Resources Safety & Health Queensland

Recognised Standard 23

Fluid Power Safety in Coal Mines

Resources Safety and Health Queensland

August 2021

Coal Mining Safety and Health Act 1999

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Recognised standards

This document is issued in accordance with PART 5—RECOGNISED STANDARDS and Section 37(3) of the *Coal Mining Safety and Health Act 1999*.

PART 5 - RECOGNISED STANDARDS

71 Purpose of recognised standards

A standard may be made for safety and health (a "recognised standard") stating ways to achieve an acceptable level of risk to persons arising out of coal mining operations.

72 Recognised standards

(1) The Minister may make recognised standards.

(2) The Minister must notify the making of a recognised standard by gazette notice.

(3) The CEO must publish on a Queensland government website each recognised standard and any document applied, adopted or incorporated by the standard.

(4) In this section—

Queensland government website means a website with a URL that contains 'qld.gov.au', other than the website of a local government

73 Use of recognised standards in proceedings

A recognised standard is admissible in evidence in a proceeding if—

(a) the proceeding relates to a contravention of a safety and health obligation imposed on a person under part 3; and

(b) it is claimed that the person contravened the obligation by failing to achieve an acceptable level of risk; and

(c) the recognised standard is about achieving an acceptable level of risk.

PART 3 - SAFETY AND HEALTH OBLIGATIONS

37 How obligation can be discharged if regulation or recognised standard made

(3) …. if a recognised standard states a way or ways of achieving an acceptable level of risk, a person discharges the person's safety and health obligation in relation to the risk only by—

- (a) adopting and following a stated way; or
- (b) adopting and following another way that achieves a level of risk that is equal to or better than the acceptable level.

Where a part of a recognised standard or other normative document referred to therein conflicts with the *Coal Mining Safety and Health Act 1999* or the Coal Mining Safety and Health Regulation 2017, the Act or Regulation takes precedence.

This recognised standard is issued under the authority of the Minister for Resources.

[Gazetted 27 August 2021]

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1 Forward

The uncontrolled release of fluids has resulted in serious injuries and fatalities in the coal industry. As a result, the Coal Mining Safety and Health Act & Regulations require a coal mine Safety and Health Management System to provide for managing risks from using fluids above or below atmospheric pressure. Additionally, industry safety alerts and bulletins related to fluid systems have been published. Despite this guidance the industry continues to report high potential incidents and serious accidents related to the uncontrolled release of fluids.

The objective of the development and implementation of a recognised standard for fluid power safety is to establish minimum standards that meet legislated objectives for risks to be as low as reasonably achievable and which when implemented will result in a further reduction in the incidence of fluid power system incidents.

This recognised standard has been developed by a committee including industry, coal mine worker and regulatory representatives at the request of Coal Mining Safety Health and Advisory Committee. The standard is based on the NSW Resources Regulator, Fluid Power Safety Systems at Mines, Mining Design Guideline MDG41. The work of the NSW industry in the ongoing development and provision of the guideline is acknowledged.

Chief Inspector of Coal Mines

2 Purpose and Scope

2.1 *Purpose*

The purpose of this recognised standard is to establish minimum safety and health standards for fluid power systems in Queensland coal mines. The implementation of this recognised standard will assist in protecting workers and other people against harm to their health and safety through the elimination or reduction of lifecycle risks associated with fluid power systems at mines.

2.2 *Scope and application*

The Recognised Standard applies to:

- Fluid power systems in coal mines in the State of Queensland.
- All plant, including but not limited to mobile plant (open cut, underground and exploration equipment), fixed installations (including pumping systems), compressed air systems, gas drainage systems etc.
- The lifecycle of the fluid power system, including:
    - Design, manufacturing and/or supplying fluid power systems (new or previously used)
    - installing or commissioning fluid power systems on a mine site
    - operating or using fluid power systems
    - maintaining, repairing, or overhauling and other life cycle activities of fluid power systems
    - Decommissioning and disposal of systems or components
    - Changes or alterations to fluid systems
- Designers and suppliers of original plant to the mine
- Repairers and service providers of fluid power systems for the mine site
- Any person, permanently or temporarily employed at the mine in any capacity that requires them to operate, maintain or rely upon fluid powered systems or associated systems

The standard provides guidance relating to:

- statutory requirements
- undertaking fluid power system risk assessments
- application of a fluid power risk control framework
- applicable technical standards
- new or hire plant (fluid powered)
- supply of fluid power components and services
- installation, repairs, and modifications to plant (fluid powered)
- inspection/testing methods of fluid powered plant
- modification of any plant/system/procedure influencing operation/maintenance of fluid powered plant
- competency assessment
- system review, including:
    - reviewing the adequacy of risk controls following an incident
    - assessing/auditing existing standards and practices.

The standard does not apply:

- Where a fluid power system has been formally risk assessed and demonstrated to be of low risk to coal mine workers in which case risks associated with the system are to be managed by the mines safety and health management system.

- Where high pressure gas reticulation is managed under Petroleum and Gas legislation.
- To aspects of mains water supply reticulation which are covered by Australian Standards and local government regulation.
- Firefighting systems covered by Australian Standards
- To gas cylinders, hose assemblies and fittings for use with LPG and oxy-acetylene

The recognised standard does not provide detailed information on environmental responses to the uncontrolled release of fluids.

The recognised standard does not preclude the use of documented standards and practices that result in superior safety & health outcomes than would otherwise be achieved by following this standard.

3 References

Appendix A contains a list of references including relevant legislation, NSW Mining Design Guidelines, Australian and International standards relevant to fluid power systems. Standards are referenced in this Recognised Standard by abbreviated titles. The full title can be found in the relevant appendix.

4 Abbreviations

The following abbreviations are used in this guideline.

Abbreviation	Description
AS	Australian Standard
AS/NZS	Australian / New Zealand Standard
CMSHA	Coal Mining Safety and Health Act 1999
CMSHR	Coal Mining Safety and Health Regulation 2017
DIN	German Institute for Standardization
FRAS	fire resistant and antistatic
ISO	International Organization for Standardization
MDG	Mining Design Guideline
MPa	megapascal
OEM	original equipment manufacturer
PPE	personal protective equipment
SAE	Society of Automotive Engineers
SDS	safety data sheet (formerly MSDS)
SHMS	safety and health management system
SI	International System of Units
SOP	Standard Operating Procedure
SSE	Site Senior Executive

5 Definitions

For this document the definitions below apply.

5.1 Fire resistant and antistatic (FRAS)

Materials that have been certified as fire resistant and antistatic. Relevant parts of the NSW MDG 3608 ‘Non-metallic materials for use in underground coal mines’ may be applicable.

5.2 Fit for purpose

Something that is sufficient to do the function it was designed to do, for the intended use, over its lifetime.

5.3 Fluid power systems

Fluid power systems include pressurised hydraulic and pneumatic systems for the transmission and control of energy. It is expected that the following fluids will be considered:

- Compressed air and vacuum systems
- Mine gas (mine gas drainage systems)
- Hydraulic fluids (mineral and water based)
- Diesel and petroleum systems, including grease
- Water (reticulated systems, high pressure water blasting/cutting)
- Other hydrocarbons, paint, paint thinners and solvents

Typical areas for consideration include:

- Mobile machinery and fixed plant installations including frother and reagent systems, vacuum systems
- Surface, underground and exploration mining equipment
- Pumping systems
- Diesel fuel systems, including diesel fuel injection systems
- Plant maintenance
- Hydraulically operated maintenance tools
- Safety critical circuits on plant e.g. braking, steering

5.4 Fluid injection

Streams of pressurised escaping fluid that penetrate the skin and enter the human body. The injection of fluid may cause death, severe tissue damage and loss of limb.

5.5 High risk area

Any area where an uncontrolled escape of fluid could place a person’s health and safety at risk.

Consider areas where fluid power system components including hoses could break, burst, or fail and expose people in the vicinity to health and safety risks such as areas:

- where fluid power pressure generally exceeds 5MPa (750psi), or
- where fluid power temperature generally exceeds 60°C, or
- of high flow/pressure/force e.g., large flow pneumatic air lines,
- within one metre of the operator in the normal operating position,
- Where maintainers are required to work within one metre of pressurised systems.

Note 1: The higher the pressure, the higher the potential for harm i.e. a system operating at 32MPa (4800psi) has a higher potential for harm than a system operating at 5MPa (750psi).

Note 2: Pressures as low as 0.7 MPa (100psi) may also present risks as skin penetration can occur where there is direct contact.

Note 3: Refer to ISO 3457 for further guidance in relation to the vicinity of risk and earth-moving machinery guarding.

5.6 Hose assembly

A flexible hose with its hose ends attached. Sometimes referred to as a flexible hose assembly.

5.7 Hose end

The hose coupling or hose fitting that is attached to each end of a single piece of hose.

5.8 Hose service life

The effective lifespan of the hose, whereby the hose meets the required factor of safety and the required likelihood of failure.

5.9 Impulse life

The set number of impulse cycles that a given fluid power component can withstand under controlled test conditions.

5.10 Lifecycle

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

5.11 Matched

A matched hose assembly is where the hose and fittings (insert/ferrule) are designed, manufactured, and routinely tested to match up to a particular manufacturer's hose and fitting type. In this case both (hose and fitting) are assembled and crimped using the methods as specified by the designer, meet the tolerance specified by the designer and have been type tested as a hose assembly, at the maximum tolerance, to the specified standards.

5.12 Modifications (alterations)

Change in the design of the mobile or transportable and fixed plant, where the change may affect health or safety, but does not include routine maintenance, repair, or replacement.

5.13 Plant

Includes any machinery, equipment, tool, appliance.

5.14 Plant safety documentation

A structured compilation of documents providing traceable evidence/information relating to the health and safety features, incorporating each phase of the lifecycle of the fluid power system from design through to demolition. It also contains a record of all 'as-built design features', including information on risks to health and safety that could arise at any phase of its life cycle.

5.15 Pressure intensification

The amplification of system fluid pressure in excess of the designed pressure to a level that is hazardous. For example, this can be caused by excess load, blockage of annulus areas in hydraulic or pneumatic cylinders, thermal effects and similar.

