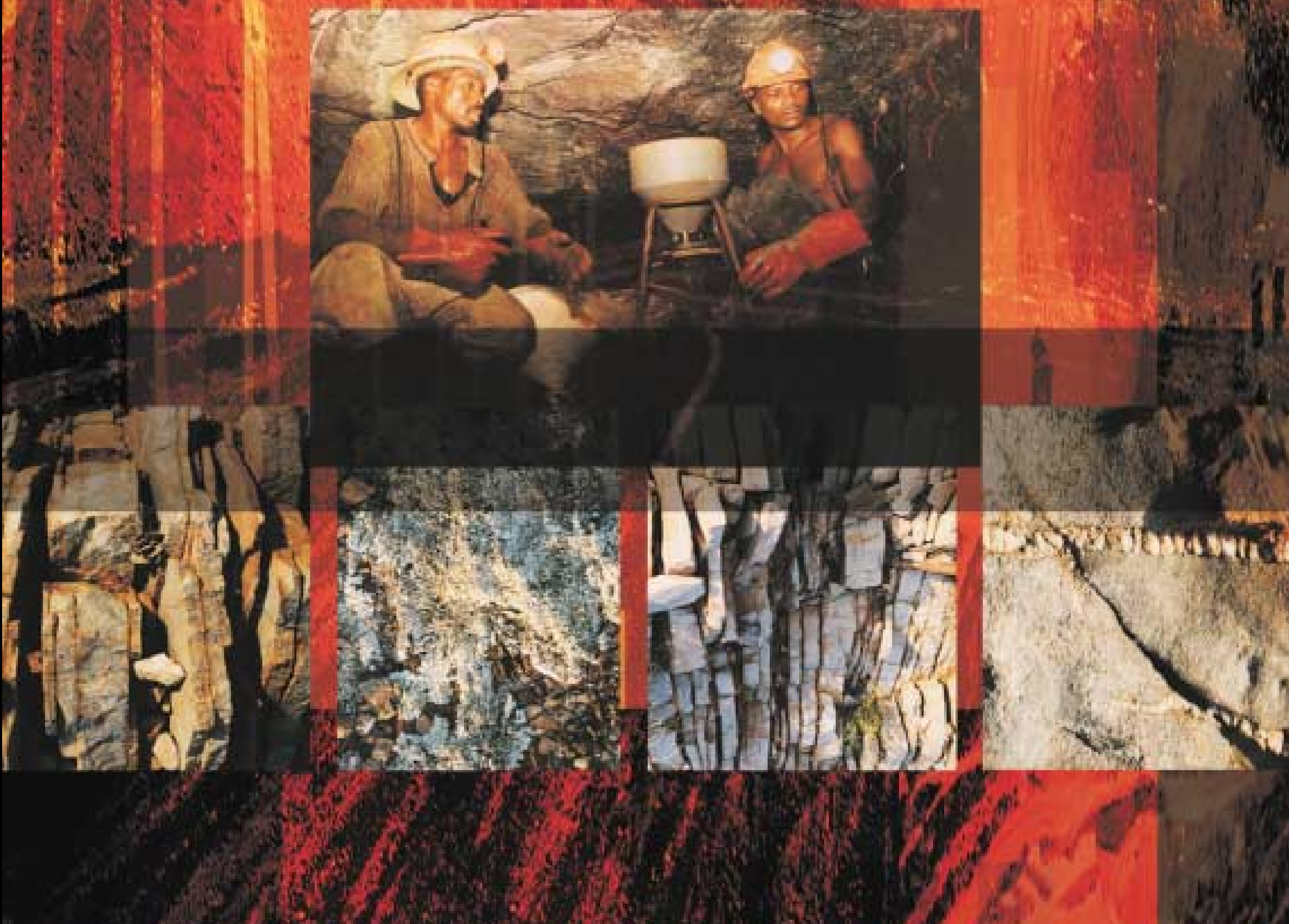
DEPARTMENT OF MINERALS AND ENERGY

MINE HEALTH AND SAFETY INSPECTORATE



ROCK BURST

Guideline for the compilation of a mandatory Code of Practice to combat Rock Fall and Rock Burst Accidents in Tubular Metalliferous Mines

REFERENCE NUMBER: DME 16/3/2/1-A3
LAST REVISION DATE: 1 February 2002

DEPARTMENT OF MINERALS AND ENERGY
REPUBLIC OF SOUTH AFRICA

MINE HEALTH AND SAFETY INSPECTORATE

GUIDELINE FOR THE COMPILATION OF A MANDATORY CODE OF PRACTICE TO COMBAT ROCK FALL AND ROCK BURST ACCIDENTS IN TABULAR METALLIFEROUS MINES

CHIEF INSPECTOR OF MINES

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CONTENTS OF GUIDELINE

PART A: THE GUIDELINE

1. FOREWORD

1.1 The majority of accidents occurring at mines are as a result rock falls, seismically or gravitationally induced. Over the last few years the fatality rate pertaining to rock fall and rock burst-related accidents has reached a plateau and no real or meaningful improvement has been attained.

1.2 In an initiative to solve this problem, a tripartite task group was established under the auspices of the MRAC. The initial terms of reference of the task group were to investigate and identify root causes of rock related accidents. Current work practices and any compliance and/or non-compliance with regulations, standards, directives, guidelines and COP, and their impact on root causes were scrutinised. Research conducted into solutions under the direction of the Safety in Mines Research Advisory Committee (SIMRAC) was also examined.

