Mine Safety

MINING DESIGN GUIDELINE | MDG 3

Main, booster and auxiliary fans in underground coal mines

Ventilation fan house, Seaham Colliery, Wallsend, 11 September 1894.

Photo: State Records NSW

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MDG 3 Main fans, booster fans and auxiliary fans in underground coal mines

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Foreword

This is MDG 3 *main fans, booster fans and auxiliary fans in underground coal mines*.

Ventilation is a primary risk control. Failure of any ventilation fan presents a major risk factor in the underground environment. At times, ventilation plant may be exposed to high levels of methane and potentially explosive atmospheres. Ventilation plant such as main fans, booster fans and auxiliary fans are crucial to providing a safe environment in an underground coal mine.

Key areas that need to be addressed in the design of ventilation fans include:

- preventing the ventilation fan becoming an ignition source for a potentially explosive atmosphere
- unintended impellor stoppage or reduced performance of the fan potentially creating an atmosphere that may be hazardous
- starting or stopping the ventilation fan
- isolation of the fan impellor and drive for people working on it
- guarding of hazardous parts of the fan during operation
- ability of the fan to operate after a pressure event in the mine.

This guideline provides an industry benchmark for designing main fans, booster fans and auxiliary fans in underground coal mines. It represents acceptable industry practice for reducing the risks associated with the use of this equipment.

Users of this guideline should rely on independent advice in applying risk and safety management systems.

A feedback sheet is provided in Appendix D. Constructive comment is essential to help the department improve this guideline.

Contents

1 Purpose and scope

1.1 Purpose

The purpose of this guideline is to minimise risks to health and safety through the use of ventilation fans at underground coal mines.

1.2 Scope

This guideline provides assistance by identifying, assessing and controlling the risks to health and safety relating to the use of ventilation fans in underground coal mines. It covers the lifecycle activities associated with ventilation fans.

In relation to booster fans, this guideline sets out design standards in parts 3 and 4.1. This does not negate the designer's work health and safety responsibilities under section 22 of *the Work Health and Safety Act 2011.*

It does not cover mandatory obligations on the mine operator under the *Work Health and Safety (Mines) Regulation 2014* in relation to ventilation control. Mine operators should also review relevant codes or guidance material relating to ventilation in underground coal mines.

1.3 Application

For all ventilation fans in underground coal mines, this guideline is applicable to all phases of the fans lifecycle. It should be used when:

- undertaking risk assessments to fulfil work health and safety obligations
- reviewing the adequacy of risk controls following an incident
- assessing/auditing current standards and practices
- designing, manufacturing, altering and/or supplying ventilation fans (new or previously used)
- operating or using ventilation fans
- altering, maintaining, repairing or overhauling ventilation fans
- developing, operating and maintaining procedures as part of the mine ventilation plan as required by the regulation.

For booster fans in underground coal mines, Parts 3 and 4.1 of this guideline are applicable to design registration under clause 177(5) of the *Work Health and Safety (Mines) Regulation 2014* and Part 5.3 of the *Work Health and Safety Regulation 2011*.

1.4 Standards

This guideline refers to the following standards, as amended from time to time:

Abbreviation of standard	Title of standard
AS 1269.1	AS/NZS 1269.1:2005:*Occupational noise management - Measurement and assessment of noise immission and exposure*
AS 1318	AS 1318-1985 : *Use of colour for the marking of physical hazards and the identification of certain equipment in industry (known as the SAA Industrial Safety Colour Code) (incorporating Amdt 1)*
AS 1319	AS 1319-1994 : *Safety signs for the occupational environment*
AS 2729	AS 2729-1994 : *Rolling bearings - Dynamic load ratings and rating life*
AS 4024.1	AS 4024.1-2014 *Series : Safety of Machinery*

Abbreviation of standard	**Title of standard**
AS 4024.1501	AS 4024.1501:2006 (R2014) *Safety of machinery - Design of safety related parts of control systems - General principles for design*
AS 4024.1502	AS 4024.1502:2006 (R2014) *Safety of machinery - Design of safety related parts of control systems – Validation*
AS/NZS 4024.1503	AS/NZS 4024.1503:2014 : *Safety of machinery – Safety-related parts of control systems – General principles for design*
AS/NZS 4871.1	AS/NZS 4871.1:2012 : *Electrical equipment for mines and Quarries – Part 1: General requirements*
AS/NZS 4871.2	AS/NZS 4871.1:2010 : *Electrical equipment for mines and Quarries – Part 2: Distribution, control and auxiliary equipment*
AS/NZS ISO 31000	AS/NZS ISO 31000:2009 : *Risk management - Principles and guidelines*
AS 61508.1	AS 61508.1-2011 *: Functional safety of electrical/electronic/programmable electronic safety-related systems - General requirements*
AS 62061	AS 62061-2006 *: Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems*
BS EN 14986	BS EN 14986:2007 *Design of fans working in potentially explosive atmospheres*
ISO 281	ISO 281:2007 : *Rolling bearings - Dynamic load ratings and rating life*
ISO 13849.1	ISO 13849-1:2006 *Safety of machinery -- Safety-related parts of control systems -- Part 1: General principles for design*
MDG 3608	NSW Department of Industry MDG 3608:2012 *Guideline for Non-metallic materials for use in underground coal mines*
SA/SNZ HB 89	SA/SNZ HB 89:2013 : *Risk management - Guidelines on risk assessment techniques*

1.5 Abbreviations

AS	Australian Standard
AS/NZS	Australian/New Zealand Standard
BS EN	British Standard European Standard
EECP Code	*NSW Code of Practice:Electrical engineering control plans*. At the time of publication of this guideline this code was in draft.
FRAS	Fire resistant and anti-static
ISO	International Standards Organisation
MDG	Mining design guideline produced by the NSW government and published on the NSW Department of Industry website.
MECP Code	*NSW Code of Practice: Mechanical engineering control plan* and the *NSW Code of Practice: Electrical engineering control plan*. Note: At the time of publication of this guideline these codes were in draft.
PCBU	Person conducting a business or undertaking
WHS (Mines) Regulation	*Work Health and Safety (Mines) Regulation 2014*
WHS Act	*Work Health and Safety Act 2011*
WHS Regulation	*Work Health and Safety Regulation 2011*

1.6 Definitions

In this guideline, the following definitions apply:

1.6.1 Alter

To change the design of, add to or take away from the plant where the change could affect health or safety. It does not include routine maintenance, repair or replacement.

1.6.2 Auxiliary fan

A fan (other than a cooling fan for equipment or a scrubber fan) used underground to direct ventilation in part of an underground mine.

1.6.3 Booster fan

A fan installed in such a way that the total ventilation flow in the place where the fan is installed passes through it.

Booster fans are put in return or intake airways.

1.6.4 Competent person

A person who has acquired through training, qualification or experience the knowledge and skills to carry out the task.

1.6.5 Effective ignition source

A potential ignition source that can ignite the explosive atmosphere if preventive or protective measures are not used.

1.6.6 Emergency stop device

A manually actuated control device used to initiate an emergency stop function.

1.6.7 Fit for purpose

Something that is sufficient and reliable to perform the function it was designed to do according to relevant standards, for the intended use.

1.6.8 Guard

Part of a machine specifically used to provide protection by means of a physical barrier.

1.6.9 Lifecycle

Design, manufacture, construction or installation, commissioning, operation, maintenance, repair, decommissioning and disposal.

1.6.10 Light metal alloy

An alloy containing aluminium, magnesium or titanium (or a combination of those metals), but only if:

- those metals make up more than 15% of the weight of the alloy, or
- magnesium and titanium make up more than 6% of the weight of the alloy.

1.6.11 Main fan

A fan that provides sufficient volume flow of respirable air to the underground workings, including an amount necessary to dilute and remove flammable and/or noxious gases.

1.6.12 Must

It is mandatory.

Indicates that legal requirements exist and must be complied with.

1.6.13 Out of balance

Is the state where centrifugal forces produce vibration upon a rotating assembly and prevent a state of equilibrium from existing.

1.6.14 Plenum chamber

A pressurised housing containing a gas or fluid (typically air) at positive pressure (pressure higher than surroundings). One function of the plenum can be to equalise pressure for a more even distribution, because of irregular supply or demand.

1.6.15 Reasonably foreseeable misuse

The use of a machine in a way not intended by the designer, that has resulted from readily predictable human behaviour.

