Windblast Guideline

MDG 1003

Produced by Mine Safety Operations Division,

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NSW DEPARTMENT OF
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1 Background

During the latter part of 1990 the Minister for Mineral Resources established an industry committee to investigate the windblast phenomenon. The Minister's concern stemmed from serious incidents at two Newcastle collieries, due to windblast. The result of that committee's work was published by the Department in March 1992 as the "Windblast Code of Practice". At that time the original code of practice was considered appropriate and accurate.

More recently, windblast has manifested at other mines in New South Wales. It has also been associated with a methane explosion at one mine in the Newcastle District. In dealing with these more recent events, additional control measures have been identified that do not feature in the original code of practice. The most significant of these has been the use of seismic equipment to measure some aspects of large goaf falls associated with windblast. In addition, the value of reviewing guidelines after they have been in effect for a period of time is recognised, and in a large part this second edition of the Windblast Guideline is the result of a time based review.

The name of this document has been changed from a Code of Practice to a Guideline to avoid any confusion regarding the legislative status of the document. This Guideline is not a Code of Practice for the purpose of the *Coal Mine Health and Safety Act 2002*. The 'Windblast Code of Practice', which this document supersedes, is similarly not a Code of Practice for the purposes of the *Coal Mine Health and Safety Act 2002*.

2 Definitions

For the purposes of this document the following definitions apply:

"<u>Windblast</u>" - windblast is an event, resulting in sudden, mass air movement, that:-

1. has the potential to cause injury to persons and/or
2. has the potential to cause damage to the mine and mining equipment and/or
3. has the potential to seriously disrupt ventilation

In almost all circumstances the "event" initiating mass air movement is a collapse of strata in a goaf area.

An air velocity of 20m/sec is considered a threshold value above which a windblast event has occurred.

"<u>Excursion Distance</u>" – the distance that an atmosphere, expelled by windblast may infiltrate accessible areas of a mine.

"<u>Hazardous Zone - Windblast</u>" - that area of a mine where conservative application of experience and/or predictive modelling identifies that windblast has the potential to cause injury to persons, damage equipment or seriously disrupt ventilation.

"<u>WMP</u>" – a windblast management plan.

"<u>Risk Assessment</u>" – As per AS/NZS 4360 – The overall process of risk identification, risk analysis and risk evaluation.

"Risk Analysis" - As per AS/NZS 4360 –The systematic process to understand the nature of and to deduce the level of risk. (Associated with an identified hazard).

"Airblast" – Equivalent of windblast in hardrock mines. Refer to MDG 1031.

For the purposes of this document the following abbreviations for units apply:

m - metres
m/sec - metres per second
kPa - kilo pascal
% - percent

3 Risks Associated with Windblast

Windblast is one of the most serious events that can occur in an underground mine. They are violent, uncontrolled and their prediction is not yet a certain science.

The effects of a windblast include:-

1. Large displacements of atmosphere from mined out areas into the working place.
2. A shock wave associated with increased air pressures.
3. Abnormal pressure differentials.
4. High velocity (hurricane force) winds.

The risks associated with windblast include:-

1. Objects, from particle size up to in some instances hundreds of kilograms in weight, becoming projectiles.
2. Violent displacement of persons including the possibility of being drawn back into the goaf.
3. Flammable, noxious and/or irrespirable gases that have accumulated in the goaf inundating the working place.
4. Water that has accumulated in the goaf inundating the working place.
5. Dusts being raised into suspension including coal dust which can become explosive.
6. Massive roof, containing quartz, generating incendive sparks hot enough to provide ignition sources.
7. Damage to electrical apparatus during the course of the windblast providing ignition sources.

3.1 Discussion

The most severe consequence of windblast is a gas and/or coal dust explosion. For such an explosion to develop, fuel and an ignition source are needed, both of which can be provided by a windblast.

Ignition sources may be either man made or natural, the later being out of positive control. In particular, the incendive nature of roof strata is critical to the risk of explosion from windblast. With respect to man made sources the presence of electrical apparatus in the working place might be classified as that with the highest probability of producing ignition energy. It must be remembered that the best electrical protection now in use may be bypassed due to damage suffered during a windblast. In the event of a windblast, pressure transducers commonly used to disconnect power may not operate quickly enough to eliminate an ignition source (although they are still useful to control secondary hazards).

