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# Disaster Prevention and Control Management

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**Abstract**

So long as resources are there, there will be mining. As long as mining is there; disasters associated are common. But from time to time, global mining community finds ways and means to prevent and control disasters. In doing so, still the world community faces innumerable challenges. In answering these challenges, policy frameworks also are done by different countries. The intellectual communities come up with constructive suggestions for sustainable development of mining from time and again. This article discusses in nutshell the Disaster Prevention and Control Management- Global Challenges, Policy Framework and Sustainable Development for Mining of Mineral and Fossil Energy Resources.


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## 1. Introduction

Disaster is "A situation resulting from an environmental phenomenon or armed conflict that produced stress, personal injury, physical damage and economic disruption of great magnitude." This article deals with the disasters in mining and their prevention and control technologies and also with the global challenges and policy framework for prevention and control of disasters in mining. Based on the cause which is responsible for the disaster, disasters are classified as follows.

### *1.1. Disaster types*

According to Clarissa Lins, disaster types categorized are related with electrical,entrapment, exploding vessels under pressure, explosives and breaking agents, falling, rolling or sliding rock or material of any kind, fall of face, rib, side or highwall, fall of roof or back, fire, handling material, hand tools, hoisting, ignition or explosion of gas or dust, impoundment, inundation, machinery related haulages, slip or fall of person, stepping or kneeling on object, striking or bumping and others [4] which are briefed hereunder:

- Electrical accidents in which electric current is most directly responsible for the resulting accident;
- Entrapment: In accidents involving no injuries or nonfatal injuries which are not serious, entrapment of mine workers takes precedence over roof falls, explosives accidents,


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inundations, etc. If a roof fall results in an entrapment accident, the accident classification is entrapment;

- Exploding vessels under pressure: These are accidents caused by explosion of air hoses, air tanks, hydraulic lines, hydraulic hoses and other accidents precipitated by exploding vessels;
- Explosives and breaking agents: Accidents involving the detonation of manufactured explosives, Airdox or Cardox that can cause flying debris, concussive forces or fumes;
- Falling, rolling, or sliding rock or material of any kind -Injuries caused directly by falling material require great care in classification. Remember that it is the accident we want to classify. If material was set in motion by machinery, haulage equipment or hand tools or while material is being handled or disturbed etc., charge the force that set the material in motion. For example, where a rock was pushed over a highwall by a dozer and the rock hit another rock which struck and injured a worker - charge the accident to the dozer. Charge the accident to that which most directly caused the resulting accident. Without the dozer, there would have been no resulting accident. This include accidents caused by improper blocking of equipment under repair or inspection;
- Fall of face, rib, side or highwall: Accidents in this classification include falls of material (from in-place) while barring down or placing props; also pressure bumps and bursts. Since pressure bumps and bursts which cause accidents are infrequent, they are not given a separate category. Not included are accidents in which the motion of machinery or haulage equipment caused the fall either directly or by knocking out support; such accidents are classified as machinery or haulage whichever is appropriate;
- Fall of roof or back: Underground accidents which include falls while barring down or placing props; also pressure bumps and bursts. Not included are accidents in which the motion of machinery or haulage equipment caused the fall either directly or by knocking out support; such falls are classified as machinery or haulage whichever is appropriate;
- Fire: In underground mines, an unplanned fire not extinguished within 10 minutes of discovery; in surface mines and surface areas of underground mines, an unplanned fire not extinguished within 30 minutes of discovery;
- Handling material: (Lifting, pulling, pushing, and shovelling material.) The material may be in bags or boxes or loose sand, coal, rock, timber, etc. The accident must have been most directly caused by handling material;
- Hand tools: Accidents related to non-powered tools when being used as hand tools do not include electric tools or air-powered tools;
- Hoisting: Damage to hoisting equipment in a shaft or slope which endangers an individual or interferes with use of the equipment for more than 30 minutes. Hoisting may also be the classification where a victim was injured by hoisting equipment but there was no damage to the equipment. Accidents involving cages, skips, buckets or elevators. The accident results from the action, motion or failure of the hoisting equipment or mechanism. Included is equipment such as derricks and cranes only when used in shaft sinking; suspended work platforms in shafts; mine cars being lowered or raised by hoisting equipment on slopes or inclines; a skip squeezed between timbers resulting in an accident; or an ore bucket tipped for any reason causing an accident;
- Ignition or explosion of gas or dust: Accidents resulting as a consequence of the ignition or explosion of gas or dust. Included are exploding gasoline vapours, space heaters or furnaces.
- Methane Ignition - A methane ignition occurs when methane burns without producing destructive forces. Damage resulting from an ignition is limited to that caused by flame and heat. Personnel in the immediate vicinity of an ignition may be burned and line brattice or other materials in close proximity may be discoloured, melted or burned. Ignitions generally involve small quantities of methane and are usually confined to a small area; however, in the case of methane roof layering, flame spread may more extensive.
- Methane Explosion - A methane explosion occurs when methane is ignited and burns violently. The flame of the explosion accelerates rapidly, heating the environment and causing destructive forces. Evidence of the destructive forces may be manifest on victims, equipment, structures, etc. Witnesses to an explosion may hear the noise generated by the resulting sound pressure wave;
- Impoundment: An unstable condition at an impoundment, refuse pile or culm bank which requires emergency action in order to prevent failure or which causes individuals to evacuate an area. Also the failure of an impoundment, refuse pile or culm bank;

