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THE AUSTRALIA / INDIA MINE SAFETY TRAINING PROJECT

(An Australian Government Aid-Funded Project)

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Abstract: *This project was performed under the Memorandum of Understanding, "Agreement on Development Cooperation between India and Australia" signed in 1990. In its initial phase the objective was to review the existing procedures and practices in mine safety in India and to update these based on contemporary practices in a country employing more advanced mining technology. Other objectives were to expose Indian Mines Inspectors (staff of the Directorate General of Mines Safety), to mining conditions and practices in Australia, and to train a number of inspectors in managing mine safety using techniques which render operators responsible for the health and safety of mineworkers in individual mines.*

The three-year program was extended by one year to provide a practical basis for the industry to appreciate the impact of modern safety management practices. At four mines, safety management plans were developed using criteria relevant to each mine and with mine management support, were monitored for changes in operational and attitudinal performance. Structured mine evacuation exercises were performed in two mines to test the effectiveness of existing practices and sophisticated equipment, to assist DGMS to identify hazardous and life threatening situations was provided and inspectors trained in its use. Emphasis was placed on the ability of DGMS to communicate freely internally between its offices and within the mining industry generally.

This paper focuses on the practical aspects of the "extension", the establishment of safety management programs at four mines, each employing a different mining technology and having safety problems typical of the employed technology. It was an objective of the project that these lessons be freely available to the industry with a view to having the benefits widely understood and the practices more generally used.

1. Introduction.

Historically, mining has been an important industry in India with recorded mining and mineral processing activities dating back more than 2000 years. In the twentieth century mining had become a significant industry satisfying an increasing domestic demand for metals and fuels. Substantial changes occurred in the post-Independence period, many of these being associated with the nationalisation of a number of mining operations. The application by successive governments of their own brand of politics and economics left a resource rich country lagging its competitors in mineral development policies and practices. With few exceptions, mining practices at this time and in some cases until much more recently, were those more readily identified with an earlier era. An immense population created a strong demand; incapable of being satisfied from local production, of both fuel and non-fuel minerals. Access to international markets with sales in foreign currency was denied because of an industry inability to maintain production at appropriate levels.

In 1994, the Government opened the metals sector to private industry. This was followed by a relaxation in the coal industry permitting private operators to mine coal, subject to its use in captive power stations. Today these restrictions are being further relaxed as India strives to maximise the value of its mineral resources. A number of major (and some junior) international explorers accepted the challenge and have become an integral part of the Indian mining scene. Mining practices, which until then were those of the Government enterprises, were subject to international scrutiny and the regulatory authority, established and operating under archaic conditions, was able to compare their record with that of more developed economies. In a number of respects, but particularly in respect of mineworker safety, the Indian industry fell far short of the achievements of most countries employing more advanced mining technology.

In September 1995, the Ministry of Labour of the Government of India requested the Australian Government (through their Bilateral Aid Program) to provide assistance to the Directorate General of Mines (DGMS). The assistance requested was to comprise training in upgrading the skills of Indian mines' inspectors and guidance in the methodology best employed by the Directorate. The concept was readily accommodated within the guidelines set out in an existing Agreement between the Government's of India and Australia signed in 1990. AusAID (the Australian Government's International Aid Agency) engaged a consultant to work with DGMS to define the parameters for a technology transfer project which would provide DGMS with a technical and legal basis for effecting major improvements in the safety record of the Indian mining industry. Out of this initiative, the India: Directorate General of Mines Safety Training Program evolved.

2. Project Background.

In March 1997, AusAID invited proposals from qualified Australian organisations to deliver the Mines Safety Training Program. A newly formed Australian company, Australian International Mine Safety Training Company Pty Ltd (AIMSTC) was contracted to deliver the project services. AIMSTC was established by three experienced mining consultancies, Geo-Eng Pty Ltd, Strata Control Technology Pty Ltd and SIMTARS (Safety in Mines Testing and Research Station, an entity within the Queensland Government's Department of Mines and Energy). The three companies brought to the new organisation; complementary skills and experience that would permit the delivery of the technical services required satisfying the project needs. An important feature of AIMSTC's planning was to involve the regulators of Queensland, New South Wales and Victoria in the project to allow DGMS inspectors to access their know-how and experience. The project was to be of three years duration and commenced on 1 July 1997. While both DGMS and AusAID had completed the broad project definition, AIMSTC's initial task was to plan in detail how the objectives could be achieved. Two visits were undertaken to India to allow Australian project personnel to assess mining conditions and the regulatory framework within which improvements were to be effected. Two visits were made to Australia by a number of members of senior management of DGMS to view relevant operations in Australia and for an exchange of views with Australian regulators. Out of these early visits and discussions a project plan evolved which addressed a range of activities which would be completed within a three-year time span. Each year's activities were further developed in successive Annual Plans. The program was to provide:

- exposure to Australian mine safety practices and technology;
- development of:
    - occupational health and safety standards and procedures;
    - codes of practice;
    - legislative standards;
    - mine safety information systems.

The Indian mining industry was under considerable pressure to increase production levels to meet the current and future demands of the country's growing economy. There was a need to increase the level of mechanisation and to introduce and apply new technologies and to do this within the ongoing liberalisation of the mining sector. DGMS saw their needs as including the exposure of their officers to new technologies, to modern developments in mining techniques and to mine safety management systems. They saw a need to review existing safety standards and regulations and safety practices and to develop and introduce new and appropriate safety standards.

The Australian Government perceived their role in the project as assisting DGMS to establish technically sound guidelines and regulations, standard testing procedures and standardised monitoring/design techniques. They also believed that the program could complement other (then) ongoing and planned projects between India and Australia in the coal-mining sector.

Both Governments believed mutual benefits would emerge from the program, including:

- for India, exposure to the most recent Australian industry safety practices and technology;
- the opportunity to adapt relevant Australian experience and practice, introducing this to the Indian industry;
- acceptance of new mining technology, thereby improving trade opportunities for Australian suppliers of mining services and equipment.

The program had as its prime objective, the improvement of occupational health and safety in the Indian mining industry. Its purpose was to provide a technical training program for DGMS officers, which would develop from their exposure to Australian technology and mine safety practices. It was expected that in the course of the program, enhanced occupational health and safety standards and procedures, new and revised codes of practice, upgraded legislative and regulatory standards and mine safety information systems would be developed. The four project components, each considered a specific project objective, were:

1. *Industry Familiarisation.* To expose senior officers of the India and Australian mining inspectorates to their respective counterparts' current industry safety practices and procedures and mining technology.
2. *Training.* To establish a training system which would provide and maintain an appropriate level of adequately trained DGMS personnel to support the development and implementation of new safety practices, systems and technology in the Indian mining industry.
3. *Development of Safety Standards and Systems*. To review existing safety standards, practices and legislative measures in different areas and, where appropriate, develop updated or new safety standards, procedures and systems.
4. *Management.* To establish a Project Coordinating Team to successfully manage, monitor and control the project.