1.6.16 Reasonably practicable

In determining what is ‘reasonably practicable’, a duty-holder must first consider what can be done and what is possible in the circumstances for ensuring health and safety. For further clarity see section 18 WHS Act.

1.6.17 Repair

Restore to the original design standard.

1.6.18 Safety-related componentry

passive systems or things such as fixed components, exhaust manifolds, gaskets, joints, positive flametraps, etc.

1.6.19 Should

A recommended course of action.

1.6.20 Ventilation fan

Includes main fans, booster fans and auxiliary fans in underground coal mines.

2 General requirements for ventilation fans

2.1 Work health and safety

2.1.1 Guidelines and safety legislation

The status of legislation, guidelines and other documents is set out in diagram format at Appendix A.

The diagram highlights documents that are mandatory, documents that should be followed (or an equivalent level of safety provided) and documents that are informative and should be considered through a risk assessment process.

Further guidance on plant is provided in the *Mechanical engineering control plan* (MECP) code and the *Electrical engineering control plan* (EECP) code.

2.1.2 General duties in relation to plant

A PCBU has a primary duty under section 19 of the WHS Act to ensure, so far as is reasonably practicable, that workers and other people are not exposed to health and safety risks arising from the business or undertaking. Without limitation, this duty includes ensuring, so far as is reasonably practicable, that as a minimum:

- the provision and maintenance of safe plant and structures
- the provision and maintenance of safe systems of work
- the safe use, handling and storage of plant and structures
- the provision of any information, training, instruction and supervision that is necessary to protect all persons from risks to their health and safety arising from work carried out as part of the conduct of the business or undertaking.

In meeting this duty at an underground coal mine, a PCBU must manage risks to health and safety associated with mining operations at the mine in accordance with Part 3.1 of the WHS Regulation and clause 9 of the WHS (Mines) Regulation, including but not limited to:

- ensuring that a risk assessment is conducted by a person who is competent to conduct the particular risk assessment having regard to the nature of the hazard
- identifying all reasonably foreseeable hazards
- eliminating risks to health and safety so far as is reasonably practicable
- if it is not reasonably practicable to eliminate risks to health and safety – minimise those risks so far as reasonably practicable in accordance with the hierarchy of risk control measures at Figure 1 below.

Figure 1 – Hierarchy of risk controls

Eliminating	**Best**
• Substituting • Isolating • implementing engineering controls	Effectiveness does not depend on human behaviour
Administrative controls	Effectiveness depends on human behaviour
Using Personal Protective Controls (PPE)	Does not control the risks directly. It controls the possible harm to a person

Note: Further guidance is provided in the MECP code and EECP code

2.1.3 Design, manufacture, import, supply

Designers, manufacturers, importers and suppliers of plant, substances and structures have health and safety duties under sections 22-25 of the WHS Act.

In relation to plant, substances and structures, these duties may be summarised as a duty to ensure, so far as is reasonably practicable, that they are without risk to the health and safety of people at a workplace who use them for the purpose for which they were designed or manufactured.

2.1.4 Calculation, analysis, testing or examination

Designers, manufacturers, importers and suppliers must also carry out, or arrange the carrying out of, any calculations, analysis, testing or examination that may be necessary for the performance of the duty imposed by sections 22-25 of the WHS Act; alternatively, in the case of importers and suppliers, it must be ensured that such calculations, analysis, testing or examination have been carried out.

2.1.5 Information to be provided

Designers, manufacturers, importers and suppliers must give adequate information to each person to whom they provide the design, plant or structure (and subsequently upon request) concerning:

- each purpose for which the plant, substance or structure was designed or manufactured
- the results of any calculations, analysis, testing or examination referred to above, including in relation to a substance, any hazardous properties of the substance identified by testing
- any conditions necessary to ensure that the plant, substance or structure is without risk to health and safety when used for a purpose for which it was designed or manufactured.

2.1.6 Maintenance of control measures

Control measures implemented to control risks presented by identified hazards at a mine must be maintained to ensure their effectiveness under clause 37 of the WHS Regulation, including ensuring that the control measure remains:

a) fit for purpose

b) suitable for the nature and duration of the work

c) installed, set up and used correctly.

2.2 Hazards associated with ventilation fans

2.2.1 Ignition hazards

Potential ignition hazards associated with ventilation fans need to be controlled over the life of the ventilation fan, these may include:

- hot surfaces, greater than 1500 C
- flames
- mechanically generated sparks
- static electricity
- faulty or inadequately protected electrical equipment
- other possible failure modes that could generate ignition sources.

Some examples where ignition hazards have previously occurred with ventilation fans include:

- failure of bearing causing heat/sparks
- failure of bearing causing excessive vibrations
- seal friction
- excessive heat from friction between rotational and stationary parts

- contact between moving and stationary parts
- out of balance of the fan impellor
- foreign objects impacting the impellor
- catastrophic failure of the fan impellor
- failure or flexing of fan housing and/or supporting base frame
- floor heave of the foundations of the ventilation fan
- roof fall within the mine
- mechanical looseness of the impellor to shaft securing mechanism
- impact damage from an external object
- static charge of non-metallic components
- ineffective earthing of the ventilation fan
- incendive sparking of light metal alloys
- heating of air current within the fan
- slippage of dive belts or failure of drive pulleys
- motor failure
- ignition from electrical components
- stray currents.

2.2.2 Ventilation fan stoppage or reduced performance hazards

Ventilation in an underground coal mine is a key risk control. When the ventilation fan stops unintentionally or there is reduced performance there will be a change to the ventilation currents within the mine. This may create an atmosphere that is hazardous to people. Ventilation fan stoppages may result in mine evacuations due to insufficient ventilation.

Some hazards associated with the unintended stoppage, failure or reduced performance of ventilation fans may include:

- high explosive gas levels (such as methane, carbon monoxide)
- increase in irrespirable or toxic gas (such as carbon monoxide, carbon dioxide, oxides of nitrogen) levels due to decreased flow rate of air
- significant changes in pressure
- the potential to increase fire risk
- excessive dust build-up
- build-up of toxic diesel exhaust pollutants
- build-up of irrespirable gases or flammable gasses in dead ends, stubs and other areas where ventilation reduction may have a more marked effect
- the effect of a reduction in air velocity leading to gas layering and higher localised gas concentration.

Ventilation fans need to be reliable. Reliability should be assessed and monitored over the working life of a ventilation fan. Some considerations that may affect fan reliability include:

- ventilation fans being designed to a specified working life
- systematic failures in the design, manufacture or commissioning of the fan
- contamination of bearings/seals/lubricants and insufficient lubrication
- failure of ventilation fan control devices
- failure of sealing arrangements between intake and discharge causing leakage and/or recirculation

- operation/alarming of a protective control function, such as bearing temperature, vibration
- failure of by-pass doors not automatically opening / closing, if fitted
- inappropriate maintenance specifications and maintenance activities

Risks are substantially less in an intake airway than with a return airway.

2.2.3 General plant hazards associated with ventilation fans

Guidance on general mechanical and electrical hazards associated with mining plant, the assessment of risks arising from those hazards, and the implementation of fit-for-purpose risk controls is provided in the MECP code and the EECP code. Further guidance on general plant is provided in the AS 4024.1and guidance on risk management is provided in AS/NZS ISO 31000 and SA/SNZ HB 89.

General plant hazards associated with ventilation fans that may lead to personal injury or death may include:

- rotating components, such as shafts, impellors, couplings
- mechanical energy (and inertia) associated with the fan impellor
- electrical energy
- potential hazards due to the environment (dust, water, strata gases, floor heave, strata failure)
- thermal energy
- excessive noise
- force of ventilation current on inlet and/or discharge of fan
- potential rotational movement of the fan impellor, shaft and drive after fan stoppage, during maintenance work
- confined work during maintenance of impellor and/or housing
- working at heights on curved surfaces.

2.2.4 Hazards from a mine pressure event

It is important that main ventilation fans are capable of operating following an explosion or other over-pressure event in the mine. Consideration should be given to things that minimise the potential damage to the ventilation fan from an over-pressure event (refer clause 59(2)(e) of WHS (Mines) Regulation), such as:

- location of main fans on the surface of the mine
- location of other fans within the mine
- minimising bends on the output side of the fan
- Minimising bends on the inlet side except where a bend is intended for the fitment of an explosion door
- installing and maintaining fit-for-purpose explosion door.