- Inundation: An unplanned inundation of a mine by a liquid or gas. The mine may be either a surface or underground operation;
- Machinery haulages: Accidents that result from the action or motion of machinery or from failure of component parts. Included are all electric and air-powered tools and mining machinery such as drills, tuggers, slushers, draglines, power shovels, loading machines, compressors, etc. Include derricks and cranes except when they are used in shaft sinking or mobile cranes travelling with a load.
- Non powered haulage: Accidents related to motion of non-powered haulage equipment. Included are accidents involving wheelbarrows, manually pushed mine cars and trucks etc.
- Powered haulage: Haulage includes motors and rail cars, conveyors, belt feeders, long wall conveyors, bucket elevators, vertical man lifts, self-loading scrapers or pans, shuttle cars, haulage trucks, front-end loaders, load-haul- dumps, forklifts, cherry pickers, mobile cranes if travelling with a load etc. The accident is caused by the motion of the haulage unit. Include accidents that are caused by an energized or moving unit or failure of component parts. If a car dropper suffers an injury as a result of falling from a moving car, charge the accident to haulage;
- Slip or fall of person: Includes slips or falls from an elevated position or at the same level while getting on or off machinery or haulage equipment that is not moving. Also includes slips or falls while servicing or repairing equipment or machinery which again includes stepping in a hole.
- Stepping or kneeling on object: Accidents are classified in this category only where the object stepped or kneeled on contributed most directly to the accident;
- Striking or bumping- This classification is restricted to those accidents in which an individual while moving about strikes or bumps an object but is not handling material, using hand tools or operating equipment;
- Other - Accidents not elsewhere classified. This is a last resort category.

## 2. Disaster prevention and control management

### *2.1. Objectives of disaster management*

A disaster1 refers to a catastrophe, mishap, calamity or grave occurrence from natural or man-made causes, which is beyond the coping capacity of the affected community. Disaster Management involves a continuous and integrated process of planning, organizing, coordinating and implementing measures which are necessary or expedient for: Prevention of danger or threat of any disaster; Mitigation or reduction of risk of any disaster or its severity or consequences; Capacity building including research and knowledge management; Preparedness to deal with any disaster; Prompt response to any threatening disaster situation or disaster; Assessing the severity or magnitude of effects of any disaster; Evacuation, rescue and relief and Rehabilitation and reconstruction.

### *2.2. Methods for prevention and control of disasters: Methane monitoring and control technologies*

Methane gas explosions are one of the most common causes of underground coal mine disasters. Methane is an odourless, colourless and highly combustible gas that leaks out during mining of coal seams and if left undetected and uncontrolled can explode violently with a small spark. Therefore, it is of paramount importance to control the methane through adequate ventilation when it is present in small amount in the air.