1.3 Subsequent to the investigation it was concluded that, as a matter of urgency, a guideline for the compilation of a mandatory COP to combat rock fall and rock burst accidents be produced. Due to the complexity and variability of conditions at mines pertaining to the design, geometry and support requirements, rigid and prescriptive guidelines would not be in the interests of rock related safety. An approach was adopted which allowed for local expertise, experience and knowledge on the mines to be effectively utilised. In addition, the position contribution of tripartism to initiate a process to combat rock related accidents would be enhanced.

1.4 This guideline is a generic document and is not intended to address the rock related accident problems, encountered on a particular mine.

2. THE LEGAL STATUS OF GUIDELINES AND COP'S

2.1 In accordance with section 9(2) of the MHSA, an employer must implement a COP on any matter affecting the health and safety of employees and any other person who may be directly affected by the activities at the mine if the Chief inspector of Mines requires it. In terms of section 9(3) of the MHSA, a COP must comply with the relevant guideline issued by the Chief Inspector.

2.2 Failure by the employer to prepare or implement a COP in compliance with this guideline is a breach of the MHSA. Any contravention of, or failure to comply with, a COP is not, in itself, a breach of the MHSA, except a contravention or failure by an employer that also constitute a failure to prepare or implement the COP. Since the DME does not approve COPs, its focus is not to enforce them either. The focus of the DME is to ensure that employers provide healthy and safe working environments at mines, i.e. focusing on system failures and compliance with the MHSA, rather than enforcing compliance with the COP.

2.3 The fact that a contravention of, or failure to comply with the COP is not a breach of the MHSA, does not mean that such breaches will have no legal implications. As far the employer is concerned, there are numerous specific and general obligations on the employer in the MHSA, aimed at ensuring the health and safety of all employees and all persons who are not employees but who may be directly affected by the activities at the mine. Where any failure to comply with a COP also constitutes a breach of any of the employer's obligations under the MHSA, the employer could be liable to an administrative fine for such breach. An inspector could also issue various instructions to the employer and employees in terms of section 54 to protect the health or safety of persons at the mine. Failure by an employer to comply with such an instruction could render the employer liable to an administrative fine.

2.4 As far as employees are concerned, section 22 places a number of obligations on employees, including that they must take reasonable care to protect their own health and safety and the health and safety of other persons who may be affected by their conduct. Where a failure by an employee to comply with a COP would also constitute a breach of the employee's duties in terms of section 22 (or a breach of section 84, 86(1) or 88), the employee could be criminally charged for such breach. As is the case with employers, the inspectorate could issue instructions to employees in terms of section 54 and failure to comply with such an instruction constitutes a criminal offence.

2.5 Employers should deal with breaches by employees of the COP in terms of the mine's standard instructions and the employer's disciplinary procedures. This is not the responsibility of the State.

3. THE OBJECTIVE OF THIS GUIDELINE

The objective of this guideline is to enable the employer at every mine to compile a COP, which, if properly implemented and complied with, would reduce the number of rock fall and rock burst accidents at the mine.

4. DEFINITIONS AND ACRONYMS

In this guideline for a COP or any amendment thereof, unless the context otherwise indicates: -

COP means Code of Practice;

DME means the Department of Minerals and Energy;

Geology means the scientific study of the Earth, the rock of which it is composed and the changes which it has undergone or is undergoing;

Ground control means the ability to predict and influence the behaviour of rock in a mining environment, having due regard for the safety of the workforce and the required serviceability and design life of the mine;

Ground Control Districts means a portion of a mine where similar geological conditions exist which give rise to a unique set of identifiable rock-related hazards for which a common set of strategies can be employed to minimise the risk resulting from mining;

Ground Control District Plan means a plan on good quality transparent draughting material of a thickness not less than 0,08 mm indicating to a scale of 1 in 2500 all applicable ground control districts of the mine;

Hazard means a source of, or exposure to, danger;

Metalliferous mine means any mines that are not diamond or coal mines;

MHSA means Mine Health and Safety Act, 1996 (Act No. 29 of 1996);

MRAC means Mining Regulation Advisory Committee;

Permanent Support means support that, once installed, is not removed;

Pillar means rock left in situ during the mining process to support the local hanging wall, roof or to provide stability to the mine or portion thereof;

Primitive (virgin) stress means the state of stress in a geological formation before the stress field is altered by mining operations;

Risk means the likelihood that occupational injury or harm to persons will occur;

Rockburst means a seismic event that causes damage to underground workings;

Rock Engineering means the engineering application of rock mechanics;

Rock fall (fall of ground) means a fall of a rock fragment or a portion of fractured rock mass without the simultaneous occurrence of a seismic event;

Rock mass means the sum total of the rock as it exists in place, taking into account the intact rock material, groundwater, as well as joints, faults and other natural planes of weakness that can divide the rock into interlocking blocks of varying sizes and shapes;

Rock mechanics means the scientific study of the mechanical behaviour of rock and rock masses under the influence of stress;

Seismically Active Mine means a mine that sustains losses to persons and/or property, underground or on surface, caused by the dynamic response to a seismic event induced when creating or enlarging an excavation;

Seismic event means the transient earth motion caused by a sudden release of the strain energy stored in the rock;

Seismicity means the geographic and historical distribution of earthquakes;

Seismology means the scientific study of seismic events by the analysis of vibrations transmitted through rock and soil materials;

Shaft means any tunnel having a cross sectional dimension of 3,7 m or over and
(i) having an inclination to the horizontal of 15 degrees or more, or
(ii) having an inclination to the horizontal of less than 15 degrees but more than 10 degrees where the speed of traction exceeds 2 m/s;

Significant Rock-Related Risk means the likelihood that the harm from a particular hazard will result in the death or permanent disability of a person.

