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TECHNICAL REFERENCE GUIDE

MAIN FANS, BOOSTER FANS AND AUXILIARY FANS IN UNDERGROUND COAL MINES

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November 2021	1	Supersedes MDG 3 *Main, booster and auxiliary fans in underground coal mines* (October 2015). This TRG was developed following a review of MDG 3 undertaken in 2020 by the NSW Resources Regulator.

Contents

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1. Introduction

This Technical reference guide (TRG) replaces MDG 3 *Main, booster and auxiliary fans in underground coal mines.*

Ventilation plant such as main fans, booster fans and auxiliary fans are crucial to providing a safe environment in an underground coal mine. At various times during the life of a ventilation fan, it may be exposed to elevated levels of methane and potentially explosive atmospheres. Failure of any ventilation fan, and the subsequent loss of ventilation to the underground parts of a mine, creates a serious risk to workers in the underground environment.

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

- preventing the ventilation fan becoming an ignition source for a potentially explosive atmosphere
- unintended fan stoppage, or reduced fan performance, that enables a potentially hazardous atmosphere to develop
- starting and stopping the ventilation fan
- isolation of the fan impellor and fan drive system for maintenance activities
- guarding of hazardous parts of the fan during operation
- ability of the fan to operate following an over-pressure event in the mine.

1.1. Purpose

The purpose of this guide is to provide information that assists with minimising risks to health and safety relating to the use of ventilation fans at underground coal mines and to provide guidance relating to design requirements.

1.2. Scope

This guide relates to main ventilation fans, booster fans and auxiliary fans.

1.3. Application

This guide is applicable for all ventilation fans in underground coal mines and to all phases of a fan's life-cycle. It should be used when:

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

This guide does not negate the designer's work health and safety responsibilities under section 22 of the WHS Act, nor does it cover mandatory obligations on the mine operator under the WHS (MPS) Regulation in relation to ventilation control. Mine operators should also review relevant Codes of Practice or guidance material relating to ventilation in underground coal mines.

2. Risk management for ventilation fans

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 150°C
- flames
- mechanically generated sparks
- static electricity
- faulty or inadequately protected electrical equipment.

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
- heat from friction between rotational and stationary parts
- sparks from contact between moving and stationary parts
- out-of-balance of the fan impellor from accumulations of dirt and moisture ingress into fan blades
- foreign objects impacting the impellor
- catastrophic failure of the fan impellor
- failure or flexing of fan housing and/or supporting base frame
- floor heave causing misalignment of foundations of the ventilation fan
- roof fall within the mine
- mechanical looseness of the impellor to shaft securing mechanism
- ineffective earthing of the ventilation fan and ducting
- incendive sparking of light metal alloys
- heating of air current within the fan
- slippage of drive belts or failure of drive pulleys
- motor failure
- sparking from, or overheating of, electrical components
- stray currents.

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 a reduction in performance, there will be a change to the ventilation air flow within the mine. This has the potential to create an atmosphere that is hazardous to people.

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

- high explosive gas levels (such as methane)
- increase in irrespirable or toxic gas levels (such as carbon monoxide, carbon dioxide, oxides of nitrogen, hydrogen sulphide) due to decreased flow rate of air
- reduction in oxygen levels, corresponding with increases in other gases
- 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 (CO_2) or flammable gases (CH_4) 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
- recirculation from booster fans and auxiliary fans (gases and dusts).

Due to the criticality of the ventilation system to the safety of the mine, it is essential that reliability is assessed and monitored over the working life of the equipment. Factors that may affect fan reliability include:

- ventilation fans being designed for 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 bypass doors not automatically opening / closing, if fitted
- operating fans outside of their design performance characteristics

- inappropriate maintenance specifications and maintenance activities
- effects of lightning strikes
- security of the power supply to the mine (e.g. in bushfire prone areas, poor high-voltage maintenance)
- build-up of contamination on the fan blades that leads to out-of-balance issues.

Note: Risks associated directly with an operating fan are substantially less in an intake airway than with a return airway due to lower levels of contaminant such as dusts, moisture and flammable gas.

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 are provided in the Mechanical Engineering Control Plan Code of Practice (MECP CoP) and the Electrical Engineering Control Plan Code of Practice (EECP CoP). Further guidance on general plant is provided in the AS/NZS 4024.1 series and 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:

- 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
- rotational movement of the fan impellor, shaft and drive motor after fan stoppage, during maintenance work, caused by windmilling induced by air movement
- confined space work activities during maintenance of impellor and/or housing
- working at heights on curved surfaces
- ineffective guarding

- falls from height.

2.4. Hazards from a mine over-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 design features that minimise the potential damage to the ventilation fan from an over-pressure event (refer clause 59(2)(e) of WHS (MPS) 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 doors or explosion panels on the surface fan. The explosion doors / panels should be designed to suit the purpose of venting an over-pressure event and not simply located for easy installation. The explosion doors / panels should be verified by calculation.
- explosion panels should be at least the same cross-sectional area as the shaft and in a direct line of the shaft
- the fans should be located away from the shaft (outside of the modelled blast zone).