Considering the likelihood that it will not be possible to control all ignition sources in the event of a windblast then a major part of any strategy for risk minimisation will involve the positive ventilation of the goaf to ensure that accumulations of gas that are flammable or likely to become flammable are not present. This also applies to the minimisation of risk associated with noxious and irrespirable gases.

The likelihood or advent of Spontaneous Combustion adds a complicating dimension to the windblast phenomenon. Goaf ventilation controls necessary to eliminate seam gases are opposite to those generally associated with Spontaneous Combustion control. In the event that a situation arises where the risk of both is present then selection of a suitable ventilation regime is going to be extremely difficult. A guide to the resolution of this dilemma may be to consider the presence of methane gas as the greatest hazard because of it's known continuous presence, the immediacy of it's danger and relative ease with which it can be measured and controlled.

In the situation where a goaf already contains a heating then the possibility of Carbon Monoxide being pushed into the working place must also be considered. Again, the selection of a suitable ventilation regime is going to be extremely difficult.

Another risk of windblast, generally associated with pillar collapse in standing panels, is inundation of working places by significant volumes of displaced water. Such working places could include the working panel or alternatively panels in the mine which are down dip of the subject area. If, following a pillar collapse, the potential for inundation exists then standing panels must be maintained free of significant volumes of water.

4 Determining the Likelihood of Windblast

In this process it will be necessary to establish the geological and mining conditions present at a mine and compare them against conditions known to be associated with windblast. Previous experience has shown that the following conditions have been associated with windblast:-

- Goaf areas having immediate roof consisting of thick, massive strata, such as conglomerate or sandstone.
- Goaf areas having thick, massive beds above the immediate coal or shale roof but lying within the expected height of caving.
- Goaf areas having horizontal igneous sills (associated with the boundaries of intrusive plugs or diatremes) lying within the expected height of caving.
- Significant areas of low width to height ratio, low factor of safety coal pillars.

4.1 Discussion

While very thick beds of massive roof, in excess of 10m, are associated with systemic windblast, irregular windblast events can also occur when thinner beds exist. Under these conditions it is not necessary for the entire goaf to cave for a windblast to take place. Numerous examples exist where only a portion of the goaf has fallen producing a powerful windblast on a limited section of the face.

On longwall faces when most of the goaf area falls simultaneously, windblast develops most strongly in the gates roads and face ends, however with smaller falls the effects of windblast can be felt along the face line. Several cases have been documented where mineworkers have been knocked down while standing mid-face following a fall where only the central third of the goaf collapsed. In these cases the windblast entered the face through the shields and travelled along the face line before returning through the shields back into the goaf. The gate roads were largely unaffected by the windblast.

When a massive bed exists above the immediate coal or shale roof line but within the expected caving height of the face, then in the goaf an air gap can develop between the top of the weak immediate roof rubble pile and the upper massive member. Subsequent failure of the massive member will cause sheets of stone to fall into the air gap thus creating a windblast. Experience has shown that the thickness of the septum between the face roof line and the lowest portion of the massive bed is important in reducing windblast effects. It is believed that if the thickness of the readily caving immediate roof is twice the thickness of the coal section being mined, as a minimum, then the risk of windblast from the upper massive beds reduces considerably. It appears that the fallen immediate roof acts as a dampener on the windblast.

In general, commencing a goaf adjacent to a geological structure is believed to help induce an early cave. However, with vertical plugs and diatremes the potential for horizontal sills to occur is significant. These sills may delay caving and have been associated with unexpected windblasts on face start up.

At least two violent windblast events have been recorded in New South Wales following the sudden collapse of small width to height coal pillars. The potential for catastrophic damage to the mine is real when a substantial area of small pillars collapses. Damage resulting from these events has been compared with that experienced in gas and/or dust explosions.

5 Determining the Likely Impacts of Windblast

Should the geologic conditions at a mine infer that windblast is likely then a risk assessment must be conducted to determine the wisdom of mining in such an environment. As part of the risk assessment a detailed risk analysis is essential to quantify each element of the hazard and in particular, the magnitude of the following characteristics of windblast must be estimated:-

- Peak velocity measured in m/s.
- Peak over pressure measured in kPa.
- Maximum excursion distance measured in metres.

This quantified data will provide the basis for an estimate of the impact windblast may have on the mine's workforce and infrastructure.

