NSW Resources Regulator

Mobile and transportable plant for use on mines and petroleum sites

Mining Design Guideline | MDG 15

This guide does not apply to mobile and transportable plant for use at underground coal mines

NSW GOVERNMENT

Document control

Published by Department of Regional NSW, NSW Resources Regulator

Title: MDG 15: Mobile and transportable plant for use on mines and petroleum sites

First published: June 1992

Authorised by: Chief Inspector

CM9 reference: PUB17/861

Amendment schedule		
Date	Version	Amendment
January 2018	7	Revised content, updated branding
February 2019	8	Corrected minor errors in numbering appendices
April 2020	9	Updated reference to AEISG code of practice for mobile processing units (section 5.3)

Foreword

MDG 15 was first published in 1992 and applied to mobile plant operating on surface parts of coal mines. MDG 15 was developed with the aim of improving an unacceptable rate of:

- → injury to people operating and maintaining mobile plant
- → fires on mobile plant
- → unplanned movement of mobile plant.

In 2002, MDG 15 was revised to apply to mobile and transportable plant in all mines (other than underground coal mines).

The number of notifiable incidents associated with mobile and transportable plant remains significant.

Key areas that need to be addressed in mobile and transportable plant include:

- → fire
- → unplanned movements
- → safe means of egress/access
- → vibration/ergonomics
- → isolation
- → safety critical systems
- → proximity detection
- → human factors
- → wheels, rims and tyres.

This guideline is not intended to be a mandatory compliance document. It is intended to highlight areas subject to past incidents and risks and identify possible risk controls for consideration. Risk assessment methods need to be used to assess the particular risks in the operating environment and determine the appropriate risk controls.

Acknowledgement

The valuable contribution of mine mechanical engineers, manufacturers, suppliers and departmental personnel is gratefully acknowledged.

Contents

1. Purpose and scope

1.1. Purpose

The purpose of this guideline is to assist in the protection of workers and other people against harm to their health and safety through the elimination or minimisation of lifecycle risks associated with mobile and transportable plant intended for use at mines and petroleum sites.

This guideline does not apply to mobile and transportable plant for use at underground at coal mines.

1.2. Scope and application

This guideline applies generally to mobile and transportable plant used at surface mines, surface parts of underground mines, underground metalliferous mines and petroleum sites.

Mobile plant includes:

- → self- propelled plant ordinarily under the direct control of an operator. For example, general earth moving plant such as excavators, dump trucks, service trucks, water trucks, mobile drill rigs, loaders, scrapers, graders and bulldozer.

Transportable plant includes:

- → trailer-mounted plant (not self-propelled) for example, pumps, welders, small generators
- → track-mounted equipment that is required to be towed for relocation purposes. For example, mobile crushers, drill rigs and substations.

This guideline also applies to heavy vehicles designed to be road-registrable but altered to operate exclusively on a mine site.

This guideline should be considered when mobile or transportable plant is being:

a) designed, manufactured, or supplied, (including supply of second-hand plant)
b) acquired for use at a mine
c) introduced to a mine
d) used at a mine
e) maintained
f) overhauled or modified
g) reviewed after an incident
h) disposed of or dismantled.

1.2.1. Exclusions

The guideline is not intended to provide guidance on vehicles registered for use on public roads. Appendix E provides some guidance for registered vehicles that may also operate on a mine from time to time.

1.3. Important information about using this guideline

This guideline should be read in conjunction with other materials that provide guidance on complying with requirements in the WHS laws[1] in relation to:

- → managing risks to health and safety
- → developing, implementing and reviewing a mechanical engineering control plan to manage any risks associated with mechanical aspects of plant and structures
- → designing plant
- → manufacturing plant
- → importing or supplying plant
- → operating and maintaining plant.

1.3.1. How to use chapters 3 to 5

Chapters 3 to 5 provide information to assist in the safe design, manufacture and supply of mobile and transportable plant for use at mine or petroleum sites. Information in these chapters is organised in three parts:

1. Chapter 3 deals with processes for designing and supplying safe plant, including control measures to address risks associated with human factors.
2. Chapter 4 provides guidance for design, manufacture and supply in relation to different aspects or features of the plant or how it is used such as brakes, guards, noise, steering, remote control and electrical systems. It includes advice on relevant Australian and international standards.
3. Chapter 5 provides guidance for the safe design of specific types of plant namely dump trucks, conveyors and mobile processing units for explosives.

Information in these chapters is intended primarily for those involved in the design process. Mine operators and other PCBUs at a mine or petroleum site who commission, purchase, use or maintain plant can use this information by:

- → providing this guide to designers, manufacturers or suppliers
- → providing additional information to the designer or supplier about the intended use of the plant and any hazards identified with that potential use
- → discussing with the designer or supplier the ways in which the plant to be supplied conforms to the recommendations in this chapter.

When plant is supplied and/or assessed to this guide, a documented assessment of this guide that identifies the relevant guideline requirements and recommendations should be provided and include the following information:

a) information that is relevant to the plant and its intended operating environment and/or duty

b) details of how the plant conforms to this guide

[1] The term WHS laws is used to refer collectively to safety legislation, refer 1.4

c) where the plant does not conform to the recommendations in this guide details of the recommended risk control measure. This would include identification of alternative control measures that should be used for the hazard.

This documentation should be kept or referred to in the plant safety file as discussed in the MECP code.

1.4. References

1.4.1. Applicable legislation

Principal safety legislation for mines includes:

- → *Work Health and Safety Act 2011* (WHS Act)
- → Work Health and Safety Regulation 2017 (WHS Regulation)
- → *Work Health and Safety (Mines and Petroleum Sites) Act 2013*
- → Work Health and Safety (Mines and Petroleum Sites) Regulation 2014

Examples of applicable codes of practice:

- → MECP code
- → EECP code
- → Managing the risks of plant in the workplace

The codes of practice can be found at:

www.workcover.nsw.gov.au/law-and-policy/legislation-and-codes/codes-of-practice

Details of the legislation can be found at: www.legislation.nsw.gov.au

1.4.2. Standards and guidelines

Appendix B contains a list of Australian and International Standards relevant to mobile and transportable plant. Standards are referenced in this guide by abbreviated titles. The full title can be found in Appendix B.

Appendix B also includes a list of relevant mining design guidelines

1.4.3. Abbreviations

Abbreviation	Full name
AS	Australian Standard
AS/NZS	Australian/New Zealand Standard
EECP	electrical engineering control plan
GCM	gross combination mass

GVM	gross vehicle mass
ISO	International Standards Organisation
MDG	mining design guideline
MECP	mechanical engineering control plan
OEM	original equipment manufacturer
OPG	operator protective guard
PCBU	person conducting a business or undertaking
Plant code	managing the risks of plant in the workplace code of practice
Work related fatalities by SafeWork	*Work Related Fatalities Associated with Unsafe Design of Machinery, Plant and Powered Tools, 2006-2011* published by SafeWork Australia November 2014 available at http://www.safeworkaustralia.gov.au/sites/SWA/about/Publications/Documents/886/work-related-fatalities-unsafe-design.pdf
WHS Act	*Work Health and Safety Act 2011*
WHS Regulation	Work Health and Safety Regulation 2017
WHSMP Act	*Work Health and Safety (Mines and Petroleum Sites) Act 2013*
WHSMP Regulation	Work Health and Safety (Mines and Petroleum Sites) Regulation 2014

This legislation can be accessed from the NSW Resources Regulator website or at legislation.nsw.gov.au

1.5. Definitions

Mobile plant; transportable plant – see section 1.2 above

1.5.1. Fit for purpose

Plant that is sufficient and able to reliably perform the function it was designed to do for the intended use, over the lifetime of the plant.

1.5.2. Remote control system

The whole of the system that controls the machine functions including remote control equipment, relevant electronic controls and interposing equipment, monitoring devices and actuating devices.

1.5.3. Safety critical systems

Safety-critical systems are those systems whose failure could result in loss of life, cause significant property damage or damage the environment, including for example, propulsion, braking, steering, warning systems and interlocks. Key considerations should relate to measures to control machine motion, measures used to mitigate a hazard and any componentry which may fail dangerously.

1.5.4. Safety-related componentry

Passive systems or items such as fixed components, steering arms, ROPS, FOPS, etc.

2. Hazards associated with mobile and transportable plant

This section provides information to assist in identifying hazards and risks associated with mobile and transportable plant.

All reasonably foreseeable hazards associated with mobile and transportable plant must be identified.

Information about hazards and risks associated with plant is critical for designers, manufacturers, importers and suppliers to meet their respective duties under the (WHS Act) to ensure that plant is designed, manufactured, imported and supplied without risks to health and safety throughout the plant's whole lifecycle.

This section is primarily aimed at the safety of personnel through risk-based methodology.

2.1. Work health and safety legislation

2.1.1. Guidelines and safety legislation

Legislation requires all hazards to be identified, the risks assessed, control measures implemented in accordance with the hierarchy of controls, maintained and reviewed.

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

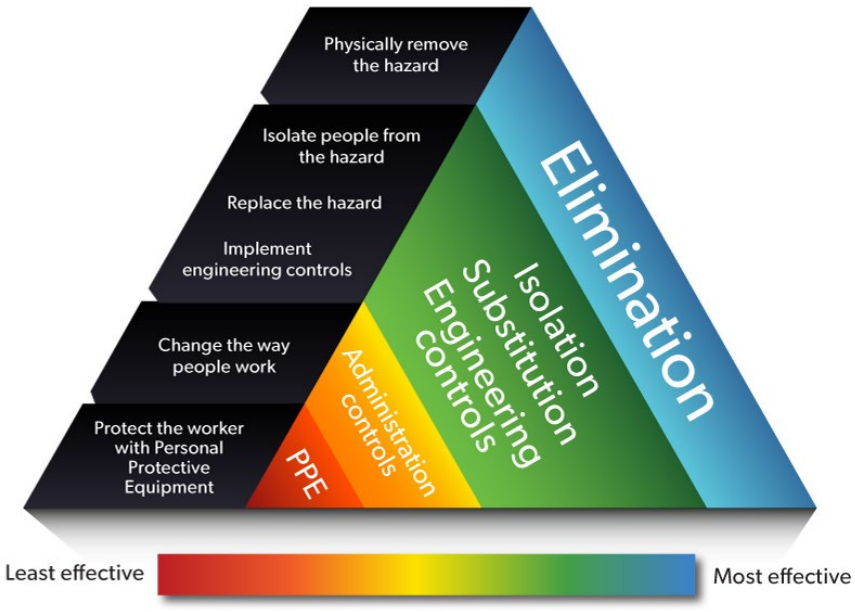
A person conducting a business or undertaking (PCBU) has a primary duty of care under section 19 of the WHS Act to ensure, so far as is reasonably practicable, that workers and other people are not exposed to health and safety risks arising from the business or undertaking. This duty includes ensuring, so far as is reasonably practicable:

- → 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 a 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 and Petroleum Sites) Regulation 2014:

- → 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
- → eliminate 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 risks so far as reasonably practicable in accordance with the hierarchy of risk control measures at figure 1 below.

Figure 1: Hierarchy of control measures.



Further guidance is provided in the mechanical engineering and electrical engineering codes of practice.

2.1.3. Design, manufacture, import, supply

Designers, manufacturers, importers and suppliers of plant, substances and structures have duties under sections 22-25 of the WHS Act. These duties may be summarised as a duty to ensure, so far as is reasonably practicable, that the plant, substance or structure is without risks to the health and safety of people at a workplace who use it for a purpose for which it was designed or manufactured.

2.1.4. Calculation, analysis, testing or examination

Designers, manufacturers, importers and suppliers must also carry out (or arrange to carry out) 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, ensure that such calculations, analysis, testing or examination have been carried out.

2.1.5. Information to be provided

Designers, manufacturers, importers and suppliers must also 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 risks to health and safety when used for a purpose for which it was designed or manufactured or when carrying out any activity discussed in the previous list.

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 by ensuring that the control measure is and remains:

a) fit for purpose
b) suitable for the nature and duration of the work, and
c) installed, set up and used correctly.

2.2. Hazard identification and consequence

For duty holders to meet their obligations and control the risks to health and safety throughout the lifecycle of the mobile and transportable plant, it is important to be able to identify hazards and potential consequences to assess and treat the risk.

Table 2 provides a list of hazards and potential consequences associated with mobile and transportable plant which should be considered.

Guidance on general hazards associated with 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 plant code and in AS 4024.1 series of standards. Guidance on risk management is provided in *How to manage work health and safety risks*

code of practice, AS/NZS ISO 31000 and SA/SNZ HB 89. AS/NZS 4024.1201 deals with risk assessment and risk reduction in relation to the safety of machinery.

Many hazards can be addressed at the design phase. For example, where mobile plant has a diesel engine installed, control of high surface temperatures sufficiently to prevent ignition when in contact with common fluids such as diesel and hydraulic oil can potentially eliminate the risk of fire on the mobile plant. This also avoids costly changes to plant after it has been manufactured.

If eliminating the risk is not reasonably practicable, using substitution, isolation or engineering controls, or a combination of these control measures should be considered, to minimise the risk. The designer should aim to use higher level controls rather than relying on administrative controls and the use of PPE as these provide the lowest form of control

Table 2 – Common hazards and consequences for mobile and transportable plant.

Energy/hazard	Mechanism/scenario - Unwanted event	Potential consequences
Kinetic energy	• Loss of control of mobile plant or unplanned / unintended movement of plant resulting in; ○ Collision with pedestrians ○ Collision with light vehicles with persons inside ○ Temporary or permanent dwellings containing persons ○ Collision with permanent structures	• Minor or major crush injury to single or multiple persons • Fatality to single or multiple persons • Equipment or production loss
Gravitation energy	• Loss of control of mobile plant or unplanned / unintended movement of plant resulting in; ○ Vehicle roll over (down slope) ○ Vehicle topple over (flat ground) ○ Uncontrolled run away • Loss of control of suspended loads or transported materials resulting in; ○ Slip or fall of materials from transport level to ground ○ Fall of load from crane or lifting device ○ Slip or fall of persons from height accessing plant for operation or maintenance	• Minor or major crush injury to single or multiple persons • Fatality to single or multiple persons • Equipment or production loss

Vibration energy	• Exposure to continual low intensity vibration (i.e. from rotating machinery) • Exposure to impact or sudden high intensity vibration (i.e. road surface irregularities) •	• Disorders of joints and muscles including the spine • Cardiovascular and respiratory changes • Long or short term back, neck and other body part sprain and strain injuries • Contusions, fractures
High pressure fluid	• Exposure to uncontrolled release of high-pressure fluid due to failure of pressure containing devices or pressure controlling devices • Exposure to uncontrolled release of high temperature fluid	• Direct fluid injection injury • Struck by projectile debris • Struck by whipping hoses • Catastrophic failure of pressurised components • Reduced component life • Loss of production/downtime • Burns from contact with eyes or skin
High pressure air	• Exposure to uncontrolled release of high-pressure air or gas due to; ○ Explosion of vehicle tyre ○ Failure of air receiver or pressurised components	• Struck by projectile debris • Struck by whipping hoses • Catastrophic failure of pressurised components • Reduced component life • Loss of production/downtime
Chemical reactions Fuel source - diesel, petrol, Hydraulic oil or other	• Exposure to heat (fire) or explosion after ignition of uncontrolled release of fuel energy (fire or explosion) • Fire because of uncontrolled release of fluid coming into contact with a hot surface such as exhaust system components	• Burns • Asphyxiation by toxic products of combustion • Equipment and production losses
High temperature	• Development of high temperatures on equipment components such as Diesel Engines • Explosion - Ignition of explosive gas or dust atmospheres • Fire - Ignition of Fuels used on or nearby mobile/transportable plant • Operator exposed to high temperature	• Skin burns from contact with hot component surfaces or released fluid. • Melted or damaged components and/or hoses (leading to uncontrolled release of high pressure or temperature fluids) • Burns • Asphyxiation by toxic products of combustion

		• Equipment and production losses • Heat stress
Toxic chemical or substance	• Uncontrolled release of toxic chemical or substance	• Skin irritation, dermatitis or burns (short term) • Skin condition or disease (long term) • Lung disease or irritation • Loss of eye sight (short or long term)
Noise (energy)	• Exposure to continuous operation noise source i.e. Diesel Engine, pumps, drills, electric motors, etc. • Exposure to discontinuous operation noise i.e. hammering, operation of functions etc.	• Loss of hearing (short term) • Loss of hearing (long term)
Electrical energy Sources	• Earth or other faults of the electrical system.' • Fire – hot joint or surface ignition	• Electric shock • Burns • Loss of control of equipment

Static electricity	• Discharge of electrical energy causing ignition of;
	  ○ explosive gas or dust atmospheres
	  ○ Stored fuel sources
		• Burns
		• Asphyxiation
		• Equipment and production losses

2.2.1. Incident data

When identifying hazards associated with mobile and transportable plant it is helpful to consider published incident data.

Appendix C provides a summary of incidents associated with mobile and transportable plant that were reported to NSW Resources Regulator over the past few years as well as summaries of fatality data from selected countries. Safe Work Australia provides useful information for some aspects of this guideline in *Work-related fatalities associated with unsafe design of machinery, plant and power tools* 2006-2011 dated November 2014.

Part of the Safe Work Australia publication, *Work-related fatalities associated with unsafe design of machinery, plant and powered tools, 2006-2011* sets out fatalities associated with runaway vehicles / park brakes. These are relevant to braking systems on mobile and transportable plant

To minimise the potential for repetition of past incidents, people in control of mobile and transportable plant should provide the designer/manufacturer/supplier with details of relevant incidents and include these in a plant safety file. The MECP code provides more information on plant records including the plant safety file.

Persons conducting a business or undertaking (PCBU) should make enquiries of designers/manufacturers/importers and suppliers as to whether they have become aware of safety related incidents involving similar plant. Designers, manufacturers, importers/ and suppliers that become aware of safety-related incidents involving their equipment may provide information to the users of affected plant by safety alerts, technical bulletins and other recommendations to rectify or address the issue.

2.2.2. Identifying hazards and risk associated with human factors

Investigations of fatalities and serious accidents have identified a significant percentage of causal factors are the result of human failings or are contributing factors in the failure of control measures. Human failings will affect safety in the workplace throughout the life cycle activity of plant. It is important to identify possible human failures and implement control measures to minimise the hazards of human failings.

