety and Health in Mines Convention (No. 176) and its accompanying Recommendation (No. 183).

The instruments cover both underground and surface sites where exploration and mineral extraction activities take place; they apply to all types of mining enterprises. Member States of the ILO which ratify the Convention undertake to adopt legislation for its implementation, including the provision for inspection services and the designation of the competent authority to monitor and regulate the various aspects of safety and health in mines. The Convention also sets out procedures for reporting and investigating disasters, accidents and dangerous occurrences related to mines, and for the compilation of the relevant statistics.

The Convention includes requirements for the provision of mine rescue, first-aid and other medical facilities. It makes it obligatory to provide self-rescue respiratory devices for workers in

underground coal mines. It covers the manufacture, storage, transport and use of explosives and initiating devices. Furthermore, national legislation has to make provision for the safe storage and disposal of waste and for protective measures for abandoned workings.

Under the Convention, mineworkers have the right to report accidents, request inspections, obtain information and remove themselves from any location where there appears to be a serious danger to their safety or health. Workers' representatives have the right to consult the employer on their safety and participate in inspections and investigations undertaken at the workplace. A series of Articles requires employers to take all the necessary measures — in order of priority — to eliminate, control or minimize the risks to the safety and health of workers in mines.

The Convention provides a floor — the minimum safety requirement against which all changes to mine operations should be measured. The need for continued vigilance remains paramount during the substantial changes that are taking place in mining world-wide. Positive results should be examined and, where appropriate, replicated through the concerted efforts of all concerned parties. This implies a higher degree of information exchange and collaboration than has been the norm. The ILO could facilitate the collection and dissemination of examples of "best practice" in improving mine safety.

The ILO does not sit idly by after a Convention has been adopted. Under the terms of the ILO's Constitution, the government of each country that has ratified a Convention agrees to make a regular report to the ILO on the measures it has taken to give effect to the provisions of the Convention to which it is a party. Complaints concerning the application of the Convention can be made to the Governing Body of the ILO, in which case an investigation is undertaken in an attempt to resolve alleged shortcomings in the application of a ratified Convention.

The ILO's work to promote the ratification of Conventions and the application of its standards involves both its supervisory bodies and the provision of assistance directly to constituents. The ILO provides advice on finding solutions to difficulties in the application of standards; it promotes the ratification of new standards; it provides training in complying with the reporting procedures; and it assists in the formulation and adoption of new labour legislation in conformity with international labour standards.

Human factors

Ensuring that the hazards in a physical working environment are well controlled, and having in place sound systems and procedures for the management of safety and health bring an organization only so far in protecting its workforce. In order to break through the ceiling, employees' behaviour must be the focus of attention. Behavioural safety is the key to effective accident reduction. The past focus on engineering and technical developments as a means to improve occupational health and safety was very successful. But such an approach is providing diminishing returns in many countries. There is therefore a need to provide officials, management and exposed workers with a better understanding of the different categories of human behaviour and performance-shaping factors that lie behind them. Without such an understanding, people will still be blamed for things they could not have done otherwise, and preventive measures will continue to be misdirected.

Effective safety management involves people. The interaction between the technical and social impact of systems needs to be handled through social dialogue at the enterprise level, as well as industry-wide, involving the workforce through its representatives. The workforce should also be involved in designing systems of work and in planning, organizing and carrying them out. All parties must act in good faith and not use occupational health and safety as a lever for other ends.

Safety culture

Increasing awareness of the limitations of the culture of "blame" as far as health and safety are concerned has given rise to the promotion of a positive safety culture, including its incorporation in regulations. No matter how safety culture is defined, the best way to improve it is one step at a time, building on small successes and allowing a change in circumstances to create a change in attitude. In other words, identify circumstances that predispose unsafe behaviour and change them, rather than attempt to change behaviour directly.

Changing workplace culture sounds easy, but there are plenty of pitfalls. These include: looking for a “quick fix” — there is no such thing; setting too many goals or having objectives that workers cannot achieve; being inconsistent; having a lack of management commitment; and neglecting training, follow-up and perseverance.

Personal motivation is important if health and safety programmes are to succeed. A clear and credible answer to the question “What’s in it for me?” must be provided. Everyone should know what the return on their investment in health and safety will be.