5.16 Design working pressure

The maximum pressure that equipment is designed to contain or control under normal operating conditions.

5.17 Safety critical system

A fluid power system whose failure or malfunction may result in death or serious injury to people or is near an ignition source.

Control measures for safety critical systems may be identified as either:

- A safety-related function or,

- Safety-related components

5.18 Safety Function

ISO 13849 defines a safety function as “function of the machine whose failure can result in an immediate increase in risk”.

5.19 Standards for Fluid power Systems

Unless otherwise specified, the appropriate Australian or international standards should be applied to reduce the risk to as low as reasonably achievable. Appropriate international standards to be considered are ISO, DIN or SAE standards.

SAE J1273 is integral to the management of hose assemblies and should be read in conjunction with this document.

6 Hazards associated with fluid power systems

Legislation requires all hazards to be identified, the risks assessed, and control measures implemented. Control measures should be implemented in accordance with the hierarchy of controls principles, maintained and reviewed. The principal fluid power system hazards and core risks to the safety of coal mine workers have been identified as the:

- Uncontrolled release of energy,
- Failure and/or malfunction of plant,
- Bursting under pressure of fluid power components,
- Fire due to flammable fluid contacting hot surfaces.

The following sections provide guidance to assist in the identification of hazards associated with fluid power systems. Information related to fluid power hazards and consequences should be considered in the development of fluid power system management plans.

6.1 Hazard identification and consequence

A list of primary hazards and potential consequences associated with fluid power systems are included in:

- Appendix B
- AS 2671
- AS 2788

6.2 Safety Alerts, Bulletins

References to Safety Alerts and Bulletins published by Resources Safety & Health Queensland (RSHQ) and other entities related to fluid power systems are listed in Appendix C.

6.3 Latent conditions

Latent conditions are influences and social pressures that make up the culture ('the way we do things around here'), influence the design of equipment or systems, and define supervisory inadequacies. They tend to be hidden until triggered by an event. Latent conditions can lead to latent failures, human error or violations. Latent failures may occur when several latent conditions combine in an unforeseen way.

In considering the hazards and risks associated with fluid power systems latent conditions should be considered.

6.4 Human factors

Human factors are often contributing factors in the failure of risk controls. The reduction of human factor potential should be considered for the lifecycle of the fluid power system. Appendix D includes further information on human errors.

6.5 Other sources of hazard information

Other sources of hazard information related to fluid power systems includes:

- The Mining Hazards database. The database can be accessed via https://www.rshq.qld.gov.au/safety-notices
- ACARP research papers
- MIRMgate
- NSW Resources Regulator publications (for example, MDG 41)

7 Fluid System Risk Management

The CMSHA deals with safety and health obligations of coal mine workers and other persons who may affect safety and health at coal mines or as a result of coal mining obligations. This includes contractors, designers, manufacturers, importers, erectors and installers of plant and substances. Details of obligations for safety and health are outlined in Part 3 of the CMSHA.

Section 42 of the CMSHA specifies obligations for the SSE in relation to the safety of persons who may be affected by coal mining operations. This includes:

a) The development of a single SHMS for the mine,

b) Ensuring the risk to persons is at an acceptable level, including exposure of coal mine workers to fluids.

The requirements of the mine SHMS are detailed in Section 62 of the CMSHA. Additionally, Section 80 of the CMSHR requires the coal mine SHMS to provide for managing risk from using fluids above or below atmospheric pressure.

The mine must develop and implement a system for the management of fluid power and fluid power systems which must be an integral part of the mines SHMS. It is recommended that the mine develop and implement a fluid management plan, consistent with the CMHSR requirements for a SHMS and the principles detailed in AS/NZS 4801 or equivalent. It may be necessary for the fluid management plan to refer to other site plans/procedures such that it forms part of the overall single SHMS for the mine.

The plan for managing fluid power systems must be underpinned by a risk assessment. In the development of the fluid power safety management plan (or similar), the relevant sections of this recognised standard should be considered.

7.1 Risk Management

Managing the risks that arise from fluid power systems should include:

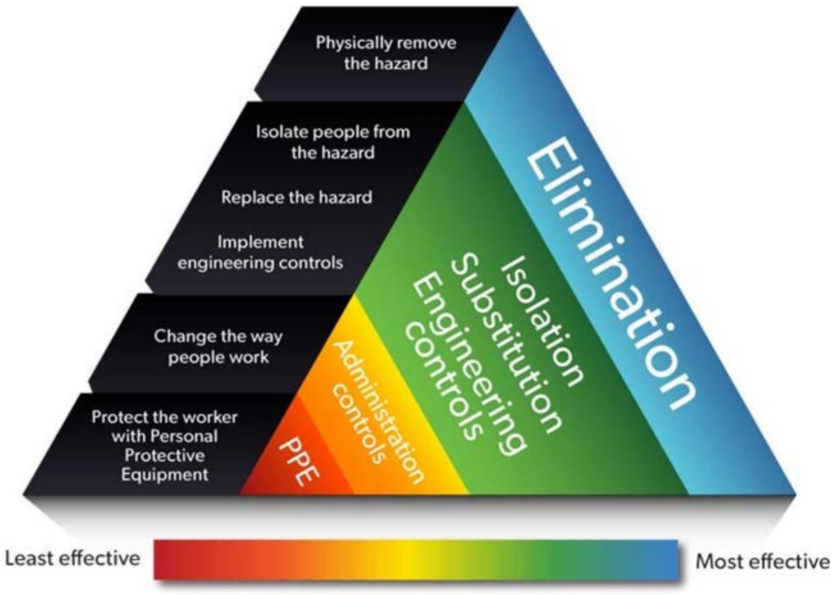
- Identifying the risk to safety and health of people operating, maintaining, and repairing fluid power systems. Most injuries occur when people are working close to fluid systems or there is a component failure, e.g. hose, fitting, pressure vessel,
- identifying all high-risk and safety critical areas,
- identifying and implementing controls to minimise risks so far as is reasonably achievable. The hierarchy of controls principles (refer Figure 1) should be applied,
- assessing the effectiveness and required reliability of any implemented control,
- consideration of recommendations and documentation from stakeholders involved (e.g. designers, manufacturers, suppliers, repairers, workers),
- developing safe work procedures,
- developing inspection, testing and maintenance requirements to ensure controls remain effective, including control measures that remains fit for purpose,
- operational monitoring of safety critical componentry to avert the risk of harm to people in the vicinity (this may include the necessity to stop the system),
- developing procedures for the installation, setup and proper use of equipment,
- Change management.

Further guidance on risk management is provided in:

- Recognised Standard 02 Control of Risk Management Practices

- AS/NZS ISO 31000, AS/NZS 4024.1201 and SA/SNZ HB 89.
- Site specific risk management processes

Figure 1 Hierarchy of Controls



7.2 Fluid Risk Control Framework

Due to the large number of fluid power systems installed or utilised on mines a structured approach to dealing with the risks is required. The following process should be applied (refer Figure 2):

1 Identify all fluid systems (e.g. installed at the mine, and on all plant)

2 Identify risks associated with each system, including foreseeable misuse & failure modes. Reference should be made to relevant sources including:

- OEM drawings, manuals, design data, residual risk registers
- incident database summaries
- standards hazard lists
- safety bulletins

3 Determine risk treatment required to minimise risks to coal mine workers

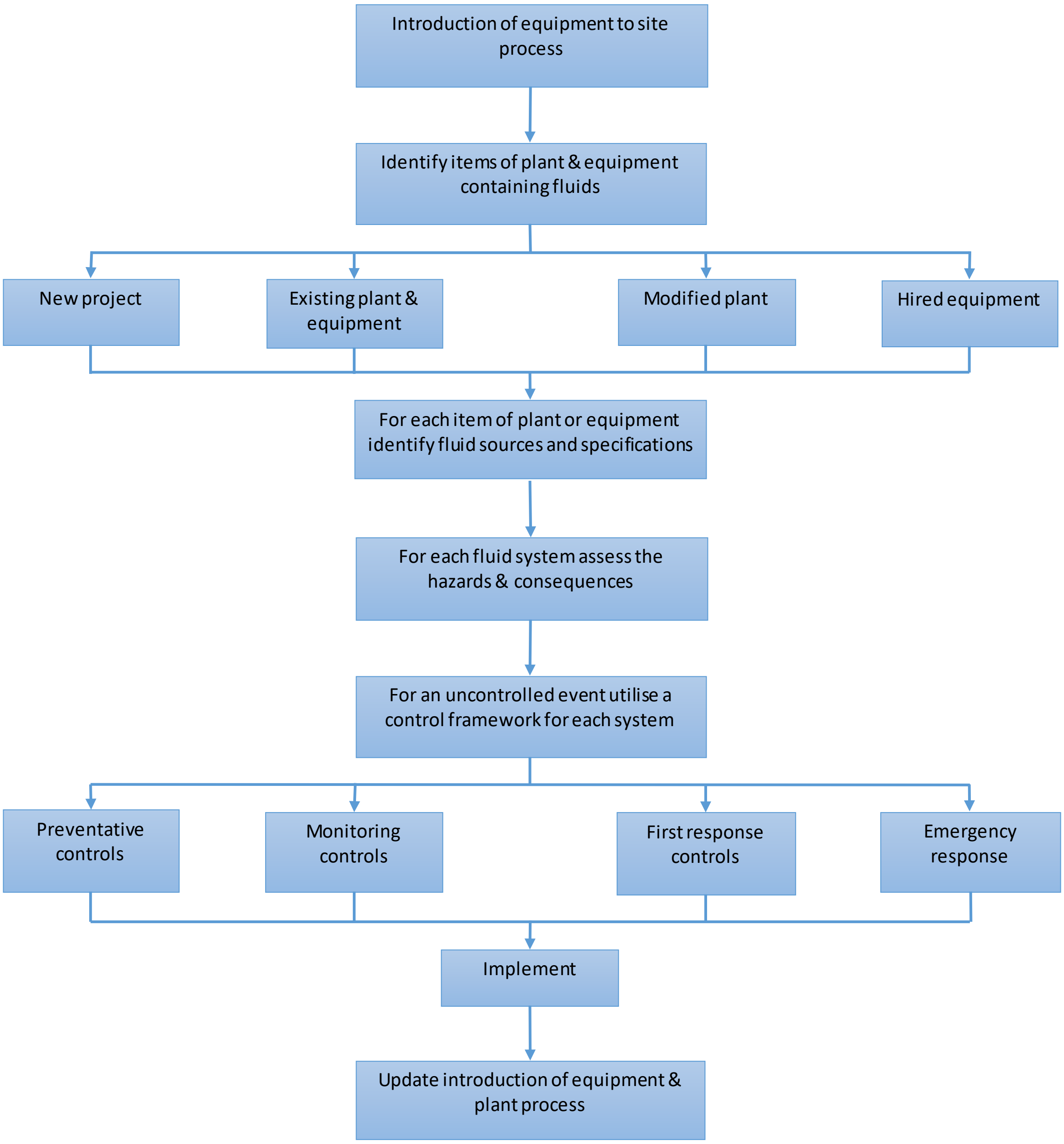
a. It is recommended that a categorisation process be followed based on the following concepts.