Considerable research has been conducted in Australia into windblast and reference is made to the following research reports, which as a minimum should be considered in the risk analysis process:-

- ACARP report C6030 – The Dynamics of Windblasts in Underground Coal Mines.
- ACARP report C7031 – Displacement of Methane from the Goaf into the working place as a result of Windblasts in Underground Coal Mines.
- ACARP report C10024 – Windblast and Methane Expulsion: Extension of field monitoring to generalise the results of projects C7031 and C8017.

6 Strategies to Control Risks Associated with Windblast

6.1 Prevention

If a risk assessment concludes that mining in a windblast environment is appropriate, then the primary control for risk management must be the prevention of windblast.

Any mining design that is likely to result in repeated displaced goaf air velocities in excess of 20m/sec is not acceptable.

Use of amelioration measures as the primary control for windblast risk management is also not acceptable. **Mining design must aim at prevention of systemic windblast** and this inturn can be achieved by ensuring a quick and regular goaf cave.

6.1.1 Longwall Extraction

The design width of longwalls should be such that caving is quickly achieved and made regular in occurrence or alternatively, that the goaf never caves. For massive conglomerate roof, goaf spans of 30m may stand for very long periods of time, however even these narrow spans may be too wide for less competent rocks such as sandstone. Design of a non caving goaf requires very careful design consideration as unseen geological features may fatally weaken a potentially stable goaf span.

If caving is to be achieved then expert geotechnical advice is essential in design formulation.

The following research reports form a start point for design considerations:-

- ACARP report C7019 – Optimisation of Longwall Mining Layouts under Massive Strata Conditions and Management of the Associated Safety and Ground Control Problems.
- ACARP report C7020 – Prediction and Management of Adverse Caving about Longwall Faces.

Under certain circumstances it may be possible to induce a goaf to cave earlier than would otherwise be the case by injection of a fluid, under pressure, into the roof strata to create fracture patterns that assist caving.

This process has been documented in the following report:-

- ACARP report C9024 – Development of Hydraulic Fracturing to Control Windblast.

Note:- to date, this technology has been employed to induce strata collapse in designs where goaf width alone has failed to induce adequate caving. Thus, hydraulic fracturing has been used as a secondary control. Hydraulic fracturing of strata should not be seen as a substitute for good caving design (that is, the selection of appropriate face widths), nor should it be seen as the primary control for windblast. Application of hydraulic fracturing should be seen in the context of section 6.2.2 "Amelioration" and 6.2.2.3 "Hydraulic Fracturing as a Windblast Amelioration Measure".

6.1.2 Pillar Extraction

The same design principles relating to goaf width apply to pillar extraction as they do for longwalls. The aim is to ensure early and complete strata caving within the goaf.

Additionally, the following practices should be considered in pillar extraction design:-

- Commencement of goaves adjacent to natural weaknesses such as faults or dykes.
- Where possible existing standing goaves should be utilised to create early caving, by continuing the goaf line.
- Panel layouts should incorporate as many entries as are possible on both sides of the goaf to dissipate the velocity/pressure effects of a windblast.
- Every effort should be made to eliminate (standing) coal left in goaf areas. Stook size should be critically examined. Any decision made on the amount of (standing) coal to be left should be consistent with sound pillar extraction safety principles.

6.1.3 Standing Pillars

The only acceptable strategy to prevent windblast from pillar collapse is to design pillars in a conservative manner with probabilities of instability that guarantee long term stability. Expert geotechnical advice is essential in deciding upon an acceptable pillar design because complex issues such as surrounding strata stiffness are often beyond the technical capacity of mine operators.

The following research report forms a start point for design considerations:-

- ACARP report C9018 – Systems Approach to Pillar Design.

6.2 Prediction and Amelioration

6.2.1 Prediction

Should windblast develop in a panel, despite the application of a design aimed at ensuring a quick and regular cave then prediction of windblast becomes paramount. In these circumstances warning of windblast is essential to enable timely withdrawal of personnel from the goaf edge to a place of safety.

To date the following warning techniques have been adopted at coal mines:-

- Monitoring of the mine environment for physical signs that indicate the likelihood of a massive goaf collapse.
- Micro-seismic monitoring.
- Hydraulic roof support leg pressure monitoring.

Experience has shown that none of these methods is infallible but the one technology that has the highest probability of detecting warning signs of windblast is micro-seismic monitoring.