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 near the ventilation fan during operation, maintenance and repair
- identify controls to eliminate, if reasonably practicable to do so, otherwise to minimise risks so far as is reasonably practicable and determine the required reliability for any implemented controls

- consider the recommendations of this TRG 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
- consider the risk of lightning entering the mine
- consider the position and location of fans and their exposure to external hazards such as bush fire, vehicle impact or failure of adjacent infrastructure
- consider the reliability of electrical supply networks and provision of alternative supplies where necessary.

2.6. Plant safety file

Risk controls associated with ventilation fans should be fully documented. These records should be maintained in a plant safety file that covers the life-cycle 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
- general maintenance requirements and strategies
- safety function proof test intervals and procedures

- maintenance records, safety inspections and test reports
- change management procedures and documentation of all changes
- change of procedures, monitoring, audit and review reports
- reports of accidents and safety statistics
- plant alterations
- documents required by legislation to be maintained, such as those required to be maintained in accordance with Chapter 5 of the WHS Regulation.

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 should 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

3.1. Design – general

Main fans, booster fans, auxiliary fans and their associated equipment are engineered systems. An engineering study should be completed by the system designer that demonstrates how risks associated with the operation of the particular fan are controlled. As a minimum, the fan design should incorporate controls detailed in this guide or demonstrate that they achieve at least an equivalent level of safety.

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 or thermal effects which are capable of igniting methane under any condition during operation. The design should be such that a position change of the impeller and its support shaft, will not allow rotating parts (such as steel parts) of the unit to rub or strike stationary components.

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^{o}C in any circumstances (refer to Appendix B for incident information).

The fan design should allow for the operation of the ventilation fan with significant "out-of-balance" for extended periods of time. Design calculations should be performed assuming the fan will be subject to infrequent cleaning.

Ventilation fan designs must facilitate inspection, measurement and cleaning of the fan impellor, housing, bearings and couplings.

Note: For more detailed information on the design of ventilation fans working in potentially explosive atmospheres, consideration should be given to parts of BS EN 14986.

3.2. Design hazard identification, assessment and control

3.2.1. Preliminary hazard analysis

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

This analysis must be carried out in consultation with the mine operator for the mine at which the ventilation fan is designed. Consideration must be given to:

- the purpose of the ventilation fan, including intended design life and potential life-cycle risks
- assessment of those hazards listed above (refer clauses 2.1–2.4).
- the impact of the fan in the mine environment
- for main fans, the impact of the fan and the exhaust emissions on the surrounding environment and other existing infrastructure. A plume study should be undertaken to

assess mine exhaust gases from the main fan and the risk of ignition within the affected area.

- the impact 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 potential ignition sources that could occur throughout the life-cycle of the fan. 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 when being used to de-gas parts of the mine
- consider possible failure modes and effects of those failures on the ventilation fan.

The design ignition hazard assessment must consider those ignition hazards identified in clause 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 gases so they do not enter the fan or discharge from it at excessive concentrations
- recirculation
- 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 on 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. Safety-related componentry

Components provided for the purposes of safety such as non-sparking copper rings 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 life-cycle inspection, maintenance, test and discard requirements, as required for life-cycle functionality.

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

3.2.4.2. 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. 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/NZS 62061, or
- other relevant functional safety 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 functional safety assessment should include:

- validation through evidence documentation
- a review of possible life-cycle 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.

Persons involved in any functional safety lifecycle activity, including any activity for verification, management of functional safety or functional safety assessment, must have the appropriate competence (i.e. training, technical knowledge, experience and qualifications) relevant to the specific duties that they have to perform.

Note 1: AS 61508.1:2011 clause 6.2.13 requires the development of procedures to ensure that life cycle activities related to functional safety are undertaken by a competent person(s).

Note 2: Guidance is provided in AS 61508.1:2011 clause 6.2.14 for factors to be considered when determining appropriateness of competence.

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 on any rotating component or in any other component on the ventilation fan that may be subject to impacts on any ventilation fan that operates underground in coal mines[1].

Note: Light metal alloys are defined in the WHS (MPS) Regulation clause 3 Definitions.

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.
- For surface infrastructure, the environmental conditions such as dust and thermal load should be considered.

3.3.3. Foundations

The following applies to the foundations:

[1] Clause 69 WHS (MPS) Regulation (light metal alloys)

- 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 the use of flange-mounted motors.
- Foundation design of main fans and booster fans must take into consideration the possibility of ground movement within the design of the base and frame of any foundations, where applicable.

Note: Ground movement may be caused by factors such as floor heave, subsidence, shrinking and swelling of expansive soils due to moisture migration, etc.