High risk and/or safety critical. In addition to the application of proven standards additional layers of protection as per the safety of machinery principles shall be applied. For example, this may include guarding, higher specification hoses, burst protection etc.

Low risk. Where an item is identified as a low risk; apply proven engineering standards

b. Controls applied should include:
   i. Preventative
   ii. Monitoring
   iii. First response
   iv. Emergency response

Figure 2 Fluid risk control framework



7.3 Information Management

Safety-related aspects of fluid power systems should be fully documented. These records should cover the lifecycle of the power fluid system and be stored and maintained in such a way that they are readily retrievable and protected against damage, deterioration, and loss. Appendix E provides guidance on information management related to fluid system information management.

Safety-related aspects of fluid power systems should be fully documented. These records should cover the lifecycle of the power fluid system and be stored and maintained in such a way that they are readily retrievable and protected against damage, deterioration, and loss. Appendix E provides guidance on information management related to fluid system information management.

8 Design and Manufacture

8.1 General

Fluid power systems should be designed and manufactured using existing engineering standards and principles, so they are fit for the intended purpose and safe to use. Within the equipment lifecycle the greatest impact to minimising risk can be made at the design phase.

Engineering standards for fluid power systems include:

- AS 2671
- AS 2788
- AS 4041 and
- ISO 17165-2 (or SAE J1273).

These standards should be read in conjunction with this recognised standard.

8.2 Design hazard identification, assessment and control

8.2.1. Design risk assessment

Designers and manufacturers must evaluate all hazards and risks to the safety of people from the operation and maintenance of the fluid power system. The designer and manufacturer must identify the design requirements and any other actions as required to control the risk in accordance with the hierarchy of risk controls refer Figure 1).

The outcome of the hazard analysis should identify the high risk and safety critical systems and any performance requirements of those safety critical systems in order to safely operate and maintain the fluid power system.

Consideration should be given to the control of risks to health and safety that may arise from reasonably foreseeable misuse of the fluid power system.

Guidance may be sought from:

- AS/NZS ISO 31000,
- SA/SNZ HB 89,
- AS/NZS 4024:1201
- AS/NZS 4024:1303

Outputs of a risk assessment should result in advice to the user of the controls of the system and the residual risks that the end user must manage.

All control measures should be assessed for their effectiveness over the lifecycle of the system.

8.3 Safety critical systems

Control measures for safety critical systems may be identified as either:

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

The 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 over the fluid power system lifecycle.

8.3.1. Safety-related componentry

All safety-related componentry should be designed, analysed, tested, and documented using good engineering practices and according to existing 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.

8.3.2. Safety-related functions

All safety-related functions arising from the design risk assessment should be clearly identified.

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, so far as is reasonably practicable. Functional safety standards include:

- application of performance levels (PL) in accordance with AS/NZ 4024.1503 or ISO 13849.1
- application of safety integrity levels (SIL) in accordance with AS 61508.1 or AS 62061
- application of machine performance levels (MPL) in accordance with ISO 19014.
- other relevant functional standards, provided an equivalent level of safety can be demonstrated.

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.

8.4 Design information

8.4.1. General

To assist in preventing misinterpretation the fluid power systems should be fully documented for the 'As Built' system. 'As Built' documentation should be available to relevant stakeholders, in particular operation and maintenance personnel from the time the plant is commissioned. Design documentation should contain sufficient detail to enable an evaluation of the fluid system by a competent person other than the designer. For serially produced equipment this information may be contained in the workshop manual.

System design information should include:

- Information on the purpose of the design of fluid power system,
- Design documentation should identify system parameters, such as pressure and flow in accordance with AS/ISO 1000,
- Circuit (schematics) diagrams, which should comply with ISO 1219-2 (see also AS 2671, as 2788 and AS 4041 as appropriate),

- Hydraulic and pneumatic symbols should be in accordance with AS 1101.1 or ISO 1219-1,
- Hose and piping assembly diagrams (see ISO 1219.1 and ISO 1219.2),
- Installation, testing, and commissioning procedures,
- Operation and maintenance manuals.

8.5 Fluid power systems design

8.5.1. General

In addition to the design risk assessment all fluid power systems should be designed taking into consideration the:

- provision of safe operation over the intended design lifecycle of the systems and components,
- relevant principles of AS 4024.1 Safety of machinery series of standards,
- factors contributing to human failure,
- provision of reasonable access to all parts that require adjustment, cleaning, or service,
- provision of appropriate engineered methods to safely dissipate pressure where stored pressure can remain in a circuit (due to check valves, load lock valves etc),
- selection of appropriate and compatible materials for the intended application and the environment likely to be encountered in service,
- specification of seals and sealing devices compatible with the fluid used, adjacent materials, working conditions and environment. Consideration should be given to incorporating elastomeric sealing for all fluid power connectors,
- minimising of excessive heat generation.

8.5.2. Fluid component safety factors

To avoid pressurised fluids escaping into the environment, fluid power system components should have appropriate factors of safety on the proof and burst pressure to design working pressure. ISO 7751 provides guidance.

For hydraulic oil fluid power systems:

- Hose assemblies should have a factor of safety of at least 4:1,
- Adaptor fittings should have a factor of safety of at least 4:1 on rated working pressure to catastrophic failure of the adaptor or fitting,
- Other fluid power components, such as cylinders, valves, actuators or similar should have a factor of safety of at least 2.5:1.

Where the above safety factors are reduced, appropriate engineering analysis and/or cycle and endurance testing should be carried out and documented.

When considering a factor of safety for components for fluid power systems due consideration should be given to fatigue life of the component.

8.5.3. Excessive pressures

A means or device must be provided to protect the circuit against excessive pressures e.g., relief valve (refer AS 2671, AS 2788 and AS 4041 as appropriate).

8.5.4. Negative Pressures

Negative pressure equipment includes hydraulic pump suctions, de-watering pumps, oil evacuation systems, supervac systems, vacuum dewatering systems in CHPPs and gas drainage systems.

- All pumps shall have suction screens or barriers for where there is an opportunity for persons or objects to be caught in the suction side of the pump.
- Where a system state may change from negative pressure to positive pressure the design and installation must cater for both load situations, e.g. a gas drainage system normally operating at a negative pressure may periodically require flushing using positive pressure.
- Tanks with large air spaces subject to thermal change.

8.5.5. Protection from uncontrolled escape of pressurised fluids

The design should minimise the risk of injury to operators and maintenance personnel from the uncontrolled escape of pressurised fluids. Controls should be provided in accordance with the hierarchy of controls.

Where an unplanned loss of fluid (detected by a loss of pressure or flow) could cause a hazard to operational or maintenance personal the fluid power systems should be designed to either shut down automatically or unload the system flow, where practicable.

Hose guards, including flexible hose coverings shall be sufficiently sturdy to stop, disperse or divert the fluid stream, in case of hose or component failure from direct contact with the operator.

8.5.6. Fire hazard

Fires on fixed and mobile plant resulting from the unplanned loss of fluid may expose coal mine workers to unacceptable level of risk whether they be operating the plant or fighting the fire. Mines must complete a fire risk assessment on all plant and implement risk reduction controls to reduce the risk to an acceptable level. AS5062 Fire protection for mobile and transportable equipment provides guidance.

Where an unplanned loss of fluid could cause a fire hazard, the fluid power systems should be designed to shut down automatically upon release of fluid, where practicable.

Consideration is to be given to segregation where component failure my inadvertently spray fluid onto an ignition source in the immediate area.

8.5.7. Unintended pressure intensification

A means should be provided to prevent or control unintended pressure intensification on all fluid power systems in particular all hydraulic cylinders should be protected. This may be achieved through the appropriate installation of unloader valves, relief valves and burst discs.

The vent port from these devices should be positioned or safeguarded to avoid injury to people in the vicinity of the fluid being ejected.

8.5.8. Filtration

Fluid filtration should be provided to protect all fluid circuits. Filtration should be selected in accordance with AS 2671 and AS 2788.

The effect:

- On control circuits when the filter is blocked should be considered,
- Of blocked or restrictive filters fitted in the return lines causing back pressure and inadvertent movement should be considered.

8.5.9. Design for maintainability

The system should be designed such that components can be safely adjusted, serviced or replaced without the need to dismantle other components. Particular attention should be given to components and hoses, which need regular maintenance.

The system design should include provision for ease of access to vent stations, oil draining stations or points and sampling or test points.

Means to take fluid samples without disconnecting fittings and at zero pressure should be provided.

8.5.10. Fluids

Fluids should be compatible with the system's components.

Where there is an unacceptable fire risk, fire-resistant fluids should be used. For example, longwall roof supports and fluid couplings on belt conveyors in underground coal mines.

Safety data sheets (SDSs) should be supplied. Additional information on the toxicity, fire effects, handling requirements and degradability should also be provided where appropriate.