2.2.5 Risk assessment

Risk assessments should, as a minimum:

- address risks to health and safety for people affected by the ventilation current
- address risks to health and safety for people in close proximity to the ventilation fan during operation, maintenance and repair
- identify controls to minimise risks so far as is reasonable practicable and assess the required reliability for any implemented controls
- consider the recommendations of this guideline and other published material on ventilation fans, such as BS EN 14986

- determine site specific requirements
- be used to assist in developing safe systems of work
- provide for ventilation fan installation being fit for the specified purpose.

2.3 Plant safety file

Safety-related aspects of ventilation fans should be fully documented. These records should be maintained in a plant safety file that covers the lifecycle of the system. The plant safety file should be initiated by the designer and be maintained by the person in control of the ventilation fan. As a minimum, the plant safety file should contain the following information:

- design specifications, performance and operational conditions
- design documentation as specified in Appendix C
- installation requirements
- hazard identification and risk assessment documents
- risk control methods
- identification of all safety critical systems and their required levels of risk reduction
- consultation records
- commissioning and test results
- maintenance records, safety inspections and test reports
- change of procedures, monitoring, audit and review reports
- reports of accidents and safety statistics
- plant alterations.

The records should be stored and maintained in such a way that they are readily retrievable and protected against damage, deterioration or loss. A plant safety file may not necessarily be one complete document; it may refer to where the information can be obtained.

The plant safety file must be kept and maintained for the life of the installation

3 Minimum design requirements for main fans, booster fans and auxiliary fans in underground coal mines

At the time of publication, parts 3 and 4.1 of this guideline are mandatory for the purposes of plant design registration for booster fans for use in underground coal mines under clause 177(5) of the WHS (Mines) Regulation and Part 5.3 of the WHS Regulation. In relation to main fans and ancillary fans the following is not mandatory.

3.1 Design - general

So far as is reasonably practicable, the ventilation fan impeller, fan monitoring, control system, and surrounding components must be designed to prevent the generation of sparks which can ignite methane under any condition of operation. The design should be such that a position change of the impeller and its support shaft, will not allow parts (such as steel parts) of the unit to rub or strike.

The following should be assessed in the ventilation fan design:

- Axial movement of the shaft or impeller
- Measurable wear, but not collapse of impeller or bearings
- Incorrect setting of shaft or guards during assembly
- Limited damage to the external drive guard and unit casing
- The provision of an effective continuous bearing temperature and vibration monitoring system to detect bearing failure as early as practical and the movement of the impeller on the shaft or other contributions to excess vibration.

All surfaces likely to generate heat and possible rubbing surfaces must be prevented from reaching 150^0C in any circumstances (refer to Appendix B for incident information).

For more detailed information on the design of ventilation fans working in potentially explosive atmospheres, refer to BS EN 14986.

The designer should consider the operation of the ventilation fan with significant “out of balance periods” in design calculations in case the fan is subject to infrequent cleaning.

Ventilation fan designs must facilitate their inspection, measurement and cleaning.

3.2 Design hazard identification, assessment and control

3.2.1 Design preliminary hazard analysis

A design preliminary hazard analysis must be carried out to identify all foreseeable hazards associated with the use of mine ventilation fans and to provide means to control risks to health and safety.

Where possible, this analysis must be carried out in consultation with the mine operator for which the ventilation fan is designed. Consideration must be given to:

- the purpose of the ventilation fan, including intended design life and potential lifecycle risks
- assessment of those hazards listed in part 2.2 above
- the impact of the fan in the mine environment
- the impact of the of the mine environment on the ventilation fan
- the range of environmental and operational conditions in which the ventilation fan is used
- the means for transport and storage of the ventilation fan
- the provision of safe access to the components of the ventilation fan, for their operation, maintenance, adjustment, repair and cleaning
- examination of failure modes of the ventilation fan and its components
- the information in Appendix B on past events.

The outcome of the design preliminary hazard analysis should identify the required safety critical systems and any performance requirements of those safety critical systems in order to safely operate the ventilation fan.

3.2.2 Design ignition hazard assessment

All ventilation fan designs must be assessed to identify all reasonably foreseeable lifecycle potential ignition sources that could occur. The assessment must:

- consider the entirety of the ventilation fan
- consider reasonably foreseeable misuse and reasonably foreseeable human error
- identify whether the potential ignition sources could occur during normal operation, expected malfunction or during rare malfunction
- identify all effective ignition sources which are capable of igniting an explosive atmosphere
- consider the effect of the ventilation fan operating in a methane enriched atmosphere and being used to degas parts of the mine
- consider possible failure modes and effects of those failures on of the ventilation fan.

The design ignition hazard assessment must consider those ignition hazards identified in 2.2.1 above.

3.2.3 Design operational risk assessment

A design operational risk assessment must be carried out in relation to the installation of a ventilation fan in the intended underground coal mine environment. The risk assessment must consider:

- dilution of noxious and flammable gasses so they do not enter the fan or discharge from it at excessive concentrations
- failure of fan controls and monitoring systems
- systems to prevent, detect and suppress a fire
- the effect of water and flooding including water causing –
    - ventilation restriction
    - electrical issues
    - an effect of the impellor
    - a break in the ventilation system (dead spots)
- the failure modes and effects on mine ventilation from any fan stoppage
- modelling of the mine environment for expected ventilation patterns from any fan stoppage
- training of personnel on human errors in relation to failures during ventilation stoppages and restarting of ventilation fans
- emergency procedures.

3.2.4 Design of safety critical systems

3.2.4.1 Controls for effective ignition sources

All effective ignition sources must be controlled. Control measures for ignition hazards should be identified as either:

- a safety-related function, or
- safety-related componentry.

The lifecycle effectiveness of the control measures must be assessed to ensure the control measures remain reliable and provide the required level of protection under all stated conditions.

3.2.4.2 Safety-related componentry

All safety-related componentry should be designed, analysed, tested and documented using current engineering standards.

Safety-related componentry must be systematically analysed to determine all reasonably foreseeable failure modes and to verify that a sufficient level of reliability has been achieved.

Systematic analysis methods such as a failure modes effects analysis, fault tree analysis or other similar analysis methods may be used to assess safety related componentry and to determine lifecycle inspection, maintenance, test and discard requirements, as required for lifecycle functionality.

Consideration should be given to fatigue testing or analysis, where applicable.

3.2.4.3 Safety-related functions

All safety-related functions arising from the hazard assessment(s) must be clearly identified.

Safety-related functions must be assessed using current functional safety standards, as amended from time to time, as applicable to the design architecture and type of components used so far as is reasonably practicable. Acceptable functional safety standards include:

- application of performance levels (PL) in accordance with AS/NZ 4024.1503 or ISO 13849.1, or
- application of safety integrity levels (SIL) in accordance with AS 61508.1 or AS 62061, or
- application of safety categories (CAT) to AS 4024.1501 and AS 4024.1502, or
- other relevant functional standards, provided an equivalent level of safety can be demonstrated.

All safety-related functions should be independently assessed and verified to confirm that the required risk reduction has been achieved, so far as reasonably practicable. The person carrying out the functional safety assessment should be competent at assessing safety functions to the specified functional safety standard above. The functional safety assessment should include:

- validation through evidence documentation
- a review of possible lifecycle systematic failures and corrective measures taken
- documentation on any assumptions used, such as those that relate to proof test intervals, periodic inspection and tests, environmental conditions and human behaviour.

3.2.5 Fan testing and performance of control functions

All safety-critical control functions must be tested, after installation and during commissioning to validate the performance of those functions. Testing of safety-related functions must be carried out in accordance with the relevant functional safety analysis and functional safety standards.

3.3 Design of ventilation fan components

3.3.1 Light metal alloy

Uncoated or unprotected light metal alloys or aluminium must not be used:

1. on any rotating component or in any other component on the ventilation fan that may be subject to impacts
2. on any ventilation fan that operates
   a) in the hazardous zone
   b) on the inbye side of the first cut-through outbye from a longwall face.

3.3.2 Fan housing

The following applies to the fan housing:

- The fan housing should be of robust construction with external stiffening around the impeller casing to reduce the potential for damage occurring during installation, movement underground, transport or handling.
- The fan housing should be designed taking into consideration potential resonance or harmonic frequencies which may occur.