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 manufactured from light metal alloys or aluminium.
- Impellers designed to be manufactured from non-metallic materials must be fire-resistant and anti-static in accordance with MDG 3608 *Non-metallic materials for use in underground coal mines* (as amended from time to time*)*.
- 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 parts of the unit to rub or strike which can generate sparks or generate sufficient frictional heat 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.
- Impellers with hollow blades should not be used as they have been known to fill with water and cause increased out-of-balances and high vibration rates.

- Impeller should not be installed directly to the motor shaft (see Safety Alert SA07-02 *Catastrophic failure of auxiliary fan*).

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 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 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.
- Bearing temperature monitoring should be set to trip no greater than by 20°C above the normal operating temperature.

Note: Operating temperatures of bearings will be affected by ambient temperatures, especially on the surface of a mine. When setting trip and alarm points, the effect of summer time maximum ambient temperatures should be considered

3.3.6. Brakes

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. This brake system should permit the partial release of the brake to enable rotation of the impeller, when required by the task.

The brake, or other system, should:

- prevent the fan from operating if not fully released
- 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 motor should be ventilated and cooled by intake air.

The grade of winding insulation must be suitable for the intended duty and should be indicated on the motor.

Note: When operated with a variable speed drive, winding insulation should be suitable for transient voltages associated with electronic switching of the power circuits.

3.3.9. Access door

Booster fan installations 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 bypass doors remain closed while the fan is operational.

3.3.10. Guarding of moving and rotating parts

Guarding must be provided, so far as is reasonably practicable, at the fan inlet to prevent objects being able to contact a spinning impeller, such as a worker, stone, ventilation tube seals, safety hats, gloves, coal or other material. The width of the openings in the guarding must be appropriate for the fan design and should not exceed 50mm 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 series.

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 be explosion protected to comply with the relevant parts of clause 78 of the WHS (MPS) Regulation.

The design of the electrical aspects of the fan should take into consideration the requirements and recommendations detailed in AS/NZS 4871.1 and AS/NZS 4871.2. Where variable speed drives (VSDs) are used to control the speed of the fan, the design risk assessment should also take into consideration the potential hazards and possible guidance requirements listed in Safety Bulletin SB11-04 *Electrical hazards associated with variable speed drives and earth fault current limited systems* (see also Appendix B).

Where a fan design incorporates a dedicated sub-station/transformer, reference should be made to AS/NZS 4871.3.

Where controls identified in these standards are not incorporated into the fan design, documentation must be maintained in the plant safety file that details why the controls have been deemed unnecessary and how the risks that would be controlled by the implementation of the recommended controls are now being controlled. Alternative controls should be at least equivalent to the recommended controls.

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Provision must be made to eliminate the risk of dangerous voltages being generated inside the motor control centre and the motor terminal enclosure due to 'windmilling' of the impeller when the fan is not energised (refer Appendix B for incidents).

3.5. Noise

The design must take into consideration appropriate noise control measures where exposure to noise at the operator's 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 functions which trigger a visible alarm if there is a departure from the fan's normal operating parameters. Power must be removed from the fan motor once unacceptable operational limits are reached. Alarms should annunciate prior to the power tripping. The trip point should be close to the normal high operating point and well below dangerous levels.

As a minimum, this applies to increases to:

- temperatures of any fan bearings (e.g. bearing pedestals, motor and gearbox bearings)
- temperature of windings in the electric motor
- vibration of critical rotating elements of the fan assembly and drive motor.

Note: Monitoring of additional operating parameters may be required by legislation.

These safety functions must operate continuously while the fan is operational.

Access tapping points for attachment of calibration check instruments which are not permanently installed e.g. vibration test location point, should be provided.

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

Bearing temperature monitoring should be carried out by means that minimise response time. External contact-type temperature-sensing devices mounted on the bearing cap may not have adequate response time to detect the rapid rise in temperature that can occur when cage and rolling elements break up.

Note: Response time is minimised by positioning the temperature probe as close as possible to the bearing. This may be done by using the greaseway access point with an adaptor that allows the bearing to be greased.

3.6.2. Power shut-off

All fans must be equipped with a device that enables power to be automatically removed in affected workings when the fan stops. Provision must be made to isolate power to all sections of the underground mine when the ventilation current is affected by a fan stoppage (refer WHS (MPS) Regulation). For example:

- for main fans – power is removed to the whole mine
- for booster fans – the power is removed to the district(s) being directly ventilated by the booster fan
- for auxiliary fans – the power is removed to the district/production panel being ventilated by the auxiliary fan.

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). For main fans and booster fans, this should include the control station on the surface.

Determination of locations for starting and stopping should consider requirements of the mine's operating procedures and inspection requirements before fans are started.

Auxiliary fans should only be started at the fan location.