8.5.11. Fluid reservoirs

Fluid reservoirs should be designed in accordance with AS 2671.

8.5.12. Marking and identification

- Sufficient marking and identification of components and operator controls should be provided to assist personnel with the safe use and maintenance of fluid power systems.
- Where a hazard could exist from the misinterpretation of a symbol, the meaning of the symbol should be clarified in writing.
- Systems components should be labelled to enable clear cross-referencing with the circuit diagram, or all systems components should be clearly identifiable to the technical documents.
- Pressures and flows should be in standard SI units in accordance with AS/ISO 1000.

Note 1: Documentation including manuals and drawings, machine component labels, signs and gauges, test equipment etc. should use common units of pressure and flow.

Note 2: Use of non-standard SI units (eg psi, bar) across mine sites has been identified as an operational risk. For example, fluid power systems may use MPa, bar or psi depending on the original equipment manufacturers specification.

Note 3: Where units of pressure and flow are not in accordance with AS/ISO 1000 risks associated with using non-standard SI units shall be considered and appropriate controls implemented eg training, conversion charts, replacement with AS/ISO 1000 compliant measuring devices.

- Permanent markings, signs and identification plates should be in accordance with AS 1318 and AS 1319.
- Markings, signs, and labels should be:
  a. installed or positioned and maintained so that they are clearly visible to maintenance and operational personnel, and

b. of durable construction and be permanently attached. It is preferable for signs and labels to be constructed of durable material e.g., engraved brass, stainless steel, or similar.

8.6 Components (other than hose assemblies)

8.6.1. General

Components should be selected, applied and installed in accordance with the component manufacturer's information and AS 2671 or AS 2788 or AS 4041 as appropriate. All components should be:

- Designed to withstand the maximum surge, dynamic and intensified pressures from the operation of the fluid power system,
- Selected to operate reliably over the lifecycle of the system,
- Operate within their rated limits, in particular the operating pressure and allowable fluid contamination level.

8.6.2. Pressure test points

All fluid systems should have provision for test points to determine pressure in that part of the circuit, including sub-circuits to enable the safe testing and monitoring of the system. Test points should be permanently labelled. As a minimum, labels should include details of the monitored circuit and circuit pressure.

Test points should be provided to limit the need for dismantling the system for regular monitoring and testing.

Pressure gauges should be provided as appropriate.

8.6.3. Vent ports

The vent port from devices that release pressurised fluid to atmosphere such as relief valves should be diffused (reduce pressure and flow), positioned or protected to prevent injury to people in the vicinity of the fluid being ejected and not expel onto ignition sources.

8.6.4. Other system components

Energy conversion components such as pumps, motors, cylinders, gas accumulators, reservoirs, etc should be designed in accordance with AS 2671 and AS 2788.

8.6.5. Valves

- All valves should be securely mounted
- Valves used for isolation should be lockable.

8.6.6. Actuators

Where there are safety risks from unplanned movement of actuators, feedback monitoring on functions should be considered.

8.6.7. Load bearing actuators

Circuits incorporating load-bearing actuators should incorporate the following safety features:

- Safety devices to protect against the effects of failure of a hose or any other hydraulic component,
- A device, such as a load lock, that will stop the movement in the event of a hose rupture or pipe fracture,
- Devices to prevent over pressurisation of the actuator,
- Where a connection is installed between an actuator port and a load locking/check valve in the form of a welded or fitted pipe, the burst pressure for the whole construction should be at least 2.5 time the maximum working pressure. The use of hoses in this application is not acceptable. Load locking valves should be designed in accordance with AS2671.

8.6.8. Pumps and pump stations

Fluid power pumps, pump stations and their associated controls should be:

- adequately supported,
- mechanically protected from predictable damage in high wear or impact areas,
- positioned for access for maintenance purposes with sufficient space around each pump,
- positioned, guarded or cooled to eliminate the likely event of injuring a person where heat is an issue,
- able to be isolated and dissipate stored energy independently of the rest of the system,
- be suitably guarded in accordance with the principles of the AS/NZS 4024.1302.

Note: NSW Safety Alert SA10-01 Longwall hydraulic system over- pressurised should be considered in the design and maintenance of fluid power pumps and pump stations.

8.7 Fluid power control circuits

8.7.1. General

Control systems should be designed to prevent unintended movement and incorrect sequencing of actuators over the lifecycle of the plant. Consideration should be given to possible control system failure modes.

Adjustable control valves should be fitted with a tamper-resistant device or require tools where the adjustment of controls may create a hazard.

Clear indication of the fluid system's operational status should be provided, for example pressure indication using a gauge.

Hydraulic/pneumatic control systems should cause the machine to fail to a safe state in the event of any fluid system failure or electrical power loss.

8.7.2. Pilot circuits

To prevent inadvertent operation of components, the pilot circuit return line should be designed to minimise backpressure on control valves. The design risk assessment should analyse all control circuits to determine effects associated with excessive backpressure.

8.7.3. Return lines

The return line should be protected against over-pressure.

8.7.4. Manual controls

General

Hazardous conditions caused by inadvertent operation of the controls should be considered in the design and be minimised.

Where the operation of the control may create a hazard, the system should be safe guarded in accordance with AS 4024.1 series.

All controls should be accessible for maintenance.

Ergonomics

An ergonomic assessment on the layout of all fluid power controls and operator gauges should be carried out. Guidance for ergonomics in the workplace can be found in AS 4024.1 series of standards.

Direction of movement

The direction of movement for manually operated levers should be consistent with the direction of operation of the actuator. AS/NZS 4024.1906 provides guidance on general principles.

Location of controls

The location of manual controls should:

- be within the reach of the operator's normal working position and such that the control can be operated without inadvertently operating other nearby controls unintentionally,
- not require the operator to reach past rotating or moving devices to operate the control,
- not interfere with the operator's required working movements,
- the location for the operation of controls should be such that the movement of the machine will not impinge on the operator's control space envelope.

8.7.5. Emergency stops

An emergency stop or stopping system complying with AS 4024.1 series of standards should be provided at each workstation. In addition, at least one emergency stop should be located remotely to the workstation to stop the system in the event of an emergency.

Restarting the system after an emergency stop should not cause the automatic operation of the system.

8.7.6. Pressure gauges

Pressure gauges should:

- be installed on all circuits at relevant locations,
- be located where the operators can clearly read the gauge,
- be labelled. Labelling or an indication should be provided to show the acceptable circuit operating range,
- be in standard SI units in accordance with AS/ISO 1000,
- not have displays that rely on multiplication or conversion factors,
- be sized such that the upper limit on the gauge exceeds the maximum pressure by 25%,
- have an isolator to protect the gauges where practical,
- for mechanical or analogue gauges have a snubber installed to protect pressure gauges.

8.8 Isolation and energy dissipation

The system should be designed such that it can be positively isolated from the energy source and enable energy dissipation of the pressurised fluid to prevent unexpected movement when maintenance activities are being carried out.

Isolation procedures must be consistent with and incorporated into the mine SOP for isolating and tagging.

- Isolation points must be capable of being locked in the isolated position
- Isolation points shall be clearly visible and labelled with status (open/closed).
- There should be a method to confirm the pressurised energy has been dissipated.
- Isolation valves should not be installed in the return circuit of a hydraulic system as they provide a means for pressure intensification if left closed.

Further guidance on the isolation and energy dissipation of fluid systems is included in Appendix G

8.9 Hose assemblies

8.9.1. General

The selection, assembly and installation of hose assemblies should be in accordance with ISO 17165-1, or SAE J1273 and ISO 17165-2.

- Hose assemblies should not be used at pressures exceeding the hose assembly's maximum working pressure.
- Hose assemblies should be selected based on the designed maximum system pressure, including surge, dynamic and intensified pressures expected in the normal operation of the system.
- Hose assemblies should be adequately sized to minimise pressure loss and avoid damage from heat generation due to excessive internal velocity.
- Hose assemblies should be selected such that both the fluid and ambient temperatures do not exceed the temperature rating of the hose assembly. Hose assemblies near external heat sources (e.g. exhaust manifolds, turbo chargers) should be adequately shielded or covered with heat-resistant sheathing or re- routed to prevent the hose assembly coming into contact with the hot surface. Refer ISO 13732-1 for guidance on guarding, sheathing.

8.9.2. Hose selection

<u>General</u>

In the selection of hoses, the following should be considered:

- Hydraulic hose should meet or exceed the performance level specified in ISO

8030/8031, ISO 18752, or SAE J517,

- Hoses should be suitable for the fluid used and the maximum system pressure and temperature,
- Hoses for conveying air or gas, water, or stone dust for use in underground coal mines should be FRAS in accordance with AS 2660. This does not apply to small diameter piping used in control systems. The hose should be effectively earthed. Steel reinforced hydraulic hose is conductive by nature of its construction and may need to be earthed to prevent charge build-up if used in air applications. Documentation/ branding must be supplied to substantiate FRAS properties.
- The effect of static electric discharge should be considered for other hoses.
- Air hoses for mine sites other than underground coal should comply with AS/NZS 2554.
- Hoses should be ozone, weather, abrasion, and heat resistant (refer ISO 6805 for underground machinery).
- Hydraulic oil hoses on plant in underground coal mines should be fire resistant.
- Where a hose is subject to system spikes and/or irregular pressure variations its life expectancy is rapidly reduced and should be evaluated, refer to SAE J1927.
- Suction hoses should be selected to withstand both the negative and positive pressures imposed by the system.
- Additional testing should be carried out where the hose specification does not cover the application.

Permeation/hose-material – fluid compatibility

Consideration should be given to the compatibility of fluids with the hose and the permeation effects on the hose, refer SAE J1273 or ISO 17165-2.

Abrasion resistance

Hoses should meet the abrasion resistance requirements, (refer ISO 6805 for underground applications).

Additional abrasions resistance may be required for specific applications. SAE J2006 provides further guidance.

Hose assembly energy diffusion devices

Where hoses are in a high-risk area and there is no other practical means to provide adequate protection from the uncontrolled escape of pressurised fluids, a hose assembly energy diffusion device may be appropriate.