Special areas means areas requiring additional attention and precautions where an increased risk of rock falls or rock bursts may develop;

Stope means an underground excavation made in removal of any ground or mineral, other than coal, but does not apply to excavations made for engine rooms and pump chambers or for development purposes such as shafts, drives, winzes and raises;

Strain burst means rock burst at the surface of an excavation;

Support means a structure or a structural feature built into or around an underground excavation to maintain its stability;

Temporary support means support that will be removed;

Tendon (support) means the generic "rockbolt", plus flexible forms such as "cable anchors";

5. SCOPE OF GUIDELINE

5.1 This Guideline covers the significant health and safety aspects associated with rock fall and rock burst hazards in tabular metalliferous mines.

5.2 The Guidelines covering the four principal mining methods are:

5.2.1 DME 16/3/2/1-A3 ".... Tabular Metalliferous Mines";
5.2.2 DME 16/3/2/1-A4 ".... Underground Coal Mines";
5.2.3 DME 16/3/2/1-A5 ".... Massive Mining Operations"; and
5.2.4 DME 16/3/2/1-A6 ".... Surface and Openpit Mines"

6. TASKGROUP MEMBERSHIP

This guideline was prepared by the MRAC Task Group on Rockfall and Rockburst Accident in Tabular Metalliferous Mines.

Mr. J E KOTZE (Chairperson)	-	State
Dr. W K RYMON-LIPINSKI	-	State
Mr. K R NOBLE	-	Employers
Mr. J W KLOKOW	-	Employers
Mr. R C MORE O'FERRALL	-	Employees

The following organisations were also consulted: -

Geotechnical Services
CSIR Miningtek
S.R.K.

PART B: AUTHOR'S GUIDE

1.1 The COP must, where possible, follow the sequence laid out in Part C "Format and Content of the COP." The pages as well as the chapters and sections must be numbered to facilitate cross-referencing. Wording must be unambiguous and concise.

1.2 It should be indicated in the COP and on each annex to the COP whether -

1.2.1 the annex forms part of the COP and must be complied with or incorporated in the COP or whether aspects thereof must be complied with or incorporated in the COP; or

1.2.2 the annex is merely attached as information for consideration in the preparation of the COP (i.e. compliance is discretionary).

1.3 When annexes are used the numbering should be preceded by the letter allocated to that particular annex and the numbering should start at one (1) (e.g. 1, 2, 3, A1, A2, A3,...).

1.4 Whenever possible illustrations, tables, graphs and the like, should be used to avoid long descriptions and/or explanations.

1.5 When reference has been made in the text to publications or reports, references to these sources must be included in the text as footnotes or side notes as well as in a separate bibliography.

PART C: FORMAT AND CONTENT OF THE MANDATORY COP

1. TITLE PAGE

The COP should have a title page reflecting at least the following:

1.1 the name of the mine;

1.2 the heading of the COP (for example, Mandatory COP to Combat Rock Fall and Rock Burst Accidents in Tabular Metalliferous Mines);

1.3 a statement to the effect that the COP was drawn up in accordance with DME guideline, reference no. DME 16/3/2/1-A3 issued by the chief inspector of mines;

1.4 the mine's reference number for the COP;

1.5 effective date; and

1.6 revision dates.

2. TABLE OF CONTENTS

The COP must have a comprehensive table of contents.

3. STATUS OF MANDATORY COP

Under this heading the COP must contain statements to the effect that -

3.1 the mandatory COP was drawn up in accordance with DME guideline Reference Number DME 16/3/2/1-A3 issued by the Chief Inspector of Mines;

3.2 this is a mandatory COP in terms of sections 9(2) and (3) of the MHSA;

3.3 the COP may be used in an accident investigation/inquiry to ascertain compliance and also to establish whether the COP is effective and fit for purpose;

3.4 the COP supersedes all previous relevant COPs; and

3.5 all managerial instructions or recommended procedures (voluntary COPs) and standards on the relevant topics must comply with the COP and must be reviewed to ensure compliance.

4. MEMBERS OF DRAFTING COMMITTEE

4.1 In terms of section 9(4) of the MHSA the employer must consult with the Health and Safety Committee on the preparation, implementation or revision of the COP.

4.2 It is recommended that the employers should, after consultation with the employees in terms of the MHSA, appoint a committee responsible for drafting the COP.

4.3 The COP must not be an overly technical rock engineering document and the participation of supervisory and employee level personnel when compiling the document is essential.

4.4 The members of the Drafting Committee assisting the employer in drawing up the COP must be listed giving their full names, designations, affiliations, professional qualifications and experience. This committee should include persons competent in rock engineering sufficient in number effectively to draft the COP.

5. GENERAL INFORMATION

Relevant information relating to the mine must be stated in this paragraph. The following minimum information must be provided -

5.1 Locality

A brief description and locality map to indicate the location of the mine in relation to towns, existing infrastructure and any other relevant features such as mines sharing a common boundary, dams, rivers and any other topographical features which could influence the strategies adopted.