3.6.4. Emergency stops

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

Consideration should be given to the installation of a remote emergency stop for auxiliary fans at the end of the ventilation ducting.

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.

Emergency stops should comply with AS/NZS 4240.1604:2014.

3.6.5. Run time

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

Note: Most mechanical fan servicing is managed through a computerised maintenance management system (work orders) and is based on run-time hours.

3.6.6. Fan monitoring

Facilities for the monitoring, display and recording of the status of the fan and its performance must be included in the design of the fan.

In addition to the local monitoring and control facilities provided, main fan and booster fan installations should be provided with remote monitoring facilities located at the surface of the mine.

The monitoring systems must trigger a visible alarm if there is a significant departure from the fan's normal operating parameters.

The system must record the date and time that any alarm is triggered, or the power supply shut off.

Monitoring results should be displayed at all control stations where the fan can be stopped and where the fan can be restarted.

The real time operating data values and any alarms must display in a place that is easily accessible by a person whose tasks include checking the condition of the fan. Trend monitoring must be available for all temperature and vibration measurements, so far as is reasonably practicable.

The log of fan alarms and trips should include events such as excessive temperature, excessive vibration, motor overload, emergency stop operation and any other events that may cause the fan to stop or prevent the fan from starting when commanded.

3.6.7. Video monitoring

For main fans and booster fans real-time video monitoring of the installation should be considered to allow for remote monitoring of the installation. This should include monitoring of the booster fan bypass doors.

3.7. Fan ventilation control

3.7.1. Fan control devices

A system to regulate the fan capacity must be provided. Typically, these systems include one of the following fan control devices:

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

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

- be monitored from the surface control room
- be remotely operated
- include remote monitoring of position of the fan control device
- be used for start-up
- have adjustment provision which is manually or automatically achieved

Control measures (e.g. bypass doors) should be provided to automatically prevent excessive levels of flammable or noxious gases entering the fan housing.

3.7.2. Inlet vane

For inlet vane guide control systems (where automatic control is not required such as on panel auxiliary fans) the open circuit volume for each position of variation of the vane control should be identified on the fan.

Manually operated inlet vane control devices should be capable of being locked in position.

3.7.3. Recording of ventilation alarms and trips

The design must provide for the electronic recording of all alarm and trip events associated with the ventilation fan, so far as is reasonably practicable. This may be incorporated in the fan monitoring as described in 3.6.6 above.

This includes methane trips, CO alarms, loss or a significant reduction of mine ventilation pressure, or a significant change in air flow.

3.7.4. Ventilation monitoring

For main fans and booster fans, the following elements must be included in the monitoring and recording functions:

- fan operating pressure (static pressure)
- the quantity of air passing through the fan
- the concentration of methane passing through the fan
- gas content of air passing through the fan, where there is a risk caused by elevated levels of gases.

Additional monitoring may also be provided, such as fan dynamic pressure (velocity pressure).

Fans may be fitted with additional sampling points for attachment of calibration check instruments which are not permanently installed.

3.7.5. Gas monitoring

Gas detectors provided for the detection and monitoring of gases must be located at points most likely to detect the presence of the monitored gasses.

The quantity and location of gas monitoring points is to be determined by risk assessment.

The risk assessment must take into consideration the following when determining the types of sensors and the locations in which to place the sensor:

- the effect of high air velocity on the detector accuracy (immediate effects)

Note: Diffusion type gas detectors that have been design registered are only assessed for air velocities up to (6 ± 0.6) ms^{-1}. Air velocities above this may impact accuracy of the detector.

- continual exposure to elevated levels of gas (may cause the sensor to drift)
- exposure to elevated levels of dusts (increases to t(50) and t(90) response time)
- the response times of detectors and data transmission, and the time for the fan control system to respond with an appropriate control measure
- maximum permissible levels of toxic and flammable gasses that can be safely passed through the fan.

For booster fans, monitoring of the air quality passing over the fan motor and the control equipment must be implemented for flammable gasses.

CO monitors should also be installed on booster fans.

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 1319 or applicable ISO standards. They should be:

- of durable corrosion resistant construction
- permanently attached
- positioned so they are clearly visible while the fan is operational.

3.8.2. Labels

Items that should be labelled include, but are 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
- confined spaces
- who is authorised to start the fan
- fan impeller direction of rotation.

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 (if applicable)
- model and serial 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
- 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.

All information that is required to be provided under Chapter 5 of the WHS Regulation must also be provided in the safety file.

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

4. Minimum design requirements for specific types of ventilation fans

4.1. Main fans

In addition to Section 3 above, the following is applicable to main fans:

4.1.1. Location

Main ventilation fans must be located on the surface of the mine. Due to the position of main fans on the surface, environmental considerations should be made in regard to noise abatement of the main fans.