Thirty DGMS officers were selected for intensive training. Training areas were agreed between DGMS and AIMSTC. Standards and systems were related to specific areas in which training took place. The eight main training areas around which detailed project activities were planned were:

- Longwall Face Support;
- Equipment Testing Standards and Approval Procedures;
- Underground Coal Mine Roadway Support and Pillar Extraction;
- New Technology in Hard Rock Mining;
- Open Cast Mining;
- Occupational Health and Safety;
- Mine Safety Management Systems;
- Environmental Management.

The initial objectives (substantially achieved in the initial three-year period) comprised:

Establishment of DGMS Institutional Training Program.

- DGMS officers were to be trained to be capable of managing the ongoing application and administration of new standards and procedures.
- DGMS officers were to be trained to a level whereby they understood and appreciated the technical criteria governing the application of the standards and procedures under various conditions.
- An in-house technical training group was to be established to ensure the continued application and support of new safety practices, systems and technology. DGMS trainers,

able to train DGMS personnel to maintain the institution's skills base and increase the numbers of trained personnel, were identified and prepared for their new roles.

Review of Existing Safety Standards and Systems.
DGMS officers, with guidance from AIMSTC personnel, were to review the existing DGMS safety standards, procedures and systems following exposure to Australian practices and the likely influx of new mining technology and systems into the Indian mining industry. This outcome was achieved through the interaction between DGMS, the AIMSTC project team and industry stakeholders, including mining companies and management, mineworkers and unions, authorised testing and approval stations and mining institutes. DGMS were to identify particular areas requiring the introduction of updated or new safety standards, procedures and systems and to plan for the introduction and circulation of these standards, procedures and systems.

Development of New Safety Standards and Systems.
It was anticipated that the review would show a need for new or updated standards, procedures and systems for, at least:

- requirements of support in longwall faces and underground roadways;
- code of safe practices and legislative standards;
- broad based mine safety information systems;
- standardisation of occupational health and safety parameters.

These objectives were largely satisfied as the project period drew to a close. AusAID had additionally authorised the procurement of a number of items of testing equipment, including intrinsically safe airborne dust sampling pumps, portable noise dosimeters, portable sound level monitors, portable noise loggers, portable gas monitors, portable blast vibration monitors and a Fourier Transform Infra-Red (FTIR) Spectrometer. DGMS laboratory staff were trained in their use and maintenance.

Although substantial progress had been made in upgrading the skills level of individual mines inspectors, concerns which had been expressed early in the program about the continuance in the industry generally of the new and revised approaches to mine safety, re-surfaced. AIMSTC emphasised in its dealings with mines (as well as with Inspectors) that worker safety is both a mine operator and an individual responsibility, and that mineworkers themselves must be aware of the difference between a safe and an unsafe working environment and, at all times, to work safely.

AusAID, in response to a further DGMS request agreed to extend the program for an additional one year with an emphasis on concept sustainability. The extended objective was to put in place at four selected mines (each using different mining technology), formal safety management systems developed by mine managements, with the cooperation and assistance of DGMS and AIMSTC. Progress at each of these 'model mines' would be subject to review and each mine would constitute a demonstration mine for the wider industry. The systems approach, using current industry risk assessment principles would survive the project, with the benefits demonstrated by improved operational and worker safety.

At two other mines, exercises emphasising mine emergency response and evacuation issues were to be coordinated, based on current Australian practice and existing mine procedures. The intention was to demonstrate the need for effective documented procedures at each mine that were fully understood by all mineworkers and which would permit a planned and safe response to any mining emergency.

This paper will review the introduction of the mine safety management systems into the four selected mines.

3. Implementation – Model Mine Program

To reinforce project outcomes, prototype Mine Safety Management Systems were developed by mine operating staff with the assistance of DGMS and AIMSTC. Four mines, each employing different extraction technologies and having different operating conditions and practices were selected for the introduction of a systems approach to mine safety, using internationally accepted risk assessment processes. Each mine, under the guidance of DGMS, designed and implemented a mine safety management program (MSMP). Each MSMP would be later reviewed for progress (against the plan) and tangible improvements in safety performance, monitored. It was anticipated that visible results would be achieved and that these mines would remain as 'model mines' illustrative of the benefits of applying contemporary management techniques to safety problems. The cooperation of the mine operator was readily obtained once the ongoing benefits were appreciated.

The model mine program was undertaken at the following four mines:

- No.1 - Vastan Mine, an open cast lignite mine owned by Gujarat Industries Power Company Ltd, Gujarat, in November 2000.

- No. 2 - Balaria Mine of the Zawar Mine Complex, an underground zinc (ore) mine, owned by Hindustan Zinc Ltd, Rajasthan, in March 2001.

- No.3 - Sendra Bansjora Mine, an underground bord and pillar coal mine, owned by Bharat Coking Coal Ltd, Madhya Pradesh, in July 2001.

- No.4 - Jhanjra Mine, an underground longwall coalmine, owned by Eastern Coalfields Limited, West Bengal, in August 2001.

Each of the model mines implemented selected and relevant mine safety management systems developed during the exercise. System development followed a process of hazard identification, risk ranking and determination of hazard controls and responsibilities in order to develop action plans for the identified hazards. The process employed is summarised below:

Step 1: *Identify MECHANISMS by which hazard can occur.*
Step 2: *Ranking of likely RISK.*
Step 3: *Identify CONTROLS (existing and possible new) for reducing RISK.*
Step 4: *Identify PROCEDURES for implementing and maintaining controls.*
Step 5: *Identify RESPONSIBILITIES.*

The action plans constitute the basis for the development of the safety management plans.

Ranking of risk is accomplished by the use of a standardised approach that considers three components of mine safety and assigns a qualitative value representative of the severity of the risk. As long as each individual mine assessment uses consistent rating factors, the risk ranking demonstrates the impact of any individual occurrence. An example of the process is later included (Annex A), and in this instance the risk rating has been prepared using the risk factors as set out below (Tables 1, 2 & 3).

It was planned that some two to three months after the mine safety management systems and guidelines had been operating, a follow-up assessment and audit program would be performed by a team of mine personnel and DGMS project officers, assisted by AIMSTC specialists. As at the time of preparation of this paper, a review had only been concluded at the Vastan and Zawar (Balaria) mines. Reference is later made to this review (Section 3.5)

The example (Annex A) uses the conveying of ore in the Balaria Mine of the Zawar Group of Mine of Hindustan Zinc Ltd (MM #2). The potential hazards in this area are identified and assessed with regard to their risk. This plan does not address a principal hazard but rather an area of activity of the mine. For the purpose of the exercise, this was deemed to be adequate to demonstrate the principles involved and how such a plan should be drawn up.