The MECP code provides more information on human factors and the Health and Safety Executive in the United Kingdom has substantial information on human factors ranging from introductory material to more detailed information on managing human failings. This is available at www.hse.gov.uk/humanfactors/index.htm

3. Design manufacture, supply

3.1. General guidance

General guidance on 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.

Key sources of information on general plant safety is provided in the AS 4024.1 series of standards (including 1201, 1301, and 1302) and the codes listed in Appendix A.

For general information on mobile plant control measures general guidance can be found in ISO 20474-1 *Earth-moving machinery - Safety - Part 1: General requirements* , and for mobile plant in underground mines (other than underground coal mines) in ISO 19296 ‘Mining mobile machines working underground’

Guidance may also be found regarding the plant procurement process from the “Earth Moving Equipment Safety Round Table” (www.emesrt.org/emesrt-design-evaluation-for-eme-procurement/).

3.1.1. Design risk assessment

The designer should carry out a design hazard analysis (design risk assessment) to identify all reasonably foreseeable hazards associated with mobile and transportable plant and to provide fit-for-purpose means to control risk to health or safety. The designer must ensure, so far as is reasonably practicable, that the plant is designed to be without risks to the health and safety to persons when used for a purpose for which it was designed. In identifying hazards, consideration should be given to:

a) the purpose of the mobile and transportable plant including its intended design life
b) the impact of the mine or petroleum site environment on the mobile and transportable plant
c) the provision of safe access to the components of the mobile and transportable plant, for the purpose of operation, maintenance, adjustment, repair and cleaning
d) risks at key lifecycle stages such as assembly, commissioning, dismantling decommissioning,
e) design parameters that may eliminate or reduce the risk of fire
f) design parameters that may eliminate or reduce the risk of inadvertent movement or loss of control (including but not limited to brakes and steering)
g) examination of failure modes of the mobile and transportable plant and its components or systems
h) information on past incidents, including but not limited to brake or steering failures, unplanned movements or loss of control, fire statistics, vehicle interactions and human error
i) The information in 2.2.

The outcome of the hazard analysis should identify:

- → the required safety critical systems and
- → any performance requirements of those safety critical systems to safely operate the mobile and transportable plant.

In conducting the design risk assessment, the designer should address any foreseeable risk scenario that may cause harm to any person during the mobile and transportable plants lifecycle. Consideration should be given to the control of risks to health and safety that may arise from reasonably foreseeable misuse of the mobile and transportable plant.

Outputs of a risk assessment should include a residual risk register and list of controls for the mobile and transportable plant. This information should be used in preparing operational or maintenance manuals and in identifying controls for the safe operation, maintenance and disposal of the plant.

All control measures should be assessed for effectiveness and required reliability.

Note that the mine or petroleum site operator should carry out an operational risk management exercise to identify hazards, implement controls, maintain and review controls which would relate to the operation of the plant in the intended specific workplace at the mine or petroleum site. Refer to section 6.

3.2. Designing safety critical systems

Safety critical systems are those systems in which failure can result in fatal or catastrophic consequences. Potential failure modes should be identified, and control measures implemented to result in fit for purpose plant in which the potential for safety critical systems to fail is eliminated or minimised.

3.2.1. Controls for identified risks

Control measures for hazards may be identified as either:

- → a safety-related function (for example: a control circuit)
- → as safety-related componentry.

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

3.2.2. Safety-related componentry

All safety-related componentry, for example wire rope and tyres should be designed, analysed, tested and documented according to engineering standards.

Safety-related componentry should 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, should 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.

3.2.3. Safety-related functions

All safety-related functions arising from the hazard assessment(s) should be clearly identified. An example of a safety-related function is a door sensor that provides a warning that the park brake has not been applied when the operator goes to leave the mobile plant.

Safety-related functions should be assessed using functional safety standards, as amended from time to time, as applicable to the design architecture and type of components used. Functional safety standards include:

- → application of performance levels (PL) in accordance with AS/NZ 4024.1503 or ISO 13849-1 or ISO 15998
- → application of safety integrity levels (SIL) in accordance with AS 61508.1 or AS 62061
- → application of safety categories (CAT) to AS 4024.1501 and AS 4024.1502
- → other relevant functional standards provided an equivalent level of safety can be demonstrated such as ISO/FDIS 19014.1.

All safety-related functions should be assessed to confirm that the required risk reduction has been achieved. The functional safety assessment should include:

- → validation though 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.

3.3. Designing to take account of human factors

Human factors refer to the environmental, organisational and job factors and human and individual characteristics that influence behaviour at work in a way that can affect health and safety. Human factors are a significant contributor to fatal and serious accidents.

Many hazards can be eliminated at the design and manufacture stages by considering human factors such as the:

- → tasks to be performed including the operating environment and the design of displays and controls
- → individuals who will use the plant and the factors that may influence them to deliberately or inadvertently operate the plant in an unsafe manner such as fatigue, inadvertence, trying to find a better way.

3.3.1. Means of minimising the potential for human factors in relation to mobile and transportable plant

Interlocks, operator warnings and other aids are some of the key types of control measures that are used in manage risks that may be associated with human factors. Some examples of these are provided below and should be considered when designing and manufacturing plant for use at mines or petroleum sites.

See Appendix D for more information.

Table 4 - Examples of the use of interlocks in mobile and transportable plant.

Examples of the use of interlocks in mobile and transportable plant
Ignition or power-on key cannot be removed unless the gear selector is in the park position (encourages use of park brakes).
Where the operator may be exposed to injury when accessing plant, such as skid steer vehicles, an interlock to prevent the operator being injured by the bucket should be included. The interlock arrangement should ensure the bucket is in the lowered position and can't be being moved whilst ever the operator is over the bucket. Severe operator leg injuries have occurred from the bucket being lowered onto the operator's legs. The park brake should also be interlocked to be in the applied position before the operator can leave the operator station. Both the foregoing interlocks are commonly connected to the pivoted drop-down bar that confines the operator to within the operator's compartment.
Provide a means to prevent incorrect polarity when jump starting plan. For example, using an additional battery.
Where equipment (e.g. a mast of a drill rig) needs to be in a specific lowered position before it is relocated then a positive means to ensure it is in the tram position should be provided. Several roll overs on drill rigs have occurred where the mast was in the raised position causing the equipment to be unstable and resulting in the equipment tipping over whilst it was being trammed.
Where covers on mobile plant result in a significant hazard if left open or unlatched interlocking should be considered to stop motion of the plant or provide a warning to the operator.

3.3.2. Warning devices

Warning devices can be used as part of the arrangements to manage risks associated with plant. These devices although engineered to monitor the state of the plant and/or the workplace require the operator to analyse the information and make appropriate decisions so must always be considered an administrative control for the purposes of the hierarchy of control.

Designers should consider the following factors when including or retrofitting alarms or warning devices:

- → Usability – will the alarm meet user needs and will the operator have the capabilities to respond as required?
- → Safety – identify the safety contribution of the alarm to the plant and the activities for which it is used. Consider human performance and reliability in the response to the alarm which is required.
- → Performance monitoring – this is a continuous improvement / review factor. Consider the design and purpose of the alarm and response to the alarm.
- → Engineering investment – this refers to a structured engineering design. All alarms should undergo a consideration of justification (is it necessary) which is then reviewed at a later stage.

Examples of warning devices are shown in Table 5.

Table 5 Example of warning devices that should be considered in designing, manufacturing or supplying mobile or transportable plant for use at mines or petroleum sites.

	Examples of warning devices that should be considered in designing, manufacturing or supplying mobile or transportable plant for use at mines or petroleum sites
1	Safe operating load is being exceeded (typically for trucks and loaders, should also be used on other equipment such as elevated work platforms).
2	Safe forward or cross grade is being exceeded (includes tilt sensing for bulldozers working on stock piles). Refer to MDG 28 *Safety for stockpiles and reclaim tunnels* for further warning devices see the following website: www.resourcesregulator.nsw.gov.au/__data/assets/pdf_file/0019/420481/MDG-28-Safety-requirements-for-coal-stockpiles-and-reclaim-tunnels.pdf
3	For articulated trucks to minimise the potential for roll over a means to sense excessive centrifugal force when cornering and excessive cross grade should be provided. This type of device has been successfully applied at several sites by using a dampened pendulum device to initially provide a warning light and if the force is increased a buzzer operates.
4	Over-speed
5	Operators fatigue measuring and alarm (for example monitors eyes blinking)

6	A device to sense when high voltage cables are being approached linked to a system to warn the operator. Fatalities have occurred in Australia when mobile plant has been driven into high voltage cables, the equipment includes loaders, drill rigs, cranes, tipping trucks, tipping trailers and excavators. Refer to work-related fatalities by SafeWork.
7	Back up beacon- lights up when ignition or power on key is turned on so workers in the area know when plant is to be moved.
8	Safety belt monitor –an audible signal when the operator is not wearing a safety belt.
9	For larger equipment, it may be beneficial to include a visible signal that is identifiable from both the operator position and externally to a supervisor (assists in enforcing the use of seat belts). Fatalities have occurred when operators fail to wear seat belts.
10	Tyre pressure monitoring with pass/fail warning in the operator compartment. This may reduce the potential for tyre explosions and loss of control of plant. (Fatalities have occurred from tyre explosions.)
11	Excessive engine revolutions per minute (may prevent catastrophic engine failure if the engine is being used to retard the plant and the wrong gear ratio has been selected).
12	Engine coolant over temperature (may prevent catastrophic engine failure, burns to operators and potentially loss of plant control).
13	Excessive engine oil temperature (may prevent catastrophic engine failure and potentially loss of plant control).
14	Low engine oil level (may prevent catastrophic engine failure and potentially loss of plant control).
15	Low engine oil pressure (may prevent catastrophic engine failure and potential loss of plant control).
16	Hydraulic oil over temperature warning (before a fire occurs).
17	Hydraulic oil low level warning (before loss of fluid results in loss of pressure and then potentially loss of control of plant).
18	Transmission oil over temperature warning (before a fire occurs).
19	Low fuel level (before engine is in danger of stopping and control of plant may potentially be lost).
20	Low air pressure (before plant is no longer safe to operate).

21	Scheduled maintenance is overdue.
22	Turn signals are operating (to warn others and the operator).
23	Brakes are applied (to warn others).
24	Automatic retard is operating (to warn others).
25	For battery powered equipment low voltage and high temperature (to reduce potential for unexpected power loss and motor failure).
26	Low fuel level warning, audible or visual (lack of fuel has contributed to a fatality).
27	For retard (braking) systems a warning that the operating temperature is becoming excessive before the system fails or results in a fire or automatically applies the emergency or secondary braking system.
28	Fire detection systems to warn the operator of a fire in areas most likely for a fire to occur (i.e. engine bay).

3.3.3. Additional operator aids

Reversing cameras **s**hould be considered where there is a hazard and the operator needs additional visibility to the rear. Reversing cameras are successful as a driver's aid in some applications however they have not prevented some incidents because they were not being used effectively.

GPS monitoring may be useful for monitoring some aspects of plant operation. Preference should be considered for systems that give meaningful feedback to the operator. For example: speeding, proximity detection to other plant, service and maintenance criteria, vehicle abuse such as excessive braking, rule violation such as failure to stop at stop sign.

3.3.4. Excessive warning devices may contribute to operator confusion from warning device overload

The designer should consider the possibility of the warning devices creating a hazard. The designer should also consider information overload when developing warning systems, particularly where multiple warnings may be given simultaneously.

Lower level warning could be given by a light while higher level systems may be better using an audible device. Care needs to be taken to avoid night time visibility loss that may be caused by excessive light within the operator's cabin.

3.4. Providing design information to end users

3.4.1. General

To minimise the potential for plant to be used outside its intended design parameters the following information should be provided by the designer, manufacturer or supplier:

a) plant operating limits and capacities (detailed in 3.4.2)
b) general arrangement drawings showing the physical dimensions of the plant including all extremities and all limits of application
c) hydraulic, pneumatic and electrical drawings and schematics
d) standards to which the plant was designed
e) safety critical systems and safety devices
f) installation, testing, commissioning and decommission manuals
g) operation, maintenance and parts documentation
h) towing instructions

3.4.2. Operating limits and capacities of mobile plant

All design limits of operation for the mobile plant should be specified. Site conditions can affect performance. Limits specified for the plant will need to be considered by end users such as mine or petroleum site operators when conducting risk assessments on the use of the plant, so it is critical this information is supplied.

Such limits should include:

- → Working grade (%)
  - Loaded at maximum gross vehicle mass (GVM or GCM as applicable). (As built)
  - Unloaded
  - Tipping
  - Fully loaded with park brake applied
  - Fully loaded with emergency brake applied
  - Other variables where applicable
- → Cross grades
  - Loaded at maximum GVM or GCM as applicable (as built)
  - Unloaded
  - Tipping
  - Other variables where applicable
- → Maximum load (tonnes)
  - Level conditions
  - On range of grades
  - Other variables where applicable
- → Maximum speed (km/h)
  - On level conditions
  - On range of grades

- Other variables where applicable

3.4.3. Safety critical systems and safety devices

The designer or supplier should provide a comprehensive list of all safety critical systems, safety devices and their functions. This list should include:

- → Instructions for systematic and periodic checking and testing of all safety critical systems and safety devices to ensure they operate as designed. Examples of safety critical systems may include steering, braking, fuel system etc. Examples of safety devices may include seat belts, ladder interlocks etc.
- → maintenance instructions that should result in all safety critical systems and safety devices remaining functional over the life of the mobile plant, if followed.
- → Note: This information may form part of the operation and maintenance information provided by the manufacturer

3.4.4. Installation, testing, commissioning and decommission manuals

Installation, testing, commissioning and dismantling procedures should be provided as follows:

- → Identification of hazards and appropriate controls associated with the installation, testing and dismantling of the plant;
- → Procedures associated with the installation, testing, commissioning and dismantling of the plant. The limits of travel of all moving elements should be shown;
- → A copy of all test results and procedures in relation to testing, setup and commissioning of the plant should be maintained; and
- → Transport and lifting requirements for the plant and its major components including:
  - component weights and dimensions
  - jacking weights
  - lifting points, jacking points and support stand locations
  - transport tie down instructions
  - lifting diagram and instructions.

3.4.5. Operation, maintenance and parts documentation

Operation, servicing and maintenance documentation should be supplied with the plant (prior to being placed in service). All documentation should be included or referenced in the MECP. This documentation should include:

- → recommended preventative maintenance requirements to maintain the plant in a safe operating condition, including lubrication, ongoing adjustments, tests, setting of controls, etc.
- → recommended schemes and procedures to maintain the plant fit for purpose, for example inspection, examination and testing.

- identification of any hazards involved in maintaining and operating the plant, including fire risk, confined spaces, etc. Guidance may be found in AS 2965.
- energy isolation and control.
- procedures to carry out routine maintenance on the plant, including setting of controls.
- trouble shooting guide
- parts documentation should be provided for plant as supplied
- Ratings of major components or systems for example drawbar pull, carrying capacity, braking system etc.
- 'as built/supplied' electrical, hydraulic, pneumatic schematic diagrams,
- recommended maintenance periods and procedures,
- all safety precautions.

All hydraulic and pneumatic symbols should be in accordance with AS 1101.1 or ISO 1219-1 *Graphic symbols for general engineering - Hydraulic and pneumatic systems*

3.4.6. Towing instructions

If applicable, towing instructions should be provided for each of the following:

- for towing the plant when inoperable
- for towing a load with the plant

In both cases the information provided should include:

- maximum load to be towed
- tow point ratings
- direction of pull.

4. Safe design of features

4.1. Providing access

4.1.1. General

Specific duties apply under clauses 78 and 79 of the WHS Regulation in relation to the managing the risk of falls where there is a risk of a fall that is reasonably likely to cause injury including where a worker is:

- in or on plant or a structure that is at an elevated level
- near an edge over which a person could fall

The *Managing the risk of falls at workplaces* code of practice provides guidance on these duties and how to comply with them.

To minimise the potential for accidents relating to mobile plant access three points of contact should be provided on access systems, with access systems being positioned to provide an ergonomic safe

access, which is intuitive for a person to use. So far as reasonably practicable access systems should be in accordance with either:

- → AS 3668 and AS 1657 or
- → ISO 2867 and ISO 14122 Parts 1 to 4.

To minimise the risk of falling, plant operators and maintenance personnel should be able to carry out normal duties without leaving a designated walkway, access platform, or the ground.

Where this is not reasonably practicable and there is a potential that a person could fall, consideration should be given to the provision of harness points or other methods of safe access provided for (such as mobile work platforms).

4.1.2. Ladders and stairs

To minimise the risk of falling:

- → stairs should be provided wherever practical
- → ladders should be installed in the 'preferred' or 'recommended zone as set out in AS 1657 or ISO 14122.1
- → the bottom step of the primary access should not be more than 400 mm from ground level as measured on flat ground.

Where this is not reasonably practicable then retractable stairs or ladders should be installed.

Flexible bottom steps should be avoided unless there is no reasonably practicable alternative.

A means of preventing retractable stairs from being damaged should be provided. Measures should be implemented to prevent the stairs or ladder being in the lowered position while the vehicle is being moved.

4.1.3. Walkways and handrails

To minimise the risk of slips, trips and falls:

- → handrails should be in a continuous length without sudden changes of direction to assist evacuation with minimal visibility
- → walkway surfaces should be non-slip and self-cleaning
- → openings in guardrails for access to ladders should be fitted with a hinged or sliding guardrail gate where reasonably practicable. Chains should not be used
- → hinged gates should open onto the platform and should be self-closing

4.1.4. Egress

Two means of egress should be provided from the operator's cabin to the ground including:

a) at least one means of easy egress (normal access e.g. cabin door) and
b) at least one means of emergency egress

At least one means of egress should be useable in the event of a hazardous condition such as, mobile plant roll-over or where the normal access is blocked such as fire, or other hazard

The emergency egress should be suitably marked and could be achieved by a second door, a push out window or other alternative means.
At least one of these means of egress should not be near a potential fire source, that is, a potential source of fuel that can be ignited and sustain a fire.

Except for escape chutes, all means of egress should have provision for three points of contact (for example, handrails on both sides of escape ladders).