- The fan housing must have the design direction of rotation prominently and permanently marked. There must be a means whereby the direction of rotation can be checked by a competent person.
- A method for draining water from the fan housing should be provided.
- Slotted holes should not be used.
- All bolts must have a means to prevent them coming loose from vibration during fan operation.

3.3.3 Foundations

The following applies to the foundations:

- The motor and all bearings in any drive train must be mounted on a single drive frame or single/joined/constant foundation. This does not preclude:
    - use of flange mounted motors, or
    - mounting of the impeller directly onto the motor output shaft.
- Foundation design of main and booster fans must take into consideration the possibility of floor heave within the design of the base and frame of any foundations, where applicable.

3.3.4 Impeller

The following applies to the impeller:

- Accurate and positive locating and locking of the impeller on its support shaft must be provided.
- Fan impellers should be designed to ensure that pockets in which dust can collect are minimised.
- Impellers must not be designed to be manufactured from light metal alloys.
- Impellers designed to be manufactured from non-metallic materials must be fire resistant and anti-static in accordance with MDG 3608.
- The fan impeller and surrounding components must be designed to prevent the generation of sparks that may ignite methane under any condition of operation. The design must be such that a position change of the impeller and its support shaft will not permit steel parts of the unit to rub or strike which can generate sparks or generate sufficient friction to ignite flammable gas, so far as is reasonably practicable.
- Those parts of the fan that would first come into rubbing contact should have one part made of either copper or brass or otherwise lined with copper or brass of sufficient thickness.
- The fan impeller should not be driven by V belts or toothed belts without functional controls to protect from slip, or broken belt.
- Hollow blades should not be used for impellers as they have been known to fill with water and cause increased out of balances and high vibration rates.

3.3.5 Bearings

The following applies to bearings:

- Anti-friction bearings for the electric motor and fan impeller should be designed for a L10 working life of at least 100,000 hours (in accordance with AS 2729 or ISO 281), to accept the combined axial and radial loadings from the fan with consideration of an acceptable fan out of balance limits. The designer should state the acceptable out of balance limits for operation of the fan.
- The selection of bearings should include consideration of the type of bearing cage material. The cages of anti-friction bearings should not be manufactured from non-metallic materials such as polyamide, unless verified by the bearing manufacture as being appropriate for the particular application.
- Bearings must be designed to be prevented from reaching 150°C.

- Bearing seals should be suitable for use in dusty, moist conditions.
- The recommended grade and type of grease, or lubricant, should be indicated on the motor or bearing housing.
- Consideration should be given to bearings with in-built monitoring devices for temperature and vibration.

3.3.6 Brakes

The following applies to braking:

- A brake or other system must be provided to hold the impeller stationary to allow maintenance and inspection so testing activities can be carried out safely, where there is a risk.
- When a brake is fitted to the shaft to prevent 'windmilling' of the motor, the brake should:
  - be able to hold fan stationary when power is off
  - be controlled so that it is not possible to exceed 150°C
  - not be able to be applied at speeds in excess of its design capabilities.

3.3.7 Lifting points

Lifting point attachments must be provided for in the design to allow relocation of the fan without damage. For moveable fans, the lifting and towing procedure must be fitted to the frame on which the fan/motor assembly has been installed. The sub-frame should be designed so that excessive deflection will not occur when the fan is lifted from those points. All attachments must be adequate for the loads applied.

3.3.8 Motor

The following applies to the motor:

- Consideration should be given to the motor being ventilated and cooled by intake air.
- The grade of winding insulation should be suitable for the intended duty and should be indicated on the motor.
- When the fan is not energised, provision must be made to eliminate the risk of dangerous voltages being generated inside the explosion protection enclosure of the motor terminals due to 'windmilling' of the impeller, refer Appendix B for incidents.

3.3.9 Access door

Main fan and booster fan placements should have a door(s) so access from one side of the fan to the other can be obtained without opening the automatic fan bypass door. These should contain a pressure lock to ensure the by-pass doors remain closed while the fan is operational.

3.3.10 Guarding of moving and rotating parts

The following applies to guarding of moving and rotating parts:

- Guarding must be provided, so far as is reasonably practicable at the fan inlet to prevent the following entering the impeller: stone, ventilation tube seal, safety hats, gloves, coal or other material. The width of the openings in the guard must be appropriate for the fan design such to protect these materials from impacting the fan impeller as a result of high air velocity. 50mm may be suitable for fans connected to ventilation ducting.
- Access to the guard for cleaning purposes should be provided.
- So far as is reasonably practicable, every inspection or access cover attached to the fan or associated material traps must be provided with positive locking devices and appropriate danger signs.
- All exposed rotating components must be effectively guarded, refer AS 4024.1.
- A procedure for safe access and maintenance must be provided.

3.4 Electrical equipment

All electrical plant used in a hazardous zone must be designed to comply with the relevant parts of clause 78 of the WHS (Mines) Regulation.

The design of the electrical aspects of the fan should take into consideration the requirements detailed in AS/NZS 4871.1 and AS/NZS 4871.2. Where controls identified in these standards are not incorporated into the fan design, reasons should be detailed and kept in the safety file for the fan.

Where variable speed drives (VSDs) are used to control the speed of the fan, the design risk assessment should take into consideration the potential hazards and possible guidance requirements listed in Appendix E – *Variable Speed Drive—Guidance for identification of potential risk*s in AS/NZS 4871.1.

3.5 Noise

The design must take into consideration appropriate noise control measures where exposure to noise at the operators station exceeds an eight hour noise level equivalent of 85 dB(A) or peak of more than 140 dB(C).

3.6 Fan control

3.6.1 Automatic protection functions

All ventilation fans must be fitted with safety control functions which trigger a visible alarm if there is a significant departure from the fan's normal operating parameters. These functions should take appropriate action on a potentially dangerous or abnormal condition arising from an increase in:

- temperatures of any fan bearings
- temperature of windings in the electric motor
- vibration of critical rotating elements of the fan assembly and drive motor

These monitoring devices must operate continuously while the fan is operational.

So far as is reasonably practicable, these devices must record the date and time that any alarm is triggered or the power supply is shut off, that is, when variations to the norm occur and must trip the power to the fan motor before unacceptable operational limits are exceeded. The devices must display the results of the monitoring and the visible alarm in a place that is easily accessible by a person whose tasks including checking the condition of the fan.

External contact-type temperature-sensing devices mounted on the bearing cap may not have adequate response time to detect the sharp rise in temperature that can occur when cage and rolling elements break up. A way to minimise response time is to position the temperature probe as close as possible to the bearing by using the greaseway access point that uses an adaptor that allows the bearing to be greased.

There should be an alarm point before the trip point. The trip point should be close to the normal high operating point and well below dangerous levels. Trend monitoring must be available for all temperature and vibration measurements, so far as is reasonably practicable.

Bearing temperature monitoring should be carried out by means that minimises response time.

Warning devices must be positioned to ensure the device will work to best effect.

3.6.2 Power shut-off

All fans must be equipped with a device that automatically de-energises power in affected workings where the fan stops. Provision should be made to isolate power to all sections of the underground mine when the ventilation current is affected by a fan stoppage. For example:

- For main fans – the whole mine power is removed.
- For booster fans – the power to the district being ventilated directly by the booster fan is removed.

- For auxiliary fans – the power to the district/production panel being ventilated is removed.

3.6.3 Start/stop controls

All fans must be equipped with starting and stopping controls at the ventilation fan. Starting and stopping controls may be provided at other suitable accessible remote location(s), including the control station on the surface. Consideration of location should include the mine's operating procedures and inspection requirements before fans are started. Typically, panel auxiliary fans should only be started at the fan site area.

3.6.4 Emergency stops

An emergency stop must be provided to stop the fan in an emergency at each control station.

Emergency stop devices must:

- be prominent, clearly and durably marked and immediately accessible to each operator of the plant
- have handles, bars or push buttons that are coloured red
- not be able to be affected by electrical or electronic circuit malfunction.

Emergency stops must comply with clauses 191 and 211 of the WHS Regulation.

3.6.5 Run time

A fan hours run meter should be fitted to assist in:

- indicating the total time of fan operation and time to next service
- providing a service alarm for excessive hours run from last service.

Where fitted, consideration should be given to providing the hour meter with:

- tamper proof security system (to prevent winding back of hours run meter)
- a tamper proof service reset.