When determining the location of the fans relative to the shaft, consideration should be given to potential damage from an over-pressure event. Fan emissions, such as gas (both toxic and flammable), dust, moisture, odours etc should be considered in relation to the location of other infrastructure in the vicinity of the fan. A plume study should be completed to properly assess the potential impact of these emissions.

4.1.2. Power supplies

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.

Consideration should be given to the provision of back-up power supplies such as generators or diesel engine systems to maintain minimum levels of ventilation during a power outage to site.

Main fans should be directly driven. Belt drives and chain drives should be avoided.

4.1.3. Maintenance

Facilities must be provided to allow for safe access to allow for regular cleaning of the impeller and housing. This should include a means to hold the impeller stationary, provision of appropriate lockable access doors and a suitable platform providing flat, level footing.

Where more than one fan is installed, facilities should be provided for effective isolation of each fan from the others 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 should be provided between the impeller and the duct work where the impellor may be accessed from.

4.1.4. Monitoring

Main fans should have an alarm at the surface, which activates when a main ventilation fan stops.

Main fans must be provided with continuous temperature and vibration monitoring of the fan motor and impeller shaft bearings.

Main fans must be provided with continuous real time monitoring of quantity (volume, pressure etc) and quality (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).

4.1.5. Explosion doors

Explosion doors or other facilities for relieving an over-pressure event without destroying the main fans should be fitted. These should be fitted between the surface end of the fan cowling and the fan through means of one or a combination of both of the following:

- explosion doors/panels, or
- design of the ventilation bend so that the bend will fail before any excessive pressure wave travels to the fan.

Explosion doors / panels should be at least the same cross-sectional area as the shaft and in a direct line with the shaft. Signage for explosion doors /panels, warning sign and restricted access should be determined by risk assessment.

4.1.6. Emergency sealing

Emergency sealing should be considered as an integral part of the fan design and installation.

The activation of emergency sealing should be able to be done remotely.

4.2. Booster fans

In addition to Section 3 above, the following is applicable to booster fans.

4.2.1. 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.

Booster fans should be located in intake roadways rather than in return roadways, where practicable.

4.2.2. 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
- 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
- modelling of various combinations of the failure of any individual fan, including any main fan or any booster 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 and consideration of the risk of fire and the propagation of the fire in the area of the booster fans
- the booster fan incidents and disasters listed in Appendix B.

4.2.3. Minimise air restrictions

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

Note: The fan impellor of a stopped fan restricts airflow.

4.2.4. Limit recirculation

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

4.2.5. Access

Booster fans must be provided with an air lock to allow passage through the fan bulkhead as necessary.

Booster fans installed in return airways should have access between the intake and return reasonably close to the fan location.

4.2.6. Bypass doors

Booster fan installations must be provided with bypass doors which open automatically when all fans in the installation stop.

The design of door hinges should be provided with lubrication systems 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.

Opening or closing of the bypass doors should not put shock loading on the ventilation system. As the doors operate automatically, they should have a system that prevents violent opening or closing of the doors.

Appropriate signage must be installed advising that the doors could open at any time due to the booster fan failure.

4.2.7. Bypass door monitoring

Remote monitoring of bypass doors must 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.

4.2.8. Dilution of potentially explosive atmosphere

Booster fans which operate in return airways should be provided with a means to dilute noxious or flammable gases before they enter the fan housing.

4.2.9. Housings

Booster fan housings should not form part of ventilation stoppings.

4.2.10. Non-explosion protected electrical

For non-explosion protected motor and controls in underground coal mines, the power to the booster fan must be automatically cut when the percentage of flammable gases in the intake passage passing through the fan control or drive room exceeds 0.25% methane by volume.

4.2.11. Monitoring

Booster fans should have an alarm at the surface, which activates when a booster fan stops.

Booster fans must be provided with continuous temperature and vibration monitoring of the fan motor and impeller shaft bearings.

Booster fans must be provided with continuous real time monitoring of quantity (volume, pressure etc) and quality (gas content) with the results displayed at both the fan and at the surface control room / monitoring station.

4.2.12. Plenum chamber

A plenum chamber may be used to house the fan drive and controls. Where used, a plenum chamber must be rated to withstand the maximum explosion pressure from an underground mine gas explosion. Requirements of 4.2.10 above are applicable to the plenum chamber.

4.2.13. Design for maintenance

The booster fan system must be designed so that routine inspection and maintenance can 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 or close inspection of components that move.

4.2.14. Brake control

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

4.3. Auxiliary fans

In addition to Section 3 above, the following is applicable 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 rotating steel parts of the unit to rub or strike stationary parts.

The fan housing should include a spacer ring made from spark 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

Exhausting 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 before it passes through the fan.

4.3.7. Debris drop box

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

4.3.8. Gas monitoring

Gas monitoring requirements for auxiliary fans should be determined by risk assessment with consideration being given to gas detectors to identify recirculation.