Micro-seismic monitoring detects audible emissions made as rock fails. Geophones are placed in the roof and these instruments detect seismic emissions. These responses are transmitted to a centralised computer on the surface. Here, special software analyses the data and the results permit an operator to form an opinion as to the likelihood of a fall. If a fall is considered likely then a warning, generally by way of audible and visual alarms, is relayed to the face. Unless the process is automated an operator must be dedicated to this task whilst ever workmen are in a zone of danger.

Performance measurement of a micro-seismic detection system at a New South Wales coal mine experiencing severe windblast determined that the system had a detection reliability of 92% with a 10 second warning period. As the warning period increased to 30 seconds reliability dropped to 75%.

These figures indicate that the best detection system available gives relatively limited warning to face personnel. Disturbingly, several very large windblasts have gone undetected and no warning was given to face mineworkers.

Whilst warning systems are essential in the management of windblast (after it has developed) they are insufficient as a sole method of risk control and other measures to ameliorate the impacts of windblast are necessary.

6.2.2 Amelioration

6.2.2.1 Operational Controls

Should windblast develop in a panel, despite the application of a design aimed at ensuring a quick and regular cave then in addition to prediction, the mine must have in place amelioration processes to control any harmful effects arising from windblast. These processes must include means for the protection of personnel together with protection of the mine through the mitigation of the effects of windblast. These processes will include both management plans and permanent measures providing continuous protection. As a minimum the mine must develop and implement the following:-

- A Control Group: This group shall be established to control, co-ordinate and manage the mines response to windblast events. This group must comprise persons with sufficient authority to implement decisions, together with appropriate expertise and representation of stakeholders.

  When invoked, the control group must maintain an event log sufficient to effectively record issues, decisions, actions and resulting events. Details for the minimum data set to be collated following a windblast event are listed in Appendix A. Any control group should not be disbanded until the risk of windblast has been eliminated.

  Note 1: The control group should not disband prior to conducting a de-briefing and a review of residual windblast risk at the mine.
  Note 2: It is acceptable that line management form part of a control group but when doing so due regard should be paid to relieving them of sufficient of their normal line management duties to enable effective contribution to the group. These arrangements should remain in place until such time that the control group is disbanded.
  Note 3: Event logs, minutes or other records should be made available to effectively communicate to the workforce, and others, matters that they need to know.

- <u>Determination of a Hazardous Zone - Windblast</u>

  The mine must define this zone in relation to all accessible areas subject to the effects of windblast. Consideration of the maximum excursion distance is essential and in no instance shall a Hazardous Zone-Windblast be smaller than the maximum excursion distance. This zone shall be appropriately sign posted and fenced.

- <u>Access control to Hazardous Zone - Windblast</u>

  The mine must develop and implement a process for the control of access of persons into any Hazardous Zone - Windblast. Elements of this procedure could include but are not limited to:-

  i) Minimising the number of persons entering the area.
  ii) Identification of the conditions under which a person or persons are permitted to enter the Hazardous Zone - Windblast. These conditions should be signposted at the entrances to the area.
  iii) Requiring persons to either obtain authority or give notification prior to entering the Hazardous Zone - Windblast. Such notification should include the number of persons entering the area, the duration thereof, and the nature of the work that they intend to perform.
  iv) Provision for special access control during emergencies.

- <u>Withdrawal of Persons</u>

  The mine must develop and implement a process for the withdrawal of persons from the Hazardous Zone - Windblast in the event of a potentially life threatening situation arising from a windblast. This process must include a specification of the conditions that would trigger a withdrawal of persons from the Hazardous Zone – Windblast **and** the conditions that must prevail before persons are permitted to re-enter the Hazardous Zone – Windblast after a withdrawal.

- <u>Control of Operations</u>

  One condition frequently used in relation to the control of operations in, and withdrawal from, the Hazardous Zone – Windblast is the amount open goaf standing. Depending upon previous experience and prudent assessment of risk, open goaf should be rated into zones being either:-

  i) Normal (or green) – meaning an area of exposed goaf that in the event of collapse will not generate a significant air velocity.
  ii) Alert (or amber) – meaning an area of exposed goaf that in the event of collapse that may generate a significant air velocity.
  iii) Stop Mining (or red) – meaning an area of exposed goaf that in the event of collapse is likely to/or will generate a windblast.

  Procedures must be established as to who is responsible for the change of status between various zones.