3.7 Fan ventilation control

3.7.1 General

Each fan installed on the surface, and each booster fan installed underground, at the mine as part of its ventilation system must be fitted with one or more devices that continuously monitor the working condition of the fan, including its static pressure.

A system to regulate the fan capacity must be considered. Typically these systems should include:

- variable inlet vanes (VIV)
- variations in shaft speeds
- change in impeller pitch
- change in impeller solidity (removal or addition of impeller blades).

3.7.2 Inlet vane

For inlet vane guide control systems (where automatic control is not required as typically used on panel auxiliary fans) the open circuit volume for each position of variation of the vane control should be identified on the fan. These devices should be capable of being locked in position to maintain constant flow pressure and prevent recirculation at the fan.

3.7.3 Recording of ventilation fan trips

The design must provide for the electronic recording of trips of the ventilation fan, so far as is reasonably practicable and their reason should be recorded. This includes methane trips, excessive temperate and excessive vibration.

3.7.4 Remote monitoring

Where regular adjustment of volume and pressure is required (as typical for main and booster fans), fan control devices should:

- be monitored from the control room
- be remotely operated
- include remote monitoring of position
- be used for start-up
- have adjustment provision which is manually or automatically achieved
- be arranged to automatically prevent flammable or noxious gases entering the fan housing.

Fan control devices may also be used to initiate fan stops.

3.7.5 Ventilation monitoring

The following apply to the design of safety functions for ventilation monitoring:

- Pressure indication must be provided to show the fan pressure at all times.
- Volume of air passing through the fan indication, and recording, must be provided.
- Monitoring of the quality (gas content) of air passing through the fan must be provided where there is a risk of toxic or flammable gasses.
- Continuously monitoring of the working condition of the fan, including its static pressure must be provided.
- The design must trigger a visible alarm if there is a significant departure from the fan's normal operating parameters.
- The recording of the date and time that any alarm is triggered or the power supply shut off must be provided.
- The display of the results of the monitoring and the visible alarm must be in a place that is easily accessible by a person whose tasks include checking the condition of the fan.
- Provision should also be made for the real time monitoring of fan dynamic pressure. Real time monitoring should be recorded.
- The ventilation fan must be designed to trip if the level of methane passing through the fan creates an unacceptable risk to health or safety. The ventilation fan may also be designed to trip if an area downstream of the fan becomes a place of risk.
- Adequate monitoring should be installed to allow the system to fail to a safety state. Monitoring devices should alarm and/or trip the power before unacceptable operational limits are exceeded. Appropriate risk reductions, as determined by the functional safety assessment apply to monitoring devices to ensure they remain functional.
- Monitoring results should be displayed at all control stations where power to the fan can be isolated and where the fan can be restarted.
- For main fans and booster fans real-time image monitoring of the installation should be considered with results being visible from the surface of the mine. This should include monitoring of the booster fan by-pass doors.

Auxiliary fans may have access tapping points for attachment of calibration check instruments which are not permanently installed.

3.8 Signs, labels and warning notices

3.8.1 General

All signs, labels and warning notices should be designed and installed in accordance with AS 1318 and AS 1319. They should be:

- of durable corrosion resistant construction

- permanently attached
- positioned so they are clearly visible.

3.8.2 Labels

Items that should be labelled include, but not limited to, the following:

- manual controls
- isolation points
- emergency stops
- removable guards
- gross weight of the fan and motor
- alarm and shut down levels on the fan control.

3.8.3 Nameplates

A durable engraved or stamped series of nameplates should be fitted in a permanent location on the fan assembly and should include the following information:

- design registration number (booster fan only)
- serial and model number
- date of manufacture
- supplier's name/make
- gross weight of the fan/motor assembly (for booster and auxiliary fans)
- maximum dynamic pressure, volume of airflow at nominal shaft speed and maximum shaft speed
- any other relevant fan performance information.

3.9 Information to be provided

The designer must provide information on risk controls necessary for the safe use of the ventilation fans. Without limitation this information must include:

- information on identifying hazards, assessing risks arising from the hazards and controlling risks from the use of the fan ventilation plant
- the purpose of the ventilation fan
- requirements for testing or inspection
- requirements for installation, commissioning, operation, maintenance, inspection, cleaning
- systems of work for the safe use of the ventilation fans
- competence of people undertaking inspections and testing
- emergency procedures.

This information should be contained in the plant safety file and should be provided before supply of the fan ventilation plant.

4 Minimum design requirements for specific types of ventilation fans

4.1 Booster fans

In addition to Part 3 above, the following applies only to booster fans.

4.1.1 Ventilation survey and analysis

A ventilation review including analysis, survey and modelling must be carried out to demonstrate the necessity for the booster fan. The survey must state the expected performance range while in operation, the location of the booster fan and its effect on the remainder of the ventilation network.

Where practical and where overall risk is reduced, booster fans should be located in intake roadways rather than in return roadways.

4.1.2 Risk assessment

The design risk assessment for booster fans must consider the following:

- Start-up and shut-down procedures of the booster fan and sequences with the main fan and other fans present in the mine, including unintended shutdown.
- Modelling of fan failure scenarios and the risks associated with these scenarios, including (without limitation) mine fire (minor and major), mine explosion, mine gas-out.
- Modelling of ventilation circuit restrictions. For example from roof falls (so far as is reasonably practicable).
- Whether the booster fan is installed in return or intake airway.
- Modelling of the removal of a significant concentration of flammable or noxious gas from an area of the mine.
- For multiple main and booster fans, modelling of various combinations of the failure of any individual fan.
- The life cycle activities of the booster fan including operation and maintenance.
- The means to prevent, detect and suppress (including automatic fire suppression) fires that may occur in the fan drive room or within 15m on either side of the booster fan.
- Booster fan houses and their precincts being constructed of fireproof materials, for at least 5 metres on the intake side and 23 metres on the return side of the fan.
- The booster fan incidents listed in Appendix B.

4.1.3 Minimise air restrictions

Every booster fan must be located in such a manner that, if it stops, it will minimise any restriction to the free passage of air delivered by the main fan.

The fan impellor of a stopped fan restricts airflow.

4.1.4 Limit recirculation

A means to control and limit recirculation of air through the booster fan must be provided.

4.1.5 Access

Booster fan installations should have access between the intake and return reasonably close to the fan site.

4.1.6 Installation

Booster fan installations must be, so far as is reasonably practicable:

- provided with by-pass doors which open automatically when all fans in the installation stop
- provided with an air lock to allow passage through the fan bulkhead as necessary.

4.1.7 By-pass doors

The door hinges should be lubricated appropriately to prevent hinges seizing.

The design of the doors must be such that minor strata movement or minor build-up of dust will not obstruct their operation.

4.1.8 By-pass door monitoring

Remote monitoring of by-pass doors should be available at the surface control room of the mine. This should be able to monitor the door position even when the power is off in the mine.

4.1.9 Dilution of potentially explosive atmosphere

Booster fans which operate in return airway should be provided with a mean to dilute noxious or flammable gasses entering the fan housing.

4.1.10 Housings

Booster fan housings should not form part of ventilation stoppings.

4.1.11 Non-explosion protected electrical

For non-explosion protected motor and controls, the power to the booster fan must be automatically cut when the percentage of flammable gases in the intake passage passing through the fan drive room exceeds 0.25% methane by volume (refer to EECP code).

4.1.12 Atmosphere monitoring

Effective means (such as gas monitors) should be provided to ensure that the atmosphere used in the ventilation device is compatible with the engineering specification for the use of the ventilation device. Atmospheres exceeding these specifications may pose a hazard for the equipment and possibly represent an explosion or fire risk for the mine.

4.1.13 Plenum chamber

A plenum chamber may be used to house the fan drive and controls. Where used, a plenum chamber must be rated to easily take the maximum explosion pressure from an underground mine gas explosion. Methane monitoring should also be performed on the intake to the motor.

4.1.14 Design for maintenance

The booster fan system must be designed so that routine inspection and maintenance may be performed without stopping the booster fan or interfering with the provision of ventilation by the booster fan. This provision does not apply to cleaning.

4.1.15 Brake control

Speed reduction monitoring may be used to control safe brake application.