Consideration should be given to flammable gas produced at the working face and travelling through the ventilation ducting as well as the risk of outburst conditions compromising the auxiliary fan location.

4.3.9. Safe use of auxiliary fans

Mine operators should conduct an auxiliary fan operational risk assessment (for each type of auxiliary fan in use at each site) and ensure the risks to health and safety for people working near ventilation ducts during installation, operation, maintenance and repair are identified and controlled. The specific hazard of workers being drawn into or sucked against the ventilation ducting, should be considered.

Safe standing zones and the detailed process steps to safely install ventilation ducting should be formalised and documented in the mine’s safety management system.

Note: Historical incident information is included in Appendix B.

4.3.10. Auxiliary fan location set up

When an auxiliary fan is positioned for operation it should be installed level and stable as per its designed criteria. The design of the fan should include provision to enable the fan to be levelled when positioned in its operating location.

4.4. Compressed air powered air movers

Where compressed air-powered air movers are installed along with auxiliary fan installations, they should be considered as part of the auxiliary fan installation and assessed accordingly.

Compressed air-powered air movers, if made from non-metallic materials, must be fire resistant anti-static (FRAS).

Note: Testing and certification requirements for determining whether an item of plant is FRAS have been identified by the Regulator in MDG 3608 *Non-metallic materials for use in underground coal mines* (as amended from time to time).

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

A venturi ventilator type of air mover consists of a tube with a venturi 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.

A venturi air mover must be effectively earthed to prevent build-up of static electricity.

Applications may include the following:

- 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
- 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 documentation and specific site requirements. This section applies to the installation and assembly of ventilation fans, whether new or after major overhauls of older fans, and may be undertaken at workshops, on the surface of coal mines or underground in coal mines.

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

People conducting installation and commissioning of plant should be trained and competent for the task.

5.2. Commissioning and testing

All fan control functions should be tested during commissioning of the fan to validate that each function performs as per the design specification.

Testing of safety-related functions should be carried out in accordance with the relevant functional safety analysis and functional safety standards.

Testing and verification activities for the validation of safety-related functions must be undertaken by, or under the supervision, of a competent person(s).

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

For main fan and booster fan installations, the commissioning tests should include verification that the mine’s monitoring systems correctly indicate fan operating status and record alarm and trip occurrences.

Commissioning and testing should include:

- inspection of the fan housing for undue deformation or other defects
- the measurement and recording of vibration in motor/fan bearings at regular intervals
- testing the operation of all control functions
- verification of alarm and trip set points. This should include confirmation back to all control stations

- correct operation of any power trip functions
- testing the operation of brakes, interlocks and controls
- performance testing (main and booster fans: Quantity of air flow, pressure, bearing temperatures and vibration readings)
- verification that noise attenuation and control measures achieve required noise levels
- performance of bypass 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
- confirmation of any conditions placed as part of the design registration for booster fans.

6. Requirements for use of ventilation fans

6.1. Operational

6.1.1. General

The mine operator and other users of fans should ensure that:

- a fan is not operated unless the user is competent or is supervised by a competent person and has received adequate information and training
- fans are 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 and maintained, as intended by the designer of the fan
- the risk of entanglement is controlled by safeguarding systems
- people do not work between fixed and moving parts of the fan, where there is a risk to health or safety

- people do not work in the immediate area of remotely or automatically energised parts of fan 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
- a fan is subject to appropriate checks, tests and inspections necessary for safety
- a fan is withdrawn from operation when there is an immediate risk to safety.

6.1.2. Risk assessment

Operators should carry out a risk assessment 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.

Operators must provide all people involved in the installation, commissioning, use and testing of a fan with all available information concerning health and safety risks of the plant.

6.2. Maintenance

6.2.1. General

The mine operator and other users of a fan 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 are carried out with reference to information provided by designers, manufacturers or otherwise developed by a competent person
- all safety features and warning devices on a fan are tested and maintained, including confirmation back to all control stations
- a competent person(s) assesses any damage to a fan, where the risk to safety may be increased
- repair, inspection and testing are carried out by a competent person
- repairs to a fan keep the fan within its design limits

- structural integrity of surface fans and booster fans should be carried out as per the manufacturer's recommendation or by determination from a risk assessment.

If access to the fan impellor is required, it is essential that the fan be stopped, and effective isolation implemented in accordance with energy isolation systems for the mine. An isolation and energy dissipation procedure should be used in conjunction with any specific 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 included to verify correct functioning of the continuous monitoring systems
- facilities to enable portable vibration and temperature monitoring devices to be safely fitted and removed without stopping the fan should be incorporated into the fan
- any person who inspects a main, booster or auxiliary fan installation should be competent to do so and should keep a record of all inspections made and of what was inspected
- trending of vibration and temperature data in relation to the effect of cleaning, lubrication and other adjustments should be included
- when predetermined out-of-balance levels are reached, investigations should be undertaken to determine the cause of fans becoming unbalanced so that the necessary corrective actions to bring the fan back into balance can be undertaken
- proof testing of all safety-related control functions must be undertaken in accordance with the designers requirements, including test intervals and test methodologies
- 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 bypass door hinges should be included
- 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 fan placement, operation and emergency procedures.