IDENTIFIED HAZARDS
Safety Definitions
Hazard: *A source of potential harm or a situation with the potential to cause loss.*
Principal Hazards: *A hazard with the potential to result in multiple fatalities.*
Risk: *The chance of something happening that will have an impact upon objectives. It is measured in terms of consequences and likelihood.*

To bring all participants to the same level of understanding regarding the process, and to gain consensus regarding the terms used in the assessment, a risk assessment course was held prior to the exercise at each mine. Each risk assessment team consisted of a cross section of disciplines at the mine.

At the Balaria Mine, the risk assessment was conducted on the area which included the production inclines, Phases One and Two. This area is from the bottom of the bottom of the bunker at 75MRL to 250 MRL, the transfer bunker, and from 250 MRL to 380 MRL on to the primary fine ore bin where it is dumped.

The hazard identification process uses the principle that a hazard can also be defined as an unplanned or unwanted release of energy. Hazards were assessed in terms of risk, defined as the product of consequence, exposure and probability. In assessing the risk, the values for the consequence of the hazard it were based on the most reasonable worst case occurrence. Cognisance was given to controls already in place.

Table 1: Values used for Consequence

CONSEQUENCE		RISK RATING
1	Catastrophe	100
2	Disaster	50
3	Multiple Fatalities	40
4	Single Fatality	20
5	Permanent disablement	15
6	Serious Injury	10
7	Lost time Injury	5
8	Medical treatment	2
9	First Aid	1

Arbitrarily, at Balaria, it was decided that hazards with a risk of above 400 would require immediate action. Those with a value below 400 but above 100 would be deemed to require attention, and those that were below 100 were acceptable, but required maintaining in order to keep them to this low level.

For hazards that require maintenance only, no controls were formulated, as the present controls were considered sufficient. For hazards that require attention, controls for improvement were formulated and for hazards that require immediate action, an action plan was drawn up.

Table 2: Values used for the Exposure of Workers

EXPOSURE		RISK RATING
1	Continuous	10
2	Frequent (Daily)	5
3	Seldom (Weekly)	3
4	Unusual (Monthly)	2.5
5	Occasionally (Yearly)	2
6	Once in 5 years	1.5
7	Once in 10 years	0.5
8	Once in 100 years	0.02

Table 3: Values used for the Probability of the Occurrence Happening

PROBABILITY		RISK RATING
1	Expected/almost certain	10
2	Quite possible/likely	7
3	Unusual but possible	3
4	Only remotely possible	2
5	Conceived but unlikely	1
6	Practically impossible	0.5
7	Virtually impossible	0.1

The Risk Assessment results and implications for the example are discussed in Annex A.

While standardised risk assessment procedures were employed at each mine, criteria were varied from mine to mine as the DGMS standard was still being developed. All risk assessment processes performed were internally consistent and the relativity of ranked identified hazards determined the priority with which hazards were addressed. The process was evolutionary also, and Model Mine No. 1 proved in many ways to be a test case, providing a basis for refining the processes employed for later mine visits. It also was the first of the series of mine visits to which DGMS Inspectors were exposed and this introduced some additional uncertainties of process. Notwithstanding, the exercise at the Vastan Lignite mine focussed on hazards peculiar to that mine and set out a management regime which led to improvements in a number of the less satisfactory activities, in terms of safety, associated with the mine. This mine, together with the second visited have been reviewed and it is pleasing to note the improvement resulting from the attention given by mine management to identified hazardous areas and practices. These are referred to in more detail in Section 3.5.

3.1 Model Mine No.1 – Vastan Lignite Mine

At the Vastan Lignite Mine introductory discussions focussed on hazard identification and on the principles and systems available for the management of safety and occupational health in the workplace. Regardless of the system employed, common principles included:

- A high level of management commitment and leadership;
- A recognised framework of OH&S across the entire workplace;

- Connection by all personnel to the OH&S system;
- Implemented safe work practices which (as a minimum) match regulatory requirements;
- Preparedness to handle emergency events;
- Investigation of accidents and removal of any dangerous situations;
- Record keeping;
- Continuous improvement;
- Openness to internal and external audit.

The processes by which these are achieved comprise:
- Regular OH&S meetings involving mine-wide representation;
- Regular reviews of work activities and equipment design and operation;
- Improvements to reduce OH&S impacts in high risk area or activities;
- Action management;
- Audit work.

To introduce the Risk Assessment technique as a means of ensuring resources can be directed to the most pressing (or most serious hazardous) concerns, mine site staff were exposed to a Safety Checklist as a basis for hazard identification as part of the assessment/ranking process. The Safety Checklist for the Vastan mine included the items and activities detailed in Table 4.

At the Vastan mine, technical presentations were made on three aspects of mine operations identified during mine inspections and discussions, as most relevant to safety issues at the mine. These were the concept of Risk Management, issues concerning Slope Stability and Integrated Mine Planning. A Risk Management Workshop involving both mine and mine contractors' staff. explored the processes of hazard identification, risk prioritisation, control method identification and action plan preparation – all specifically related to conditions prevailing at the Vastan Mine. Workshop teams addressed two different issues, Slope Stability problems (of concern because of slope failures endangering a nearby village), and Integrated Mine Planning. This latter Workshop concluded that more short term planning was required to better manage the development of mining areas, haul roads and external and internal dumps. The Workshop also concluded that the mine planning software capability was not being fully utilised.

The outcomes included a listing of hazards, a recommended treatment, identification of implementation issues and an action list. Hazards identified for which actions were recommended included:
- Dumper operation in foggy conditions;
- Haul Road crossings;
- Minimisation of fire risk during refuelling;
- Unauthorised personnel and vehicles on site;
- Minimising risk of tyre inflation ring flying off dumper tyre during inflation;
- Slopes stability issues associated with the future eastern slope;
- Minimising potential for head injuries;
- Ensuring safe and efficient performance of regular maintenance activities;
- Manual work component of tyre changing; Regular reviews of safety of operations.

Of specific concern at this mine, and a problem at many open cut mines in heavy rainfall areas, is the serious hazard to mine workers and to mine equipment as a result of massive slope failures. It is possible to reduce the risk of such failures by specialist geo-technical investigation and testing, and slope design, a much-preferred approach to adopting traditional slope angles based on previous failure experience in assumed similar ground conditions.