Fig. 1. Methane monitoring equipment

For detecting methane gas level, the coal mining equipments are recommended to be fitted with methane monitors in order to enable the machines as well as the electricity to be automatically shut off once the methane level reaches 1.5%. Recently developed sensor-based methane detectors utilising radio frequency identification (RFID) technology can be deployed in any part of a deep underground coal mine transmitting methane concentration readings wirelessly to the surface. For instance, US-based Tunnel Radio has developed a wireless detection system for monitoring methane gas and carbon dioxide (CO2). It comprises of an easy-to-install gas sensing module suitable for battery-powered application. The device can send precise gas-level readings to the surface computer system on a continuous basis even in the harshest environments.

### *2.3. Dust monitoring and control technologies*

Fig. 2. Dust generation with shearer

Dust build-up in the underground mining area is another major cause of coal mine explosions. The inhalation of silica and coal dust also poses serious health hazards for the miners. The use of air ventilators and water sprays and the regular cleaning of coal dust lying on the surface are some of the basic techniques to prevent coal dust explosions. An array of dust-buster agents including binders, foams and antioxidants are also being developed to mitigate the chances of coal dust related disasters. GE's newly launched CoalPlus technology for example, can reduce coal dust by up to 90% in different coal mining operations.

The coal dust explosibility meter (CDEM), a portable and handheld instrument for instant monitoring of the ratio between coal dust and rock dust levels in the underground mine, is currently available in the market. The device originally developed by USA's National Institute for Occupational Safety and Health (NIOSH) is being commercialised by Sensidyne. Personal dust monitors (PDM) have also been developed to give miners a tool to track exposure to respirable coal dust in real-time.

### *2.4. Automated underground mining*

Automated underground mining is the most promising technology to prevent fatal mining accidents such as drilling, blasting, loading and hauling at deep undergrounds and can be performed using unmanned vehicles and machines operated from a remote location. Apart from efficiency and productivity, the biggest advantage of mine automation is the fact that humans can be kept out of harm.

Fig. 3 Automated underground mining

Mining companies around the world are either using or considering to use automated mining technologies. De Beers Finsch diamond mine in the Northern Cape, South Africa, Codelco's El Teniente copper mine in Chile and Rio Tinto's West Angelas Mine in the Pilbara region, Australia are among the first underground mines to adopt automated haulage and transport systems. BHP Billiton has also started experimenting driverless trucks and an automated remote operating centre for its iron ore operations in the Pilbara region of Australia. Vale has decided to make its Carajas Serra Sul S11D iron ore mine automated and completely truck-less. Rio Tinto has announced that it will deploy the world's biggest underground automation system for block caving operations at the Argyle underground diamond mine.

### *2.5. Rock -falls prevention technologies*

Rock and roof falls is one of the most common causes of underground mining accidents. The basic precautionary measures to prevent such accidents are taken during the preparation of mining layout designs with the aim of minimising the effects of potential geologic hazards. Constant monitoring of rock faces is required to prevent such accidents. Some big pit mines are also using electronic surveillance systems checking for loose rocks and tension cracks to prevent rock fall from high walls.

Fig. 4. Automated temporary roof supporter

Few processes in underground mining such as rock bolting and pillar recovery are prone to rock-fall and rib-fall related injuries. Automated Temporary Roof Support (ATRS), Mobile Roof Supports (MRS) and automated roof bolting system involving self-drilling injectable rock bolts are some of the new technologies providing protection against such injuries. Companies such as Fletcher, JOY, Hilti and Orica are at the forefront in producing a range of such solutions.

Paste backfill is a promising technology capable of preventing roof falls effectively in underground hard rock mines. The paste backfill material prepared by mixing tailings with appropriate proportions of cement and water is transported underground by pipeline to be used for vertical roof support, ground and pillar support, pillar recovery, and for creating working platforms.

### *2.6. Proximity detection and collision warning*

Fig. 5. First aid of injured worker

Collision between machinery or between machinery and personnel is one of the common causes of accidents in underground as well as open pit mines. Proximity detection technology can be installed on mobile machinery to detect the presence of personnel or machinery within a certain distance of the machine.

NIOSH developed an active proximity warning system called the Hazardous Area Signalling and Ranging Device (HASARD) for warning workers through visual, audible and vibratory indicators as they approach dangerous areas around heavy mining equipment. Caterpillar has also developed detection technology called Cat Detect Personnel that features as one of the five sub-modules of its integrated mining management suite Cat MineStar. The technology involving RFID tags worn by the workers and the detectors mounted over the machines to warn operators with audio and visual indications of possible collisions, speeding or rollovers.