When an accident happens, the focus is on the person who triggered it. But designers, managers, supervisors, trainers and risk analysts are also part of human behaviour and affect the degree of risk at the workplace. Their behaviour sets the agenda for safety, culture and worker behaviour reflects it. Efforts to influence workers’ behaviour must start by analysing safety culture and its effect on accidents.

Many companies, including in the mining industry, have safety “core beliefs” that have been developed and agreed through social dialogue. They form part of the contract of employment and influence behaviour from top to bottom of an enterprise. Examples of these core elements that are necessary for creating and maintaining a safety culture include:

- All fatalities, injuries and occupational diseases are preventable;
- No task is so important that it cannot be done safely;
- All hazards can be identified and their risks managed;
- Everyone has a personal responsibility for the safety and health of themselves and others;
- Safety and health performance can always be improved;
- Safety is a condition of employment;
- Training is an essential element of safe workplaces;
- Safety audits must be conducted to ensure compliance with standards;
- All injuries, unsafe practices and incidents with injury potential must be investigated and all deficiencies must be corrected promptly;
- Safety off the job is as important as safety on the job;
- It is good business to prevent injuries and illnesses;
- People are the most critical element in the success of a safety and health programme.

The achievement of a safety culture needs a genuine and visible commitment and leadership from the top, with health and safety being a line management responsibility. Improving health safety performance should be accepted as a long-term goal that requires sustained effort and interest. To this end, there should be sound codes of practice and health and safety standards and a commitment to ensure that health and safety have adequate resources. Managers at all levels must regularly assess performance; and the factors that influence the behaviour of managers, supervisors and workers must be properly managed. The ILO proposes to develop guidelines on occupational safety and health management as an important plank in the development and promotion of a safety culture.

The long-term implementation of good safety, health and environmental practices — i.e. the continuous integration of a safety culture as an essential part of more general social cultures — is the only way to curtail the spiralling costs of health care delivery and environmental protection while increasing productivity. A safety culture can be built only through a long-term process of awareness-raising and education; consultation and consensus building among the social partners and other stakeholders involved in occupational health and safety and environment issues; and the participation of national economic and financial institutions.

The growth of a safety culture depends on the availability of reliable information as a tool for good decision making and the sound management of resources. Despite continuing efforts, the methods for collecting and interpreting occupational accident and diseases statistics are not well-developed, much less internationally harmonized and comparable. Data are essential for the establishment of international and national surveillance systems that are capable of providing early warnings of new

occupational and environmental hazards. Data are also necessary for the definition of the indicators needed to measure the success or failure of occupational health, safety and environment programmes and to identify the areas where action may be needed. Sound data are also a prerequisite for targeting scarce resources and for developing best practices.

For comparisons to be made between different operations, a common definition of disabling injuries is needed, together with common indicators so that safety performance can be monitored and assessed. Safety is not competitive and so information should be shared, for example through an international safety network that would enable knowledge to be pooled, best practices to be identified, research to be carried out and information disseminated. While there is already collaboration among research agencies, the Internet provides a wide gateway for much broader comparison and collaboration.

Traditionally, prevention and protection actions have had relatively low priority in terms of investment and financing. This is partly due to the difficulty in measuring accurately the costs of accidents and disease. In purely money terms, the direct costs of a few deaths might matter little to a large company in the short term. There could even be short-lived economic benefits in not devoting resources to preventing rare or catastrophic events, or even to preventing occupational diseases where, because of the delay between exposure and the onset of sickness, the discounted cost of investment in protection exceeds the eventual savings in reduced compensation. But such an approach is anathema to any industry with a long-term perspective. Nonetheless, safety and health need to be ensured through regulation and a safety culture.

Safe work

In order to help meet the need for increased action to protect safety, health and the environment, the ILO is developing a global programme on “safe work for all”. Targeting hazardous occupations, including mining, the objectives of the programme are, inter alia, to:

- Ensure that labour protection issues are given increased attention nationally and internationally;
- Ensure the ILO’s constituents can develop preventive policies and programmes;
- Establish a global technical cooperation programme on occupational health, safety and the environment.

Through advocacy campaigns, statistical programmes, national programmes of action, training programmes and international exchanges of information, this new programme will create alliances and partnerships to promote government action and support national action to protect workers’ health and welfare.

Risk management & risk assessment

Since human behaviour holds the key to further improvements, greater effort will need to be directed towards promoting an understanding of risk assessment, risk management and safety audits that are specifically based on the behavioural contribution to accidents. For example, through the development of management tools that allow a proactive approach to be taken to address behavioural aspects of safety performance. These include the identification of the potential for human error; examining attitudes to safety; training; equipment design and maintenance; and moving towards effective solutions.