Table 4: Safety Checklist – Vastan Mine

ITEM	ACTION
Safety Induction	Establish and undertake safety induction briefing of all visitors to the mine. Establish, undertake detailed safety induction of all employees and contractors working at the mine.
Safety Training	Establish and undertake appropriate regular training in safety issues for each work group and/or work place. Establish safety guidelines for working in various locations, or with equipment.
Site Access Control	Establish and implement measures to control access to the mine, including: • restrictions on visitors and local farmers/residents to enter mine environs, • restriction of employees to high hazard areas, • traffic routes around the site for various types of equipment and vehicles.
Safety Equipment and Facilities	Ensure appropriate protective equipment is supplied and used by all employees. Ensure appropriate safety equipment is available in case of an emergency. Ensure access to appropriate medical treatment in case of an emergency.
Incident Reporting	Establish incident (accident and near miss) report forms. Ensure incident reports are prepared for each accident or near miss. Ensure each incident is investigated by appropriate staff and safety action recommended. Ensure hazard control actions are implemented and audited.
Hazard Identification	Establish hazard identification checklist to be used prior to commencing a job. Ensure checklist is used. Ensure appropriate hazard elimination/control measures are implemented prior to commencing work on the job.
Risk Assessment	Establish work risk assessment system on mine development and operations. Undertake job risk assessments Ensure required hazard control mechanisms are implemented.
Geo-technical Assessment	Establish geo-technical risk assessment for mine. Ensure potential failure mechanisms are identified. Ensure appropriate site investigations and material testing is undertaken. Ensure appropriate monitoring systems are established. Ensure potential failure mechanisms are analysed and appropriate mine design modifications are made to maintain acceptable stability and risk. Audit mine geo-technical conditions.

3.2 Model Mine No 2 - Balaria (Zawar Mine complex)

The mine site work program at the Zawar Mine Complex was divided into 3 components, each performed by a separate team. Teams were assigned to review:

- Risk Assessment and Mine Safety Management;
- Strata Control;
- Occupational Hygiene.

A risk assessment/safety management plan workshop was completed jointly by teams undertaking the first two assignments. The third team completed a separate program of work involving noise and dust surveys at a number of different sampling locations in the mine

The standards, guidelines and mine safety management systems identified, developed, implemented and recommended to the mine management as part of the Model Mine No.2 program (by each team) include:

Risk Assessment and Mine Safety Management Plans
Following the workshop, a risk assessment was completed on activities associated with conveying of ore within the Balaria Mine (refer Annex A, the example used for demonstrating the system). In this exercise, a number of hazards were identified as requiring attention. Three of those hazards were identified as requiring immediate action and action plans were formulated for:

- control of respirable dust at the mine;
- reduction of risk of falls of persons'
- prevention of transformer/distribution control box fires.

The team prepared a Safety Management Plan for Dust Hazard Control. The plan identified the resources and responsibilities for implementation. It was recommended that mine management implement the plan and that the other Safety Management Plans identified be formulated and implemented.

Strata Control
Following the workshop on risk assessment and development of mine safety management plans, a risk assessment on the Strata Control issues for stoping operations at Balaria Mine was completed. Subsequently, a Stoping Strata Control Plan was developed which outlined in general terms the implementation and management of issues identified in the risk assessment. The mine was to complete and implement this plan. The AIMSTC/DGMS/Balaria Mine team recommended that further assessment, development and implementation is undertaken for:

- the development of a Strata Management Team;
- the development of Stoping Hazard Plans;
- an assessment of pillar stability;
- an assessment of regional mine stability – in the Western Stopes;
- the development and implementation of monitoring protocols and response guidelines.

Occupational Hygiene
A series of underground and surface dust and noise field surveys was completed at the Balaria Mine. Based on the survey results a Safety Management Plan for Occupational Hygiene and Occupational Health, Dust and Noise Management was prepared.

Recommendations were developed which outline the resources and actions required over the next 3 months for the implementation of the management plan.

3.3 Model Mine No 3 - Sendra Bansjora Colliery

The mine site work program at Sendra Bansjora Colliery comprised two components, each being undertaken by a separate group. The components were:

- Mine Fires;
- Inundation.

A 2-day joint risk assessment workshop was first completed, mine fires and inundation being the identified high-risk hazards for which safety management plans would be developed. Each group undertook a process of detailed hazard identification, risk ranking and determination of hazard controls and responsibilities in order to develop action plans as the basis for developing safety management plans.

Action plans for Mine Fires and Inundation developed during this work program are now part of the mine operating procedures.

Standards, Guidelines and Systems.
The standards, guidelines and mine safety management systems implemented and/or recommended to mine management for implementation included prioritising the procedures developed as part of the Mine Fires Safety Management Plan and the Inundation Safety Management Plan.

Mine Fires.
From a risk assessment for mine fires at Sendra Bansjora Colliery, a number of hazards were identified as requiring attention. These included:
- Seam IV Isolation Trench.
- Other Procedures - several procedures relating to the control/prevention of mine fires already exist but many do not exist or are not documented. It was considered that it should be possible to develop and/or document the majority of these procedures prior to the planned review.
- Mine Fires Safety Management Plan - these identified procedures will form the basis for the Mine Fire Safety Management Plan to be developed and implemented.

Inundation.
From a risk assessment for inundation, a number of hazards were identified as requiring attention. Three hazards were identified as requiring immediate action and action plans were formulated for:
- Pillar failure due to fire, allowing connection with surface water body (Ekra Jore);
- Failure of river bank during heavy rain;
- Failure of drift dam, 10 to 11 Seams.

Action plans were also developed for:
- Surface flooding or water body entering through goaf or mine entries;
- Barriers against flooded old workings failing under hydrostatic pressure;
- Accidental holing into old flooded workings.

The order in which the identified procedures are to be developed was based on the risk ranking. Those procedures associated with the 3 hazards requiring immediate attention would be developed and implemented first. The identified procedures will form the basis for the Inundation Safety Management Plan (to be developed and implemented).

Safety Management Plans.
In order to assist with the on-going development of the mine safety management plans, AIMSTC provided Sendra Bansjora Mine a guideline for standards development of Safety Management Plans, prepared initially for the guidance of DGMS personnel. AIMSTC also provided DGMS and the mine team with a number of international technical papers on inundation of underground mines.

3.4 Model Mine No 4 - Jhanjra Colliery

The mine site work program at Jhanjra Colliery was divided into 2 components with each component being undertaken separately as follows:
- Strata Control;
- Mine Environment -Ventilation and Spontaneous Combustion.

A joint risk assessment workshop was conducted before undertaking the separate components. During the workshop, strata control and spontaneous combustion of coal in the underground workings were identified as high-risk hazards for which safety management plans would be developed. A process involving hazard identification, risk ranking and determination of hazard controls and responsibilities was followed to develop action plans for each identified hazard. Action plans for Strata Control and Spontaneous Combustion were developed during this work program.

Standards, Guidelines and Systems.
The standards, guidelines and mine safety management systems implemented and/or recommended to mine management for implementation included prioritising the procedures developed as part of the Strata Control Management Plan and the Spontaneous Combustion Safety Management Plan.