The mine operator should prepare procedures to be used in the event of the stoppage of a fan and should be readily available at the surface of the coal mine and at suitable locations in the vicinity of fans underground. These procedures should include starting, stopping and degassing of the mine or district/production area.

6.2.4. Restarting after a power failure

The mine operating procedures should address restarting after a power failure. The following should be considered before restarting:

- if there is a need to evacuate personnel in the area being ventilated
- before restarting the fan, a competent person should assess the gas levels and determine if the fan can be safely started
- minimise flammable or noxious gases from entering the fan and entering trafficable roadways (e.g. by use of the bypass 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 designing the alterations is competent to be a designer for that type of fan.

A risk assessment should identify the risks that are introduced as a result of the alteration. The risks may be new risks related directly to the alteration or a reduction in the safety of the existing risk controls. Suitable controls that manage the new risks or the reduction of effectiveness of an existing risk control must be implemented.

Alterations should not result in a reduction to safety of the fan.

NSW Resources Regulator

Appendix A References

Definitions

In this guide, the following definitions apply:

NAME	DEFINITION
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.
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.
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 may be located in return or intake airways.
competent person	A person who has acquired through training, qualification or experience the knowledge and skills to carry out a task.
effective ignition source	A potential ignition source that can ignite the explosive atmosphere if preventive or protective measures are not used.
emergency stop device	A manually actuated control device used to initiate an emergency stop function.
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.
guard	Part of a machine specifically used to provide protection by means of a physical barrier.

life-cycle	Design, manufacture, construction or installation, commissioning, operation, maintenance, repair, decommissioning and disposal.
light metal alloy	an alloy containing aluminium, magnesium or titanium (or a combination of those metals), but only if: (a) those metals make up more than 15% of the weight of the alloy, or (b) magnesium and titanium make up more than 6% of the weight of the alloy.
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.
must	It is mandatory. Indicates that legal requirements exist and must be complied with.
out-of-balance	Is the state where centrifugal forces produce vibration upon a rotating assembly and prevent a state of equilibrium from existing.
plenum chamber	A pressurised housing containing a gas or fluid (typically air) at positive pressure (pressure higher than surroundings). One function of the plenum chamber can be to equalise pressure for a more even distribution, because of irregular supply or demand.
reasonably foreseeable misuse	The use of a machine in a way not intended by the designer, that has resulted from readily predictable human behaviour.
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.
repair	Restore to the original design specification.
should	A recommended course of action.

	Note: Deviations from recommendations should be provided with a respective management control, shown to provide the same level of safety outcome.
ventilation fan	Includes main fans, booster fans and auxiliary fans in underground coal mines.
windmilling effect	An aerodynamic effect that causes an idle fan impellor to rotate when air flows across its blades.

Abbreviations

NAME	DEFINITION
AS	Australian Standard
AS/NZS	Australian/New Zealand Standard
BS EN	British Standard European Standard
EECP CoP	NSW Code of Practice: Electrical engineering control plan
FRAS	Fire resistant and anti-static
ISO	International Standards Organisation
MDG	Mining design guideline
MECP CoP	NSW Code of Practice: Mechanical engineering control plan
PCBU	Person conducting a business or undertaking
TRG	Technical reference guide
WHS Act	*Work Health and Safety Act 2011*
WHS Regulation	Work Health and Safety Regulation 2017
WHS (MPS) Act	*Work Health and Safety (Mines and Petroleum Sites) Act 2013*
WHS (MPS) Regulation	Work Health and Safety (Mines and Petroleum Sites) Regulation 2014

Standards

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

STANDARD	TITLE
AS 1269.1:2005	Occupational noise management - Measurement and assessment of noise emission and exposure.
AS 1319:1994	Safety signs for the occupational environment.
AS 4024.1	Series: Safety of Machinery.
AS 4024.1501:2006 (R2014)	Safety of machinery - Design of safety related parts of control systems - General principles for design.
AS 4024.1502:2006 (R2014)	Safety of machinery - Design of safety related parts of control systems – Validation.
AS/NZS 4024.1503:2014	Safety of machinery – Safety-related parts of control systems – General principles for design.
AS/NZS 4024.1604:2014	Safety of machinery – Design of controls, interlocks and guarding—Emergency stop—Principles for design.
AS/NZS 4024.3611:2015	Safety of machinery Conveyors - Belt conveyors for bulk materials handling.
AS/NZS 4871.1:2012	Electrical equipment for mines and Quarries – Part 1: General requirements.
AS/NZS 4871.2:2010	Electrical equipment for mines and Quarries – Part 2: Distribution, control and auxiliary equipment.
AS/NZS ISO 31000:2018	Risk management - Principles and guidelines.
AS 61508.1:2011	Functional safety of electrical/electronic/programmable electronic safety-related systems - General requirements.