When using diffusion devices:

- the hose assembly energy diffusion device should be able to diffuse the energy in the hydraulic fluid to a level where the risk of fluid injection is minimised,
- provision should be made for the safe periodic inspection of the hose contained within the diffusion device. Inspection of hose assemblies should be undertaken with the sleeves removed. It should be combined with fatigue testing to failure of the hoses assembly to allow prediction for the remaining useful life of the other hoses assemblies in the system,
- diffusion sleeves are required to be a loose fit over the hose to redirect the energy of any ejected fluid,
- the sleeve should be manufactured from high abrasion, ozone, heat resistant material and should be suitably attached,
- in underground coal mines, this sleeve should be fire resistant,
- stainless steel or other metal mesh has been successfully used to guard high pressure hydraulics from the workplace.

<u>Hose assembly restraint devices</u>

Where a risk of hose whipping in the event of failure of hose or fittings including quick release fittings is identified; whip restraints shall be used.

Where ‘whip restraints’ are used:

- the restraint needs to be capable of withstanding the kinetic loading of a hose failure,
- mountings (tether points) for whip restraints should be load rated,
- Whip restraints, where fitted should not interfere with the function of the sleeving if fitted and should be routinely inspected,
- For air or gas applications, whip restraints should be considered for hose assemblies operating above 700 kPa or greater than nominal bore 35, if there is a risk to people from the failure of the hose.

<u>Fire resistance</u>

All hydraulic hose assemblies should be fire resistant unless the hose is in a low risk fire area.

Fire resistance hoses should be tested in accordance with AS 1180-10B or ISO 8030 and the average duration of the flaming and glowing should not exceed 30 seconds.

Note: MDG 3608 provides guidance on FRAS in underground coal mines. In some applications, a high level of fire resistance may be required, such as brake, turbo lube hose assemblies and fire suppression system hoses. These hoses may need to comply with less common specifications such as (or equivalent level of fire resistance provided) SAE Aerospace Standard SAE AS 1339-2003

(R2007), Hose Assembly, Polytetrafluoroethylene, Metallic Reinforced, 3000 psi, 400°F, Lightweight, Hydraulic and Pneumatic. The operating limit for this hose assembly is -54°C to +232°C.

Antistatic hose

Where hydraulic hose assemblies require antistatic properties, they should meet the requirements of clause 14 of ISO 6805 when tested in accordance with ISO 8031 or MDG 3608.

PVC piping

Nylon or PVC piping for pneumatic safety control systems should not be used 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.

Air compressor discharge hoses

To safely handle elevated discharge temperature of air compressors elastomeric (rubber type) hose assemblies should not be used on a delivery line between an air compressor and air receiver. Fit-for-purpose polytetrafluoroethylene with steel braid is satisfactory. All delivery hose assemblies should be heat resistant, guidance is given in SAE J517.

Environment

Hose assemblies should be suitably rated or shielded to withstand environmental conditions that can cause degradation. Environmental conditions which should be considered include ultraviolet light, ozone, alkalinity/acidity, oils, chemicals, corrosive materials, coal build up, water, vibration, air pollutants, high and low temperature, electricity, abrasion, and external loading.

Effective service life

To minimise the potential for hose failure and to maximise the effective service life of hose assembly, design and installation should be carried out in accordance with SAE J1273 or ISO 17165-2. Poor design of installation standards is a predominate factor in effective service life.

In addition, consideration should be given to:

- Impulse life. Guidance on factors which may affect impulse life are included in SAE J1273 or ISO 17165-2,
- working fluid temperature, velocity, and contamination,
- external cover protection that may be exposed to abrasion, impact damage, rubbing or gouging,
- shielding to protect hose assemblies from heat sources such as engine manifolds,

exhausts, turbos etc.,
- accidental damage caused by falling rock, vehicle collision, tensile load, shear load, crushing, fire,
- mechanical loads – vibration, tensile, shear, bending in more than one plane (torsional effects), not adhering to manufacturer's minimum bend radius (MBR) specifications,
- corrosive spillage, molten metal, pressure surge,
- corrosion of end fittings and reinforcement wires (alkalinity / acidic water) / coal (sulphur),
- hose life degradation (ref S-N studies) refer ACARP report C17020 "Performance based Specifications for Longwall Hose Assemblies",
- environmental factors (temperature, UV, ozone, chemical, etc),
- installation/routing (orientation, clamping, vibration, mechanical loads, equipment extension, securing methods, etc.)

8.9.3. Hose ends

General

Hose ends should not be interchanged and should be properly matched to the hose based on proven type test result.

The fitting and hose manufacturer's recommendations should be strictly followed.

Hose ends, adaptors and flanges should be in accordance with recognised standards.

Worm-drive clamps should not be used on:
- Brake systems
- Hand-held hose lines

Where hose connections are used in an installation where they could work themselves loose due to movement, vibration, rotation or similar and people are in the vicinity could be exposed to risks to safety or health, consideration should be given to installing soft-seal or other high-performance connections.

Staple type fitting

Staple fittings should only be used in proven applications (such as longwall installations) when there is no other reasonably practicable alternative fitting.

Note: It is preferable to use a fitting which shows signs of leakage prior to a total disconnect of the fitting.

Staples are not recommended above those pressures nominated in DIN 20043, BS 6537 and SAE J1467. All staple life expectancy is limited by cyclic loading (cyclic fatigue). This information should be included in suppliers' data.

Note: Further information is available from ACARP document C19011 "Longwall hydraulic staple lock staple fatigue assessment", Safety Alert SA06-18 "Longwall staple failures Non-standard type hose ends and adaptors".

Non-standard staple type fittings

Staple type hose ends and adaptors which do not comply with a recognised standard, such as "staple less", 'super staple' or 'pin type' connections should:

- Be assessed to SAE J1065 and proof tested to ISO 6605 or SAE J343 or AS 1180.5. Testing to ISO 6802 is preferred,
- Be designed such that the use of other manufacturer's proprietary fitting/components cannot easily be mistaken and used in the wrong system creating a hazard to the end user,
- Be suitable for the intended application over the fitting lifecycle, such that the fitting does not fail due to fatigue, cyclic loading or contamination from the intended operating environment or removal and assemble for maintenance.

For staple applications, see Safety Alert SA06-18, i.e., staples are one-use only and should be replaced when hoses and components are replaced.

8.9.4. Flexible hose assembly manufacture

Hose and hose end manufacture should be carried out under a quality system certified to comply with ISO 9001 and ISO 9002, which includes appropriate batch testing for conformance and records.

- Suppliers of manufactured hydraulic hose assemblies should verify that the hose and fittings used are matched,
- All hose assemblies should be visually inspected before dispatch and inspections recorded,
- Hose assemblies should be supplied free from water, debris, metal shavings, dirt or any other foreign material. End connections should be sealed and capped to maintain cleanliness,
- Hose assemblies should be packaged such that external abuse during shipping, handling and storage does not damage the hose or fittings,
- Completed hose assemblies may be certified to ISO 6605, SAE J343, AS 3791 or AS 1180.5.

8.9.5. Markings of hose assemblies for identification

Markings should be designed to last for the life of the hose assembly and be placed on both ends (where practical) of the hose assembly and be visible without removing protective devices such as sleeving or restraints.

Hose, hose ends, and hose assemblies should be labelled to enable traceable history.

8.9.6. Testing and certification of hose assemblies

General hose assembly proof testing

Hose assembly proof testing minimises assembly related errors which may cause premature failure of the hose assembly in the operating environment.

- Documented risk assessment shall be used to identify hose assemblies that are required to be proof tested (eg high risk assemblies). Proof testing should be carried out in accordance with ISO 6605 or SAE J343 or AS 1180.5.
- Hoses manufactured on site or by a mobile facility shall be proof tested at two times the working pressure.
- Static testing should be carried out using compatible hydraulic fluid rather than with compressed gases. Teflon hose should be tested with water.

High risk hose assemblies

- All hose assemblies which will be installed in high-risk applications must be proof tested at two times the maximum working pressure.
- The test pressure should be held for a period of 30 to 60 seconds. There should be no indication of leakage or failure.
- Proof testing should be conducted using compatible fluid rather than with compressed gases.

Note: Polytetrafluoroethylene type hose should be tested with water only.

Type testing of hose assemblies – dynamic cycle testing

The matched hose and hose end should be dynamically type tested at the impulse pressure and to the number of test cycles specified by the hose's manufacturer or by the hose's relevant standard (ISO 1436, ISO 3862, ISO 4079, ISO 6805, ISO 11237, ISO 18752 or SAE J517), whichever is greater, in accordance with ISO 6803, hydraulic pressure impulse test without flexing at the lesser minimum bend radius as specified by the hose's manufacturer or by the hose's relevant standard.

In applications of high dynamic cycling consideration should be given to type testing the hose assembly in accordance with ISO 6802, 'hydraulic impulse test with flexing' to minimum bend radius, for 80,000 cycles at 120% of the working pressure.

Individual hose assembly test documentation

Each test certificate should bear a unique number for traceability. This document should be held by the manufacturer and be available upon request.

Batch certificate of conformance

A certificate of conformance should be supplied on request.

8.9.7. Hose assembly tracking

A hose assembly tracking system should be utilised to assist with individual hose assembly reliability management.

8.9.8. Hose Assembly Installation

General

Hose assembly installation should consider ISO/TS 17165-2 or SAE J1273.

- Fluid power systems should be installed in accordance with the design documentation. The design documentation should identify the exact location and route of all components and hoses.
- Hose routes, lengths and supports should be clearly identified at the design stage. The hose route should allow for hose replacement and access. All air, hydraulic, fuel, refrigerant and fire suppression hoses should be routed separately and suitably clamped (to prevent vibration and pulsation causing fretting between services leading to hose and cable failure).
- Exposure of the hose reinforcement reduces hose life significantly. The use of a hose cover protection should be considered.
- Hoses should not be bundled together and tied with cable ties.