Strata Control.
A risk assessment for strata control at Jhanjra Colliery was performed for the development of the Strata Management Plan and arising from this, a number of hazards were identified as requiring attention, with priorities set based on risk assessment ratings. Procedures were identified that need to be developed to control these hazards. Several procedures relating to strata control in the mine already exist, but many others are not documented or do not exist. The majority of those procedures identified in the Action Plan as requiring to be developed or documented are to be completed prior to the December review. The procedures will form the basis for the Strata Control Management Plan.

Spontaneous Combustion.
A risk assessment for spontaneous combustion at Jhanjra Colliery was completed as part of the exercise. A number of hazards were identified as requiring attention and an Action Plan was formulated for the control of these hazards. The majority of the identified procedures relating to control of spontaneous combustion at the mine already exist, but many of the procedures were not documented. New procedures identified in the Action Plan requiring to be developed will be addressed, as will procedures that are to be documented, and all will form the basis of the Spontaneous Combustion Safety Management Plan.

Safety Management Plans.
In order to assist with the on-going development of the mine safety management plans, AIMSTC referred Jhanjra Mine to the previously provided DGMS Guideline for Development of Safety Management Plans.

3.5 Review/Audit of Model Mines 1 & 2.

Vastan Mine
In June 2001, some six months after the visit during which the initial risk assessment exercise was completed, a return visit was made to review those aspects of mine operations which were the subject of installed safety management programs. In general the result was pleasing. The following comments below were made following the review.

Hazard Control.
It was evident that substantial work had been carried out on the hazards identified in the initial visit. Discussions with management, staff and contractors confirmed that the high risk score hazards had all been addressed in varying degrees and control measures put in place. These included:

- increasing security of access into the mine area;
- restricting or controlling crossings and limiting access on haul roads;

- maintenance procedures for tyre changing;
- stopping truck operations in foggy conditions;
- modifying the failed batter slope;
- controlling and diverting drains which could affect batter stability prior to the monsoon period.

The follow up by the mine operator of recommended actions (high risk score items) was deemed commendable. A number of the lower ranked risk hazards remain and these will need to be addressed in future programs.

On-going Risk Management Programs.
The mine had decided that there should be a quarterly program for carrying out a hazard assessment at particular sites or functions in the mine. This program which is to be defined annually, should provide a great opportunity for continuous improvement in the mine.

Guidelines for Safety Management in Mines.
During the initial visit a Guideline to include Risk Management methods within a Safety Management System was developed. Vastan Mine decided that the Risk Management process should be the responsibility of the Safety Committee and hence would fit within the Safety Management System. The Vastan Mine had accumulated their safety information in a Safety Management Manual. This concept was incorporated in the Guideline and tested against mine management. The draft Guideline has been further refined in discussion in Udaipur, Dhanbad and in Australia.

Balaria Mine

This review took place only some three months after the initial visit. Because of this relatively short period, the review focussed on intent and commitment, and in addition, the process being followed. Three of the identified problem areas ie. strata control, dust control and noise control, were reviewed against the action plans earlier developed. An interview process using review sheets developed by mine personnel was employed. This process aimed to identify documentary evidence of the actions initiated or in its absence, verbal conformation of actions. It is normal in audits to insist on documentary evidence.

Standards, Guidelines and Systems
The review confirmed the development of the following standards:
- Stoping Strata Control Management Plan,;
- Dust hazard Control Plan;
- Occupational Health Management Plan;
- Prevention of Falling of person in the incline shaft;
- Prevention of Transformer fires.

While not yet been fully implemented, procedures have been put in place that will ensure their implementation and regular monitoring. It is of interest that the final two standards were mine initiatives following the initial visit, and are being introduced to the extent that equipment and facilities are available. The Review Team deemed the efforts of the mine in respect of these issues, commendable.

Team performance
Balaria mine management provided good support to those mine staff actively involved in implementing the program. The overall performance demonstrates the benefits that can be achieved by committed and trained staff in respect of safety management issues. For the benefit of other mines which can benefit from a consideration of similar programs, the Balaria team:

- demonstrated a high level of commitment to the process and to the principles underlying the establishment of safety management plans (including the planning for more and previously unidentified hazards);
- used a team approach with involvement of subordinate managers, safety and health officers;
- has had progress constrained only by lack of knowledge and availability of monitoring instruments;
- has the ability, with adequate support, to be a ‘demonstration team’ for portraying the value of the process;
- could benefit significantly from further training in dust sampling and dust allaying techniques;
- has the ability to, with further training, extend their capabilities to allow their value to the mine and the industry in respect of specific aspects of mine safety, to be more widely demonstrated.

3.6 Review/Audit of Model Mines 3 & 4.
3.7

This activity had not been conducted at the time of preparation of this paper. It is scheduled for completion in mid December 2001. AIMSTC believes that progress in the management of mine safety will be demonstrated.

4. Mine Emergency Planning.

As an additional and practical demonstration of the systems approach to mine safety, and which would constitute a residual component of the program – contributing to its sustainability, AIMSTC conducted simulated emergency response exercises at two mines, selected by DGMS as representative of mines in specific regions.

The program was delayed by a diaster of major proportions at the first selected mine, the Bagdigi mine in Bihar. With planning underway, and just a few weeks ahead of the simulated exercise, the mine was flooded as a consequence of miners 'holing through' into the flooded working of an adjacent abandoned mine, a number of miners lost their lives in the resulting inundation. Inquiries revealed that survey errors in the adjacent mine led Bagdigi miners to believe they were operating within adequate safety tolerances.

The first exercise was rescheduled and relocated to the Sijua colliery of TISCO and was concluded in May 2001. The second exercise was conducted at CIL's Western Coalfields Silewara Colliery in July 2001. Follow-up visits have been made to both mines to review their continuing performance.

The following notes relate to the Silewara Colliery exercise.

Assessment Procedures and Results
The exercise was planned and conducted in accordance with the 'Guidelines for the Conduct of Emergency Procedures Exercises' as established and utilised by the Queensland (Australia) Emergency Exercise Management Committee. The guidelines propose that exercises:

- be systematic;
- be consistent with the concept of mutual assistance from other mines;
- require direct reference to the risks at the mine;
- recognise that exercises should not necessarily be held on day shift;
- be inclusive of external agencies such as Mines rescue stations, police, media and senior company officials;
- have an audit and evaluation process;
- be subject to risk assessment principles to ensure the exercises do not introduce new safety risks to persons at the mine.

In recognition of these guidelines, the Silewara emergency exercise involved the following assessment and evaluation process:

- assessment documents were produced establishing the systematic initiation, control and assessment of the exercise;
- a scenario was developed strictly in accordance with the hazards present at Silewara Colliery;
- the Mines Rescue Brigade, senior company officials, DGMS officers, Workers Safety Officials and the ambulance service were involved;
- a total of 5 assessment teams comprising 21 persons were selected to evaluate and record the results of the exercise;
- de-briefings were conducted of all assessment teams to evaluate the results.