4.2 Main fans

In addition to Part 3 above, the following apply to main fans:

- Main fans must be located on the surface of the mine.
- Due to the position of main fans on the surface of the mine, environmental considerations should be made in regards to noise abatement of the main fans.
- Explosion doors and/or a means of relieving an explosion without destroying the main fans should be fitted. These should be fitted between surface end of fan cowling and the fan through means of either–
    - explosion doors
    - design of the ventilation bend so that the bend will fail before any excessive pressure wave travels to the fan.
- The power supply for the main fan should be effectively isolated from all underground power so the fan can be run without power being available underground.
- Fans that are remotely located away from the mine adit should:
    - be able to be stopped and started remotely
    - have continuous real time monitoring of quantity (volume, pressure of the moving air) and gas content with the results displayed at both the fan and at a convenient personnel access point to the mine (for example the surface control / monitoring station).
- Main fans should be provided with continuous temperature and vibration monitoring of the fan motor and impeller shaft bearings.
- Main fans should be directly driven. Belt drives and chain drives should be avoided.
- A safe means should be provided to allow regular cleaning of the impeller and housing. This should include a means to hold the impeller stationary and provision of appropriate lockable access doors.

- Where more than one fan is installed, means should be provided for effective isolation of one from the other for maintenance work.
- For fans connected to shafts or any place where there is potential for a person to fall from within a fan casing or conducting work externally to the fan, effective fall prevention means should be provided. Compliance with AS 1657 may be appropriate.
- Guarding between the impeller and access to it should be provided.
- Main fans and booster fans should have an alarm at the surface, which activates when a main ventilation fan stops.

4.3 Auxiliary fans

In addition to Part 3 above, the following apply to auxiliary fans.

4.3.1 Anti-sparking design

The design should be such that a position change of the impeller and its support shaft will not allow parts such as steel parts of the unit to rub or strike.

The fan housing should include a spacer ring made from special spark/heat generating resistant material so if shaft-bearing failure occurs this is the first material the impellor contacts.

4.3.2 Sealing

Fan housing sealing should be such that if return air is drawn through the fan the return air cannot flow over fan/motor assembly bearings.

4.3.3 Foot-mounted motors

Where foot-mounted motors are used, a positive means such as locating pins should be provided in addition to hold down bolts to prevent relative movement between the motor and fan housing.

4.3.4 Towing

Frames fitted with wheels for ease of towing should be fitted with a mechanism to prevent inadvertent movement when parked.

4.3.5 Trickle stone dusters

Trickle stone dusters are commonly used as part of auxiliary fan installations. Where stone dust is to be distributed by the fan it should be added at the discharge of the fan. The design risk assessment should include consideration of the effect of the trickle duster device on the velocity pressure of the fan discharge.

4.3.6 Toxic and flammable gas dilution

Auxiliary fans, where used to draw air from an area that may contain gas, should be fitted with a means to safely dilute the concentration of the gas to acceptable limits.

4.3.7 Debris drop box

Auxiliary fans should have a ‘drop box’ area installed on the inlet side of the fan as a collection area for excess debris to gather for easy collection. This area should be able to be accessed while the fan is operational.

4.3.8 Compressed air powered air movers

Where these are installed along with auxiliary fan installations, they should be taken into account as part of the auxiliary fan installation, and assessed accordingly.

Compressed air movers must be FRAS as set out 87(2) of the WHS (Mines) Regulation. FRAS means compliant to testing and certification process as published by gazette. At commencement of the WHS (Mines) Regulation was Guideline *MDG 3608 Non-metallic materials for use in underground coal mines (*Schedule 12 clause 30).

Compressed air movers should be effectively earthed to prevent build-up of static electricity.

A **Venturi Ventilator** type of air mover consists of a tube with a venture throat, through which air is entrained by the effect of a high speed stream of compressed air. These devices can produce high air flows when the overall ventilation resistance is relatively low. They should only be used for localised air movement such as short drivages.

Applications may include –

- positioned without ducting to prevent gas layering or to dilute and remove gas from cavities and the corners of face stables, to dilute local airborne dust levels or reduce effective temperature
- used with ducting as auxiliary ventilators, especially with small installations in advance headings and where the noise of a fan would present a problem
- used as the motive power in auxiliary ventilation systems when the auxiliary fan is stopped at weekend periods
- used as the motive power in methane drainage systems, particularly at the return ends of retreat faces and where methane is controlled in stopped off districts.

5 Requirements for installation and commissioning of ventilation fans

5.1 General

Ventilation fans should be installed and commissioned in accordance with the design documentations and specific site requirements. Generally this section applies to the installing and assembly of ventilation fans, whether brand new or after major overhauls of older fan ventilation plant, at workshops, on surface of coal mines or underground in coal mines.

Results of the inspections and tests should be recorded and kept in the plant safety file.

A risk assessment should be carried out to identify potential hazards that may arise and methods to controls those risks arising from the installation and commissioning process.

People conducting installation and commissioning of plant should be trained and assessed for competence.

5.2 Commissioning and testing

Commissioning and testing must include –

- inspection of the fan housing for undue deformation or other defect
- the measurement and recording of vibration in motor/fan bearings at regular intervals
- testing the operation of controls and trip set points
- testing the operation of brakes, interlocks and controls
- performance testing
- performance of by-pass doors
- testing of the ventilation system controls to ensure allowable flammable and or noxious gas levels are not exceeded
- inspection and testing criteria required as a result of designer/manufacture/supplier information.

5.3 Noise

Appropriate noise control measures must be implemented where exposure to noise at the operators station exceeds an 8 hour noise level equivalent of 85 dB(A) or peak of more than 140 dB(C).

6 Requirements for use of ventilation fans

6.1 Operational

6.1.1 General

The mine operator and other users of fan ventilation plant should ensure that –

- fan ventilation plant is not operated unless the user is supervised and has received adequate information and training
- fan ventilation plant is only used for the purpose which it was designed, unless the designer assesses that the change does not present an increase in risk to safety
- safety features are used as intended by the designer of the fan ventilation plant
- the risk of entanglement is controlled by safe guarding systems
- people do not work between fixed and moving parts of the fan ventilation plant, where there is a risk to health or safety
- persons do not work in the immediate area of remotely or automatically energised parts of fan ventilation plant without appropriate controls and systems of work in place
- hot parts are adequately guarded
- measures are provided to prevent unauthorised alterations or use of fan ventilation plant
- fan ventilation plant is subject to appropriate checks, tests and inspections necessary for safety
- fan ventilation plant is withdrawn from operation when there is an immediate risk to safety.

6.1.2 Risk assessment

The ***mine operator*** of ventilation fans must carry out a risk assessment.

This operational risk assessment should be carried out before the use of any ventilation fans in the mine. This risk assessment should be reviewed and a new operational risk assessment carried out whenever variations in design, use, conditions or environment could change the risk.

The risk assessment should include each fan location and the area that is being ventilated.

The ***mine operator*** of ventilation fans must provide all persons involved in the installation, commissioning, use and testing of fan ventilation plant all available information concerning health and safety about the plant.

6.2 Maintenance

6.2.1 General

The mine operator and other users of fan ventilation plant should ensure that in relation to repair and maintenance of ventilation fans:

- necessary facilities and systems of work are provided and maintained
- inspections, maintenance and cleaning is carried out with reference to information provided by designers, manufacturers or otherwise developed by a competent person
- all safety features and warning devices on fan ventilation plant are tested and maintained
- a competent person(s) assesses any damage to fan ventilation plant, where the risk to safety may be increased
- repair, inspection and testing is carried out by a competent person
- repairs to fan ventilation plant keep the fan ventilation plant within its design limits.

If access to the fan ventilation plant is to be used, the fan ventilation plant must be stopped and a lockout, danger tag, permit or other control measure must be used to minimise risk. An isolation and energy dissipation procedure should be used. This should be in accordance with any procedure developed for the task.

6.2.2 Maintenance procedures

The following apply to the maintenance management system:

- Cross checks between continuous vibration monitoring and periodic more sophisticated vibration monitoring should be considered.
- Means to safely fit and remove portable vibration and temperature monitoring devices without stopping the fan should be considered.
- Any person who inspects a main, booster or auxiliary fan installation should be competent to do so and should keep a log book of all inspections made and of what was inspected.
- Graphing of vibration and temperature data in relation to the effect of cleaning, lubrication and other adjustments should be considered.
- Fans should be rebalanced when reaching predetermined out of balance levels.
- There should be periodic proof testing of all safety-related control functions.
- Maintenance systems should include trending of recorded data in relation to operation of main, booster and auxiliary fans.
- The cleaning of impellors
- Regular lubrication of by-pass door hinges should be considered.
- All inspections, faults and incidents should be recorded.
- Adjustable inlet vane controls should be included in the maintenance schedule for separate lubrication.