Managing risks involves much more than undertaking a risk assessment, which itself does not improve safety and health performance. An overlying management system must be in place in order to undertake risk assessments effectively and therefore improve health and safety performance. In other words there must be a system that manages risk management.

The purpose of introducing risk management is to improve health and safety. The challenge is how to introduce risk assessment in a well thought-out, structured approach that is understood and practised by all, and is seen to be beneficial. The primary purpose of a systematic risk assessment of

existing operations is the comprehensive identification of the hazards associated with a particular task or operation, the risks associated with those hazards and a list of appropriate risk control measures.

Improvements that are based on the introduction of risk assessment involve four issues:

- Ability to conduct comprehensive, systematic, high quality risk assessments;
- Creation of the infrastructure and having trained risk assessment teams;
- Creation of the process that leads to a widespread active involvement of staff and workers;
- Development of a management structure that ensures an effective speedy rational implementation of improved or extra controls that will lead to lower risk.

The accuracy of the decision as to whether the risks are adequately controlled is largely subjective, and is likely to remain so for a while. But where crucial safety decisions are being made on the basis of subjective judgements, it is essential that the decision incorporates all the necessary information, including consideration of the human factors.

It is inadequate to say that a risk is controlled by existing codes, rules and procedures if no one has checked whether they are practical; whether they are known and understood; and whether they are followed. Similarly, there is no defence against unsafe behaviour in the untested assumption that the training provided is adequate. Safety audits — used to back up and check risk assessment action — that simply check whether provision is made, without addressing its effectiveness, are equally inadequate in promoting safe behaviour. The increasing practice of using accredited third party auditors who undertake structured audits of safety management systems and core risks, if carefully managed, can facilitate analysis and provide a sound basis for improved behaviour and performance.

Education and training

The examination of the ability of a workforce to behave safely must be an integral part of risk assessment and other safety management tools such as audits. There is no point in advocating the importance of safety behaviour if it is not feasible to behave safely.

Education and training are the foundations for enabling improvement in occupational health and safety. Sound basic education for work, certified induction and refresher training and certified company-specific training as part of lifelong learning are crucial for the implementation of effective health and safety hazard prevention programmes — for trainers and for supervisors and workers. They must be supplemented by specific seminars and refresher training and improvement programmes

There is a clear link between poor or inadequate education and training and poor health and safety performance. Competence is increasingly being used as the basis for safe operations. Competence — a person's ability to perform at a satisfactory level in the workplace, including the person's ability to transfer skills and knowledge to new situations and achieve agreed outcomes — defines what people need to do and to what standard at every level in the industry or in an enterprise. Competency-based training has facilitated the introduction of health and safety competencies into various industry competency standards. This has proved to be a fresh approach to certification that is linked to career progression.

Conclusions

As health and safety regulations become less prescriptive and more emphasis is put on the human factors that affect health and safety performance, a key objective in the 21st century will be to instil a strong safety culture in all aspects of mining. An improved safety culture is partly a question of resources and technology. But above all, it requires better information, management and higher ethical standards in confronting the ever present, ever evolving changes at the workplace. Different strategies will be needed to meet different circumstances and degrees of economic and technological development, without compromising the final goal. Because the types of issues that predispose unsafe behaviour and their relative importance will vary from mine to mine, there is no single solution to the promotion of safe behaviour. The main strategies involve: compelling; facilitating; rewarding; training;

informing; and participating. Also, it is clear that many issues arising from a more detailed, systematic evaluation of the factors influencing safe behaviour are unlikely to be immediately obvious. If they were, they would have been dealt with.

Careful data collection and analysis will enable risks to be identified and managed and information shared both nationally and internationally. The fostering of closer ties between manufacturers, regulators, employers, workers' representatives and the medical and safety professions, leading to meaningful social dialogue, will pave the way to break through the ceiling that has led to improvements in health and safety in mining becoming stalled in many mining operations.

Safety, health and environmental issues must be considered as an integral part of other mainstream social priorities, such as health, conditions of work, employment, training, industrial relations, and social security. The pressures on the world of work, be they driven by financial, technological, environmental or social factors of globalization, can only be dealt with by integrated management approaches at all levels.

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