External loads

- External mechanical loads should be minimised during the installation of a hose assembly.
- Swivel type fittings or adapters should be used to ensure no twist is put into the hose assembly. In some applications live swivels may be necessary, e.g. two rotating components.
- Hose assemblies are designed for internal forces only, they should not be used in applications which apply external forces to the hose or hose end.

8.9.9. Inspection

The installed hose assembly should be inspected as per SAE J1273.

- The period of inspections should be evaluated to establish the frequency of visual inspections and functional tests with the hose duty, history, manufacturer’s information, and operating environment being considered.

8.10 Pipework

Pipework should be designed, selected, and installed in accordance with AS 2671 and AS 2788 and should be designed to meet all dynamic, shock and environmental loads.

- The factor of safety for all pipe work should be at least 2.5:1 on the maximum working pressure to the yield strength.
- Pressure piping should be in accordance with AS 4041.
- Pressure pipe fittings and flanges should be in accordance with SAE J514, SAE J516, SAE J518, ISO 12151, ISO 10763, ISO 6162 as applicable.
- External loads should not be imposed on pipework or fittings at any time unless designed and adequately supported for the specified load.
- Pressure rating of connectors should be at least equal to the piping.

8.11 Support and installation

Pipe and fittings should be:

- mounted to minimise installation stresses from, vibrations, pulsation’s, thermal expansion and its own mass,
- located and guarded against foreseeable environmental damage,
- located such that it is not readily accessible for people to stand on. Where it is accessible then pipework should either be guarded or be robust enough, when supported to carry a vertical load of 1.5KN without permanent deformation or damage.
- securely supported at appropriate intervals along its length, refer AS 2671 and AS 2788,
- run in a neat and tidy manner,
- mechanically protected from damage in high wear areas,
- routed to prevent coming into contact with surfaces that may wear or rub the pipe work or fittings,
- provided with guards where employee’s continually work (workstations e.g. longwall boot end valve bank),
- accessible for maintenance without disturbing adjacent hoses and components.

8.12 Adaptors/fittings

Adaptors and Fittings should:

- Have corrosive resistance specified suitable for the environment. See section 8.12.1,
- be designed to withstand the maximum normal operating pressure of the system.
- All batches of fittings should be type tested to 2.5 times the working pressure. Fittings should be correctly rated for their duty, external load and pressure. Consideration should be given to use the correct fitting type for the application and pressure, (e.g. Thread type fittings may not be suitable for swivel applications and high pressures for larger diameters).
- Multiple fittings should be minimised (e.g. Christmas tree fittings) by utilising designed and tested manifolds.
- Super Staple Lock fittings shall comply with MDG41TR - Technical Reference 1.
- Incompatible fittings shall not be used as this creates a hazard and potential failure.
- Homemade or fabricated fittings should not be used, unless they have been designed by a qualified engineer, tested and certified to comply with the relevant standards. In cases where a special fitting is required it should be provided with full certification stating the working pressure, test pressure and safety factor.
- All adaptor fittings used in underground environment should be manufactured in one piece either from bar stock (straight fittings), or from fully forged adaptor blanks (shaped fittings).
- Quick release Victaulic clamps shall only be considered for use after a risk assessment covering their specific use has been completed.
- Galvanised water type fittings shall not be used on hydraulic pressure circuits.

8.12.1. Corrosion resistance

The operating environment should be identified to allow the degree of corrosion resistance to be selected. It is recommended that a salt spray test acceptance criterion be specified for the mine operating environment.

- For a low corrosive environment, all steel hose ends and hose adaptors should achieve a minimum of 72 hours (red rust) when subjected to a salt spray test in accordance with ASTM B117 or ISO 9227. For some more corrosive atmosphere it may be necessary to specify in the range of 200 up to 1000 hours of resistance.
- Additional corrosion resistance may be required for specific applications.

8.13 Pressure equipment

8.13.1. General

All pressure vessels, including accumulators, should be designed, inspected, maintained and operated in accordance with:

- AS 1200, 'pressure equipment'
- AS 1210, 'pressure vessels'
- AS 1271 'safety valves'
- AS 2971, 'serially produced pressure vessels'
- AS 3788, 'pressure equipment – in-service inspection'
- AS 3873, 'pressure equipment – operation and maintenance'
- AS 3892, 'pressure equipment – installation'
- AS 4037, 'pressure equipment – examination and testing'
- AS 4343, 'pressure equipment – hazard levels'
- AS 4458, 'pressure equipment – manufacture'
- other equivalent international standards where applicable (these may include ISO, ASME, EN).

The manufacturer should provide a current 'certificate of inspection' with the delivery of equipment, as applicable.

A drain line with a manual valve should be provided to drain the lowest point of all air receivers. This line and valve should be suitably protected against damage during transport.

8.13.2. Hydraulic accumulators

The following information is applicable to hydraulic accumulators.

- Hydraulic accumulators should be securely installed and protected from damage by falling objects.
- The attachments to the accumulator should be by means of a minimal length adapter and flexible hose for mobile plant.
- Fittings should be located or otherwise guarded to provide mechanical protection against operational and maintenance damage e.g., Rock damage or stepping onto components during maintenance etc.
- A means (e.g. bleed valve) should be fitted to allow service personnel to quickly deplete pressure. The fluid should return to tank and the tank depressurised.
- A means for service personnel to relieve gas pressure safely in a gas-charged accumulator(s) should be provided.
- A means of diffusing pressure (e.g. relief valve) should be provided between the

manual gas charging circuit and gas-charging accumulators.

- Gas charged accumulators should be in accordance with AS 2671.
- Spring type accumulators should be labelled with a warning informing the content is under spring pressure.
- Accumulators should be installed providing adequate protection to personnel.
- Accumulators should be protected against damage and an uncontrolled release of energy.
- Accumulators should incorporate a means for confirming pressure on oil side (e.g. pressure gauge).
- Warning sign to identify accumulators in the hydraulic system and to depressurise before maintenance work should be installed. (Generally, be at the main isolation points and on the hydraulic circuit/drawing).

8.14 Hydraulic Tooling/Testing Equipment

Typical applications are (but not limited to) “Enerpac”, “Porta-Power”, development roof bolt tensioners, chain tensioner units, hydraulically operated bead breakers, hydraulic hose test rigs and test points.

- All equipment of this types shall be treated as safety-critical/ high-risk and conform to the factor of safety in ISO 7751
- The repair and replacement of hydraulic hose and fittings will be in accordance with manufacturers recommendations and be suitable for the required rating of the associated hydraulic components
- All equipment shall be tracked, inspected and maintained in accordance with site specific documented requirements

9 Assembly and installation

9.1 Manufacture and assembly

Manufacturers and assemblers of fluid power systems and components should use the design specifications provided by the designer.

The following should be considered in the manufacture and assembly of fluid power systems and components:

- Specific conditions relating to the method of manufacture.
- Instructions for fitting or refitting parts.
- Instruction where hot or cold parts or material may create a hazard.
- Specifications of material.

- Schematic diagrams.
- Specifications for proprietary items e.g. electric motors.
- Component specifications including drawings and tolerances.
- Assembly drawings.
- Assembly procedures including specific tools or equipment to be used.
- Manufacturing processes e.g., requirements for crimping.
- Details of hazards presented by materials during manufacturing.
- Safety outcomes for programming.

Any alterations during the manufacturing / assembly phase of a fluid power system are considered a design change in which designers' obligations apply.

9.2 Installation at mines

9.2.1. General

This section applies to the installation of fluid systems, including pumps, hoses, valves, gauges, components, accumulators and actuators when being carried out on mines.

Fluid power systems should be installed or reassembled in accordance with the designer's/manufacturer's installation/assembly documentation, which should identify the exact location and route of all components and hoses.

Before the installation of a fluid power system the following should be identified:

a) the installation program (schedule),
b) all hazards, risks and controls associated with the installation, including but not limited to:
    - exposure to dangerous areas before installing guards, whip restraints
    - plant interacting with people
    - plant interacting with other plant e.g. connected services and installations
    - any special tools, jigs, fixtures or appliances necessary to minimise the risk of injury
    - any environmental factors affecting installation.
    - when a risk assessment is required
    - tasks which require an installation procedure or safe work method statement (SWMS)
    - tasks that can be covered by people's competencies
    - training requirements prior to or during installation
    - change management, auditing and review requirements.

9.2.2. Installation procedure

The installation procedure should include:

- Isolation, depressurisation and re-energising instructions
- change of shift or hand over procedures
- testing procedures
- competencies to complete the task safely
- tools and equipment required
- group isolation if applicable.

Procedure input

The installation procedure should be prepared from:

- equipment manufacturers' and designers' recommendations
- site risk assessments, risk reviews and job safety analyses
- safety alerts
- relevant standards and guidelines
- site knowledge through consultation with workers
- other site-specific requirements.

9.2.3. Inspection and test plan (ITP) – verification

An inspection and test plan (ITP) should:

- be developed to identify all critical inspections, stops and checks during the installation
- verify the system is installed in accordance with the design documentation and the site standards, for example routing of hoses, component locations, etc
- be completed prior to the normal operation of the system
- be carried out by a person independent to the person that installed the system
- raise a non-conformance report (NCR) where defects or non-conformances are identified.

9.2.4. Installation records

'As Built' installation records should be documented with the relevant drawings and manuals updated. The mine should maintain as built records. These records should be kept in the plant safety documentation records.

9.3 Longwall installations – underground coal mines

Longwall pre-installations or relocations in underground coal mines should include consideration of:

- pump installations, routing of the hydraulics hoses to the face and retention of the hoses
- reducing the installation pump pressure to the lowest practicable pressure, for example 35Mpa to 10Mpa during the installation phase
- the location and function of remote emergency stops
- how the hoses are installed and connected
- remote operation for roof supports during recovery and installation
- alterations or changes to existing high-pressure supply including venting of any installation/recovery system, the labelling and training
- the removal of entrapped air prior to powering leg cylinders or other actuators. For example, operate a ram a few times before raising the leg cylinder
- how the temporary pump station and hydraulics should be installed
- failure modes for hydraulic actuators should be such that they will not add risk to the work area. For example: roof support shield legs should fail internally or have adequate fluid discharge capacity external to the cylinder which does not add risk to the workplace. This may also apply to roof support advance cylinders, roof support canopy alignment cylinders and canopy tip cylinders.