All assessment tools were developed against the internal standing orders of Silewara Colliery and in line with accepted practice for system audits.

While most persons involved in this exercise found their way to a place of safety, significant numbers of other persons did not. The potential exists for this number to increase significantly in the event of a real underground fire. It was apparent there had been a significant underestimation of the expected time required for persons to walk to their place of safety. Such a finding is not surprising and it is commonplace for the effect of poor visibility on walking speeds to be underestimated.

Of equal importance was the apparent lack of experience (and hence awareness) of the effects, consequences and extraordinary rates of propagation of heat and toxic gases that underground fires can generate. Such a lack of awareness may have lead to some degree of complacency with the persons involved in this evacuation exercise.

Results, Findings and Recommendations.
The main focus of the recommendations was to come up with improvements that are fiscally and technically viable for the Indian mining industry.

Major outcomes and opportunities for the improvement of the emergency preparedness and response systems at the Silewara Colliery include:

- All miners performed admirably in very difficult conditions and fully committed themselves to the exercise. The miners were extremely fit and handled the difficult egress conditions with no apparent difficulty.

- The nature of the fire and the type of rescue equipment available would have meant that in a real fire situation no one would have escaped from that section. Conveyor belt fires produce enormous amounts of smoke and toxic gases and with the limited ventilation available at this mine the smoke would not clear rapidly. Filter Self-Rescuers (FSR) were not suitable for the distances travelled in this mine. Under smoke conditions it is at least a two-hour walk out of the mine and FSRs have a realistic life of only 45 minutes. Oxygen self-rescuers would suffice if they were issued and caches were available to enable miners to complete the long walk out of the mine.

- The establishment of a refuge station underground would go a long way towards solving this problem. This station also needs to be equipped with a water supply and fail-safe communications with the surface, ideally through a borehole. An area of the mine was identified as suitable having an independent ventilation supply that could be used for this purpose. (Mine management indicated that the construction of a refuge chamber would go ahead with an objective of completion by December 2001).

- Rope guidelines should also be installed from the working faces to the refuge chamber to enable the miners to reach this safe haven. This type of system has been used with some success in Australia and is more effective than many high-tech electronic guidance devices. (Mine management will implement this recommendation).

- The assessor teams in some cases caused confusion and tried to direct the evacuation of the miners. The role of the assessors is to prevent injury and to log the actions of the escaping miners. Many of the miners would not have done as well as they did without the help of the assessors and some of their non-blindfolded supervisors.

- The fire fighting equipment and procedures were totally inadequate to fight a belt fire. The occurrence of a conveyor belt fire is not beyond the realms of possibility at Silewara Colliery and should be regarded as possible. Normal fire extinguishers are totally ineffective against this type of fire. Fire fighting training and equipment levels should be improved as a matter of urgency.

Regular exercises of this nature should be carried out and scenario-planning precursors to the exercises should also be carries out.

Gas monitoring was not carried out effectively during this exercise. The purchase of basic gas monitoring equipment should be investigated as a matter of urgency.

For the nature of the mining operation the alarm combination of telephone, whistles sirens and eucalyptus smell worked satisfactorily.

The exercise at the Silewara Colliery differed little from that conducted at Sijua Colliery and similar conclusions and recommendations were recorded. It is believed that these mines are typical of the industry and can be confidently referred to as industry indicators. To a large extent, Australian conditions, findings and recommendations were replicated here.

What has resulted from the carrying out of the two exercises and their subsequent follow-up is a blueprint for management action at all mines in India. DGMS are now equipped to cooperate with mines for all types in planning and executing evacuation or similar training exercises to equip mines for eventualities which, hopefully, may never arise.

From the Silewara Colliery, the lessons of this evacuation exercise can be applied much more generally. All mines should:

- Regularly test all aspects of the mine emergency system;
- Conduct simulated emergency response exercises with mine management responding pro-actively to this element of (underground coal) mining;
- Examine the adequacy of self-rescue equipment for the particular circumstances pertaining to the individual mine;
- Review the adequacy of (underground) fire fighting equipment for the likely fire situations;
- Ensure mine to surface communications are appropriate for emergency situations;
- Establish (independently ventilated) refuge chambers where underground conditions permit.

5. Conclusions and Acknowledgments.

This paper draws extensively on a series of individual reports prepared by AIMSTC specialists who have undertaken and directed the activities described in the paper. The activities described in some detail are those conducted in Year 4 of the project and which were designed to demonstrate the practical value of earlier ‘groundwork’.

The vast scale of the industry has meant it was not possible in a program of this nature to directly influence mine operators at all levels and in all segments of the industry. By first training the mines inspectors, and in Year 4, by extending this training into typical operating mines, it is hoped to leave a residual skills base which will serve as a catalyst for an ongoing and increasing emphasis on mine safety.

The challenge is now with the industry in India. There is now a knowledge base and some practical examples of the benefits which result from a systems approach to safety management. To extend this broadly across the industry requires a commitment from the regulators, the operators and importantly, the unions and mineworkers. There is no reason why within some years India cannot challenge those countries employing more advanced mining technologies by recording a comparable safety record.

The contribution of the three shareholder companies of AIMSTC, and their key personnel, Robert Guy (Project Manager) of SCT International Pty Ltd, Stewart Bell (Deputy Project Manager) of SIMTARS, and Geo-Eng International Pty Ltd is acknowledged both for their input to the project and to this paper. The assistance of the Mines Inspectorates of the Australian states of Queensland, New South Wales and Victoria is also gratefully acknowledged.

DGMS Project Director Bhaskhar Battarcharjee and Project Managers, Rahul Guha and Ashim Sinha, have coordinated the Indian input to the project. The enthusiasm and commitment of Rahul Guha in particular should not go unacknowledged and his contribution to the paper and the project is now a matter of record.

AusAID, the Australian Government’s International Aid Agency, sponsored and funded the (Australian component) of the project. Their support has been unequivocal and their commitment to ensuring that the project ethic survives the project formed the basis for the very productive Year 4 program. The support from both Canberra and New Delhi has greatly assisted the execution of the project. Their permission to publish this paper is appreciated.

ANNEX A

RISK ASSESSMENT EXAMPLE conducted at Balaria Mine

Completed 6 April 2001

1. INTRODUCTION

This plan has been drawn up as an exercise to demonstrate the process of conducting a risk assessment and the method of deriving a plan to ameliorate the effects of the identified hazards.

Following a course on basic risk assessment principles the participants selected a hazardous area to assess and develop a plan to control the risks in this area, to an acceptable level.

The area chosen was the conveying of ore in the Balaria Mine of the Zawar Group of Mine of Hindustan Zinc Ltd. Potential hazards in this area were identified and assessed with regard to their risk.