4.1.5. Confined spaces

Confined spaces are a significant issue in working with mobile and transportable as there are spaces on or in mobile and transportable plant where there may be harmful concentrations of airborne contaminants. See the guides detailed in appendix A and the SafeWork NSW Confined spaces code of practice for more information.

Confined spaces should be avoided wherever possible, by design. All confined spaces on mobile plant should be identified and labelled.

4.2. Brakes

4.2.1. General

Effective braking systems are critical for the safe use of mobile and transportable plant. Adequate means of braking should be available to safely bring mobile plant to rest under all conditions of operation and to hold the mobile plant stationary. This includes adequate braking measures in the event of the failure of the primary braking system. Unplanned or unexpected movement of mobile plant are a significant source of incidents at mine sites refer to work related fatalities by SafeWork Australia for fatalities relating to failure to apply park brakes.

In designing braking systems, consideration should be made of possible human factors and appropriate automatic brake initiation devices to activate the braking system(s).

To control the risks associated with uncontrolled movement, all mobile plant should be fitted with a service brake system, a secondary brake system, and a parking brake system. Transportable plant should be equipped with a means to hold the plant stationary to minimise the risks associated with out of control plant.

Braking systems on mobile plant should be in accordance with the following standards:

- → ISO 3450:2011 - for wheeled and high-speed, rubber-tracked earth moving plant
- → ISO 6292-AS 2359 - Powered industrial trucks and tractors - Brake performance and component strength
- → ISO 10265:2008 - for all other crawler earth moving plant with maximum speed less than or equal to 20 km/h
- → ISO 19296 - for mobile plant in underground mines (other than underground coal mines)
- → other standards which provide an equivalent level of safety

In addition:

a) Mechanical braking systems should be fail safe[2], to minimise the potential for brake failure.
b) To prevent brake wear and/or overheating, an effective interlock should be provided to protect against mobile plant being driven with any brake applied. Provision may be provided to override this interlock for maintenance activities.
c) Brake lining material must not contain asbestos.
d) A warning light easily visible from the operator's seat and/or an audible alarm should be used to monitor the state of all pressurised braking systems.
e) Suitable connecting points for checking pressures of all braking systems should be provided.
f) A suitable brake warning device should be provided to monitor brake drag where required. For example, residual brake pressure.
g) A clearly identifiable means of monitoring brake wear and the required adjustment range should be provided.
h) Air or hydraulic energy storage for service brake applications should be independent from the requirements of other systems.
i) Oil immersed brakes should be considered if a potential for fire exists or under circumstances where a harsh environment causes significant loss of performance through wear, moisture or corrosion and damage.

4.2.2. Brake slope capability

The brake slope capability should be determined in accordance with ISO 3450-2011 Annexure B. This information is essential to for all mobile plant, which may travel on a gradient of greater than 10%, refer SB06-13.

Designer's information on the performance of the service, secondary and park brake braking systems should include:

- → the maximum longitudinal grade, in conjunction with the maximum speed that the service and secondary brakes are each individually able to stop and to hold the gross vehicle mass of the plant (GVM or GCM as appropriate)
- → the maximum longitudinal grade the park brake can hold the plant stationary at gross vehicle mass (GVM or GCM as appropriate)
- → operator instructions for descending and ascending a grade.

The specified design gradients for the mobile plant should be within the stopping and holding capability of the service, secondary and park brake systems.

4.2.3. Brake skid and traction control for wheeled plant

Provision should be made to minimise the potential for locking of wheels, so far as is reasonably practicable. For example, anti-lock braking systems (ABS).

Consideration should be given to the provision of enhanced braking controls. These should include:

[2] The meaning of fail safe is set out in the plant code.

- → a means to eliminate, or minimise so far as is reasonably practicable, drive wheel spin. For example, automatic spin regulation (ASR)
- → auto retard capabilities
- → capability for pressure proportioned (front to rear) brake control for improved vehicle control under all operating conditions.

4.2.4. Brake system periodic verification

Information on brakes should be provided in manuals to enable periodic verification tests for brake systems. This information should include:

- → the means for the operator and maintenance people to check the brakes, including a method of verifying the functionality of the service, secondary and park brakes
- → the means to check brake performance following brake maintenance which includes:
  - acceptance criteria and test methods for verifying the functionality and performance of the service, secondary and park brakes
  - deceleration limits and stopping distances for the service and secondary braking systems
  - holding limits for park brakes
  - considerations for dynamic brake testing.

4.2.5. Park brake system

The work-related fatalities by SafeWork Australia has recorded eight work-related fatalities that were coded to runaway vehicle/park brakes. In nearly all cases, the fatal incident was the result of the driver failing to properly apply the park brake of their vehicle. The document further notes that “The Australian Trucking Association recommend that trucking operators consider fitting driver door interlocks that sound an alarm if the door is opened when the transmission is in neutral and the park brake is not applied (ATA, 2013). This simple technology could help prevent numerous incidents of runaway vehicles”.

All mobile plant should be equipped with a park brake system capable of being applied and released from the operator’s position. The park brake system should have the capability of holding the mobile plant stationary (at its gross vehicle mass in both forward and reverse directions) on the greater of:

- → the maximum grade as specified by the mine or petroleum site, or
- → a 15% grade in both forward and reverse directions.

Safety chocks or other positive means to prevent movement should be provided in the event of the mobile plant being immobilised.

Once applied, the park brake system should not rely on any exhaustible energy source.

Whenever the operator leaves the cab, a means of verifying that the park brake has been applied should be in operation, where reasonably practicable. This system should be used to initiate an audible warning device if the park brake is not applied.

Note: This may not be suitable for mobile and transportable plant where the operator is required to leave the cabin on a regular basis as part of the plant’s normal operation.

Consideration should also be given to the automatic application of brakes, refer to 4.2.9.

4.2.6. Multiple circuit braking systems

Service, secondary and parking brake systems may be independent circuits or may share common components or functions. Where common components are shared, in the event of a failure or contamination of any single component, the brake system should provide stopping capability in accordance with the secondary brake system performance criteria of ISO 3450.

4.2.7. Oil immersed braking systems

To minimise the potential for fires from overheated brakes and to minimise the potential for premature failure of brakes from the effects of harsh mining environment oil immersed brakes should be considered.

Oil immersed braking systems should be designed so that the temperature does not reach the flash point for the oil. The designer, manufacturer or supplier should specify the oil (or standard of oil) that is to be used and include this in information supplied with the plant.

The temperature of any oil immersed braking system should be monitored with appropriate warning/alerts provided to the operator as necessary. The use of fire-resistant brake fluid should be considered for all non-oil immersed hydraulic brake systems.

4.2.8. Brake testing

To verify the condition of braking systems, end users will need to undertake testing. Information should be provided from the designer/manufacturer/supplier on acceptable deceleration limits for all retardation and braking systems. Consideration should be given to carrying out periodic dynamic brake testing, refer to AS 2958. A means of using measurement for maintenance checking (or at least indication) of mobile plant deceleration should be provided where practical for plant. For example, a portable means of recording brake application, frequency and length of application.

This is particularly useful for:

- → operator training
- → identifying effectiveness/ deterioration of the braking system rather than relying on "operator feel"
- → providing pre-warning of possible brake failure
- → complementing periodic inspections.

4.2.9. Automatic application of brakes

Automatic application of brakes should be considered as they may correct operator error or prevent serious accidents. For example; a brake could automatically apply when:

- → the operator leaves the cabin
- → when the engine shuts down
- → for over speed where the retard envelope is exceeded

→ for other scenarios when operator error is apparent.

The rate of application of automatic brakes should not be too severe. The potential for wheel skidding should be minimised. This rate of application may well be different to the rate of application for emergency brakes.

Where a system component fails, or system energy drops below a required design level, then the secondary brakes should automatically apply.

A warning device that effectively indicates to the operator that the braking system is about to apply automatically should be provided. Operators should be trained in the operation of the automatic brakes.

4.2.10. Retard system

A retard system provided resistive energy to the motion of the mobile plant. It should not be considered part of a braking system, even though it may be the primary source of retardation.

Note: retard systems will not operate under some circumstances, such as when the mobile plant is operating outside the retard envelope (i.e. the plant going too fast) or when the retard system is too hot, or a fault occurs. Consequently, it is essential the service brake system always remains functional. In the event of a failure of the retard system, the service brake system is the method the operator uses to bring the mobile plant back into control.

Retard systems are generally used on long steep grades to provide effective speed control. The following should be considered for retard system:

a) Engine retard systems should be designed so that they will not stall the engine. Stalling of the engine can lead loss of control of the plant.
b) All retard systems should be designed to cater for maximum load combined with the maximum steepness and length of the grade.
c) Electrical retard system should be designed to adequately dissipate any heat generated without resulting in a hazard. If a retard system results in excessive temperatures, automatically applying the service brake system to bring the plant safely to a stop is required.
d) Automatic application of the retard system could be considered prior to an over speed event.
e) Any automatic retard system should have the capability of manual operation.

4.3. Controls and warnings

4.3.1. General

To minimise human factors, operator controls should be:

→ consistent in nature

→ labelled

→ within the zones of comfort and reach of the intended people.

Consideration should be given to ISO 10968, EN ISO 6682 and ISO 6405-1.

The operating controls should be clearly marked to show their function and mode of operation in accordance with ISO 6405-2.

4.3.2. Warning device

An audible warning device (for example, horn) should be provided for use as a manually initiated warning device.

4.3.3. Air device

Where an audible warning device is air operated, a secondary warning device should be provided (e.g. for electric start trucks where air is not available until the engine is operating, then an electric horn is required.)

4.3.4. Pre-start warning

An automatically initiated pre-start warning device should be provided where a hazard exists if people may be near the plant and it is started or moved. This applies particularly to draglines, large shovels, loaders and other large plant where it is difficult for the operator to ensure that no one is exposed to a hazard when the plant is started.

4.3.5. Reversing

An automatic reversing warning system should be provided on all plant except bi-directional plant.

Audible alarms may be replaced by alternative methods, provided they give an equivalent level of safety and consideration is given to environmental noise impacts. Some guidance may be found in ISO 6393 "*Earth-moving machinery - Determination of sound power level - Stationary test conditions*". Refer to section 3.14.

4.3.6. Emergency stop

Emergency stop devices should include the following features:

a) An emergency stop should be initiated by pushing a large red button.
b) Manually operated, automatic lock-off, manual reset type.
c) On activating the emergency stop device, the device should latch either electrically or mechanically, such that the actuation can only be reversed by a deliberate action.
d) The plant should not restart automatically after the emergency stop has been reset.
e) Be capable of being operated with minimal effort without danger to the operator.
f) Be designed such that the operation of the emergency stop is a deliberate action.
g) The control voltage should be extra low voltage.

Section 4.3 of the plant code provides information on mandatory requirements for emergency stops.

4.3.7. Emergency stop function

Emergency stop devices should be provided to enable the emergency shutdown of the machine. These devices should be in accordance with AS 4024.1604 or ISO 13850.

The emergency stop function should operate in all operating modes.

The emergency stop function should be designed so that the operation of the mobile or transportable plant is stopped in appropriate manner, without creating additional hazards, according to the risk assessment.

The risk assessment should set out the choice of shutdown functionality, taking consideration to operator safety, mobile plant operation and other hazards which may be present. The hazardous motion should be stopped as quickly as possible so that additional hazards are not created.

This does not preclude the use of:

- → electronic control systems within emergency shutdown functions where those electronic control systems have been included in the functional safety assessment
- → shutdown devices other than emergency stop buttons.

Note: Emergency stop systems are not a substitute for operator action to bring mobile plant to a controlled stop i.e. for rubber tyred high-speed mobile plant, operators may need to bring mobile plant to a safety speed.

4.3.8. Emergency stop location

Emergency stops should be located to enable the plant engine to be stopped and brakes applied in the event it is necessary to minimise a hazard. Position of e-stop should be determined via risk assessment. Suggestions for typical location of emergency stop include:

a) at the operating station, and ergonomically within the zone of reach and located to minimise the risk of inadvertent operation
b) near the normal boarding point onto the plant, and so that a person can reach the device from a position on the ground at the boarding point
c) locations away from the front of outblowing fans or airflows as these may direct fire to the control point
d) locations that avoid inadvertent operation of the emergency stop.

4.4. Engine compartment

To minimise the potential for serious fires, loss of control, serious bodily injuries including burns relating to plant the following should apply.

4.4.1. Surface temperature control

The surface temperature of the engine system should be controlled to eliminate hot surface ignition of fuels such as escaped hydraulic oil, diesel fuel and engine coolant.

Notes:

1. AS 5062 provided guidance on minimising the risk of heat sources and fires initiating in mobile plant.
2. Commonly, the highest temperature areas are exhaust manifolds, turbo charger exhaust side housings and exhaust pipes and mufflers.

3. Surface temperature control methods may include insulating, lagging and water jacketing (e.g. in marine or group 2 protected engines) Implementation of new controls should not introduce other hazards of equal or greater risk.
4. Any change in engine heat arrangements should be made in consultation with the engine manufacture so all issues are understood.
5. The addition of sound proofing around the engine compartment may create additional heat requirements, raising the fire risk.

The maximum operating surface temperature of the engine and ancillary components should be measured and recorded.

4.4.2. Location of services

The following apply to the location of service access points within the engine compartment:

a) The location of services including fuel, hydraulic oil and electric power within the engine compartment should be avoided wherever possible.

b) Any services required to be in the engine compartment should be effectively shielded from exposure to heat sources and protected from forces, which cause wear and tear.

c) The potential for physical damage to services during maintenance work should be considered and managed.

d) The above should also be considered for operator pre-start checks.

4.4.3. Fuel and hydraulic circuits

To assist in preventing the initiation of fires in the engine compartment:

a) hydraulic components should not be located where main ventilating air will cause leaking oil to be spread over the engine compartment

b) hydraulically driven fans should not be used where potential exists for an oil leak from the fan hydraulics to contact hot surfaces (e.g. resistor bank cooling). Where there is no alternative to using hydraulic driven fans then the fan hydraulics should be suitably guarded to ensure that oil does not come in contact with ignition sources.

c) all fuel tanks should be fitted with non-leaking caps which are effective irrespective of the angle of the plant

d) all fuel filters should be of metal construction or alternatively installed within a metal container to minimise fire risk.

4.4.4. Pipes and hoses

When pipes and hoses fail, they release volatile fuels to make contact with hot surfaces resulting in fires for example from fuel or oil being sprayed onto the hot surface of a turbo charger. Such fires can result in:

- → death or injury to plant operators and bystanders as a direct result of the fire or in the event of an explosion
- → injuries sustained by people escaping from the fire
- → injuries from high pressure fluid injection

→ capital losses associated with the damage to the plant from fire.

Effective control measures should be applied to manage these risks including the following in relation to pipes, lines and hoses:

a) All fuel lines should be metal, or metal braided.
b) All pipes/hoses should be constructed of fire-resistant material and should be routed away from hot engine surfaces.
c) An effective shielding should be considered between the pipe/hose and any adjacent components which have operating surface temperatures more than 150 degrees Celsius.
d) All pipes/hoses should be routed in a manner which will give them maximum mechanical protection against wear and damage.
e) All connections should be suitably rated for the use and environment.

Refer to MDG 41 for additional information on pipes and hoses.

4.4.5. Radiator caps

Radiator caps for cooling systems should not be able to be opened while there is pressure in the cooling system. Cooling systems should be fitted with a means of safely relieving pressure to prevent burning personnel and should be able to be accessed safely.

A means to check coolant level without the removal of the radiator cap should be provided.

A means of filling the radiator without removing the radiator cap should be provided.

Note: In some circumstances, pressure relieving devices are not effective (i.e. “after boil” on an overheated engine) and personnel should wait until the cooling system has reduced in temperature before removing the radiator cap. Pressure relieving devices should remain in the relieving position until manually reset.

4.5. Ergonomics

A person competent in ergonomics should assess the ergonomic aspects of the plant. This assessment should take into consideration the intended use and operating environment. The assessment should also examine all relevant ergonomic matters relating to human factors.

Specific duties apply to designers, manufacturers, importers and suppliers of plant or structures in relation hazardous manual tasks including consideration of factors such as vibration. See the guides set out in Appendix A for more information.

This assessment should be documented. AS/NZS 4024.1401, ISO 10968 provides guidance.

4.5.1. Vibration

Vibration can result in long-term muscular skeletal injuries. Adequate preventative measures should be taken to prevent excessive vibration being transmitted to the plant operator during the operation of any equipment.

Where there is a risk from vibration creating a risk to health or safety of the operator then a vibration assessment should be carried out by a person competent in such assessments.

The transmitted vibration during operations should not exceed the limit levels specified by AS 2670.1 or the European Directive 2002/44/EC. Long shifts are common in the mining and petroleum industries and this needs to be considered when determining exposure and designing plant to eliminate or minimise exposure to vibration.

Significant damage to operators of plant has occurred due to excessive vibration over extended periods of time. An example of statistical information regarding injury caused by vibration in the underground situation is shown in the following safety bulletin. These principles may also apply to surface plant operation – refer to the Safety Bulletin:

www.resourcesregulator.nsw.gov.au/__data/assets/pdf_file/0011/584867/SB15-06-Analysis-aims-to-reduce-injuries-while-travelling-underground.pdf

4.6. Fire control

Fires may result in injury to workers and loss of control of plant. Fires may also be the cause of asphyxiation, tyre explosion, fuel tank explosions and other unwanted events.

4.6.1. Fire risk assessment

Designers/manufacturers/importers/suppliers should undertake a risk assessment of all fire risks with the mobile plant in accordance with AS 5062, '*Fire protection of mobile and transportable equipment' and MDG 1032*.

The fire risk assessment should:

a) identify all potential fuel and ignition sources
b) identify and measure maximum operating surface temperatures
c) consider previous incidents associated with mobile plant fires
d) identify means/control measures to minimise the potential for a fire
e) identify what fire protection is required, including consideration of manually and/or automatically operated fire suppression systems
f) How sound attenuation enclosure of the engine compartment may affect the fire risk.

A fire risk assessment should include consultation with a mobile plant operator, a maintainer, a specialist fire expert and the mobile plant manufacturer's representative as applicable.

Where several models or variants are being designed the risk assessment should consider each variation.