5.2 Geological Setting

Geological structures, such as faults and dykes and stratigraphy, around individual orebodies or seams must be described and any hazardous conditions highlighted. A typical geological section of the mine must also be included. A detailed geological assessment may not be necessary but a map showing major geological features in relation to mining outlines and shafts must be included.

5.3 Mining environment

The mining environment describes major subdivisions of an orebody, which dictates specific fundamental extraction strategies and occurs on a regional scale thus crossing mine boundaries.

Under this section the following information must be provided:

5.3.1 Orebodies mined: A general description of orebodies or seams being mined, including any relevant information such as average and range of mining depth, orebody width, and dip and strike, must be given.

5.3.2 Regional Hydrology: The regional hydrology such as the occurrence of any significant groundwater and/or any other relevant information must be described.

5.3.3 Seismological Setting of the Mine: The seismological setting must identify and describe the seismic hazards for the different ground control districts and/or emission sources (geological structures, abutments, face burst, etc). Effort should be concentrated on identifying those structures or configurations that create hazards. Where possible, the nature and quantity of the seismic emissions associated with the individual reefs, emission source (geological structures, face bursts, etc.) or ground control districts should be described.

Describing the seismic hazard posed by the different sources could be done in terms of-

- number of events per magnitude ranges (emphasis on the larger magnitude ranges that are potentially hazardous);
- frequency of occurrence, e.g. statistics per ground control district per seismic source; and
- percentage of events that cause damage and/or damage severity per magnitude ranges.

5.4 Ground Control Districts

5.4.1 The location and extent of ground control districts must clearly be described in the COP. The nature of the virgin stress field in which mining is to take place, as well as the occurrence of significant pore water and any other local geological features, must be included here.

5.4.2 All ground control districts must be indicated on a Ground Control District Plan, which must be kept in an office designated for that purpose by the employer.

5.4.3 It is possible that the ground control district in which off reef excavations are located may not correspond with those on reef. If this should be the case, these ground control districts must be described and clearly indicated on the Ground Control District Plan.

5.5 Mine Rock Fall and Rock Burst Incident Analysis

5.5.1 The COP must contain a tabulation of the mine's five year history of rock-related casualties (fatals, reportables and disabling incidents) and non-casualty incidents (where available), categorised according to rock bursts and rock falls per 1000 employees at work for both surface and underground operations.

5.5.2 This information must be graphically represented depicting annual statistics to facilitate easy interpretation of the data and to highlight trends

5.5.3 The COP must reflect the incident trend associated with the identified hazards. From this information the risk associated with each hazard can be established. These statistics should be normalised with respect to production tonnage in the different ground control districts.

6. TERMS AND DEFINITIONS

Any word, phrase or terms of which the meaning is not absolutely clear or which will have a specific meaning assigned to it in the COP, must be clearly defined. Existing and/or known definitions should be used as far as possible. The drafting committee should avoid jargon and abbreviations that are not in common use or that have not been defined. The definitions section should also include acronyms and technical terms used.

7. RISK MANAGEMENT

7.1 Section 11 of the MHSA requires the employer to identify hazards, assess the health and safety risks to which employees may be exposed while they are at work and record the significant hazards identified and risk assessed. The COP must address how the significant risks identified in the risk assessment process must be dealt with, having regard to the requirement of section 11(2) and (3) that, as far as reasonably practicable, attempts should first be made to eliminate the risk, thereafter to control the risk at source, thereafter to minimize the risk and thereafter, insofar as the risk remains, provide personal protective equipment and to institute a programme to monitor the risk.

7.2 To assist the employer with the hazard identification and risk assessment, all possible relevant information such as accident statistics, research reports, various geological, hydrological, seismological information and geotechnical parameters or rock excavation processes must be considered.

7.3 In addition to the periodic review required by section 11(4) of the MHSA, the COP should be reviewed and updated after every serious incident relating to the topic covered in the COP, or if significant changes are introduced to procedures, mining and ventilation layouts, mining methods, plant or equipment and material.

8. ASPECTS TO BE ADDRESSED IN THE MANDATORY COP

The COP must set out how the significant risks, identified and assessed in terms of the risk assessment process referred to in paragraph 7.1, will be addressed. Unless there is no significant risk associated with that aspect at the mine the COP must cover at least the aspects set out below.

- The significant rock-related hazards must be recorded, listed and fully described in such a manner that the risk management strategies can be cross-referenced to them.

- The COP must detail all the strategies employed to combat rock-related hazards/risk (rock bursts and rock falls). These strategies embody various principles, techniques and methodologies employed to reduce the risk peculiar to a particular ground control district and include such aspects as mining layouts, mining sequence, support, and monitoring procedure.

- Where hazards/risks are related to specific ground control districts, the relationship must be clearly indicated.

- The strategies adopted to deal with each of the significant rock related risks should be described under the appropriate sub-sections. These strategies must be cross-referenced to the listed significant hazard(s) that they address.

- The strategies must cover even the most obvious significant risk created by hazards in the work place, such as rock loosened by the blast; time dependent rock dilatation and stress fracturing; brows and geological discontinuities.

- The COP must require that where any experimentation with rock excavations or support system that differs substantially from that contained in the COP is carried out, full documentation regarding such experimentation be kept at the mine, including records of related risk assessments and motivations for the experimentation.

- All strategies must be technically appraised by a competent person.