When mining under Alert (or amber) conditions special protective measures for workmen must be implemented. These include but are not limited to:-

- Provision of personnel protective equipment. This should include as a minimum full face helmets, safety glasses that can't be dislodged, leather jackets, gloves, knee and elbow protectors, stout clothing for the body, arms and legs, and provision to ensure that items such as cap lamps and self rescuers cannot be separated from the workman in a windblast.
- Limits on the nature of work to be permitted in gate roads and gate ends. This should also specify the number of persons permitted to be in these areas at any time.
- Provision of life lines at all points in the Hazardous Zone – Windblast. These life lines shall be equipped to permit continuous attachment to the lifeline irrespective of a persons location or nature of work. The life line shall have personnel activation that would allow an individual to immediately detach from the life line if safety conditions so required. All life lines will need to be equipped with inertia reels to control the extent of motion experienced by any person subjected to windblast.
- Provision of safe havens that can be accessed by any person within seconds irrespective of his location. The safe havens must ensure that a person is either located away from the line of air movement or is protected from the force exerted by air movement.
- Provision to maintain all loose objects in a secure position. Any loose item such as a hand tool or step ladder or drum can become (and has in the past) a lethal projectile.
- Provision of pressure switches that are capable of safely isolating electric power to all equipment in the Hazardous Zone – Windblast in the event of a windblast.

6.2.2.2 Other Safety Controls

Ventilation Design

The mine must establish the risk that windblast is likely to have upon the ventilation system in the mine. This process could be aided by ventilation modelling. The end result of this process is to reduce the risk to the integrity of mines ventilation system from windblast. The process must also aim to minimise the impact of windblast in the Hazardous Zone – Windblast and to ensure the quickest return to normal ventilation conditions as is possible following a windblast.

Matters to be considered include but are not limited to:-

- Ventilation quantities, pressure differentials, disposition of main airways, together with bleeder headings, balance roadways and waste ventilation.
- Design and construction of ventilation structures that are capable of resisting the effects of overpressures created by worst case windblasts.
- Criteria for ventilation monitoring at the mine sufficient to determine if the mine ventilation system is meeting the design intent before, during and after a windblast.

Gas Monitoring

The mine must establish and maintain a robust system of gas monitoring capable of providing real time gas analysis of explosive gases in the Hazardous zone – Windblast before, during and after a windblast.

Matters to be considered include but are not limited to:-

- Type and location of gas monitoring points and information to be provided by the system.
- Criteria for setting, acceptance, re-setting and reporting of gas monitoring system alarms.
- Location of monitoring stations, specification of frequency, specification of method of measurements (including equipment and procedures).
- Criteria for maintenance and calibration of gas monitoring systems in use at the mine.
- Strategies and methods to ensure consistency and repeatability in measurements.
- Criteria for maintenance and calibration of gas sampling and analysis equipment in use at the mine.

<u>Prevention of Explosions</u>

The mine must establish processes that prevent the likelihood of gas and/or dust explosions arising from windblast.

Matters to be considered include but are not limited to:-

- Removal of electric power to the panel in the event of a windblast.
- Maintenance of the highest level of stonedusting in the mining panel at all times.
- Provision of explosion barriers in all gateroads.
- The introduction of a continuous stream of stonedust **<u>in the goaf area</u>** during mining to neutralise coal dust deposits that may accumulate there. This provision is in addition to the normal use of trickle dusters in the return airway.

6.2.2.3 <u>Hydraulic Fracturing as a Windblast Amelioration Measure</u>

This process involves high pressure injection of a fluid (usually water) into carefully selected horizons in the roof strata. The purpose of this injection is to open known zones of rock weakness and thereby create fractures in the rock mass which will reduce its integrity. This weakened rock mass should fall more regularly and in smaller amounts thus **reducing** the risk of windblast. Experience at one mine suffering from severe windblast found that hydraulic fracturing reduced the size of goaf falls by up to 60% but reduction in windblast effects <u>was not of the same proportion</u>. It is worth repeating that hydraulic fracturing aids in the reduction of, but does not eliminate, windblast.

Hydraulic fracturing has hazards of its own and the process needs careful and diligent management if it is to be implemented safely and successfully. Timing of both hydraulic fracturing and operation of the face, needs careful consideration to ensure maximum effect without adding any risk to those involved in the injection process.

Reference is again made to the following research report:-

- ACARP report C9024 – Development of Hydraulic Fracturing to Control Windblast.

Hydraulic fracturing can be a powerful tool in the process of ameliorating windblast and should be included in any plan to address windblast hazards.