4.6.2. Fire extinguisher(s)

Due to the high number of fires on mobile plant at mines, it is very important that all mobile plant with an onboard operator is fitted with a portable fire extinguisher (more than one may be required). The fire risk assessment should determine the type(s), numbers of and location(s) of the portable fire extinguisher with consideration to

→ being in a readily accessible location where access would not present a hazard to the user
→ being in an area that is least likely to be affected by fire

→ the recommendations in AS 5062 ‘Fire Extinguishers’, AS 2444 and AS 1850.

Fire extinguishers should be:

→ easily detached from their mountings

→ have gauges that are easily readable

→ be of a size suitable for the purpose (i.e. appropriate for the type and extent of fire that might occur on the plant).

4.6.3. Firewalls

Firewalls are non-flammable barriers used to separate a heat source from a fuel source. Firewalls should be suitably rated to withstand the potential fires identified in accordance with the fire risk assessment. Firewalls should:

a) be installed for all diesel-powered plant

b) be considered for all electric powered plant

c) separate the engine (heat source) as far as possible from the any fuel source (e.g. diesel fuel, hydraulic fluid)

d) not interfere with the engine ventilation

e) be located to isolate and separate high volume pressurised hydraulic fuel sources (e.g. this applies to hydraulic pump locations).

4.6.4. Pressurised fluid relief

Where there is a risk of fuelling a fire from pressurised fluid systems (such as hydraulic systems, steering systems, accumulators and pressurised fuel tanks,) consideration should be given to providing a method for relieving the pressurised fluid from the vicinity of all the emergency stop points at ground level.

This typically is applicable to large mobile plant.

4.6.5. Automatic shut-off quick fill fuelling systems

Fires have occurred during the refuelling process as the automatic shut-off failed to operate due to lack of backpressure to shut-off the quick fill.

When designing for quick fill refuelling systems, consideration should be given to:

a) identifying all risk scenarios that may give rise to fuel spillage and/or fire during the refuelling process and the provision of reliable control measures in accordance with the hierarchy of risk controls

b) carrying out a failure modes effects analysis (FMEA), or similar analysis, on the final design to identify lifecycle inspection and maintenance requirements

c) using refuelling systems that do not rely on fuel tank pressurisation to stop fuel flow when the tanks are full

d) locating fuel fill points and air vents away from hot engine components as far as possible

e) ensuring fuel dispensing flow rate and air vent capacity of fuel tanks is correctly matched

f) ensuring refuelling nozzles and fuel tank receivers are a matched set

g) checking the designs of fuel tanks to ensure they can accept the high delivery flows and pressure of the refuelling system on a cyclic basis without deformation or deterioration of the fuel tank

h) installing decals on or near the fill points with maximum designed flow rates

i) verifying that the quick fill system design is compatible with the refuelling farm or tanker delivery capacities

j) an engineering means or alternative cap to prevent regular “splash” fill points from being left open and preventing pressurisation of the fuel tank during refuelling

k) using hose compatible with diesel fuel and capable of withstanding the maximum refuelling pressure, even if used as a drain line.

l) The information in SB15-03, Fires ignite while refuelling mobile plant with quick-fill fuel systems

4.6.6. Fire detection and suppression

When the fire risk assessment indicates that detection and suppression systems are needed to manage fire risks such systems should be designed, manufactured, tested and commissioned in accordance with AS 5062. Also refer to AS 1850, AS 1851 and AS 2444. Engine shutdown may be applied by an engine management system, fire suppression system, emergency stops or manually initiated.

Incident data shows the operators leave the plant when it is on fire without shutting the engine down. Failure to shut down the engine results in providing fuel to the fire. When a fire suppression system is installed, activation of the system should automatically stop the fuel supply and stop the engine.

Where mobile plant is in motion, operator training, and procedures should include bringing the plant to a stop as quickly as possible.

4.6.7. Fire protection system design

The fire suppression system should be designed to provide protection to personnel from fires. Design considerations should include:

a) fail to safe, where practical for the type of fire protection system

b) the volume of the area to be covered by the fire protection system

c) the ventilation of the area to be covered by the fire protection system

d) the quantity of fuel, including diesel fuel, oil or other combustible material that may be available to feed the fire

e) identification of hot surfaces where ignition of escaped fluids can occur (e.g. turbo chargers, exhaust manifolds, exhaust tubing and mufflers, resistor boxes)

f) the potential for injury to workers who may come in contact with the extinguishing agent (in either the stored or discharged condition)

g) pressurised carbon dioxide systems are not preferred due to the potential of asphyxiation

h) a means to safely charge/fill the fire protection system

i) ozone protection legislation

j) a pressure relief system to prevent over pressurisation,

k) The ways the system might fail to suppress the fire (i.e. failure modes of the fire protection system).

4.6.8. Activation of fire protection systems

Clear indication of the selected mode of operation (automatic or manual) should be visible from the operator's normal driving position.

Manually operated controls to trigger the system should be provided:

- → within the operator's cabin and located within reach of the operator's normal operating position
- → at ground level or other locations as determined by risk assessment
- → visual indication should be provided for the plant operator to show whether the system is ready for operation or has been discharged.

4.6.9. Electrical control

Each component of an electrical system that supplies fire protection equipment should be separately controlled by an isolator.

The fire suppression system isolator should be clearly marked "Fire Suppression System". This isolator is in addition to the main isolator used to control other components of the equipment. This should apply to both mechanical and electrical controlled systems.

Loss of electric power should not prevent the operation of the fire extinguishing system by manual initiation.

4.6.10. Automatic fire suppression

Where fitted, automatic fire suppression systems should be interlocked to automatically shut down all power so that the plant cannot be operated if the fire suppression system is disabled or faulty.

Where interlocking occurs, the system should allow for manual override to allow control by the operator when required (i.e. for maintenance, rectification, post-event management).

Where automatic fire suppression systems are fitted or installed, a visible and audible warning should be given to the operator when a fire is detected.

4.6.11. Shutdown delay

Automatic fire suppression systems should operate in a sequence that allows the operator to evacuate the plant. The following should be considered:

- → a moving vehicle should be able to be safely brought to a stop
- → the engine should shut down as soon as possible
- → a time delay to allow the operator safe egress.

4.7. Fluid systems

Fluid systems are a convenient and effective method of energy transfer in mobile and transportable plant. This section provides guidance on hazards with fluid systems and control measures which may be

applied in the design, manufacture and supply to minimise unwanted events during plant life cycle activities.

4.7.1. General

Mobile and transportable plant should be assessed against the relevant recommendations of MDG 41, *Guideline for fluid power system safety at mines*.

4.7.2. Fire resistance of hose

Hydraulic hose should be fire resistant unless the hose is in an area with a low risk of fire.

So far as is reasonably practicable, brake, turbo lube hoses and fire suppression system hoses should be able to withstand a fire in its surrounds without failure.

4.7.3. PVC piping

Nylon or PVC piping should not be used for pneumatic safety control systems unless the loss of pressure within these systems causes the system to fail to safety. All such piping should be adequately protected and shielded from contact with hot and/or sharp surfaces.

4.8. Guards and shields

Guards and shields systems should have the capability of isolating a hazard to control harmful consequences. Specific duties apply to plant designers in relation to guards. The plant code provides guidance on mandatory requirements for guards and how to comply with these requirements.

When a hazard cannot be eliminated by design, then appropriate safeguards should be provided. Safeguards should be designed to prevent:

- → workers reaching into the danger zone or other body parts becoming caught or entangled
- → the hazard from the failure of a component
- → contact with a danger point (e.g. nip, shear or crush point)
- → inadvertent contact with hot, hazardous or pressurized fluids (e.g. from fluid couplings or torque converters or hydraulic systems, turbochargers and exhaust manifolds, power take of shafts).

Guards and shields should comply with the relevant requirements of the AS 4024.1 series of standards. ISO 3457 provides some specific guidance for earthmoving machinery

Guards should be fitted:

- → on every fan to prevent contact
- → to prevent contact with every moving component that is readily accessible and can result in injury
- → in the vicinity of any access way where a worker may contact moving equipment.

Moving components within the engine bay should also be suitably safeguarded.

4.8.1. Shields

Shields should be fitted to protect any hydraulic hoses that may be damaged by impact (for example in wheel arch areas, under body).

Shields should be fitted in the vicinity of the turbo charger and exhaust manifold area to prevent pressurised fluids (such as hydraulic / engine oil / diesel fuel) from spraying on hot surfaces. Shields should not create additional fire risk by:

- → trapping fuel or oil around the turbo charger or exhaust manifold.
- → becoming hot enough to ignite flammable fluid e.g. hydraulic oil or diesel.

4.8.2. Fire resistant guards

The use of fire-resistant guards is an important control measure to protecting workers from fires. It is strongly recommended that fire resistant guards be provided as follows:

a) Any covers shields or guards should be constructed from steel or from fire resistant material where the failure of the material is likely to place an operator at risk if a fire occurs. This generally applies to guards or shields that form part of access systems, e.g. engine covers of rear dump trucks.
b) The degree of fire resistance should suit the size of the fire that may eventuate.
c) The engine compartment should be effectively shielded from the operator's compartment in the event of a fire.
d) The means of egress should be effectively shielded from the engine compartment and other significant potential fire sources to provide safe egress for the operator in the event of a fire.

4.9. Marking, signs and labels

Marking, labelling and signs are important as they identify the plant and assist in the safe use of plant over life cycle activities.

4.9.1. General

Where appropriate, permanent markings, signs and labels should be in accordance with AS 1318, AS 1319, ISO 3864, ISO 7010 and ISO 9244.

Where a hazard could exist from the misinterpretation of a symbol the meaning of the symbol should be clarified in writing.

4.9.2. Construction and location

Markings, signs and labels should be of durable construction, be permanently attached and be appropriate for the environment.

Markings, signs and labels should be installed or positioned and maintained so that they are clearly visible.

4.9.3. Labelling

As a minimum, labelling should include:

a) identification of all controls including direction of movement where applicable in accordance with ISO 6405-1 and ISO 6405-2
b) isolation points
c) emergency egress points
d) emergency stops with "EMERGENCY STOP" written.
e) emergency engine shutdown
f) Information is also available in ISO 7010-E020

4.9.4. Compliance plate

Compliance plates or conformance marks should be provided on components where required by the relevant standard and should be displayed in a prominent position. For example, ROPS, FOPS, pressure vessels.

4.9.5. Mobile plant name plate

Mobile plant should have a name plate which provides the following information.

a) the manufacturer and plant model
b) the year of manufacture and the mobile plant serial number
c) weight related limits of the plant, such as tare weight, gross weight, ROPS weight
d) other appropriate plant details.

4.9.6. Limits of application

In the operator's cabin, information should be provided regarding all limits of application of the plant.

On board identification of grade (cross and fore/aft) with the safe limits identified should be provided. This applies particularly to rubber tyred plant, track mounted plant and overburden drills but should also be considered for other plant.

Plant operators are often not able to estimate the grade they are operating on, particularly less experienced operators. Operator error in estimating grade has been identified during accident investigations for drill rigs, excavators, loaders, articulated trucks and cranes.

Note: This information assists in correct operation of mobile plant, it should not be considered a substitute for task risk assessment, operator training and the use of fit-for-purpose plant.

4.9.7. Warning and danger signs

As a minimum warning signs should include:

a) a warning sign adjacent to all accessible rotating components
b) a warning at all accumulators that pressure is to be safely released or isolated before work commences. Refer to MDG 41.
c) a warning on any spring applied component that it contains a spring under compression

d) a warning that "hearing protection should be worn" is to be placed on the plant at relevant locations where the noise exceeds regulatory levels and personnel are required to carry out operational or maintenance activities. For further information: ISO 7010-M003, ISO 7010-W038 and the for *Managing noise and preventing hearing loss at work* code of practice

e) a warning that the park brake should be applied and implements lowered before leaving the mobile plant

f) any other relevant danger or warning signs as identified by risk assessment

g) for analogue gauges, minimum safe operating limits should be indicated by green and red zones. For digital displays, a clear visual or audible indication should indicate whether the pressure is outside the safe operating range

h) any automatic or self-starting plant or plant started remotely should be identified as such.

Further guidance may be typically found in ISO 7010-M003 and ISO 7010-W038.

4.9.8. Action in event of fire

The required operator action in event of a fire occurring should be provided within the operator compartment visible from the normal operating position, similar to the following:

IN CASE OF FIRE

→ Safely stop machine

→ Shut down all power and apply park brake

→ Activate fire suppression system (if fitted)

→ Initiate mine emergency response

Do not endanger yourself by attempting to get down from moving equipment.

Symbols/pictograms may be also used to communicate operator actions in a fire.

4.9.9. Towing, lifting, jacking and supporting plant

Information on the designated locations for towing points, lifting, jacking, tie-down and supporting the plant should be identified in the manual including appropriate instructions.

All towing, lifting, jacking, tie-down and supporting points on plant should be appropriately identified. For example, labelled and painted a different colour for identification.

4.10. Lighting

Lighting is required to give appropriate visibility for safe use of mobile and transportable plant throughout the life cycle activities. Safe operation of mobile plant relies on good visibility for the operator of the plant and any other plant operators or other personnel in the vicinity. At night, suitable lighting on mobile and

transportable plant will be necessary to maintain good visibility. Hazards associated with poor illumination should be identified and control measures implemented, monitored and reviewed.

Refer to investigation fatality report:
www.resourcesregulator.nsw.gov.au/__data/assets/pdf_file/0005/553523/Ravensworth-Investigation-Report.pdf

4.10.1. General

The following applies to mobile plant, which is intended to operate at night or under low light conditions such as fog:

- → Suitable lighting should be provided for mobile plant to allow the plant to operate safely as appropriate for its operational environment. This includes mobile plant which normally operates bi-directionally.
- → Consideration should be given to ISO 12509 for lighting, marking lights, and reflectors.
- → The main access should be adequately lit without interfering with operator visibility.

4.10.2. Emergency lighting

Emergency lighting should be provided to allow for safe egress in the absence of normal power, unless the operator can leave the plant safely without exposure to hazards or risk of injury.

This typically applies to larger items of mobile plant such as large excavators.

4.10.3. Reversing lights

Reversing lights should be provided on all plant except on mobile plant that operates bi-directionally.

The lights should provide the operator with adequate visibility when reversing at night.

Note: Mine site consideration should also be given to additional work lightning to provide adequate visibility when reversing

For audible reversing alarm refer to section 3.6.5.

4.10.4. Brakes and direction indicators

Mobile plant that is intended to operate on haul roads or other trafficable roads should be provided with the following:

a) direction indication blinker lights at the front, rear and side of the plant
b) service brake indication lights readily visible from the rear of the mobile plant
c) retard brake indication lights readily visible from the rear of the plant. This is applicable for electrical and mechanical retarding systems
d) consideration should also be given to indication on the front of trucks for service brake and retard operation so oncoming mobile plant is aware of the truck's operational mode
e) indicators should be of the multiple LED types or similar.

4.10.5. Reflectors/parking lights

Parking lights are used to identify the presence and shape of parked plant. Parking lights may also be used as operational lights to maximise the visibility and shape of the plant.

Adequate reflectors, reflective tape and/or parking type lights should be provided on all mobile plant to make it readily visible from any direction and hence reduce the likelihood of a collision (e.g. during operation and for broken down plant). This includes lights or reflectors visible from the side arranged in strips to assist in identifying the length of the plant. This applies to diesel-powered overburden drills, dump trucks, loaders and graders but should also be considered for other plant.

Reflectors, reflective tape and or parking lights should also be placed on the tray head board or highest extremity of all trackless plant to provide visibility from all directions in undulating terrain.

4.11. Noise

Specific duties in relation to noise apply to designers, manufacturers, importers, suppliers, installers and constructors of plant or structures. See the guides detailed in Appendix A and the *Managing noise and preventing hearing loss at work* code of practice for more information.

Consequences of noise may include:

- → hearing loss
- → nearby workers may be distracted from their tasks and may have difficulty hearing others or being heard by them
- → impact on neighbours or others in the area outside the mine or petroleum site.

4.11.1. Noise assessment

Information should be provided on the noise emission values of mobile and transportable plant, the operating conditions of the plant when the noise emission is measured, and the methods used to measure the noise emission.

Noise analysis should be carried out in accordance with the AS/NZS 1269 (series) with consideration to ISO 6394 and ISO 6396.

The sound power level and sound pressure level determined in these tests should be published in the operation and maintenance manual.

Note: where the type of mobile plant that is outside the scope of these standards, an alternative industry published standard could be used.

4.11.2. Operator or bystander noise exposure

ISO 6394 and ISO 6396 specify the method for determining the emission sound pressure level of the plant at the operator position. AS/NZS 1269 provides guidance on the measurement and assessment of noise emission and exposure to a bystander of the plant.

4.12. Operator's cabin and protection

Specific duties apply in relation to operator protection under clauses 214 – 218 inclusive of the WHS Regulation 2017.

This section of the guide is intended to provide guidance on operator and passenger protection in mobile plant.

4.12.1. Operator protective devices

So far as is reasonably practicable a suitable combination of operator protective devices must be provided, used and maintained where there is a risk of:

a) mobile plant overturning
b) things falling on or against the operator of the mobile plant
c) an operator being ejected from the mobile plant
d) the plant colliding with any person or thing
e) mechanical failure of pressurised elements of plant that may release fluids that pose a risk to health and safety.

All passengers must be provided with the same level of protection equivalent to that provided to the operator.

A risk assessment should be carried out to determine the risk of unintended overturning, an object hitting the operator or a falling object coming into contact with the operator. For example, overburden drills operating near high walls, should be provided with a falling object protective structure.

4.12.2. Roll over protection

Roll over protection (ROPS) is mandatory on tractors and should be fitted to the following mobile plant due to the risks of roll over:

a) wheeled prime-movers
b) wheeled off-highway dump trucks
c) wheel and track dozers
d) scrapers
e) graders
f) rollers
g) loaders
h) excavators
i) water trucks operating on haul roads
j) fuel and lubrication trucks intended to be operating on haul roads (not road registered delivery trucks).

It is mandatory for earthmoving machinery to be fitted with securely fitted protective structures. ROPS should be in accordance with ISO 3471, except for excavators. Excavators should have tip over protection (TOPS) which should be in accordance with ISO 12117, AS 4987, or ISO 12117-2, as applicable.