8.1 Strategies: Overall Mine Stability

The COP must set out a

- strategy for the overall stability of a mine must include measures to avoid catastrophic accidents or situations that give rise to a multitude of minor accidents;

- description of the overall mining method and sequencing to be followed. Where more than one seam occurs in close proximity to another, and where the mining of one or more seams is expected to have an adverse effect and induce hazardous conditions on the other, the strategy adopted to manage this risk must be described;

- description of the measures to ensure the correct selection, use and maintenance of the equipment employed in support operations;

- description of the appropriate and ongoing rock engineering input to ensure overall mine stability.

In the case of-

8.1.1 Shallow hard rock operations:

The COP must set out a

- description of the design methodology to avoid uncontrolled collapses of the mine or portion/s thereof, and the effects of the mining methods employed on surface structures and topography;

- description of the design methodology and criteria used for the specification of regional and -in-panel support;

- description of the reasons for the selection of the specific type of support pillar.

8.1.2 Deep hard rock operations:

The COP must set out a

- description of how processed seismic data is to be used in the mine design methodology and operating procedure;

- description of all rock burst damage control measures, such as rapid yielding props, backfill, mining configuration (layout), mining sequence, specialised support elements or any other energy absorbing support;

- description of the strategies adopted for mines or those portions thereof that are seismically active, sub-divided into *seismic energy emissions control* and *rock burst damage control*-

  - all *seismic energy emissions control* measures and techniques to prevent or reduce seismic emissions such as stabilising pillars, backfill, rock excavation sequencing, limiting of excess shear stress on geological structures, mining through dykes, face layout and shapes, preconditioning, limiting of energy release rates, excavation advance rate and remnant removal or any other special rock excavation processes;

  - all *rock burst damage control* measures, such as rapid yielding props, backfill, mining configuration (layout), mining sequence, specialised support elements or any other energy absorbing support.

8.2 Strategies: Protection of Mine Accesses/Exits

The COP must set out a description of the strategies for the protection of existing mine accesses/exits (e.g. shafts and/or other main entrances/exits) covering at least the following:

- a summary of the rock-engineering appraisal of the current stability of mine access/exit access ways;

- measures employed to monitor ground movement;

- measures to protect employees against the risks associated with instability of access/exit ways;

- measures employed to minimise the risk associated with movements caused by the extraction of shaft pillar; and

- referencing of relevant reports.

8.3 Strategies: Stability of Tunnel and Service Excavations

The COP must set out a

- description of the strategies to combat significant risks in tunnels and service excavations covering at least the following:
  - damage to the walls of excavations, resulting from rock breaking processes (explosives);

- poor rock conditions caused by geological features;
- high or changing stress conditions, and
- proximity to other workings.

• description and substantiation of the excavation process and sequence for all large excavations.

ANNEX 1 sets out guidelines for tunnel and surface excavation support strategy and is appended for information/reference purposes only.

8.4 Strategies: Mineral Excavation Process (Stoping)

The COP must set out a description of the strategies for treating the significant rock-related risks arising from the mineral excavation processes (stoping operations) covering at least the following:

• loose rock arising from changes in the prevailing stress regime, rock breaking practices (explosives), face support, draw point support, undercutting and pillar cutting;

• prevailing geotechnical and seismological conditions (regime);

• sources, relative locations and probable related geological structures of seismic energy emissions;

• prevailing differing geotechnical and seismological conditions (regime) for different sections of the mine;

• stope gully and siding excavation process;

• stope gully support design methodology inclusive of the location and support of two separate and independent exit(escape) routes for each panel;

• description, substantiation and documentation of the methodology to select the most appropriate face and back area support design criteria such as energy absorption capability, yieldability, and areal coverage. SIMRAC projects (GAP 032 and GAP 330) describes such a proposed design methodology;

• description, substantiation and documentation of the methodology for the support of bord and pillar workings, as well as high extraction mining;

8.5 Strategies: Special Areas

The COP must set out a description of the strategies capable of identifying and treating an increased risk of rock falls or rock bursts, which may develop during the course of routine rock excavation operations covering at least the following:

- conditions leading to the designation and classification of such areas as "Special Areas";
- description of additional/special attention or precautions measures;
- measures to effect rapid modifications to processes and/or procedures should such action require urgent review;
- description of the role and responsibility of the competent person in the identification of such special areas.

8.6. Strategies: Rock-Breaking

The COP must set out a description of the rock-breaking strategies adopted to minimise blast-induced damage to excavations walls covering at least the following:

- type of explosives and accessories used;
- drilling patterns and accuracy of drill holes;
- selecting and application of explosives and accessories to the conditions prevailing in different ground control districts;
- method and sequence of initiation of explosive charges.

8.7 The Impact of Mining Activities on Neighbouring Mines

The COP must set out a description of measures that will ensure that neighbouring mines exchange relevant information where the possibility exists that one mine's activities might have a significant detrimental impact on the activities of an adjacent mine, covering at least the following:

- rock excavation processes, methodology, techniques, sequence, excavation speed, etc;
- regional support;
- prevailing common geological features/regime;
- percentage extraction of mineral resources/reserves;
- location, magnitude and nature of seismic events; and
- the timing and overall sequencing for the removal of the boundary pillar separating adjacent mines.