6.2.3 Instruction and training

All mine employees involved with fan installations should have appropriate levels of training, including at management level, to deal with incidents involving the fan placement, operation and emergency procedures.

The mine operator should prepare procedures to be followed in the event of the stoppage of a fan and should post a copy of these procedures in a conspicuous place at the surface of the coal mine and at suitable locations in the vicinity of the fans underground.

6.2.4 Restarting after a power failure

The mine operating procedures should address restarting after a power failure depending on the duration of the stoppage. The following should be considered before re-starting after a fan stoppage:

- If there is a need to evacuate personnel in the area being ventilated.
- Before restarting the fan, a qualified person should enter areas evacuated to determine whether gas levels are such as to allow the fan to be started safely.
- Minimise flammable or noxious gasses from entering the fan and entering trafficable roadways. (for example by use of the by-pass and restriction device on auxiliary fans or regulators on booster fans).

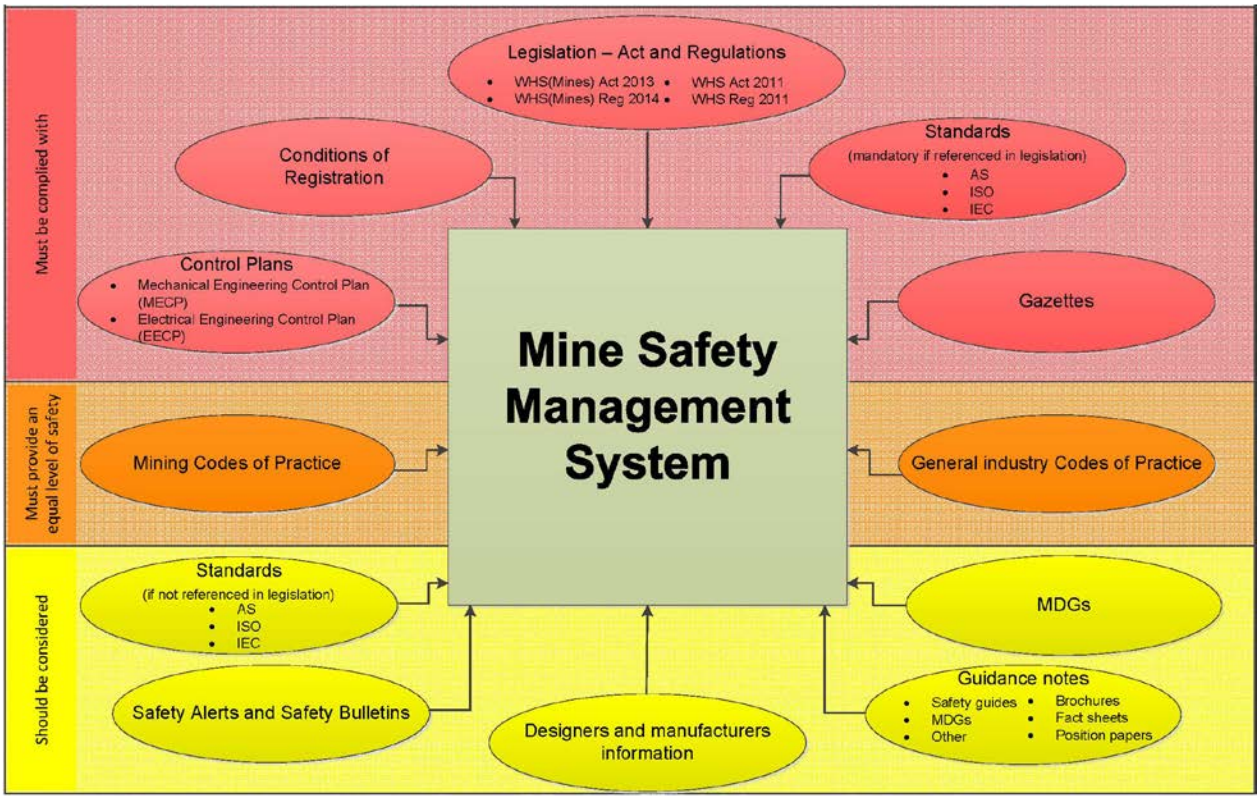
6.3 Alterations

Alterations to ventilation fans must not be carried out unless the person undertaking the alterations fulfils the duties of a designer and all other requirements under Part 5.3 of the WHS Regulation. A risk assessment should identify the alterations are safe and are able to be performed without reduction to safety.

Operators should conduct an operational risk assessment on the modified plant before putting the machine into operation. This risk assessment should ensure that no new hazards are introduced unless appropriate controls are implemented.

Appendices

Appendix A – Mud map of guidelines and legislation



Appendix B – Incident Information

B1 - Safety alerts

Since 2005 NSW Department of Industry has issued the following two safety alerts on ventilation fans.

Alert No.	Title
SA07-02	Catastrophic Failure of Auxiliary Fan
SA05-02	Unsafe Flameproof Enclosure Auxiliary Fan

B2 Incidents with booster fans

Booster Fans have been extensively used in European countries.

A collection of 47 reportable incidents over the period 1997 to 2003 were reviewed to produce the following graphs.

41 of the 47 reports provided the time that the booster fan was not operating. The average off time was approximately 2 hours and 7 minutes. The range was 30 minutes to 14 hours 45 minutes. One result of "several days" was excluded from this calculation.

Figure 1 shows a graph of the booster fan off times.

Figure 1 - Booster fan Off Time

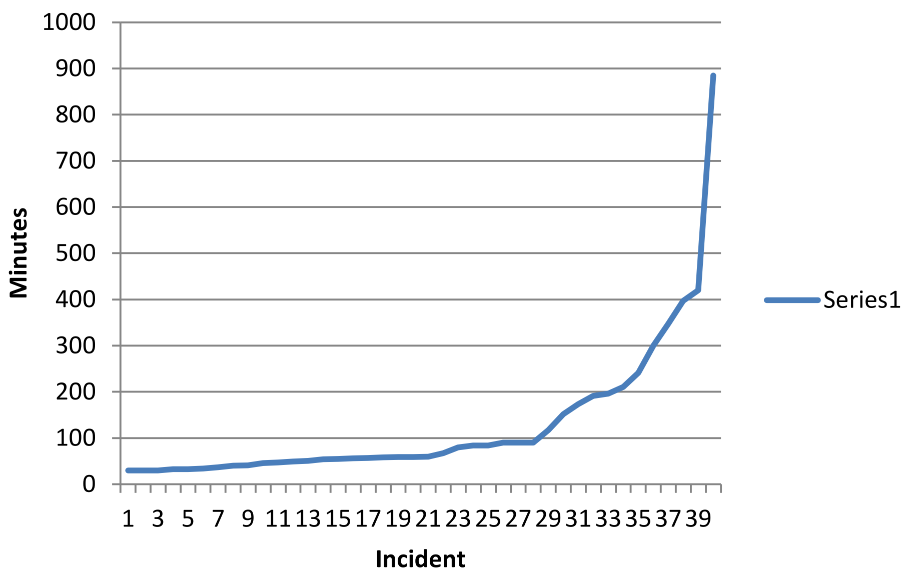
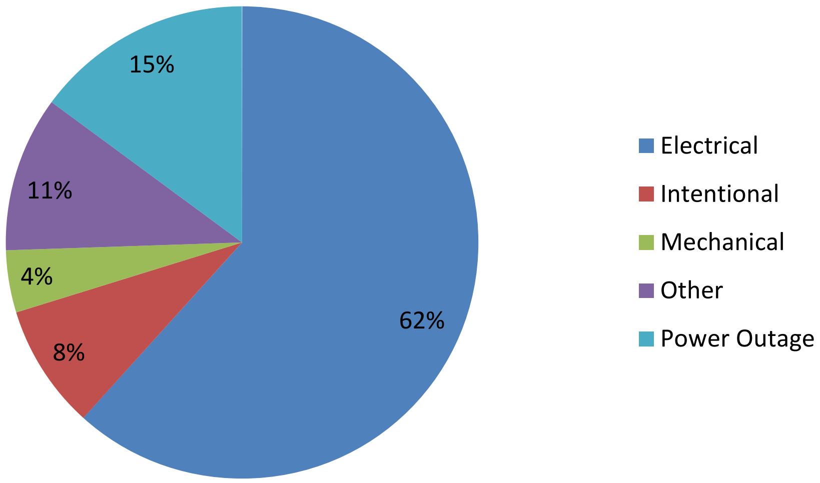


Figure 2 is a pie chart showing the causes of booster fan off times.