Note: For fork lifts, refer to ISO 6055/AS 2359.9.

4.12.3. Falling object protection

It is mandatory for earthmoving machinery to be fitted with securely fitted protective structures. Falling object protection (FOPS) should be fitted to the following plant where the operator is seated in accordance with ISO 3449. This includes plant such as:

a) loaders
b) graders
c) dump trucks
d) rollers
e) dozers
f) drilling rigs – wheel or track mounted
g) blast-hole drills on the surface of mines
h) fuel and lube trucks which may operate near high walls
i) trucks underneath loading bins.
j) The falling object protection used should be designed and manufactures provide suitable protection for the operator under all conditions in which it may be used.

Refer to investigative report:
www.resourcesregulator.nsw.gov.au/__data/assets/pdf_file/0011/345746/Ravensworth-loading-bin-fatality-report.pdf

For earthmoving plant, FOPS should be in accordance with ISO 3471, except for excavators. Excavators should have an operator protective guard (OPG) in accordance with ISO 10262, where applicable.

4.12.4. Cabins

The following apply to operator cabins:

a) Operator cabins should be totally enclosed and sound-suppressed.
b) Maximum visibility should be provided to the operator. For example: cabin could be integral with any ROPS, TOPS, FOPS or OPG operator protection system.
c) A risk assessment should be conducted to determine the required glass specification for protection from impact and pressure. As a minimum, windows should be fitted with laminated glass or equivalent. For Dozers subject to engulfment on stockpiles, 276kpa (40psi) dual pane impact resistant glass should be considered (see MDG 28, *Safety Requirements for Coal Stockpiles and Reclaim Tunnels*).
d) Windscreen washing and wiping facilities should be provided.
e) Where tilt cabins are used on mobile plant, they should be so supported that seat-belted personnel within the cab cannot be injured by inadvertent movement of the cab relative to the plant chassis.
f) Storage for tools should be outside the cabin. Where cabins have storage space, this should be secured to prevent projectiles in any accident.
g) The operator and/or passenger cabin should be designed to minimise any protruding or sharp edges that may cause injury in the event of an accident or sudden movement.
h) Exposure to airborne dust or emissions should be minimise though pressurised filter cabins.

4.12.5. Heating, demisting and fresh air supply

Heating, demisting and fresh air supply should be provided as follows:

a) be capable of adequately demisting the operator's cabin window
b) supply filtered external makeup air sufficient to maintain a positive pressure inside the operator's cabin with windows and doors closed
c) the air supply system should make adequate allowance for deterioration of door and window seals
d) the heater should have isolating valves fitted to both supply and return lines adjacent to the engine to allow changing of heater hoses and/or core without disturbance to the engine cooling system.

Guidance on the operator enclosure environment is given in ISO 10263 Parts 1 to 6.

4.12.6. Air conditioning

Where air conditioning is used as a control measure to prevent heat stress or consequences from other environmental hazards the following should be considered:

- → the mounting of the air conditioner and accessories should not interfere with operator visibility or cabin headroom within the applicable ergonomics standard
- → the air conditioner's mountings should not interfere with the structural integrity of ROPS, FOPS, TOPS or OPG
- → the air conditioner intake location should be located to avoid:
  - exhaust emissions
  - areas where significant fuel and heat sources are present or where fumes from a fire may be expected to concentrate.

Note: Provisions of the *Ozone Protection and Synthetic Greenhouse Gas Management Act and Regulations may apply.*

4.12.7. Seats and personal restraint systems

Seats and personal restraint systems (for example, seat belts, padded bar type device) should be in accordance with the following:

a) the operator's seat should be a high-backed type where suitable, fully suspended and adjustable, see ISO 11112
b) seat belts should be provided for all seats on any rubber-tyred plant and tracked plant
c) all seat belts and anchorages should comply with SAE J386 or ISO 6683
d) personal restraining mechanisms should be designed and installed under the plant manufacturer/supplier's instructions and wherever possible factory fitted to the plant.
e) all equipment fitted with legislated operator protection systems must include seat and personal restraint as part of those systems.

4.12.8. Visibility

The following apply to operator visibility:

a) Operator visibility should be maximised, for example, auxiliary plant should be located where it will not interfere with visibility.

b) The manufacturer/supplier should provide an as-built drawing which identifies the operator's field of vision. A suitable diagram should be available in the operator's cabin;

c) Reference should be made to ISO 5006 in the review of visibility.

d) Guidance on rear view mirrors is given in ISO 14401 Parts 1 and 2.

e) Closed circuit television system/reversing cameras should be considered for large plant blind spots.

4.13. Pressure vessels

Pressure vessels under certain conditions may violently fail, resulting in harmful consequences. This section provides guidance to avert those harmful consequences.

4.13.1. Standards

All pressure vessels should be designed, inspected, maintained and operated in accordance with the following standards (or equivalent international standards):

- → AS 1200 Pressure Equipment
- → AS 1210 Pressure Vessels
- → AS 3788 Pressure Equipment – In Service Inspection
- → AS 3873 Pressure Equipment – Operation and Maintenance
- → AS 3892 Pressure Equipment – Installation
- → AS 4343 Pressure equipment – Hazard levels
- → AS 2030.1, Gas cylinders – General requirements
- → AS 2030.5 Gas cylinders – Filling, inspection and testing of refillable cylinders.

Pressure equipment may need to have their designs registered. The plant code and other guidance listed in Table 1 of Appendix A provides guidance on plant registration or refer to Schedule 5 Parts 1 & 2 of WHS Regulation 2011.

4.13.2. Accumulators

To eliminate or minimise the risks associated with accumulators the following matters should be addressed:

a) All accumulators should be designed, manufactured, installed, labelled, maintained and inspected in accordance with the standards in 4.13.1. Accumulators are regarded as pressure vessels so depending on their size and pressure rating, may require design registration.

b) Accumulators should be securely installed.

c) Where a hydraulic system incorporates an accumulator the attachments to the accumulator should be by means of a minimal length adapter and flexible hose.

d) Fittings should be located or otherwise guarded to provide mechanical protection against operational and maintenance damage, for example rock damage, stepping onto components during maintenance and similar.

e) A manual bleed valve or other prescribed method should be fitted to allow pressure relief for maintenance purposes. This should preferably be accessible from ground level and fluid should return to tank.

f) A safety relief valve should be included in the manual gas charging circuit where gas charging accumulators are installed.

Warning – fatalities and serious bodily injuries have occurred due to failure of the fittings connecting accumulators to hoses. Refer to MDG 41 for information on fit-for-purpose hoses.

4.14. Steering

Failure of steering systems can result in catastrophic consequences. This section gives assistance in control measures to minimise the occurrence of harmful outcomes.

4.14.1. General

All plant should be capable of safe operation in the event of engine or power failure to enable the plant to be brought safely to rest. Steering should comply with ISO 5010.

Power assisted and fully powered steering systems should preferably be separate from other systems and circuits. Where this is not the case the power assisted and fully powered steering systems should have priority over other systems or circuits except for an emergency steering system.

4.14.2. Emergency steering

Emergency steering should be provided where the plant operator may not be able to safely bring the plant to rest in the event of engine failure or loss of power. The operation of tractor scrapers, articulated trucks and dumpers poses particularly risks. Fatalities have occurred due to emergency steering systems failing to operate when required.

Emergency steering should be capable of at least 1.5 turns lock to lock of the steering wheel after an engine shutdown. This is to enable the operator to control the plant to bring it safely to rest. Control measures used to effect emergency steering should include devices to automatically confirm that emergency steering is fit for use during plant operation.

Emergency steering should comply with ISO 5010.

4.15. Lifting, towing, jacking and supporting

Lifting, towing, jacking and supporting arrangements rely on engineering systems. This section provides guidance in affecting such system to minimise unwanted events.

4.15.1. General

To enable mobile plant to be lifted or towed for maintenance purposes, appropriate lifting, towing, jacking and supporting points should be provided, as applicable to the type of mobile plant. The principles referring to mobile plant in this section should be considered where applicable to transportable plant.

4.15.2. Lifting of mobile plant

The design of jacking and support stands should comply with AS 4100 or 3990. Where lifting of mobile plant is required, a fit for purpose means of lifting should be provided for and details included in the operating manual.

All lifting points should be provided with a minimum factor of safety of 2.5 on all rigid parts and a factor of safety of 4:1 on any chains, slings or connectors. Consideration in the design of lifting lugs should be given to any side pull forces which may reasonably occur from the rigging arrangement.

4.15.3. Towing of plant which is inoperable

Where towing may be required, a means of towing should be provided for and included in the operating manual. In achieving this:

a) designed towing attachments and connectors should be at the front and rear of the plant
b) towing attachments should be designed to tow an unpowered machine up any operational grade
c) information on the maximum design load and direction of load specified should be provided in the manual
d) information should also include consideration for release of the brakes and operation of the steering system for the movement of the mobile plant where there is an engine failure
e) a minimum factor of safety of 2.5 on rigid parts of the towing system (such as attachments, drawbars) should be provided
f) for the design of towing points consideration should be given to potential impact forces on the towing system resulting from dynamic loading.

Typical guidance is available in ISO 10532 for performance of machine mounted retrieval devices. Information can also be found in:

- → ISO 15818 for lift and tie down requirements on earthmoving machinery
- → ISO10532 for machine mounted retrieval device requirements
- → ISO 1333 for lifting devices for dumper body supports and operators cab tilt support devices.

4.16. Wheels, rims and tyres

Fatalities have resulted from issues relating to wheels, rims and tyres. This section provides guidance to designers/manufacturers/importers and suppliers to assist in minimising the potential for unwanted events over life cycle activities.

Wheels, rims and tyres on mobile plant should be capable of withstanding designed wheel loads and intended mobile plant duty. The type and size of wheel/rim/tyre should be stated. Principles in this section should also be considered for transportable plant.

Split wheel rims should not be used, unless there is an effective means to prevent disassembly when the rim/tyre is attached to the mobile plant. Appropriately documented procedures with fit-for-purpose equipment should be used when carrying out maintenance or service activities. Fatalities have occurred while carrying out maintenance and service activities involving split rims. Split wheel rims include multi-piece rims, multi-piece wheels and divided wheels where two sections of the wheel are bolted together.

The manufacturer of wheels/rims, tyres should recommend:

- → the maximum permissible duty cycle (TKPH) and tyre pressure
- → procedures for servicing wheel rims and tyres, including in particular multi-piece wheel rims, refer AS 4457.1 & AS 4457.2.

For further information refer to SafeWork Australia document *Guide for split rims*

Note: The above standards apply to wheels and rims with a diameter of 600 mm (24 inch) or more, however the principles should be applied to all wheel assembles.

4.17. Proximity detection and collision avoidance

Fatalities have resulted from the unwanted harmful interaction of plant and people. Risk management techniques should be used as a basic process to identify the level of risk and the need by proximity detection and/or collision avoidance system.

Proximity detection systems alert people to the imminent interaction between equipment to people, equipment to infrastructure and equipment to equipment.

Collision avoidance is initiated by proximity detection and includes provision for evasive action.

MDG 2007 provides further information on how to select and implement these systems.

Taking consideration to the type of mobile plant and the intended mobile plant activities, proximity detection and collision avoidance systems should be provided, so far as reasonably practicable, where there is a serious risk to safety.

4.18. Remote control plant

Fatalities have occurred from the unwanted harmful interaction of plant and personnel. Refer to the International fatality data base for further information.

Risk management techniques should be utilised as a basic process for remote control plant operation. Refer to AS/NZS 4240.1 & 2 for information on remote control system for mining equipment.

4.19. Driverless operation of plant

Driverless plant is capable of navigation and operation on a designed route and operational criteria. It has minimum human interaction and does not require the presence of a driver either on board the plant or operating the plant remotely. The context of the operation and operational parameters are pre-set, controlled and monitored usually through computer control at a remote location.

Driverless plant may detect surroundings using radar, lidar, GPS, Odometry, and computer vision. Advanced control systems interpret sensory information to identify appropriate navigation paths, as well as obstacles and relevant signage. Driverless cars have control systems that are capable of analysing sensory data to distinguish between different cars on the road, which is very useful in planning a path to the desired destination.

The driverless plant should be designed to perform all safety-critical earth-moving and mining functions related to its defined operations. The operator may provide destination or navigation input but is not required for direct control during the defined operation.

Table 6 below may assist in identifying key hazards associated with driverless plant and selecting the appropriate controls to manage those hazards. The table may also assist in discussions between the mine or petroleum site operator or other PCBU acquiring the plant and the designer or supplier in relation to the development or supply of such plant.

Table 6: Key hazards and control measures in relation to driverless plant.

Hazard	Control measures

Interaction of people and plant	Eliminate or minimise inadvertent access of personnel into autonomous operational plant areas by adhering to the hierarchy of risk control preferably utilising control measures that are not affected by human behaviour. Refer to section 2.2.
	
	Possible controls include:
	• avoiding the need for personnel to interact with operating plant
	• identifying areas as 'no go zones' when the equipment is in operation
	• providing means to minimise the potential for access by unauthorized personnel and trespassers for example
	  ○ using proximity detection devices to assist with the management of no-go zones
	  ○ using fencing or other physical barriers
	Provide for authorised access in the event of maintenance and breakdown activities supported by safe systems of work including-
	• provide means to safely isolate and verify isolation of plant before maintenance proceeds
	• consider whether effective isolation will require isolation of the whole or part of the plant
	• consider isolation of plant operating nearby and the use of designated maintenance areas
	• have clearly documented means of isolation and means to ensure isolation has been achieved
	Provide for authorised access during commissioning supported by safe systems of work including
	• minimising the need for people to interact with the plant during commissioning activities (consider remote sensing and gauges and/or, computer monitoring to provide data on performance criteria)
	• providing means to isolate and verify isolation of plant before access is required during commissioning. Consider whether effective isolation will require isolation of the whole or part of the plant and isolation other plant operating nearby
	Provide for competency of personnel as appropriate including training and assessment of competency in:
	• the safe operation of autonomous plant
	• installation and commissioning
	• administrative and engineering arrangements to limit access of personnel into autonomous operational plant areas

- safe repair and maintenance procedures
- ensuring that training is applied in practice (for example monitoring compliance with procedures and providing refresher training as needed)
- ensuring procedures and training are revised as changes are made

Unintended operation of plant or unplanned movement	Provide arrangements to limit and manage access to software controls and operational controls including • testing and commissioning software to a documented procedure every time changes are made, or components are changed • the level of commissioning for each change should be identified Ensure equipment operates as intended by including the following considerations: • Identifying critical plant parameters and providing multiple layers of control for these parameters (for example LOPA – layers of protection analysis). The layers of control should be checked for effectiveness • providing a reliable means to prevent ingress of water into electrical controls, such as the use of suitable IP rated components • ensuring that the control system will not respond to extraneous signals (e.g. from in-mine radio communications or other sources) in an unplanned or unexpected fashion • providing a means to detect contamination, wear and deterioration of critical components (such as spool valves, hydraulic components etc.) • providing a means, where possible and appropriate using engineering controls, to prevent operation of the plant before a hazardous situation results should contamination, wear and deterioration of critical components occur (for example a hazardous situation caused by the seizure of a pilot operated spool valve). • the designer determining the appropriate safety integrity of componentry to ensure that the system meets specification and operational requirements Establish arrangements to monitor, review and revise control measures including: • Monitoring for any issues (issues may be identified through consultation with workers, observation of work activities or capturing and analysing relevant data, safety alerts and bulletins) • A clear management process to address incidents and advice such as safety engineering bulletins from OEMs • Maintain an open dialogue between OEM and mine or petroleum site operator to ensure an exchange of safety related information. • Providing play back software that is clear, relevant and user friendly such as for software that provides plant performance details from electronic data logs, for example logging an unplanned movement) Designers/manufacturers/suppliers should identify and provide information on the limitations of the system for example potential for interference from other devices, tolerances on navigation arrangements

For further information, a committee draft standard ISO/CD 17757 *Earth-moving machinery and mining – autonomous and semi-autonomous machine system safety* is under development and a draft was distributed for review and comment in November 2015.

Western Australia Department of Mines and Petroleum Resources Safety has a code of practice available *Safe mobile autonomous mining in Western Australia*.

4.20. Electrical requirements

4.20.1. General

The electrical wiring of all mobile and transportable plant should be designed and manufactured to comply with the requirements of AS/NZS 4871.1 and AS/NZS 4871.6 or an equivalent standard.

Note: IEC 60204.1 provides some guidance on electrical requirements for machines, however it may not cover all recommendation in the AS/NZS 4871 series of standards.

4.20.2. Trailing cable supplied plant

Trailing cable supplied plant should comply with the requirements of AS/NZS 3007 series, AS 60204.1 and AS 60204.11 or equivalent standards.

5. Safe design of specific types of plant

5.1. Dump trucks

To minimise injury to drivers/operators, dump trucks should be so designed so that the tail from one vehicle is not able to enter the cab of another vehicle or alternate means are implemented to protect the operator.

This should not be achieved by any means that restricts the operator's visibility, for example, moving the operator's cabin back.

Means to achieve this typically include consideration of:

- → extended bumper bars
- → proximity systems that alert relevant personnel and/or control systems
- → collision avoidance systems.

5.1.1. Dump body warning device

To avoid the unwanted events of a raised dump body tray connecting with overhead structures for example power lines or affecting truck stability, control measures should be implemented.

A warning device should be provided in the operator's cabin, to indicate when the rear dump body is elevated.

The device should be visual and/or audible and located such that it is readily noticed by the operator.

5.1.2. Dump body interlocks

When the rear dump body is elevated, propulsion in the forward and reverse direction should be inhibited. However, forward propulsion may be provided when either:

- → an interlock limits forward direction to first gear (or slow speed) and the interlock remains active until the dump body has fully lowered
- → a switch is provided to restrict propulsion to the forward direction only which contains the following features:
  - when operated and held in position, forward propulsion is possible at low speed only
  - when released the switch should automatically return to a position where all propulsion is inhibited while the rear dump body is raised
  - the switch should not prevent the operation of the rear dump body raised warning device.
  -

5.1.3. Dump body restraint

To avoid crush injuries to workers involved in maintenance and inspection beneath a dump body, rear dump trucks should be provided with a 'means' of restraining the dump body when in the raised position for inspection or maintenance.