### *2.7. Computerised permit-to-work system*

Fig. 6. Computerised working

The effective management of a permit-to-work system is critical to mine safety as it tracks the authorisations and competencies of employees while identifying the key risks involved with a particular job.

A computerised permit-to-work system collating all required documentation for specific types of work, taking into account the specific identified hazards and the precautions needed to be taken by workers is helpful in ensuring mine safety at the work authorisation level. ApplyIT, a South African software company for example, has developed a permit-to-work authentication system called IntelliPERMIT that integrates all aspects of permits-to-work, access control and risk assessment, tracks the authorisation levels of each employee at work and ties permits into access control with biometric fingerprint identification. IntelliPERMIT has been installed at Newmont Mining Corporation's Boddington mine in Australia.

### *2.8. Fatigue monitoring*

Distraction caused by long working hours creating tiredness in truck drivers and machine operators working at the mine site is a common cause of accidents. The technology, capable of constantly detecting the onset of fatigue and micro sleeps in the operators and creating an alert for them is helpful in preventing such accidents.

Seeing Machine, an Australian company has developed fatigue monitoring systems called Driver Safety System (DSS) using patented eye and head tracking technology. The DSS comprises of a dash-mounted camera constantly detecting the fatigue and distraction in the driver's eyes. Caterpillar entered into an agreement with Seeing Machine to market the fatigue monitoring system in March 2013.

- Methane capture from coal mines could prevent possible underground explosions.
- Coal dust control is a necessary preventive measure against coal mine explosions.
- The adoption of automated mining technologies is on the rise.
- Advanced roof-bolting system offers protection against rock-fall related injuries.
- Proximity detection technology might prevent several collision-related injuries.
- Boddington mine in Australia has adopted computerised work-authorization-system.

### *2.9. Global challenges in disaster prevention and control management*

Governance for risk management: Appropriate governance for disaster risk management is a fundamental requirement if risk considerations are to be factored into development planning and if existing risks are to be successfully mitigated.Development needs to be regulated in terms of its impact on disaster risk. Enhance global indexing of risk and vulnerability, enabling more and better inter-country and inter-regional comparisons. Support national and sub-regional risk-indexing to enable the production of information for national decision makers develop a multi-tiered system of disaster reporting.

Disaster risk management: The systematic management of administrative decisions, organisation, operational skills and abilities to implement policies, strategies and coping capacities of the society or individuals to lessen the impacts of natural and related environmental and technological hazards.

## 3. Policy framework for institutional and legal arrangements

A typical DM comprises six elements: pre disaster phase includes prevention, mitigation and preparedness while the post disaster phase includes reconstruction, rehabilitation and recovery.

### *3.1. Disaster management Act, 2005 disaster management*

As disaster management is a multi-disciplinary process, all Central Ministries and Departments will have a key role in the field of disaster management. The nodal Ministries and Departments of Government of India (i.e. the Ministries of Agriculture, Atomic Energy, Civil Aviation, Earth Sciences, Environment and Forests, Home Affairs, Health, Mines, Railways, Space, Water Resources etc.) will continue to address specific disasters as assigned to them.

### *3.2. Roadmap for sustainable development in mining*

These are some of the most noteworthy sustainability initiatives in the sector: Use of new technologies to reduce energy use, Conversion of waste water into potable water, Preservation of water resources by conservation, recycling and minimizing pollution, Reclamation of biodiversity in areas impacted by mining operations and maintenance of existing biodiversity in land holdings, Reduction of emissions and waste products and reuse of waste materials in smelting Operation. Employment of community members including women, Management of community and employee health even in areas not directly impacted by mining activities, Provision of training programs for community members, Identification and protection of subsistence-related resources of local communities, including water, plants and wildlife, Planning for mine closures before the beginning of any mining activities, Use of mine closure as an opportunity to rehabilitate land, Development of extensive written policies for all aspects of company’s activities in consultation with stakeholders.

## 4. Conclusions

Men are commonly exposed to disasters during mining of resources. In a move to face such disasters, policy frameworks and preventive measures have also been developed from time to time. To realize sustainable development of mining, these measures in place ought to be observed meticulously and in addition further researches need to be conducted to answer the unmet challenges still surfacing the mining industry.

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