8.8 Monitoring of Rock-Related Hazards/Risks

8.8.1 Seismic monitoring and analysis strategy

The COP must set out a description of the seismic monitoring system and its accompanying performance characteristics that caters for the prevailing conditions at the mine covering at least the following:

- location accuracy and network sensitivity in relation to working places, referenced to the conditions prevailing in the various ground control districts;
- appropriateness and the suitability of the data and its accompanying analysis. To this end the current Guide to Routine Seismic Monitoring in Mines "Handbook on Rock Engineering Practice for Tabular Hard Rock Mines" as well as other literature should be referenced; and
- data/information quality management system to ensure the optimum functionality of the network and data/information;

- measures to ensure that appropriate monitoring and analysis of the seismic data is conducted, recorded and communicated methodically, inclusive of a brief description of the available tools e.g. hardware and software and the analysis that these facilitate and its contribution to the analysis strategies, safe rock excavation process planning and design and operating procedures.

8.8.2 Monitoring the stability of workings

The COP must set out a description, either under this heading or under individual strategies, of the measures to determine the stability of the workings covering at least the following:

- monitoring of rock structures in the workings;

- monitoring (identification and recording of significant geological, discontinuities such as faults, slips, brows, intrusions); and

- monitoring of closure in stopes.

SIMRAC project GAP 414 may be used as optional guidance on this matter.

8.9 Intergrated Mine Process Design and Planning

The COP must set out a description of the provision made for integrating the management of rock related risks into the overall mine planning process. This should include the role of all individuals, the recording and archiving of all decisions and the execution procedure.

8.10 Support Design Methodology

Support design methodologies used must be properly motivated and documented.

8.11 Rock Engineering Support Service

ANNEX 3 attached hereto sets out these aspects on which a person competent in rock engineering should provide input. ANNEX 3 is attached as information for consideration in the preparation of the COP.

PART D: IMPLEMENTATION OF THE COP

1. IMPLEMENTATION PLAN

1.1 The employer must prepare an implementation plan for its COP that makes provision for issues such as organisational structures, responsibilities of functionaries and programmes and schedules for the COP that will enable proper implementation of the COP. (A summary of, and a reference to, a comprehensive implementation plan may be included.)

1.2 Information may be graphically represented to facilitate easy interpretation of the data and to highlight trends for the purpose of risk assessment.

2. COMPLIANCE WITH THE COP

The employer must institute measures for monitoring and ensuring compliance with the COP.

3. ACCESS TO THE COP AND RELATED DOCUMENTS

3.1 The employer must ensure that a complete COP and related documents are kept readily available at the mine for examination by any affected person.

3.2 A registered trade union with members at the mine or where there is no such union, a health and safety representative on the mine, or if there is no health and safety representative, an employee representing the employees on the mine, must be provided with a copy on written request to the manager. A register must be kept of such persons or institutions with copies to facilitate updating of such copies.

3.3 The employer must ensure that all employees are fully conversant with those sections of the COP relevant to their respective areas of responsibility.

ANNEX 1

TUNNEL AND SERVICE EXCAVATION SUPPORT STRATEGY AND DESIGN GUIDELINES
(For information only)

1. Support Strategy

1.1 General

A procedure should be established and described to ensure that the potential rock conditions for all tunnels are assessed for their effective working life. Support systems must be designed, selected, used, installed maintained and removed taking cognisance of the various rock conditions that may prevail.

Where conditions in the tunnel are expected to deteriorate as a result of a changing stress field or weathering, the techniques used in identifying the location of such deterioration should be described. Upon identification, the design and implementation of secondary support must be specified.

Particular attention should be given to the support of the area in the vicinity of the working face. In this regard, the timing of the installation/removal of temporary and primary support is important and, together with examination and making safe procedures, must be specifically dealt with.

When poor ground conditions are encountered in the working face area, the strategy to be adopted to deal with these conditions, such as the alteration of tunnel shape, smooth wall blasting and areal support, must be described.

The strategy should describe a separate support strategy for wide tunnels (e.g. breakaways) and, where existing tunnels have to be widened, the sequence of mining and additional support installation must be stipulated. In addition where excavation interaction is anticipated this must be considered in the support strategy.

The strategy must describe how the problem of corrosion of support elements is managed in excavations with a medium or long term operating life.

1.2 Support Installation

The majority of rock reinforcing tendons installed on mines is grouted in place and the effectiveness of these tendons is reliant on good quality grouting.

Ever since the introduction of these tendons, the quality of grouting has been of considerable-concern. The quality of grouting cannot be evaluated visually and no instrument is currently available that can measure the effectiveness of the grouting. The "pull test" which is often used is destructive, slow and cumbersome and only identifies very poorly grouted tendons. It is therefore necessary that the problem be addressed at source to ensure that the best quality grouting possible is achieved.

Methods must be established and described to achieve consistently good quality grouting, including the training of support crews in tendon grouting and quality control.

Where ungrouted tendons are used, procedures must be described to ensure that the tension in the tendons is maintained and kept up to standard while the excavation is in use.

All materials used for support must be subjected to quality control testing according to laid down procedures. For purposes of ensuring quality the testing of the materials must be done at an institution accredited under the South African National Accreditation System(SANAS).

If friction anchored tendons are used, then the capacity of anchorage beyond the depth of instability must be capable of supporting the potentially unstable rock mass.

1.3 Rehabilitation

Rehabilitation and re-supporting of tunnels are carried out frequently on many mines. The conditions under which this work is carried out are often dangerous. A specific procedure must be adopted for each situation.