Longwall hoses are characterized by many hoses, hoses of different pressure ratings, different functions, risk of cross contamination and the inability to read pressure rating of hoses which are encapsulated by diffusion of sleeves. Hence preference should be given to using a consistent colour code at hose ends.

Longwall hose assemblies and/or pipes should have a unique coupling style or size to prevent cross- connection of different circuits.

10 Commissioning

10.1 General

Any new, overhauled or modified fluid power systems should be commissioned in accordance with the designer's documentation and AS 2671, AS 2788 and AS 4041 as applicable.

10.2 Commissioning Plan

A commissioning plan should be developed for the fluid system. The plan should consider:

- potential hazards and risks associate with commissioning the fluid power system
- commissioning in accordance with the designer's, manufacturers and site-specific requirements
- commissioning criteria should be quantifiable and set pass failure limits for each test.
- examination and tests to prove the correct operation and installation of all safety devices
- pressure testing each component of the system at the designed working pressure where required
- a testing schedule to check, test and operate all functions in a safe manner with consideration to the electrical commissioning checks
- documenting results of commissioning checks
- a system to identify commissioning is complete and the system is ready for normal operation.

10.3 Decommissioning of fluid power systems for further use

A decommissioning plan should be developed for the fluid system. The plan should consider:

- safe disposal and recycling of fluids retained in the fluid power system
- withdrawal of fluids from reservoirs and components where practical to reduce the potential for spills from assemblies and components
- retained pressure should be released
- consideration for the potential for pressure intensification and fitment of appropriate safeguards
- safe disassembly procedure of the plant structures including effects on stability and movement of components.
- durable labelling of components with retained fluids and stored energy

All fluid may not be able to be withdrawn from all components without complete disassembly. Components with retained fluids should be marked with the appropriate SDS information.

11 Operation

11.1 General

This section applies to the operation of fluid power systems.

The characteristics of any hydraulic systems or components should be fully understood for the safety of personnel in the workplace.

The supplier shall provide relevant information and instructions to the mine to operate, maintain and repair equipment in a safe operating condition. (e.g. service, parts manual, hydraulic schematics, control circuits, functional specification, training manuals etc).

An operational and maintenance risk assessment must be carried out before using the machine or system.

11.2 Procedures

11.2.1. Operational procedures

Site specific operational procedures should be developed based on the application of the designer's operational procedures and site specific environmental conditions. Procedures should outline:

- how the fluid power system is operated in a safe manner,
- the identification of residual risks and how to address them, e.g. any PPE that should be worn,
- the designed operational limits (envelope),
- the operational functions and expected response to controls,
- normal operations conditions such as pressures, temperatures, flows, actuator positions, etc,
- any environmental conditions which would affect the operation of the fluid power system,
- storage and handling of hydraulic fluid.

11.2.2. Emergency procedures

Emergency preparedness is an essential part of working with fluid systems and should form part of the emergency management plan and First Aid Management Plan.

- Procedures must be developed for operators' responses and initiation of wider responses to emergencies. At a minimum procedures must be in place for response to a hydraulic oil fire, personnel trapped by actuators, or suspected fluid injection.
- Emergency response to fluid systems emergencies including fluid injection should be

considered as part of an emergency first aid simulation or exercise at the mine.
- Emergency procedures must include actions to be taken in the event of a fluid injection injury or a suspected fluid injection refer Appendix F for guidance.

Note: Do not delay or treat as a simple cut. Specialist treatment is urgently required.

11.3 Defects

Defects identified during operation should be reported and dealt with in accordance with the mine's defect management system. Variances to the normal operating condition should be reported.

11.4 Prestart and operational inspections

Pre-start and operational checks and inspections should be carried out on a regular basis and should be carried out in accordance with the designers' recommendations.

12 Inspection, maintenance, and repair

12.1 General

The fluid power system should be regularly inspected, maintained and repaired so that the system remains fit for purpose and in a safe condition to operate over its lifecycle.

Inspections, maintenance and repairs should be carried out in accordance with site specific procedures based on the designer's documentation and should extend to:
- verifying the functionality of the circuit,
- systematically inspecting and maintaining all components of the system,
- the inspection of hose assembly condition against established criteria,
- periodically checking safety critical systems and warning devices,
- maintenance strategies which incorporate component lifecycle inspections,
- only using competent persons familiar with the particular fluid power system.

12.2 Safe working with fluid power systems

When working with fluid power systems:
- never feel for leaks,
- never vent hydraulic fluid to atmosphere unless it is safely controlled, such as into collection drums/trays or through a diffuser,
- never disconnect any line that has not been de-energised and tested for de-energisation,

- always apply energy isolation procedures.

12.3 Inspection, maintenance and repair procedures

Safe systems of work should be developed and maintained for routine activities such as fluid sampling, component testing, inspections, etc. A risk assessment should be carried out for all abnormal maintenance activities and a work procedure made available and followed where there is significant risk, e.g. replacement of any item that may cause a significant risk if removed or installed incorrectly i.e. (hazardous task).

12.4 Isolation and energy dissipation

The mine must have an energy isolation management plan. This plan will include:

- an energy isolation process used for the de-energisation of all energies,
- an assessment process for people who need to demonstrate competence,
- identified specific isolation processes for high risk activities,
- emergency management,
- training.

All safe work methods should identify energy isolation, dissipation and verification requirements. Appendix G offers guidance on the requirements for energy isolation management.

12.5 Hose assembly management

12.5.1. General

A hose management program should be developed, implemented and maintained. The hose management program should be established and maintained in consultation with relevant stakeholders, including site management, maintenance and suppliers. The hose management program should be integral with the mines maintenance system and the site-specific maintenance strategies.

The hose management program should include:

- a database of the range of hose assemblies on the mine site,
- a maintenance schedule such that all hose assemblies are inspected at a frequency as required for their risk to safety and equipment operation,
- Pre-used hose assemblies or hoses with no known history (e.g. longwall, monorail, AFC/BSL hoses) should not being reinstalled unless inspected and proof tested,
- hose failure mode analysis.

A hose management program should be developed, implemented and maintained. The hose management program should be established and maintained in consultation with relevant stakeholders, including site management, maintenance and suppliers. The hose management program should be integral with the mines maintenance system and the site-specific maintenance strategies.

The hose management program should include:

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- a maintenance schedule such that all hose assemblies are inspected at a frequency as required for their risk to safety and equipment operation,
- Pre-used hose assemblies or hoses with no known history (e.g. longwall, monorail, AFC/BSL hoses) should not being reinstalled unless inspected and proof tested,
- hose failure mode analysis.

12.5.2. Hose failure modes

When hoses are replaced a record of their failure should be recorded. These failures should be periodically reviewed and used for future improvement. Refer SAE J1927

The mine's hose management plan should aim for the in service 'inspection and assessment to discard' the hose prior to a 'catastrophic in-service failure' occurring. Consideration should be given to the failure modes of the fitting, particularly staple or pin type fittings.

12.6 Hose inspections

12.6.1. General

All hose assemblies and adaptors should be inspected periodically, in accordance with the mine's maintenance plan, by a competent person to ensure the system remains in a safe operating condition. Where hose assemblies show damage, steps should be taken to determine the suitability for continued use.

Hoses should be visually inspected insitu to determine if they are operating properly, without leaks or signs of failure.

The inspection frequency of in-service hoses should be based on the severity of the application, past failure history and the risk to people safety if failure occurs.

12.6.2. In-service inspections

In-service inspection of hose assemblies should only be carried out by competent personnel, who can make a valid assessment of the condition of the inspected hose assemblies and provide recommendations as to whether the hose assembly:

- is fit for continued service
- is fit for limited service
- should be replaced immediately.

12.6.3. Hose replacement criteria

Hose assemblies should be replaced when the hose assembly is damaged and is no longer fit for purpose or does not offer the desired level of safety.

Mines in consultation with suppliers should establish discard criteria.

12.7 Maintenance

Hydraulic hoses and components have a finite life, and at some stage the hose assembly should be replaced irrespective of the visual condition. This period may vary depending upon the risk to people upon failure of the hose, the effective service life and the site hose management plan.

Where hose assemblies in high risk areas have been in service for a period of greater than five years (but less than eight years) then they should be replaced, unless:

- a sample of hose assemblies have been inspected and tested in accordance and
- an assessment based on service history and condition is made to justify an extended period.

Consideration should be given at what point in time is it better to replace all hoses at once rather than replace an individual hose, based on the age and expected remaining life of the remaining hoses.

12.7.1. Filtration

Fluid power system filtration and replacement or testing of filtration components should be considered in the maintenance schedule.

12.7.2. Pipe/tube assemblies

The environmental effects on the pipes and fittings such as corrosion should be considered in the maintenance plan.

Repairs to pressure piping will be carried out by appropriately qualified personnel in accordance with approved repair procedures based on relevant Australian standards for pressure piping.

12.7.3. Hydraulic component cleaning

Hydraulic component cleaning agents used should not compromise the integrity of the fluid power system and components. Some cleaning agents have been known to degrade seals and hoses.

12.8 Repairs and defects

12.8.1. General

A site-specific work procedure should be available for the replacement of all major components and where an item may cause a risk to people if replaced incorrectly.

System components should only be replaced with components manufactured to the same standard. Procedures must be in place to ensure replacement components meet the system specification. Following repairs, the functionality of the system should be checked.

All repairs to notified defects should be recorded. Safety defects should be reported to the designer/manufacturer.

12.8.2. Recommissioning after repairs

The system should be checked to ensure it is in an operable state, e.g. hoses not connected, ports left open, and connections tight. The system and related components should be thoroughly cleaned to minimise the risk of fires and other safety & health hazards from uncontained fluids and waste.

When re-energising fluid power systems after repairs the area should have restricted access to people until verification of system integrity is confirmed. If practical re- energisation should be carried out at a low pressure to minimise risk and verify system integrity where practicable.