Figure 2 - Causes of Booster Fan off time



Note:

Electrical:	Typically these were circuit breaker trips or earth leakage faults or unstable power supply issues.
Intentional:	These for planned outages, weather or spontaneous combustions events
Mechanical:	These were gearbox or other mechanical issues directly related to the fan
Other:	These were accidental damages caused to the power cables or supply
Power Outage:	Storms or other reasons for loss of the power supply to the mine.

A sample of the reportable incident reports are provided in the table below.

Year	Description	Issue / cause
1997	At a large coal mine there was a reduction in ventilation lasting for a period of 34 minutes when the power supply to a remotely supervised booster fan was interrupted by a dip of voltage on the external 33kV distribution network. The mine had approval for the remote starting of the booster fan after a disturbance but the fan's airflow interlock was incorrectly set and a catcher coil protection mechanism is one of the 6.6kV SF6 circuit breakers failed and prevented the facility from being used. During the breakdown, underground environmental conditions were not seriously impaired and methane levels remained within statutory limits	Reduction of ventilation. ELECTRICAL - Fan stoppage from failure of electrical controls
1999	At a large coal mine, while attempting to repair an earlier fault on a surface supply cable, a short circuit fault was caused when a specialist 'high voltage' contractor struck a second buried 11,000 volt cable with a pick axe. Power was lost to the mine for a period of 25 minutes. The contractor was fortunate to sustain only minor flash burn injuries to his hands and face. As a result, an underground booster fan was stopped for a period of 51 minutes. Auxiliary ventilation was also lost inbye developments which required degassing	Reduced ventilation. OTHER – Power lost as a consequence of other work.
1999	At a large coal mine, an official carrying out an inspection smelled burning and an investigation found flames coming from around the supports adjacent to a bank of booster fans. The fire was extinguished using a portable extinguisher and the area was cooled with water from a hydrant. The fire was caused by spontaneous combustion due to a combination of slips, a rib tell tale monitor, a poor standard of sealing the airlock and a lack of fireproofing within the roadway. A CO monitor at the booster fan had given a warning of an increase in CO from 6 to 7 ppm 3.5 hours earlier but no action was taken. There were 19 persons underground at the time an no one wore their self rescuers. Matters pursued with the manager included an improvement to the standard of sealing and fireproofing and review of monitoring action levels. A notice to extend the maximum interval of inspections of the booster fan has been revoked.	Spontaneous Combustion and fire. INTENTIONAL - Slips, sealing and fire proofing
1997	At a time when the mine was on a single 66kV circuit risk due to REC equipment failure external to the mine, a fault developed at the main substation and the mine's incoming power supplies were totally lost. All ventilating fans stopped causing a substantial reduction in ventilation of the mine. An emergency generator and associated apparatus provided in accordance with the scheme made pursuant to Reg. 4 of the Mines (Safety of Exit) Reg 1988 was used to evacuate the 86 men who were caught underground. All men were brought to the surface within 3 hrs 20 mins and no-one suffered any ill effect. A single 66kV incoming feed to the mine was restored after 4hrs 27 mins and the last booster ventilating fan was restarted after a whole stopping period of 6 hrs 37mins. No adverse underground environmental conditions were encountered.	Reduced ventilation. POWER OUTAGE – External to mine
1998	A remotely supervised underground booster fan was stopped for 49 minutes when, without warning, the low SF6 gas pressure trip operated on the 6.6 kV switchboard's incoming circuit breaker. An electrician was directed to the site to change over to the standby circuit but his traveling time exceeded 30 minutes. During the stoppage, there was a reduction in ventilation from 220m³/s to 170 m³/s but no adverse environmental conditions resulted.	Reduced ventilation. ELECTRICAL - Trip
2003	A booster fan stopped after the temporary loss of power to the mine in a thunderstorm. It could not be restarted for a period of 55 minutes following the failure of the environmental monitoring system leading to the need to put the standby monitoring systems into operation. No adverse conditions arose from the incident.	Reduced ventilation. POWER OUTAGE – External to mine

Year	Description	Issue / cause
2003	Thirty minutes after an alignment check and an oil change in the bearing box of 650kW axial flow booster fan, made in response a rising trend of low frequency vibration, a supervisor heard change in running tone and saw what he thought was oil vapour or smoke rising from fan nose cone area. He stopped the fan and found a slightly high oil level, which he corrected before restarting the fan. When he did so he saw smoke and hot particles nose cone. On examining the fan internally he found glowing embers around the base of the bearing box and quickly doused them with water. No persons were withdrawn, suffered ill effects or used self-rescuers. Preliminary findings indicated that bearing box overheated due to wear of drive side ball bearings which in turn ignited deposits of coal dust and paint on the base of the bearing box. The bearing box has been replaced, improved temperature monitoring provided, and inspection and maintenance arrangements improved.	Reduced ventilation. MECHANICAL - Gearbox failure

B3 Disasters involving booster fans

Known disasters involving booster fans:

- ***OXCROFT – 1919 -*** Two booster fans in series, by-pass doors closed with fan stopped, exploded on restart by an electrician – six fatalities.
- ***AUCHENGEICH – 1959 -*** Belt driven booster fan caught fire, spreading to timber lagged roadway – 47 fatalities.
- ***SUNSHINE – IDAHO SILVER MINE – 1972 -*** Four series booster fans – spontaneous combustion of timber caused a fire which was spread to the workings by the series ventilation system – 91 fatalities.

Appendix C - Typical fan documentation

The following information provides a useful checklist for fan installations and should be provide before the fan is commissioned.

a) General arrangement drawing including:
    i) The overall dimensions mounting of the fan:
    ii) Indication for the position of the:
        A. locations of all controls
        B. location of all indicators.
        C. Fan specifications to include:
            1) motor power rating
            2) motor speed
            3) fan flow and performance
            4) fan rotation (direction)
            5) unit mass
            6) maximum recommended bearing temperature
            7) maximum vibration limits.
        D. Cross section through fan showing:
            1) blade clearances
            2) rubbing material
            3) fan retaining method.
    iii) Type of grease for bearings
    iv) The results of noise testing
    v) Position of all inlet, outlet and control ducts
    vi) Details of fault and shutdown devices fitted
    vii) A reference to electrical schematic
    viii) All fans shall be fitted with correct rated lifting points
    ix) The manufacture to supply calculations for specifications purposes.
b) Electrical schematic should include:
    i) the general operating systems for the fan
    ii) all power and control schematics
    iii) fault calculations and protection settings.
c) Certificates of conformity for explosion protected electrical equipment. For all electrical equipment a statement of compliance.
d) A letter of compliance including:
    i) the manufacturer's letter head
    ii) a statement indicating compliance with MDG 3 and the guidance note requiring registration if applicable
    iii) the fan model number, serial number, date of manufacture
    iv) an authorised person's signature indicating compliance.
e) Additional information may include:
    i) a marked up copy of this guideline showing compliance and non compliance
    ii) the noise test report
    iii) all relevant letters and drawing for associated items including electric components
    iv) letters or test reports for attachments
    v) other test reports as may be required by certification arrangements
    vi) an electrical system letter of compliance
    vii) risk assessment report which effectively identifies, assesses and controls hazards relating to the safety of people associated with the operation, maintenance and testing of the equipment.
f) Certification and registration requirements
g) Certification drawings
h) Letter of compliance
i) Requirements for parts, service, maintenance and inspection
j) Operators' manuals
k) Nameplate showing:-
    i) design registration number if applicable
    ii) serial and model number
    iii) date of manufacture
    iv) supplier's name/make
    v) gross weight of the fan/motor assembly.

Appendix D - Feedback sheet

Your comment on this guideline will be very helpful in reviewing and improving the document.

Please copy and complete the feedback sheet and return it to:

NSW Department of Industry, Division of Resources & Energy, Mine Safety
PO Box 344
Hunter Region Mail Centre NSW 2310

Do you require any further information?

Any information which is irrelevant or superseded?

Any other comments?