This plan does not address a principal hazard but rather an area of activity of the mine. For the purpose of the exercise, this was deemed to be adequate to show the principles involved and how such a plan has to be drawn up.

The results of the exercise follow.

2. IDENTIFIED HAZARDS

Safety Definitions

Hazard: A source of potential harm or a situation with a potential to cause loss.

Principal Hazards: means a hazard with a potential to result in multiple fatalities.

Risk: The chance of something happening that will have an impact upon objectives. It is measured in terms of consequences and likelihood.

Prior to the exercise, a risk assessment course was held in order to bring all participants to the same level of understanding regarding the process and to reach a consensus regarding the use of the terms to be used in the assessment.

The risk assessment exercise was conducted on the selected area which included the production inclines, Phases One and Two. This area is from the bottom of the bottom of the bunker at 75MRL to 250 MRL, includes the transfer bunker, and from 250 MRL to 380 MRL on to the primary fine ore bin where transported ore is dumped.

The team consisted of a cross section of disciplines on the mine.

A hazard identification process was held using the principle that a hazard can also be defined as an unplanned or unwanted release of energy. The hazards were assessed in terms of risk, defined as the product of consequence, exposure and probability.

The values for the consequence of the hazard were based on the most reasonable worst case occurrence. Cognisance was given to controls already in place.

The results of the risk assessment are presented in Table A1.

Hazards with a risk of above 400 were deemed to require immediate action, those with a value below 400 but above 100 would be deemed to require attention, while those below 100 were acceptable, but required maintenance to keep them at this low level.

The controls for the groups of hazards were formulated accordingly. For hazards that require maintenance no controls were structured, as the present controls are considered sufficient.

For hazards requiring attention, controls for improvement were formulated and, for those controls that require immediate action, an action plan was drawn up.

Table A1: Risk Assessment results

	No.	HAZARD	Risk Assessment			
ENERGY			Consequence	Exposure	Probability	Risk Rating
Gravity	1	Fall of person.	15	5	7	525
“	2	Rolling/falling of stones & rocks.	10	5	3	150
“	3	Ore bouncing at loading/transfer points.	10	5	3	150
“	4	Belt rolling down after breaking.	10	5	3	150
“	5	Material striking person/systems after winch rope breakage.	20	3	2	120
“	6	Loosening ore in jammed chute.	10	3	3	90
“	7	Belt rolling down due to power failure.	5	5	2	50
“	8	Person falling from platform.	15	5	1	75
“	9	Falling tools, tackle, materials during maintenance.	10	5	3	150
“	10	Uncontrolled movement of belt reel while changing.	10	2.5	1	25
Mechanical	1	Loose parts caught between pinch points.	20	5	2	200
“	2	Rollers causing damage to belt.	5	5	2	50
“	3	Shaft failure, causing projectiles.	15	5	3	225
“	4	Breakage of rope of take-up winch.	15	5	1	75
“	5	Breakage of belt due to improper joints.	15	5	2	150
“	6	Sway of belt due to improper jointing.	5	5	2	50

Table A1 contd.

"	7	Improper shut-down procedure	40	5	1	200
"	8	Malfunctioning of sequence control.	5	5	1	25
"	9	Foreign materials damaging belt.	5	5	7	175
"	10	Uncontrolled movement of belt while jointing.	5	3	3	45
"	11	Slippage of tools/tackle.	10	5	7	350
"	12	Failure of lifting tackle while in use.	20	2.5	1	50
"	1	Electrocution.	20	5	3	300
Electrical	2	Fire due to short-circuiting.	10	5	2	100
"	3	Transformer/OCB fire.	40	5	2	400
"	4	Motor burns.	2	5	2	20
"	5	Failure of control devices.	5	5	7	175
"	1	Belt fire due to friction.	15	5	3	225
Heat Energy	2	Gear box heating.	15	5	3	225
"	3	Bursting of fluid coupling.	40	5	1	200
"	1	Bursting of air pipe.	15	5	3	225
Fluid & Air	2	Bursting of water pipe.	15	5	3	225
"	3	Bursting of fluid coupling.	40	5	1	200
"	1	Damage to hearing.	15	2.5	3	112.5
Other	2	Dust hazard.	50	10	7	3500
"						

ANNEX B **Project Postscript**

Information below has been added (September 2005) to indicate the ongoing level of serious accidents in the mining industry in India before and after the implementation of the Mine Safety Project. Data has been supplied by the Directorate General of Mines (from their records) at the request of, but has been interpreted by the author.

The information was requested to complement the presentation of the December 2001 paper at the Third Pacific Economic Cooperation Conference Minerals Network Meeting in Tiayuan, China in September 2005. Its inclusion was to permit a value judgement to be made about this technology transfer program and to determine if the positive impact associated with the program was reflected in ongoing mining accident rates. The program commenced in June1997, with the final Inspector training complete in Australia in May 1999. Upgraded mining regulations were progressively issued in the form of industry circulars and the DGMS internal training program was not established until the completion of project field activities in the third quarter of 2001. The Model Mine Program (Project Year 4 – July 2000 to June 2001) introduced new concepts of managing mining safety into the industry in a very limited way, being intended to act as a catalyst for the industry at large. It did not, and could not have far reaching implications in the short term.

Data below refers to the ten years, 1994 to 2004 for which serious accident and production statistics were made available by DGMS. The project took place in Years 4 to 8 (1997 to 2001), partway through the reporting period.

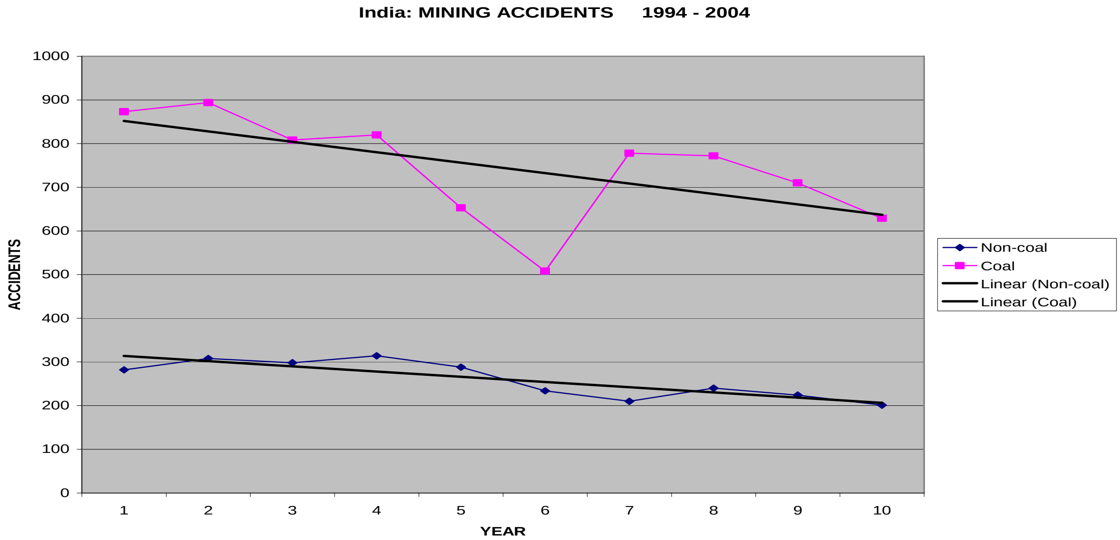
Information relating to the incidence of serious accidents for the coal and the non-coal sectors has been tabulated with this data being used to calculate accident rates in relation to production – a common international determinant of safety performance.