Any power down controls should be able to be isolated.

This 'means of restraint' should:

- → consist of posts, pins, slings or similar
- → have a minimum safety factor of 4 to 1 when applied to the maximum possible down load that can be exerted on the dump body when the dump body is in the raised position, except where a load lock type device is fitted, and its operation is confirmed on the body lift cylinder in which case a minimum FOS of 2:1 should apply.

For further guidance, see ISO 13333.

5.2. Conveyors

Conveyors on mobile and transportable plant should comply with AS 4024.3610. and AS 4024.3614.

5.3. Mobile processing units for explosives (MPUs)

To prevent unwanted outcomes involving explosives plant (vehicles) used for the manufacture of explosives, mine sites should comply with the *Australian Explosives Industry and Safety Group (AEISG) code of practice for mobile processing units* (as amended from time to time).

6. Use of mobile and transportable plant

The plant code and the MECP code provide practical guidance on complying with legal requirements for the safe operation, maintenance and disposal of plant. The use of mobile and transportable plant at a mine or petroleum site must be undertaken in accordance with the mechanical engineering control plan

for the site. This chapter provides **additional** guidance in relation to mobile and transportable plant at mine or petroleum sites including:

- → introducing the plant to site
- → operational arrangements
- → the impact of road design and characteristics, including grade, camber, surface, radius of curves and intersections,
- → isolation and energy dissipation
- → maintenance

Roads and other vehicle operating areas are a principal mining hazard at mines sites. Schedule 1 of the WHSMP Regulation sets out additional matters to be considered in developing a principal hazard management plan for roads and other vehicle operating areas.

6.1. Introduction to site

6.1.1. General

The MECP code provides guidance on introducing plant to a site. Hazards should be assessed to minimise the potential for injury to personnel such as from fire, unplanned, movement and plant not being fit for purpose. Before use at a site, plant should be assessed against the mine standards (as specified in the MECP) or other appropriate standards (for example - Cranesafe Inspection Report).

The introduction to site should include:

- → assessing the mobile and transportable plant to the relevant recommendations in this guideline
- → checking the mobile and transportable plant for potential fire risks, such as rubbing hoses
- → checking the functionality of all safety critical systems
- → checking the mobile and transportable plant to the mines engineering standards and their MECP.

The plant should be accompanied by the plant safety file to assist with mine site assessment.

On the introduction of any plant to a mine site a risk assessment(s) to identify risks associated with that plant should be conducted. Part of such risk assessment(s) should include:

- → hazards to the operator
- → hazards to the maintainer
- → hazards associated with operating that plant in the overall context of the site
- → risk assessments should include learnings from incident reviews and consider human and organisational factors.

Plant that is not covered by MDG 15 but may be required to operate on a mine or petroleum site should be subject to:

6.1.2. Plant safety file

a) The mine operator should maintain a register of all plant on the site. The MECP code provides details of what should be included in a plant safety file.

b) In the case of **mobile plant**, the records should contain the following additional fields:

   i. description of the mobile plant, as described by the mobile plant manufacturer (for example rear dump truck, six-wheel drive articulated truck, load haul dump, wheeled loader, etc)
   ii. unladen mass of the mobile plant
   iii. maximum payload of the mobile plant
   iv. maximum number of people the mobile plant is designed to transport.

c) In the case of **transportable plant,** the following additional fields should be contained within the file:

   i. description of the transportable plant as described by the manufacturer
   ii. mass of the transportable plant

d) In the case of **remotely controlled plant**, the records should contain the following additional fields:

   i. legal name of the remote-control system manufacturer
   ii. type of remote-control system (radio, umbilical cord, infra-red, etc)
   iii. model number of the remote-control system
   iv. serial number of the remote-control system receiver and all associated transmitters
   v. legal name of owner supplier of the remote-control system
   vi. date the remote-control system was used or arrived at the mine site.

e) In the case of **autonomous plant (driverless)**, the records should contain the following additional fields:

   i. legal name of the autonomous control system manufacturer
   ii. type of autonomous control system (radio, umbilical cord, infra-red, etc.)
   iii. model number of the autonomous control system
   iv. serial number of the autonomous control system receiver and ALL associated transmitters
   v. legal name of owner supplier of the autonomous control system
   vi. date the autonomous control system was used or arrived at the mine site.

6.1.3. Risk of fires on mobile plant

Where the mine operator or other PCBU is considering the risk of fire associated with plant the mine or petroleum site operator or other PCBU should undertake a fire risk assessment. See 4.6.1 for matters to be considered and who should be involved in a fire risk assessment.

6.1.4. Plant not specifically designed for mines

Attention should be paid to road registerable plant or other plant not specifically designed for mines to ensure it is suitable for the conditions at the mine for example:

- → Conducting an in-service performance brake test to verify the mobile plant can stop on the maximum grades for use such as when planning to use a concrete agitator on the decline into a metal mine.
- → Ensuring appropriate maintenance regimes. There have been several incidents where backhoes, water trucks, tractors, and similar where the safety critical systems on the plant have not been maintained in a satisfactory condition.

Pre-operational and periodic inspection by a competent person should include checking:

- → the vehicle has been maintained and is in a fit for purpose condition to enter the mine or petroleum site
- → all safety critical systems are functional
- → the vehicle is structurally sound including inspection of the undercarriage, body, suspension, brakes and all other structural areas
- → tyres are in good condition
- → brakes are functioning properly and are appropriate for the operating environment and grades.

Consideration should be given to how the plant will comply with any site rules and whether arrangements such as flags, escorts or flashing lights are needed.

The crane safe assessment program operated by the Crane Industry Council of Australia may provide a means to assess a crane's safety using a third-party assessor. Care still needs to be taken to ensure that the crane can operate safely for its proposed use.

6.2. Operational arrangements for mobile and transportable plant

6.2.1. Operational considerations

In managing the risks associated with the operation of mobile and transportable plant at the mine or petroleum site the following should be considered:

a) Training operators in the safe operation of the plant. For example, the safety critical systems, the emergency systems, fire detection and suppression systems, the correct gear, speed and use of retarder to descend a grade whether empty or fully loaded.
b) Operating factors such as road conditions, visibility, traffic and weather.
c) Ensuring operator/passenger restraint systems are used.
d) Where safety features or warning devices are incorporated into plant, ensuring the features or devices are used as intended.
e) Undertaking prestart safety checks to identify all defects, which may affect the safe operation of the machine. The use of the plant should be discontinued until assessed by a competent person as fit for purpose.
f) Arrangements to ensure mobile plant is not overloaded or operated outside the operational limits as specified by the designer/manufacturer/supplier.

g) Seats and restraint devices should be used exclusively for safely carrying and securing persons. On no account should these seats be used to carry goods or ancillary equipment.

Specific duties apply under the WHS Regulation in relation to the use of plant. Under clause 206 the mine operator or other PCBU with management or control of plant at a workplace must take all reasonable steps to ensure that plant is used only for the purpose for which it was designed, unless the person has determined that the proposed use does not increase the risk to health or safety.

6.2.2. Haul roads and grade operating limits

Steep grades create significant risks when operating mobile plant at mine or petroleum sites. To manage these risks, consider the following:

- → designing haulage roads to grades of 10% or less wherever reasonably practicable.
- → reviewing site haulage routes to identify all plant travelling on grades more than 10% (for brake slope capability, see ISO 3450) and verifying with the plant manufacturer or a competent person that the plant can safely operate on that grade.
- → Implementing appropriate control measures where descending grades exceed 10%. For example, a sign placed at the top of the ramp stating the grade, the gear to be preselected; and the maximum descending speed.

These considerations should be reflected in the arrangements for the design of mine haul roads and included in the principal hazard management plan for roads and other vehicle operating areas. See the *Safety management systems in mines* code of practice for more information on principal hazard management plans.

The MECP or the principal hazard management plan for roads and other vehicle operating areas for the mine or petroleum site should include:

- → details of the maximum safe operating grade of all mobile plant
- → arrangements for ensuring plant is not operated on higher grades
- → arrangements to prohibit the use of mobile plant without adequate braking capacity. Some mobile plant may not be suitable for use on grades greater than 10% because of inadequate braking capacity.

6.2.3. Risks associated with out of control plant

Loss of control of mobile plant poses major risks at mine or petroleum sites and results in many incidents. In managing the risks of mobile plant duty holders should identify all foreseeable hazards associated with plant if control is lost and adopt appropriate control measures. In identifying these risks duty holders should ensure the following matters are considered:

a) the potential failure of any safety critical systems, or other safety related components of the plant
b) the condition of roads including; line of sight for the operator, potential for impaired vision from dust, fog, rain or other factors, signage and fit for purpose bunding or windrows
c) site environmental conditions that may lead to loss of traction between the wheels/tracks and ground or skidding
d) operator error (see Appendix D)

e) operator actions in an emergency, such as abandoning the plant without initiating emergency procedures in the event of fire or loss of control. Emergencies may include the failure of brakes, steering, a major fire, a lightning strike or contact with overhead power lines.

6.3. Isolation and energy dissipation

A person should not carry out repairs to mobile or transportable plant unless all energy sources is isolated and cannot be reconnected accidentally before it is safe to do so.

The system of isolation adopted should incorporate a tagging system, a locked isolation system or permit system and in any case, should also include a method of verification that isolation and / or energy dissipation is effectively established. Human error should be considered when selecting the type of isolation system.

The MECP code, AS 4024.1603 and MDG 40 *Hazardous energy control* provided guidance on energy isolation

Effective means of energy isolation, dissipation and verification of should include:

a) **identification of all energy sources** to prevent a release of energy, (such as stored fluid power, gravity, (suspended loads), springs, electrical) and / or prevent unintended activation or movement of equipment
b) provision of a **means to isolate** all identified energy sources to prevent a possible state change. This includes purpose designed isolation devices that are lockable. This also includes using purpose designed mechanical stops to isolate against gravity where required.
c) provision of a **means to safely dissipate fluid.** If used as part of the isolation process a dissipation device should be a purpose-designed dissipation device and lockable.
d) provision of a **system that verifies** that pressure has been dissipated. (Test for dead or safe state)
e) **clear identification** of all isolation and dissipation points
f) **provision of safe work methods** for the use of the isolation, dissipation and verification devices. Should include removal and restoration of energy.
g) information on **required people competence** to isolate, diffuse and verify isolation.
h) information available in the MECP code.

Note: There may be more than one source of electrical or hydraulic energy supply as well as gravity, all of which should be isolated.

Where energy is unable to be isolated, procedures should be developed to ensure the safety of workers involved. Regrettably failure to isolate effectively has resulted in several fatal accidents. It cannot be overstressed how important it is to understand and apply isolation techniques which are appropriate for the circumstances.
Refer to the fatality database: www.resourcesregulator.nsw.gov.au/safety-and-health/incidents/international-mining-fatality-review

6.4. Maintenance

To minimise unwanted outcomes during maintenance activities appropriate control measures should be implemented. Fatalities have resulted from inappropriate maintenance activities. Refer to the fatality database.

Maintenance arrangements for mobile plant should be in accordance with the MECP for the mine and should:

a) identify and document all safety critical systems
b) maintain, periodically check, test and verify all safety critical systems and warning devices to confirm functionality
c) ensure safety critical systems are maintained to be effective
d) confirm relevant workers involved with plant are familiar with all safety critical systems, trained, unimpaired and competent for the task at hand
e) ensure a competent person inspects plant periodically and verifies it is safe to operate
f) ensure a competent person inspects plant that has safety related defects or damage before the mobile plant is placed back into service
g) ensure major repairs or modifications are carried out in consultation with the manufacturer or verified by a competent person as safe
h) ensure operator/passenger restraint systems are supplied, correctly installed and maintained
i) ensure site maintenance practices are periodically audited against the site's safety management system and MECP
j) ensure any changes to the supplied safety features or devices are assessed and documented by a competent person. Where possible the designer or manufacturer should be involved in any assessment regarding the safety feature. The competent person should assess that the change does not present an increased risk to health or safety.
k) include post maintenance inspections to minimise the risk of fire from the maintenance activities.

    Note: Fires have occurred after mobile plant being returned to service following maintenance due to fuels such as hydraulic oil spill in the engine compartment. Similarly, failure to do up hoses or clamps to the correct tension, failure to re-install shields or guards and poor housekeeping can also result in fire. A specific fire risk inspection following service or maintenance activity may reduce the possibility of fire.

l) follow manufacturers recommended maintenance practices and use components (especially hoses and tubes) that are properly installed (and routed). Always use the manufacturers recommended parts (or equivalent).

The plant code and MECP code provides guidance on several matters relating to maintenance (see section 4.5.2.3 of the MECP code.) Section 4.5.3.1 of the MECP code provides guidance on the routine and non-routine maintenance records that should be included in the plant safety file to assist in ensuring

The MECP code also includes guidance on safe work procedures, training and competency.

6.4.1. Training in relation to mobile and transportable plant maintenance

Training in relation to the plant should include, as a minimum, the following:

a) knowledge and understanding of hazards and the required controls. For example: maintaining plant adjacent to power lines, or maintenance activities concerning tyres, wheels and rims.
b) plant safety procedures, including emergency procedures
c) the correct and safe way of operating and maintaining the plant

d) understanding the purpose, function and use of safeguards which protect personnel
e) reporting of faults and defects
f) statutory requirements including guarding, ROPS, registration of pressure vessels, noise management, etc
g) automatic and manual fire system
h) actions in the event of a fire.

Training material and refresher courses should be updated as new information becomes available

6.4.2. Safety critical systems

The person conducting a business or undertaking with management or control of the plant should periodically verify all safety critical systems and safety devices are installed, functional, maintained with records being kept in the plant safety file. Refer to 3.2 for design, manufacture and supply information

6.4.3. General maintenance arrangements

The MECP for the mine or petroleum site should provide for the following general matters:

a) keeping a register of slings and lifting equipment and inspecting equipment as part of a maintenance program.
b) maintaining fire extinguishers in accordance with AS 1851.
c) testing on-board brakes and electrical retard brakes as part of the maintenance plan including keeping a record of the results
d) applying the principles of *Australian Standard AS 4457.1 Earth-moving machinery – Off the road wheels, rims and tyres – Maintenance and repair, Part 1: Wheel assemblies and rim assemblies*
e) periodic inspection of tyres by competent people in accordance with the tyre manufacturers documented procedures. Maintenance and repair criteria as in AS 4457 parts 1 and 2 should be considered.
f) ensuring walkways, flooring, work areas etc. are kept clean to allow safe use and prevent fires.
g) providing for safe access to allow maintenance and service activities to occur
h) periodic structural integrity inspections of plant.

6.4.4. Structural repairs

Structural repairs to mobile and transportable plant should be designed and implemented under the direction of the original designer, manufacturer or otherwise a competent person such as a professional structural or mechanical engineer.

The repairs should meet the designers, manufacturers or competent persons requirements.

Details of any repairs that have been carried out to ‘as built/supplied’ plant should be included in the plant safety file.

6.4.5. Wheels, tyres and rims

Wheels, tyres and rims have been parts of plant which have been involved in several fatalities. This equipment requires particularly attention to ensure unwanted or catastrophic outcomes do not result.

Refer to the fatality database: https://www.resourcesregulator.nsw.gov.au/safety-and-health/incidents/international-mining-fatality-review

Rims should be subject to a lifecycle fatigue maintenance strategy. Refer to 3.2 for design, manufacture and supply for life cycle strategies. This should be developed in consultation with the designer/suppler of the rim and should include:

a) life cycle of maintenance for wheel and rim assemblies
b) compliance with AS 4457.1
c) the initial periodic examination in operating hours or months
d) the ongoing periodic examination of all the components
e) the maximum duty cycle that the components will be subjected to on the various plant at the mine or petroleum site, for example graders, loaders and trucks
f) repairs

All **rims** should be individually identified, and a register kept for the life of the rim. All components of wheel/rim assemblies should be uniquely marked for identification to ensure incorrect matching is avoided. The register should include:

a) the brand
b) the type/model
c) the part numbers for each component of the assembly.

The **tyres** should match the duty cycle of the plant. The following should be considered when selecting tyres or introducing plant to site:

a) load
b) distance travelled
c) tyre rubber compound
d) tyre pressure
e) average speed
f) maximum speed
g) road conditions (curves, surface)
h) tyres should be maintained and repaired in accordance with the manufacturer/supplier's recommendations and AS 4457.2.

6.4.6. Modifications or alterations

Alterations to plant may have significant outcomes even where the modification appears minor. Section 4.5.2.4 of the MECP code provide guidance on alterations to plant and things that can be done to ensure alterations do not resulted in unwanted consequences.

7. Appendices

Appendix A - Relevant codes of practice and guides

Table 1: Codes of practice and guidance in relation to mobile and transportable plant for use and mine or petroleum sites

Applies to a person conducting a business or undertaking that:	Relevant material	Where to find it
has management or control of plant	*Managing the risks of plant in the workplace code of practice* (the plant code)	SafeWorkNSW at www.workcover.nsw.gov.au/law-and-policy/legislation-and-codes/codes-of-practice
is a mine or petroleum site operator	the *Mechanical Engineering Control Plan Code of practice (the MECP code)*	NSW Resources Regulator website at www.resourcesregulator.nsw.gov.au/safety-and-health/publications/codes-of-practice
designs plant	*Guide for safe design of plant*	Safe Work Australia at www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/guidance-safe-design-manufacture-import-supply-plant
manufactures plant	*Guide for manufacturing safe plant*	Safe Work Australia at www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/guidance-safe-design-manufacture-import-supply-plant
imports or supplies plant	*Guide for importing and supplying safe plant*	Safe Work Australia at www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/guidance-safe-design-manufacture-import-supply-plant

Guidance on design, manufacture, important and supply of plant

Safe Work Australia has produced a series of guides to provide information on the safe design, manufacture, import and supply of plant. These guides provide information on the duties that apply under the WHS Act and WHS Regulation and practical guidance on how to comply with these requirements.

In addition to the guidance listed in table 1 above the Information Sheet*: Plant Designers, Manufacturers, Importers and Suppliers* has also been developed to provide advice for small businesses and workers who design, manufacture, import and supply plant.