AS/NZS 62061:2019	Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems.
BS EN 14986:2017	Design of fans working in potentially explosive atmospheres.
ISO 281:2007	Rolling bearings - Dynamic load ratings and rating life.
ISO 13849.1:2015	Safety of machinery -- Safety-related parts of control systems - Part 1: General principles for design.
MDG 3608	Guideline for Non-metallic materials for use in underground coal mines.
SA/SNZ HB 89:2013	Risk management - Guidelines on risk assessment techniques.

Appendix B Incident information

Safety alerts, bulletins and investigation reports

The following information should be referenced, and the recommendations taken into consideration, when identifying hazards and assessing risks associated with ventilation fans.

DOCUMENT	TITLE
SA05-02	Safety alert: Unsafe flameproof enclosure auxiliary fan
SA07-02	Safety alert: Catastrophic failure of auxiliary fan
SB11-04	Safety bulletin: Electrical hazards associated with variable speed drives and earth fault current system
SA20-05	Safety alert: Worker sucked into auxiliary fan ventilation tube
Royal Commission Report	The Royal Commission on the Pike River Coal Mine Tragedy reported to the Governor-General on 30 October 2012.
IIR19-02	Causal investigation – Workers evacuated after gas levels rise

Incidents involving booster fans

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.	Reduction of ventilation. ELECTRICAL - Fan stoppage from failure of electrical controls.

	During the breakdown, underground environmental conditions were not seriously impaired and methane levels remained within statutory limits.	
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 pickaxe. 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 people underground at the time and 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.	Reduced ventilation. POWER OUTAGE – External to mine.

	All men were brought to the surface within 3 hours 20 minutes and no-one suffered any ill effect. A single 66kV incoming feed to the mine was restored after 4 hours 27 minutes and the last booster ventilating fan was restarted after a whole stopping period of 6 hours 37 minutes. No adverse underground environmental conditions were encountered.	
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 220m^3/s to 170 m^3/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.
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 people 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.

Disasters involving booster fans

Known disasters involving booster fans:

- **UNITED KINGDOM, Derbyshire – Oxcroft Colliery – 1919 -** Two booster fans in series, bypass doors closed with fan stopped, exploded on restart by an electrician – six fatalities. https://www.nmrs.org.uk/mines-map/accidents-disasters/derbyshire/oxcroft-colliery-explosion-creswell-1919/
- **SCOTLAND, Lanarkshire - Auchengeich Colliery - 1959 -** Belt driven booster fan caught fire, spreading to timber lagged roadway – 47 fatalities. http://www.scottishmining.co.uk/250.html
- **USA, Idao – Sunshine 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. http://cholla.mmto.org/mines/sunshine_report.pdf

Appendix C Example checklist for fan installations

The following information may be of assistance as a checklist for fan installations and should be provided before the fan is commissioned.

- general arrangement drawings including:
  - the overall dimensions mounting of the fan
  - indication for the position of the:
    - locations of all controls
    - location of all indicators
    - fan specifications to include:
      - motor power rating
      - motor speed
      - fan flow and performance
      - fan rotation (direction)
      - unit mass
      - maximum recommended bearing temperature
      - maximum vibration limits
    - cross section through fan showing:
      - blade clearances
      - rubbing material
      - fan retaining method.
  - type of grease for bearings
  - the results of noise testing
  - position of all inlet, outlet and control ducts
  - details of fault and shutdown devices fitted
  - a reference to electrical schematic

  - fans are fitted with correct rated lifting points
  - the manufacture to supply calculations for specifications purposes
- electrical schematics should include:
  - the general operating systems for the fan
  - all power and control schematics
  - fault calculations and protection settings
- hydraulic and pneumatic schematics (where applicable)
- certificates of conformity for explosion protected electrical equipment. For all electrical equipment a statement of compliance
- a letter of compliance including:
  - the manufacturer's letterhead
  - a statement indicating compliance with this TRG
  - the fan model number, serial number, date of manufacture
  - an authorised person's signature indicating compliance
- additional information may include:
  - a marked up copy of this TRG showing compliance and non-compliance
  - the noise test report
  - all relevant letters and drawing for associated items including electric components
  - letters or test reports for attachments
  - other test reports as may be required by certification arrangements
  - an electrical system letter of compliance
  - 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
- certification and registration requirements

- certification drawings
- letter of compliance
- requirements for parts, service, maintenance and inspection
- operators' manuals
- nameplate showing:
  - design registration number if applicable
  - serial and model number
  - date of manufacture
  - supplier's name/make
  - gross weight of the fan/motor assembly.