Table B.1 Number of Serious Accidents in Indian Mines - 1994 to 2004.

		Non-Coal				**Coal**		
Year		**Fatal**	**Serious**	**Total**		**Fatal**	**Serious**	**Total**
1994	1	57	225	282		156	717	873
1995	2	58	250	308		137	757	894
1996	3	63	235	298		131	677	808
1997	4	68	246	314		143	677	820
1998	5	54	234	288		131	522	653
1999	6	60	174	234		132	376	508
2000	7	50	160	210		117	661	778
2001	8	62	178	240		105	667	772
2002	9	50	174	224		81	629	710
2003	10	54	147	201		83	546	629
2004	11	47	119	166		83	343	426

Despite a significant increase in the accident level in the year 2000, the overall trend is one of continuous improvement over the ten year period. The coal industry has recorded an average decrease of the order of 5% per annum and the non-coal industry around 4%. Chart B.2 below clearly indicates the longer term trends. What is clear is that despite individual year variations, the trend already established pre-project continues through the life of the project and beyond. It cannot be established convincingly that the implementation of this specific project had a visible impact on industry accident rates, performance improvements being possibly due to factors already in train.

Chart B.2 India Mining Accidents 1994 to 2004



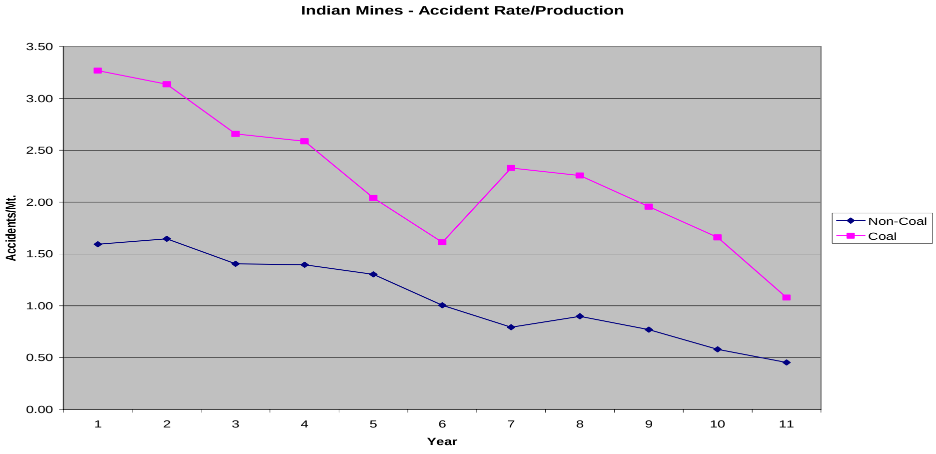
However, absolute figures of accidents do not reflect the level of activity within the industry in a reporting period. For comparative purposes, and international comparisons are available, relating the incidence of accident occurrence to the concurrent level of production provides a more accurate picture of ongoing industry performance. Table B.3 below sets out for the same period as above, the level of accident occurrence per million tonnes of production in both the coal and non-coal sectors.

Table B.3 India: Serious Accidents per Mt. of Production.

		Non-Coal				**Coal**		
Year		Serious Accidents	Production Mt.	Accidents/Mt.		Serious Accidents	Production Mt.	Accidents/Mt.
1994	1	282	177	1.59		873	267	3.27
1995	2	308	187	1.65		894	285	3.14
1996	3	298	212	1.41		808	304	2.66
1997	4	314	225	1.40		820	317	2.59
1998	5	288	221	1.30		653	320	2.04
1999	6	234	233	1.00		508	315	1.61
2000	7	210	265	0.79		778	334	2.33
2001	8	240	267	0.90		772	342	2.26
2002	9	224	291	0.77		710	363	1.96
2003	10	201	347	0.58		629	379	1.66
2004	E	166	366	0.45	E	426	395	1.08

Decreases in the incidence of accidents of the order of two thirds over this ten year period are observed for both industry sectors. This is more clearly illustrated in Chart B.4 below.

Chart B.4 Indian Mines: Accident Rate with respect to Production - 1994 to 2004.



While Table B.5 below is not directly comparable with figures for serious accidents presented above, in that it relates the fatality rate to production levels for coal mines, it demonstrates the progress being made in India in the reduction of the incidence of coal mine fatalities. However it also demonstrates that in comparison to the 'developed' countries of U.S.A and Australia, fatality rates are too high and continuing attention to reducing these is mandatory. India, with the assistance of Australia has demonstrated a commitment to this objective.

Table B.5 Comparison of Coal Mines Fatality Rates in other Countries (1994 to 1998).

	Fatality Rate per million tonnes of coal mined						
Year	India	Czech Rep.	Japan	West Germany	U.K.	U.S.A.	Australia
1994	0.90	0.12	0.14	0.29	0.05 (1992).	0.04	0.02
1995	0.77	0.26	0.32	0.26	N.A.	0.05	0.02
1996	0.48	0.15	0.00	0.25	N.A.	0.04	0.04
1997	0.52	0.23	0.47	0.19	N.A.	0.03	0.02
1998	0.47	0.13	N.A.	N.A.	N.A.	N.A.	N.A.

It is still unclear how the influence of the India: Mine Safety Training Project is reflected in the safety performance of the Indian mining industry. All the indicators are that India is coming to terms with a problem long recognized as of major concern to the industry and the country, and that the initiatives being taken, the procedures being put in place and the emphasis on safety as a mine operator responsibility are all contributing factors in the documented improvement. The extent to which the technology transfer program has contributed is a matter of conjecture but those associated closely with the program believe strongly that it contributed to the safety ethic being identified as being of prime importance in achieving production targets, and lessening the incidence of accidents.

Countries with less than acceptable mine safety records can learn from the techniques employed and the program objectives which emphasize the role of every individual mine worker as responsible for his (and his workmate's) safety. The basic concept inherent in every Safety Management System is to recognize, and eliminate or minimize those hazards conducive to accidents, prior to that situation being recorded as the cause of a serious accident, perhaps one having fatal consequences.