1.4 Large Excavations

The methodology to be followed in designing these excavations and the implementation thereof must be stated. Designs must take into account the stress field and any changes therein, available techniques such as rock mass classification, numerical modelling, seismic data analysis, support design criteria and the influence that the size of the excavation and blasting technique have on the stability of excavations. The long-term rock mass monitoring programme must be described. At depths where stress fracturing will occur during excavation cutting, the support sequence and blasting technique employed must take into account the orientation and extent of the stress fracturing at the various stages and sequential deformation of the rock mass to ensure stability throughout the excavating process. The procedures to be followed must be in the form of a reference report from the rock engineering department/consultant.

2 Design Guidelines

2.1 General

To design an appropriate support system, it is first necessary to define the functions required of it. The strategy must define the functions of the different support systems used on a specific mine.

In shallow excavations or in excavations developed in stress relieved ground, the function of support is merely to pin individual potentially loose blocks, generally defined by geological discontinuities, to the competent rock mass.

In cases of weak, friable rock or rock which is likely to deteriorate by weathering, the support must hold in place all the friable material by supplying maximum area support as early as possible.

In deep mine tunnels where highly fractured rock is encountered, the support must reinforce the annulus of fractured rock by the installation of tendons to assist the rock to support itself. In such cases, tendons need to be installed in a regular pattern to generate frictional forces between rock slabs. In cases of intense fracturing, tendon interaction will be limited and areal support must also be provided to prevent fallout and control the deformation of the rock slabs between tendons.

It is necessary to determine the force-deformation characteristics of the support elements comprising the support system, both under quasi-static and dynamic loading conditions. A record of the force-deformation characteristics of the different support elements used on the mine must be kept.

In broad terms, the design process must involve the following:-

- Determine or assess the rock mass environment for which the support is to be designed, e.g. the rock mass will be controlled by the geotechnical structure in a low stress environment and stress controlled failure in a high stress environment.

- Determine or assess the probable volume of rock to be supported or reinforced in all the rock walls as well as the expected deformation of the rock mass.

- Determine or assess the estimated structure of the rock mass.

- Establish criteria for the selection of all the support elements that constitute the support system, so as to cope with the anticipated rock mass structure (fractured/discontinuous) and deformation loading conditions (quasi-static or dynamic). The key characteristics, which govern their suitability for different environments are strength, initial stiffness, yieldability, energy absorption capacity, length of tendons, area coverage compatibility with other support elements and extent of interaction in order to integrate them into an effective system.

2.2 Control of Rock falls

The strategy must stipulate the extent of areal coverage and support resistance required to control the rock fall problem.

The support resistance requirements must be calculated with reference to potential fallout thickness as determined from analyses of accidents.

2.3 Reduction of Rock burst Damage

In service excavations likely to be affected by seismic events, the support system must be capable of absorbing kinetic energy.

Approximately half of the incidents classified as rock bursts are not severe, catastrophic events, but rather the dislodging of blocks of rock in a state of unstable equilibrium. Peak ground velocities experienced in these types of rock bursts are of the order of a few cm/s. For the control of this type of damage, conventional rock tendon and mesh support will suffice.

Where peak ground velocities start exceeding 1 m/s, significant kinetic energy and momentum are imparted to the rock, resulting in potentially large displacements. Under these circumstances, a yielding support system is required.

Using block ejection thickness determined from analyses of the anticipated depth of instability, it is possible to calculate a minimum energy absorption requirement per square meter of rockwall.

The energy absorption criterion for the components of the support system in the hanging wall (hw) is:

$$E_{hw} = 1/2mv^2 + mgh$$

Under dynamic loading conditions suitable attention should be given to shear deformation.

The energy adsorption criterion for the components of the support system in the sidewalls (sw) is:

$$E_{sw} = 1/2mv^2$$

Where: E = energy absorption

m = mass of ejected rock

v = peak ground velocity

h = deformation limit of support

g = 9,81 m/s^2

In the absence of mine specific data for rock ejection thickness and peak ground velocity, current industry data must be used.

Recent work has given an improved understanding of the interaction of the reinforcement and support system within a discontinuous rock mass structure. This new understanding should be considered in the design of support systems in the deep level mining environment. (Please refer to SIMGAP Project Report GAP 335).

ANNEX 2

STRATEGIES FOR SPECIAL AREAS

(For information only)

1. Designation of Special Areas

1.1 Whenever it appears or can be anticipated that there is an increased risk of rock bursts and rock falls occurring in an existing or proposed working place, such working place should be designated a special area. This designation allows management to make rapid modifications where such action is urgently required. All such changes must be motivated and documented. The procedure for doing this must be stated in the COP.

1.2 A competent person should be used to monitor special areas and must record the location of all special areas, the classification and declaration procedure and the monitoring of such areas. The records must be available for scrutiny. The procedure for doing this must be described in the COP.

2. Special area classification

It is recommended that special areas be classified as either “Restricted” or “Precautionary”.

Restricted (R)

In this situation, the procedures listed become obligatory for the duration of the declaration.

Precautionary (P)

Precautionary measures are applied at the discretion of the employer in consultation with the competent person and the Special Areas Committee at the mine. Such deliberation/decisions must be documented and be available for scrutiny. Such decision may merely require the restriction of entry of persons into a working place.

If alternative classification terminology is used, it must be clearly defined.