Codes of practice

Codes of practice are admissible in court proceedings under the WHS Act and Regulations. Courts may regard a code of practice as evidence of what is known about a hazard, risk or control and may rely on the code in determining what is reasonably practicable in the circumstances to which the code relates. Compliance with the WHS Act and Regulations may be achieved by following another method, such as a technical or an industry standard, if it provides an equivalent or higher standard of work health and safety than the code

The plant code provides practical guidance on how to manage health and safety risks of plant once it is in the workplace, from plant installation, commissioning and use through to decommissioning and dismantling. It applies to persons who conduct a business or undertaking and have management or control of plant in the workplace, as well as to persons who install and commission plant

The MECP code provides guidance on the preparation, implementation and periodic review of a mechanical engineering control plan (MECP), as required under the *Work Health and Safety (Mines and Petroleum Sites) Regulation 2014* (WHSMP Regulation). The MECP code applies to mine operators at mine or petroleum sites required to have a mechanical engineering control plan. The mechanical engineering control plan (MECP) provides how the mine or petroleum site operator will manage any risks associated with mechanical aspects of plant and structures.

The WHS codes of practice available on the SafeWork NSW website at www.safework.nsw.gov.au/resource-library/list-of-all-codes-of-practice

Codes with specific relevance to plant
Managing the risk of falls at workplaces
Managing the risks of plant in the workplace
Confined spaces
Hazardous manual tasks
Managing noise and preventing hearing loss at work

Safe design of structures

Other relevant codes of practice (visit the SafeWork NSW website for a full list)
How to manage work health and safety risks
Work health and safety consultation, coordination and cooperation
Spray painting and powder coating
Welding processes
Managing electrical risks in the workplace
Managing risks of hazardous chemicals in the workplace
Managing the work environment and facilities

Appendix B- Relevant Standards and mining design guidelines

Abbreviation of standard	Title of Australian or Australian and New Zealand standards
SA/SNZ HB 89	SA/SNZ HB 89:2013: *Risk management - Guidelines on risk assessment techniques*
AS 1101.1	AS 1101.1:2007: *Graphic symbols for general engineering - Hydraulic and pneumatic systems*
AS/NZS 1200	AS/NZS 1200:20002015: *Pressure Equipment*
AS 1210	AS 1210-2010: *Pressure vessels*
AS 1269.1	AS/NZS 1269.1:2005: *Occupational noise management - Measurement and assessment of noise emission 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 1657	AS 1657-2013: *Fixed platforms, walkways, stairways and ladders - Design, construction and installation*
AS/NZS 1850	AS/NSZ NZS 1850:2009: *Portable fire extinguishers - Classification, rating and performance testing*
AS 1851	AS 1851-2012: *Routine service of fire protection systems and equipment*
AS 2030.1	AS 2030.1-2009*: Gas cylinders - General requirements*
AS 2030.5	AS 2030.5-2009*: Gas cylinders - Filling, inspection and testing of refillable cylinders*
AS 2444	AS 2444-2001*: Portable fire extinguishers and fire blankets - Selection and location*
AS 2865	AS 2865:2009: *Confined Spaces*
AS/NZS 3007	AS/NZS 3007:2013: *Electrical equipment in mines and quarries - Surface installations and associated processing plant*
AS 3788	AS/NZS 3788:2006: *Pressure equipment - In-service inspection*
AS 3873	*AS/NZS 3873:2001: Pressure equipment - Operation and maintenance*
AS 3892	AS 3892-2001: *Pressure equipment - Installation*
AS 3990	AS 3990-1993: *Mechanical equipment - Steelwork*
AS 4024.1	AS 4024.1-2014: *Series: Safety of Machinery*
AS/NZS 4024.1201	AS/NZS 4024.1201:2014: *Safety of machinery - General principles for design - Risk assessment and risk reduction*

AS 4024.1301	AS 4024.1301-20142006: *Safety of machinery - Risk assessment - Principles of risk assessment*
AS/NZS 4024.1302	*AS/NZS 4024.1302:2014: Safety of machinery - Risk assessment - Reduction of risks to health and safety from hazardous substances emitted by machinery - Principles and specification for machinery manufacturers*
AS/NZS 4024.1401	AS/NZS 4024.1401:2014: Safety of machinery - *Ergonomic principles - Design principles - Terminology and general principles*
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 4024.1603	AS 4024.1603:2006 (R2014): *Safety of machinery - Design of controls, interlocks and guards - Prevention of unexpected start-up*
AS 4100	AS 4100 Supp 1-1999: *Steel structures - Commentary (Supplement to AS 4100-1998)*
AS/NZS 4240.1	AS/NZS 4240.1:2009: *Remote control systems for mining equipment - Design, construction, testing, installation and commissioning*
AS/NZS 4240.2	AS/NZS 4240.2:2009: *Remote control systems for mining equipment – Operation and maintenance for underground metalliferous mining*
AS 4343	AS 4343:2014: *Pressure equipment - Hazard levels*
AS 4457.1	AS 4457.1-2007: *Earth-moving machinery - Off-the-road wheels, rims and tyres - Maintenance and repair - Wheel assemblies and rim assemblies*
AS 4457.2	AS 4457.2-2008: *Earth-moving machinery - Off-the-road wheels, rims and tyres - Maintenance and repair - Tyres*
AS/NZS 4871.1	AS/NZS 4871.1:2012: *Electrical equipment for mines and quarries – General requirements*
AS 4987	AS 4987-2002: *Earth-moving machinery - Tip-over protection structure (TOPS) for compact excavators - Laboratory tests and performance requirements*
AS 5062	AS 5062-2006: *Fire protection for mobile and transportable equipment*
AS/NZS ISO 31000	AS/NZS ISO 31000:2009: *Risk management - Principles and guidelines*
AS 60204.1	AS 60204.1-2005: *Safety of machinery - Electrical equipment of machines - General requirements (IEC60204-1, Ed. 5 (FDIS) MOD)*
AS 60204.11	AS 60204.11-2006: *Safety of machinery - Electrical equipment of machines - Requirements for HV equipment for voltages above 1000 V a.c. or 1500 V d.c and not exceeding 36 kV (IEC 60204-11, Ed. 1.0 (2000) MOD)*

AS 61508.1	AS61508.1-2011*: 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*

Abbreviation of standard	Title of ISO standards
ISO 1219-1	ISO 1219-1:2012: *Fluid power systems and components - Graphical symbols and circuit diagrams - Part 1: Graphical symbols for conventional use and data-processing applications*
ISO 2867	ISO 2687:2011: *Earth-moving machinery - Access systems*
ISO 3449	ISO 3449: 2005: Earth-moving machinery - *Falling-object protective structures - Laboratory tests and performance requirements*
ISO 3450	ISO 3450:2011: *Earth-moving machinery - Wheeled or high-speed rubber-tracked machines - Performance requirements and test procedures for brake systems*
ISO 3457	ISO 3457:2003: *Earth-moving machinery - Guards - Definitions and requirements*
ISO 3471	ISO 3471:2008: *Earth-moving machinery - Roll-over protective structures - Laboratory tests and performance requirements*
ISO 5006	ISO 5006:2006/Cor 1:2008: *Earth-moving machinery - Operator's field of view - Test method and performance criteria - Technical Corrigendum 1*
ISO 5010	ISO 5010:2007: *Earth-moving machinery - Rubber-tyred machines - Steering requirements*
ISO 6393	ISO 6393:2008: *Earth-moving machinery - Determination of sound power level - Stationary test conditions*
ISO 6394	ISO 6394:2008/Cor 1:2009: *Earth-moving machinery - Determination of emission sound pressure level at operator's position - Stationary test conditions - Technical Corrigendum 1*
ISO 6395	ISO 6395:2008: *Earth-moving machinery - Determination of sound power level - Dynamic test conditions*
ISO 6396	ISO 6396:2008/Cor 1:2009: *Earth-moving machinery - Determination of emission sound pressure level at operator's position - Dynamic test conditions - Technical Corrigendum 1*

ISO 6405-1	ISO 6405-1:2004/Amd 1:2010: *Earth-moving machinery - Symbols for operator controls and other displays - Part 1: Common symbols - Amendment 1: Additional symbols*
ISO 6405-2	ISO 6405-2:1993/Amd 2:2004: *Earth-moving machinery - Symbols for operator controls and other displays - Part 2: Specific symbols for machines, equipment and accessories - Amendment 2: Additional symbols*
ISO 6682	ISO 6682:1986/AMD 1:1989: *Earth-moving machinery - Zones of comfort and reach for controls - Amendment 1*
ISO 6683	ISO 6683:2005: *Earth-moving machinery - Seat belts and seat belt anchorages - Performance requirements and tests*
ISO 7096	ISO 7096:2000: *Earth-moving machinery - Laboratory evaluation of operator seat vibration*
ISO 10262	ISO 10262:1998/Cor 1:2009: *Earth-moving machinery - Hydraulic excavators - Laboratory tests and performance requirements for operator protective guards - Technical Corrigendum 1*
ISO 10263-1	ISO 10263-1:2009: *Earth-moving machinery - Operator enclosure environment - Part 1: Terms and definitions*
ISO 10263-2	ISO 10263-2:2009: *Earth-moving machinery - Operator enclosure environment - Part 2: Air filter element test method*
ISO 10263-3	ISO 10263-3:2009: *Earth-moving machinery - Operator enclosure environment - Part 3: Pressurization test method*
ISO 10263-4	ISO 10263-4:2009: *Earth-moving machinery - Operator enclosure environment - Part 4: Heating, ventilating and air conditioning (HVAC) test method and performance*
ISO 10263-5	ISO 10263-5:2009: *Earth-moving machinery - Operator enclosure environment - Part 5: Windscreen defrosting system test method*
ISO 10263-6	ISO 10263-6:2009: *Earth-moving machinery - Operator enclosure environment - Part 6: Determination of effect of solar heating*
ISO 10265	ISO 10265:2008: *Earth-moving machinery – Crawler machines – Performance requirements and test procedures for braking systems*
ISO 10968	ISO 10968:2004: *Earth-moving machinery - Operator's controls*
ISO 11112	ISO 11112:1995/Amd 1:2001: *Earth-moving machinery - Operator's seat - Dimensions and requirements - Amendment 1*
ISO 12100	ISO 12100:2010: *Safety of machinery - General principles for design - Risk assessment and risk reduction*
ISO 12117-2	ISO 12117-2:2008/Cor 1:2010 *Earth-moving machinery - Laboratory tests and performance requirements for protective structures of*

	excavators - Part 2: Roll-over protective structures (ROPS) for excavators of over 6 t - Technical Corrigendum 1
ISO 12117	ISO 12117:1997/Cor 1:2000 *Earth-moving machinery - Tip-over protection structure (TOPS) for compact excavators - Laboratory tests and performance requirements - Technical Corrigendum 1*
ISO 12509	ISO 12509:2004: *Earth-moving machinery - Lighting, signalling and marking lights, and reflex-reflector devices*
ISO 13333	ISO 13333:1994: *Earth-moving machinery - Dumper body support and operator's cab tilt support devices*
ISO 13849-1	ISO 13849-1:2006 *Safety of machinery -- Safety-related parts of control systems -- Part 1: General principles for design*
ISO 13850	ISO 13850:2006: *Safety of machinery - Emergency stop - Principles for design*
ISO 14122-1	ISO 14122-12001/Amd 1:2010 *Safety of machinery - Permanent means of access to machinery - Part 1: Choice of fixed means of access between two levels - Amendment 1*
ISO 14122-2	ISO 14122-2:2001/Amd 1:2010 *Safety of machinery - Permanent means of access to machinery - Part 2: Working platforms and walkways - Amendment 1*
ISO 14122-3	ISO 14122-3:2001/Amd 1:2010 *Safety of machinery - Permanent means of access to machinery - Part 3: Stairs, stepladders and guard-rails - Amendment 1*
ISO 14122-4	ISO 14122-4:2001/Amd 1:2010 *Safety of machinery - Permanent means of access to machinery - Part 4: Fixed ladders - Amendment 1*
ISO 14401-1	ISO 14401-1:2009: *Earth-moving machinery - Field of vision of surveillance and rear-view mirrors - Part 1: Test methods*
ISO 14401-2	ISO 14401-2:2009: *Earth-moving machinery - Field of vision of surveillance and rear-view mirrors - Part 2: Performance criteria*
ISO 15998	ISO 15998:2008: *Earth-moving machinery - Machine-control systems (MCS) using electronic components - Performance criteria and tests for functional safety*
ISO 19296	Mining — Mobile machines working underground — Machine safety
ISO/FDIS 19014.1	Earth-moving machinery -- Safety -- Part 1: Methodology to determine safety-related parts of the control system and performance requirements. General information
ISO 20474-1	ISO 20474-1:2008: Earth-moving machinery - Safety - Part 1: General requirements

Abbreviation of standard	Title of SAE standards
SAE J386	SAE J 386:2006 (R2012) *Operator Restraint System For Off-road Work Machines*

Abbreviation of MDG	**Relevant Mining Design Guidelines (MDGs)**
MDGs are found on NSW Resources Regulator website: www.resourcesregulator.nsw.gov.au/safety-and-health/publications/mdg	
MDG28	MDG 28:2013 *Safety requirements for coal stockpiles and reclaim tunnels*
MDG 40	MDG 40:2007 *Guideline for Hazardous Energy Control (Isolation or Treatment)*
MDG 41	MDG 41:2010 *Guideline for fluid power system safety at mines*
MDG 1032	MDG 1032:2010 *Guideline for the prevention, early detection and suppression of fires in coal mines*
MDG 2007	MDG 2007:2014 *Guideline for the selection and implementation of collision management systems for mining*
MDG 3608	MDG 3608:2012 *Guideline for Non-metallic materials for use in underground coal mines*
Industry fatality database	www.resourcesregulator.nsw.gov.au/safety-and-health/incidents/international-mining-fatality-review

Appendix C – Incidents associated with mobile and transportable plant

C1 – Reportable incidents

Figure B1 illustrates the relative occurrence of various kinds of incidents involving mobile plant in use at surface mines in NSW, Australia. The incidents were reported to the NSW Resources Regulator from January 2011 through December 2013. During this time, there were 1411 reported incidents and 88 injuries.

Figure C1 – Incidents of mobile plant, January 2011 to December 2013

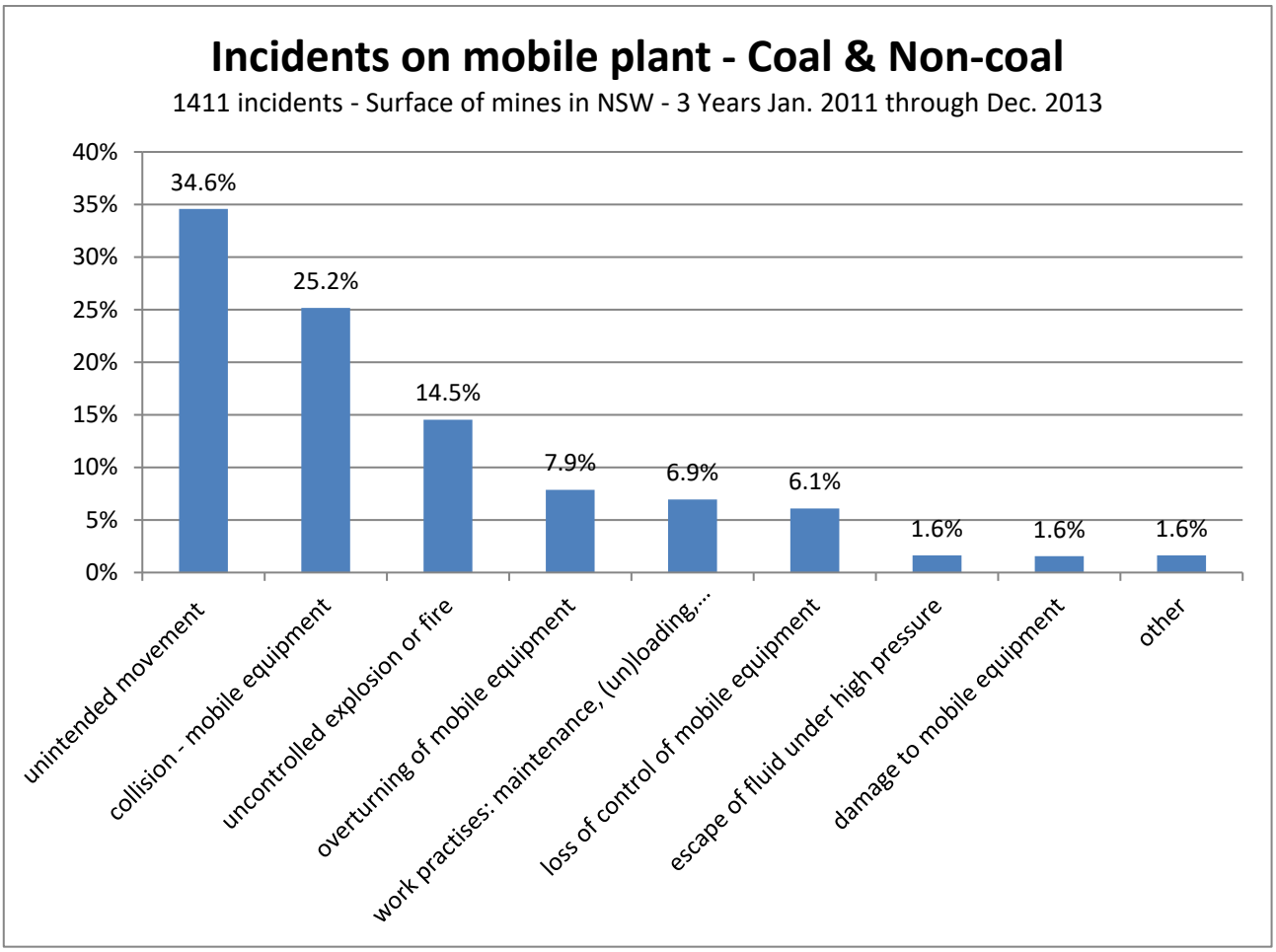
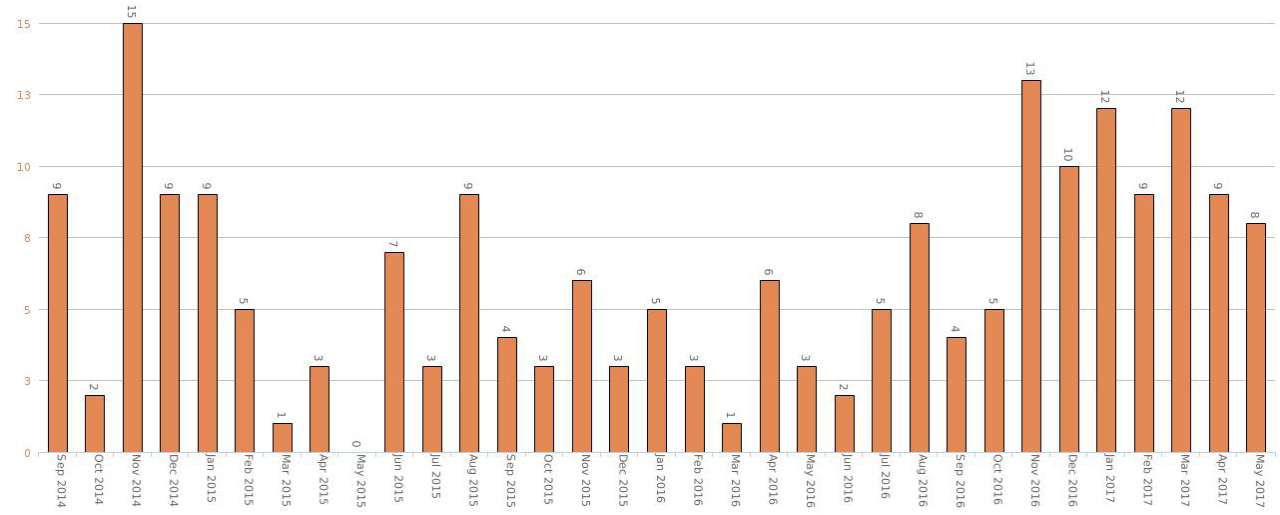