7.0 Time Limits for Windblast Management

The development of windblast results from a failure, by the mine, to understand and/or design for conditions that exist at the mine. Windblast controls, as listed in section 6.2, can only be seen as short term measures. Their currency is limited until such time as design parameters are altered in order to create windblast free conditions.

It is expected that should windblast prediction and amelioration controls be invoked at a mine then they shall apply for as short a time as possible.

8.0 Training

The mine must develop and implement training programs for the supervisory staff and mineworkers.

In particular, the mine must have standards for training which define:-

- Who or which entities are to conduct training and the requisite level of certification or other qualification required by trainers.
- The classes of persons at the mine who are to receive training.
- The competencies sought to be imparted to those classes of persons.
- Means by which the acquisition of required competencies is to be assessed.
- Frequencies for reinforcement of competencies through re-training.
- Means by which additional training needs are to be identified.

The minimum content of training at the mine must cover, but in no way is limited to:-

- The importance of compliance with windblast management plans (WMP) in effect at the mine;
- Roles and responsibilities of persons in relation to the operation of the WMP;
- Means for the identification of windblast related signs including:-
    1. Increase or change in caving characteristics of the goaf.
    2. Identifiable changes in geological conditions.
    3. Increase or change in gas concentrations.
- Appropriate means of recording and reporting the observation of any windblast related signs.
- Standards and technical specifications associated with the WMP.

The mine must maintain objective evidence of the conduct of training and the assessment of competencies imparted by that training.

Appendix 'A' - Minimum Information Set

In the event that a windblast risk is realised the mine must have in place a process for the collection and recording of information relevant to windblast at the mine in a form which will assist with:-

- Characterisation of the number, type and extent of windblast events that have occurred at the mine.
- Windblast event prediction.
- Hazardous Zone - Windblast - affected area determination.
- Review of the effectiveness of the WMP in managing the windblast risk at the mine.

The information should be retained in a form which will allow its use in subsequent re-assessment of the windblast risk at the mine and review of the adequacy of the WMP for the mine. In addition, the information should be made available for the purposes of the assessment of regional windblast risk or for the review of this Code as required.

Areas of measurement could include but are not limited to:-

1) Mine.
2) Date.
3) Seam (s).
4) Geographic
    - Area and depth of origin.
    - Location with respect to the seam, roof, floor or elsewhere.
    - Location of the event.
5) Description of the event.
    - Description.
    - Size and extent of the event.
    - Details of any personal injuries sustained.
    - Damage sustained by the mine.
    - Approximate extent of goaf falls.
    - Estimated height of goaf falls.
    - Air over pressures and velocities in openings near the goaf (monitoring system required prior to event).
    - Micro-seismic event monitoring.
    - Hydraulic roof support leg pressures.
    - Results of monitoring or other detection data.
    - Photographic records (of the goaf edge and adjoining gate roads at regular intervals and the affected area after a windblast has occurred).
6) Evaluation of effectiveness of predictive tools, eg.
    - Results of seismic monitoring.
    - Results of hydraulic leg pressure monitoring.
    - Results of mine environment monitoring eg. roof, rib and roadway conditions adjacent to the area generating the windblast.
7) Evaluation of amelioration and protective actions

8) Temporal.
- Time since material affected has been first exposed.
- Date and approximate time of goaf falls.
- Working time for panel.
- Rate of retreat.
- Standing/interruption time(s).
- Face startup/finish delays.
- Diary of events and decisions.

9) Mine Environment.
- Description of the surrounding mine and mine conditions.
- The position of the working face at the time of the goaf fall.
- Panel dimensions (width, length).
- Roadway design - dimensions.
- Strength of coal.
- Cleat/jointing.
- Faulting/structures.
- Stability of pillars (abutment, roadway) and adjacent areas.
- Nature of roof and floor strata.
- Working height and section.
- Roof/rib support.
- Mining method (longwall, bord & pillar).
- Caving - closed/open goaf.
- Area of standing goaf.
- Water (effect of de-watering via gas drainage).

10) Ventilation.
- Design - single, flanking, bleeders.
- Nature of goaf ventilation.
- Pressure and flow magnitude.
- Ventilation appliances and seals. Performance before, during and after the event.
- Ventilation flows and pressures.
- Ventilation stability.
- Seam gases.
- Airway constriction (falls, flooding).