3. Special areas declaration procedure

A procedure must be established which provides for;

(a) the identification and criteria of the classification and/or declaration of a special area;
(b) a written notification in respect of (a) to relevant personnel;
(c) acknowledgement of receipt by personnel of the notification referred to in (b);
(d) a work place entry and exit (escape) procedure;
(e) the type and spacing of support to be used; and
(f) a separate file for each working place classified as a special area containing all relevant information regarding the classification, declaration procedure, and monitoring of that area.

To ensure the smooth operation of the entire procedure, the employer may appoint a competent person to ensure the effective implementation and operation of the entire procedure.

ANNEX 3

THE ENVISAGED ROLE, FUNCTION AND CONTRIBUTION OF EFFICACIOUS ROCK ENGINEERING SUPPORT SERVICE

(This annex to be used for information purposes only)

1. PURPOSE

The purpose of an efficacious Rock Engineering Support Service (RESS) is to assist the employer in ensuring that rock mechanics and strata control principles for the safe and economic design of mine workings is applied.

The RESS should assist the employer with the proactive identification of significant rock-related hazards/risks and to advice on appropriate measures to treat the same before persons are injured or workings damaged.

2. ENVISAGED BASIC SUPPORTIVE ROCK, FUNCTIONS AND DUTIES

To achieve the purpose of an efficacious RESS, the RESS must provide a basic supportive role, function and contribution as follows:

2.1 Participate in planning activities in order to identify and evaluate all layouts and face positions to determine any potentially dangerous or damaging situations created by, or likely to be created by, mining operations.

2.2 Review, identify and make recommendations to management with regard to systems, procedures and techniques employed by the mine to reduce or eliminate rock fall and rock burst hazards.

2.3 Establish an efficacious monitoring, recording and reporting systems, which will ensure that relevant information is timeously provided to the correct people in planning and operating functions.

3. PARTICIPATION IRO PLANNING AND DESIGN ACTIVITIES

The RESS should participate/assist/make the following contributions to the rock excavation and design processes/activities:

3.1 assist with the design of rock excavation layouts, which will provide conditions conforming the requirements of affected relevant authorities with regard to surface structures.

3.2 design/propose efficacious mine support systems.

3.3 assist in the selection of the most appropriate rock excavation processes, techniques and accompanying regional support system for prevailing conditions by applying best practise rock-engineering analysis to ensure that the desired level of stability of excavation are maintained throughout the required operations time horizon.

3.4 advise on efficacious risk management strategies to treat significant rock-related hazards/risks.

3.5 advise on the use of protection, control and support pillars at the mine.

3.6 advise on the location, shape, damage prevention measures and support of all tunnels and other service excavations to ensure stability throughout the excavation's active life.

3.7 evaluate and advise in respect of rock excavation processes, sequences and plans so as to ensure, as far as reasonably practicable, that:

- 3.7.1 the probability of seismic events/rock bursts are eliminated, minimised or controlled;
- 3.7.2 the factors affecting the stability of off-reef excavations are taken into account;
- 3.7.3 support systems perform to design criteria under current and anticipated rock-related conditions; and
- 3.7.4 that precautions necessary for the excavation of remnant blocks are specified.

3.8 in board and pillar workings:

- 3.8.1 advise on the appropriate board width in accordance with sound rock engineering principles and best practise as well as on the appropriate accompanying board support systems;
- 3.8.2 advise on the appropriateness and correct application of standardised rock excavation process planning and design techniques;
- 3.8.3 evaluate and advise in respect of the planning and design of pillar extraction processes in accordance with sound rock-engineering principles and best practise.

4. SEISMIC EMISSION MONITORING, ANALYSIS AND DAMAGE CONTROL

The RESS, assisted where necessary by competent persons using appropriate seismic monitoring equipment should monitor, analyse and interpret incidence of seismic emissions and advise on damage control measures:

4.1 in seismally active mines, advise the employer on a efficacious strategy to treat the incidence and impacts of rock bursts, for inclusion in the mine's Mandatory COP, and

4.2 on mines or sections of mines where the bulk of the mineral reserves (ore) are located in remnants or pillars, perform a periodic detailed hazard identification and risk assessment of the whole mine, focussing on sequencing or phasing of the extraction of the pillars or remnants in such a manner as to ensure that they can be mined out without significant risks to persons involved with such excavations.

5. ROUTINE MONITORING AND SPECIAL INVESTIGATIONS

The following roles, assistance and inputs are envisaged for the RESS in respect of routine monitoring and special investigations:

5.1 regular monitoring of pillar performance to ensure that they conform to design requirements;

5.2 regular inspections of production and service workings to detect abnormal conditions and departures from planned layout;

5.3 regular inspections of important chambers during the excavation, to ensure adherence to the designed excavation sequence installation of permanent support;

5.4 regular monitoring of the performance of support systems in important excavations;

5.5 where a significant risk of instability exists in shafts, regular monitoring of displacements and, in particular, fault plane intersections;

5.6 investigation of unusual ground conditions, report findings and recommendations regarding remedial action;

5.7 appropriate participation in/assistance with the investigation of all rock-related fatal accidents, inclusive of the completion of the rock engineering aspects of the official accident report, and

5.8 inspection of all significant rock bursts and falls of ground and submission of a report.

6. QUALITY ASSURANCE IRO SUPPORT SYSTEM/ELEMENTS

The RESS to advice the employer in respect of an efficacious quality assurance system for the support elements/system used at the mine.