Figure C2 – Fires on mobile plant, September 2014 to May 2017



The NSW Resources Regulator conducted a review of in-service fires on mobile plant at NSW mines.

www.resourcesregulator.nsw.gov.au/__data/assets/pdf_file/0008/738341/In-service-fires-on-mobile-plant.pdf

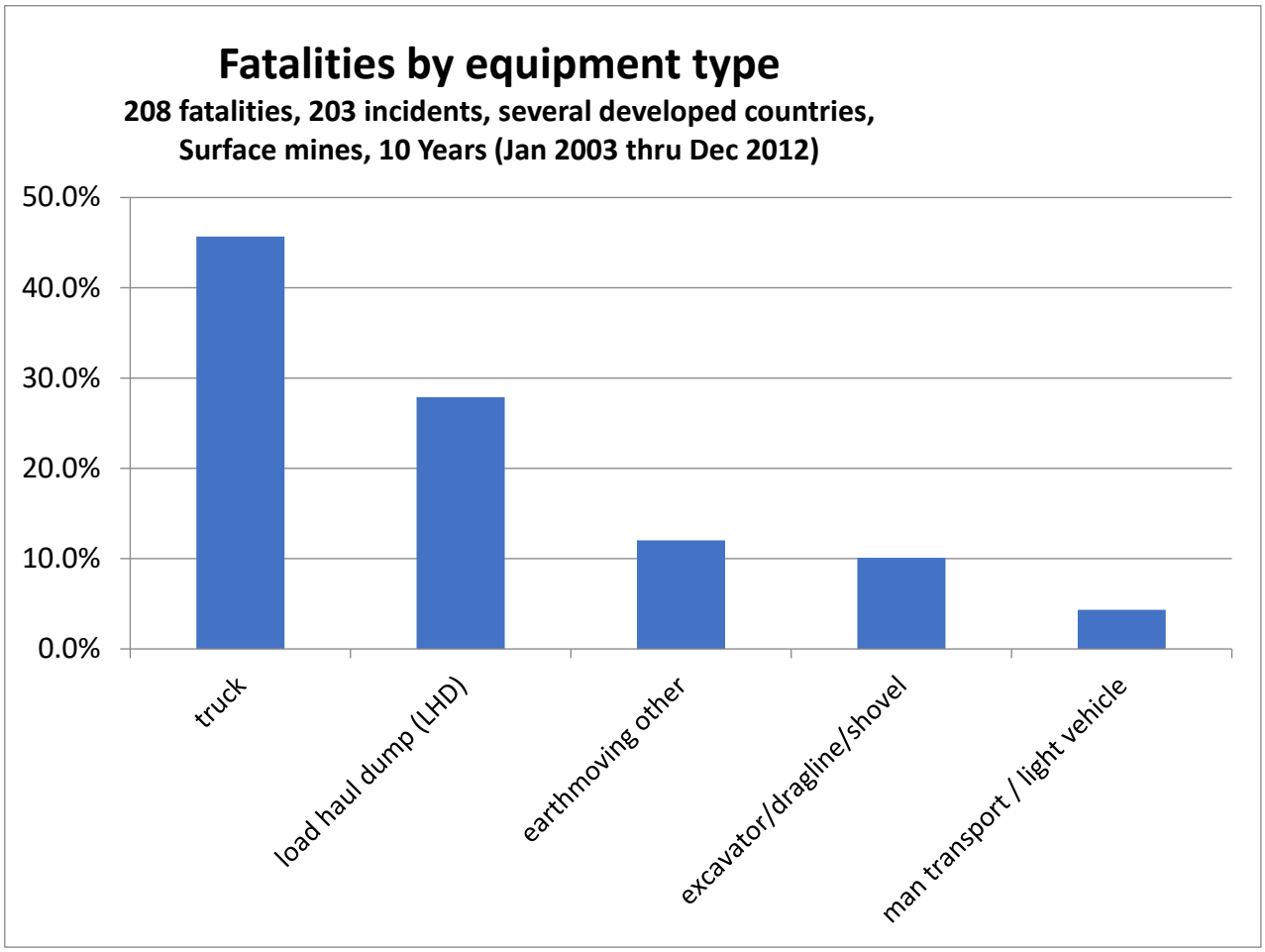
The intent of this report is to present data collected from ancillary reports graphically for industry review. It is hoped that the reader may gain an insight to the broader understanding of fires on mobile plant across the NSW mining industry and prompt a review of the effectiveness of current preventative measures. The report also provides an initiative for the industry to consider a shift of focus towards elimination of ignition/heat sources to drive a step change in occurrence of fires.

C3 – Fatality data

The figures that follow show statistics taken from the international fatality database compiled by NSW Resources Regulator. The data set represents 208 fatalities resulting from 203 incidents which occurred in several developed countries over 10 years from January 2004 through December 2012.

The proportion of fatalities associated with various types of mobile equipment is shown in Figure B2 below.

Figure C2 – Fatalities by equipment type, January 2003 to December 2012

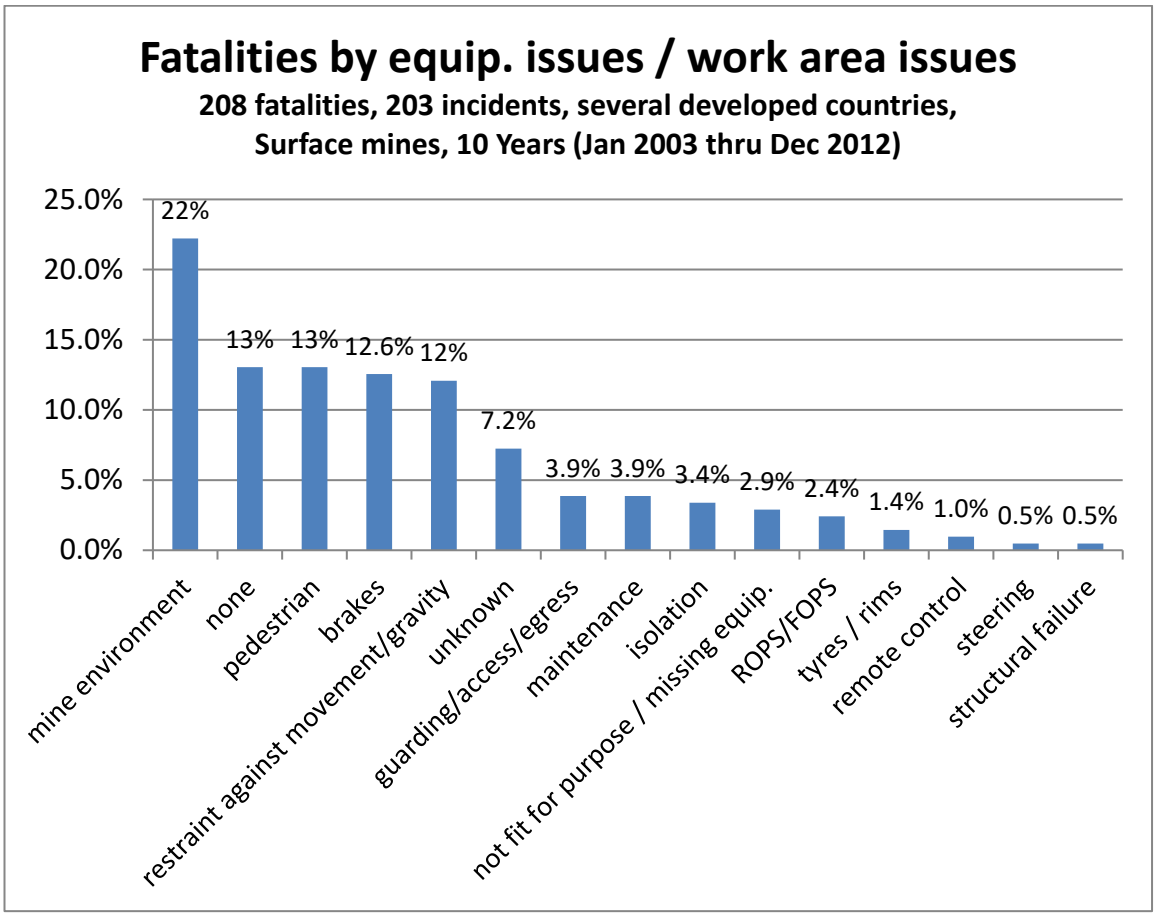


The proportion of fatalities associated with mobile equipment issues or work area issues are shown in Figure C4.

“Work area issues” include:

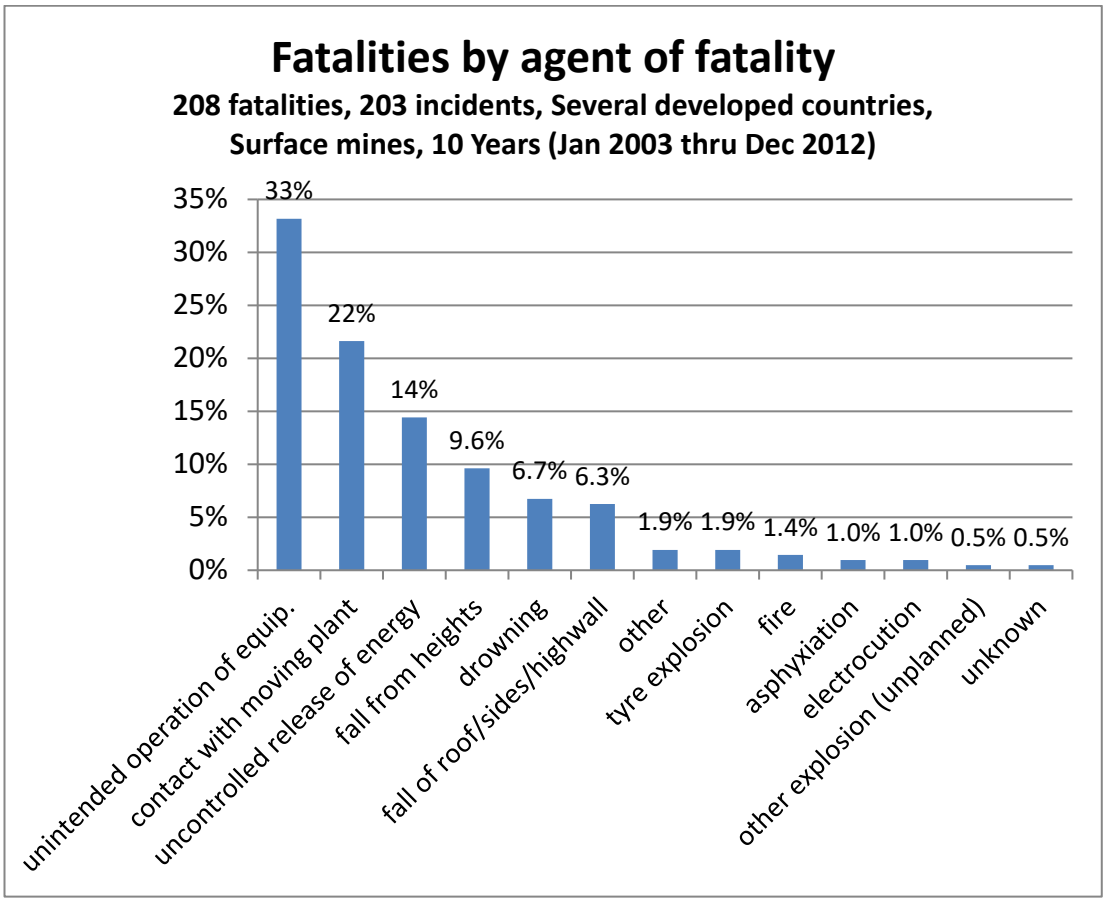
a) Mine environment (e.g.; falls over highwalls, drownings in bodies of water)
b) Pedestrian (e.g.; lack of, or violation of rules governing vehicle-pedestrian interactions, visibility issues.)
c) “None” means no equipment fault or work area issue contributed to the incident. For example, loss of control by the operator, not driving to conditions, overloading, speed.

Figure C4 – Fatalities on mobile plant by work area – January 2003 to December 2012



The proportion of fatalities associated with mobile equipment issues or work area issues are shown in Figure C4.

Figure C5 – Fatalities on mobile plant by agent, January 2003 to December 2012



C3 - Categorised fatality data

Refer to: www.resourcesregulator.nsw.gov.au/safety-and-health/incidents/international-mining-fatality-review

Specific fatality incident that may relate to sections of this guide include the following categories:

Categories:	Number of fatalities:
Cranes and Lifting	104
Truck and Loaders	446
Stockpile	18
Drill Rig	121
Brake Failure	65
Energy Isolation	285
Fluid Power System	19

Total number of fatalities: 1058

Appendix D – Reference of controls in relation to human factors

Tables D1 and D2 below provide a reference to examples of controls discussed in this guide that are relevant to managing the risks of mobile and transportable plant associated with human factors. Table D1 lists engineering controls and table D2 lists controls involving warnings or alarms.

Table D1. Automatic control measures which may be used to minimise the effects of human failings.

Control measure	Possible consequence averted
Automatic Braking	Out of control plant
ABS (Anti-locking braking systems)	Possible skidding and loss of control
Auto-Retard	Prevents over-speeding, averting possible runaway and loss of control
Automatic Application of Brakes	Averts unwanted events in the case of human failure where the brake is inadvertently not applied.
Radiator caps not capable of being removed unless pressure is relieved	Prevents injuries such as steam burns

Automatic shut off for refuelling	Control measure to prevent a fire risk from spillage as the result of over filling fuel tank
Fire suppression activation automatically stops the fuel flow and stops the engine	Prevents the fuelling of an established fire through addressing a common human failing of the operator not shutting off fuel
Prevent operation of plant if fire the suppression system is not operational	Ensures a risk control measure is always available. Preventing the plant being used.
Automatic confirmation that the emergency steering is operational prior to plant start up	This is a risk control measure to ensure mobile plant emergency steering is available to bring the plant safely to rest in the event of normal steering failure
Split rim assemblies on plant wheels should not be used	History of fatalities and injuries mostly during maintenance and service activities
Proximity detection and collision avoidance	Unwanted plant interaction
Dump body interlocks	Unwanted interactions with overhead structures and minimises instability of plant
Locking of isolating systems	Prevention of unwanted events involving fatal and injury consequences

Appendix E – Mobile plant not specifically covered in this guide

For mobile plant not intended to be covered by this guide, the mine or petroleum site should have an introduction to site assessments and undertake a risk assessment on the intended duty/operating environment.

Mines which use long or steep grades should implement a more rigorous inspection system to ensure the vehicle is safe to enter the mine or petroleum site.

Plant that is not covered by MDG 15 but may be required to operate on a mine or petroleum site should be subject to:

- → a pre-operational and periodic inspection by a competent person which should include:
  - the vehicle has been maintained and is in a fit for purpose condition to enter the mine or petroleum site

- all safety critical systems are functional
- a structural inspection is carried out of the undercarriage, body, suspension, brakes and all other structural areas
- tyres are in good condition
- brake functionality
- site rules for flags, escorts, flashing lights.

Typically applies to vehicles that participate indirectly in the mining or any earth-moving activity for the winning of a product and are predominately based on a mine site (e.g. excludes: personnel transporters, light vehicles, trucks less than 12t GVM , delivery or pick-up vehicles, freight of mined product predominantly on public roads).

All public road registrable 'plant' that is not currently registered which is used for mining, petroleum or earth-moving activities (e.g. water trucks, haul trucks, service trucks, explosives trucks, truck-mounted exploration drill rigs, mobile cranes) should be subject to an inspection by a competent person prior to the mobile plant operated on a mine or petroleum site.

For mobile cranes, a crane safe inspection (The Crane Industry Council of Australia - CICA) is an example of a method to verify the plant is fit for purpose.

An in-service performance brake test should be carried out to verify the (mobile plant) can stop on the maximum grades for use. For example, a concrete agitator to be used on the decline into a metal mine.

Some items of plant used at mine or petroleum sites, such as backhoes, water trucks, tractors, and similar, may be registered or registrable for use on public roads. The registration regime for such plant may not require regular authorised maintenance inspections like other commercial trucks. There have been several incidents with this type of plant on mine or petroleum sites, where the safety critical systems on the plant have not been maintained in a satisfactory condition.

Any plant that is road registerable but is not registered which is used at the mine site outside its normal duty will need to be assessed to ensure it is fit for purpose and is maintained to road registration requirements. For example, trucks carrying heavier loads at lower speeds than is normal practice.