12.9 Storage and Transport

12.9.1. Hose storage

Hose and hose assemblies should be stored in accordance with ISO 8331 and supplier recommendations.

- A system of age control should be implemented to ensure hose assemblies are used prior to shelf-life expiration.
- Storage areas should be relatively cool and dark, as well as free of dust, dirt, dampness and mildew.

- A programme of periodic inspection and testing shall be implemented for stored hoses, refer to SAE J273
- Hoses that have been removed from service (eg longwall monorail hoses,) including parked equipment such as truck fleets) and planned to be re-used shall be inspected and proof tested prior-to re-use.
- Hoses and hose assemblies should be re-proof tested after 5 years from their cure date and discarded after 8 years unless recommended otherwise by the hose manufacturer. After successfully retesting, the hose assemblies should be clearly remarked.

12.9.2. Intensification in storage or transport

Any component with the potential for intensification, especially in storage or transport should be supplied with a means that will pressure relieve (blowout), (e.g. non-metallic caps, breather) in the event of the component being pressurised.

12.10 Audits

All site inspection, maintenance and repair activities should be periodically audited against the:

- mine's inspection and maintenance system
- designer's/manufacturer's recommendations
- keeping of records
- Appropriateness and currency of competencies.

Audits should be carried out by a person not normally involved in the maintenance activities.

12.11 Records

Records should be kept on the results of all inspections, maintenance and repair activities.

- These records should be reviewed to determine if any modification and improvements could improve safety and the reliability of the equipment.
- Fluid power circuits and maintenance documents should be kept up to date and be readily available for use on the equipment.
- Any change in design or duty should be recorded and appropriate changes implemented. These records form part of the fluid power system safety document.
- Training records of persons trained in the site fluid management plans and competency documents
- Incident investigations pertaining to fluid management systems
- Pressure equipment and inspection register.

13 Change to fluid power systems and components

Manufacturers, suppliers, operators and maintainers of fluid power systems should plan and cater for the effective management of change to minimise risk to an acceptable level. Any change that may have an impact on the safety and health of workers should be risk assessed in accordance with the mines risk management practices, be authorised at an appropriate level, documented and understood by operators.

Changes to manufacturers and supplier's equipment specification and manufacturing processes which may affect serviceability or life of components (eg a change in manufacturing process results in a reduction of fatigue life of a component) must follow a change management process and make sure that mines are informed of the changes and likely impacts.

14 Decommissioning, dismantling and disposal

14.1 General

Where the fluid system is to be decommissioned, relocated and recommissioned, a risk assessment on the decommissioning process should be carried out. Standard work procedures should be developed and followed.

Decommissioning procedures should be developed for the reclaim of hazardous substances and for long term storage.

Items to be considered when decommissioning fluid systems include:

- environment (underground and/or surface)
- pressure intensification
- cleanliness of the hydraulic system (if system is to be recommissioned)
- storage of fluids
- corrosion protection (if system is to be recommissioned)
- handling during and after storage (associated equipment)
- long term care and maintenance
- disposal procedures
- potential use of storage fluids

14.1.1. Decommissioning fluid power systems for disposal

Where a fluid power system is to be decommissioned and disposed, consideration should be given to the following:

- Consideration should be given to the potential for future usage of the plant.
- Withdrawal of fluids from reservoirs and components where practical to reduce the

potential for spills from assemblies and components.

- Retained pressure should be released.
- The potential for pressure intensification and fitment of appropriate safeguards.
- Safe disassembly procedure of the plant structures including effects on stability and movement of components.
- Safe disposal and recycling of fluids retained in the fluid power system.
- All fluid may not be able to be withdrawn from all components without complete disassembly. Components with retained fluids should be marked with the appropriate SDS information.

15 Training and competence

All persons that work with fluid power systems or components of fluid power systems shall be trained and have been assessed as competent for the works they undertake.

15.1 Coal mine workers

The mine training scheme and training needs analysis shall include training and competency requirements for personnel involved with fluid power systems.

Fluid systems management awareness training shall be provided for all coal mine workers, including supervisors and contractors that work with or around fluid power systems. It is recommended that refresher training be undertaken on an annual basis.

15.1.1. Operator competence

All equipment operators of fluid power machinery should be competent in:

- the operational and emergency procedures
- all operational functions
- preoperational checks
- understanding the indicating devices, which indicate the equipment operating condition (e.g. flow, pressure, error messages, motor current and voltage)
- understanding of energy isolation process, in particular for hazardous activity isolation
- understanding the hazards associated with working near fluid power systems.

15.1.2. Inspection, maintenance and repair competence

All people associated with the maintenance of the fluid power system (including contractors) should be competent to safely carry out work on the fluid system.

Training of competent personnel should include:

- system functional requirements and operating parameters
- troubleshooting and individual component testing
- safe energy isolation and dissipation in accordance with the mine's isolation management plan
- electrical / fluid power interfaces and control circuitry
- hose management
- importance of cleanliness

Specific competence on energy isolation should be carried out on large and complex fluid power systems such as longwall roof supports.

The training program should be established using courses recognised by the Australian Skills Quality Authority (ASQA), supplemented by relevant plant and site-specific training.

Some relevant competencies include:

- MEM18018C – Maintain pneumatic system components (Previously Pneumatics 1)
- MEM18019B – Maintain pneumatic systems (Previously Pneumatics
- MEM18020B Maintain hydraulic systems components
- MEM18021B Maintain hydraulic systems
- MEM18052B Maintain fluid power systems for mobile plant

15.2 Designers, manufacturers, suppliers and installers

Designers, manufacturer's, suppliers and installers shall have in place training and competency requirements for person involved in working with fluid power components and systems.

People fabricating hose assemblies shall be competent and trained in the proper use of equipment, materials, assembly procedures and testing. Competency assessment training and assessment records shall be maintained.

15.3 Competence of hose assemblers and installers

Hose assemblers and installers must be trained and competent to undertake fluid power system work. Copies of training records should be available.

16 Review and audit process

The mine should regularly review and continuously improve fluid power system risk management elements and practices to ensure there is an acceptable level of risk throughout the lifecycle of each fluid power system.

Triggers for plan review will be established. Triggers for review may include:

- Incidents
- action plans
- frequency of inspections
- results of audits and new practices
- training
- frequency of review
- new technology

17 Appendices

17.1 Appendix A: Relevant standards and documents

	Queensland Coal Mining Legislation
	Coal Mining Safety and Health Act 1999
	Coal Mining Safety and Health Regulation 2017

Abbreviation of standard	Title of standards
AS/ISO 1000	AS ISO 1000-1998: The international system of units (SI) and its application
AS 1101.1	AS 1101.1:2007: Graphic symbols for general engineering - Hydraulic and pneumatic systems
AS 1180.5	AS 1180.5-1999: Methods of test for hose made from elastomeric materials - Hydrostatic pressure
AS 1180-10B	AS 1180-10B-1982: Methods of test for hose made from elastomeric materials – Determination of combustion propagation characteristics of a horizontally oriented specimen of hose using surface ignition
AS/NZS 1200	AS/NZS 1200:2015: Pressure equipment
AS 1210	AS 1210-2010: Pressure vessels
AS 1271	AS 1271-2003: Safety valves, other valves, liquid level gauges, and other fittings for boilers and unfired pressure vessels
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 2030.1	AS 2030.1-2009: Gas cylinders – General requirements
AS/NZ 2033	AS/NZ 2033-2008: Installation of polyethylene pipe systems
AS/NZS 2554	AS/NZS 2554: Hose and hose assemblies for air
AS 2660	AS 2660-1991: Hose and hose assemblies – Air/water – For underground coal mines
AS 2671	AS 2671:2021: Hydraulic fluid power - General rules and safety requirements for systems and their components (ISO 4413:2010, MOD)

AS 2788	AS 2788:2021: Pneumatic fluid power - General rules and safety requirements for systems and their components (ISO 4414:2010, MOD)
AS 2971	AS 2971-2007: Serially produced pressure vessels
AS 3788	AS 3788:2006: Pressure equipment – In-service inspection
AS 3873	AS 3873-2001: Pressure equipment – Operation and maintenance
AS 3892	AS 3892-2001: Pressure equipment – Installation
AS 4024.1	AS 4024.1-2014: Series: Safety of Machinery
AS/NZS 4024.1302	AS/NZS 4024.1302:2014: Safety of machinery - Risk assessment - Reduction of risks to health from hazardous substances emitted by machinery - Principles and specifications for machinery manufacturers
AS/NZS 4024.1501	AS/NZS 4024.1501-2006 (R2014): Safety of machinery - Design of safety related parts of control systems - General principles for design
AS/NZS 4024.1502	AS/NZS 4024.1502-2006 (R2014): Safety of machinery - Design of safety related parts of control systems – Validation
AS/NZS 4024.1503	AS/NZS 4024.1503:2014: Safety of machinery – Safety-related parts of control systems – General principles for design
AS/NZS 4024.1906	AS/NZS 4024.1906:2014: Safety of machinery - Displays, controls, actuators and signals - Indication, marking and actuation - Requirements for the location and operation of actuators
AS 4037	AS 4037-1999: Pressure equipment – Examination and testing
AS 4041	AS 4041-2006: Pressure piping
AS/NZS 4024:1201	AS/NZS 4024.1201:2014: Safety of machinery - General principles for design - Risk assessment and risk reduction
AS/NZS 4024:1303	AS/NZS 4024:1303:2014: Safety of machinery - Risk assessment - Practical guidance and examples of methods
AS/NZ 4130	AS/NZ 4130-2018: Polyethylene (PE) pipes for pressure applications
AS 4343	AS 4343:2014: Pressure equipment – Hazard levels
AS/NZ 4401	AS/NZ 4401-2006: Plastics piping systems for soil and waste discharge (low and high temperature) inside buildings—Polyethylene (PE)
AS 4458	AS 4458-1997: Pressure equipment – Manufacture

AS 4795	AS 4795.1 – 2011: Butterfly Valves for Waterworks Purposes – Wafer and Lugged
AS/NZS 4801	AS/NZS 4801-2001: Occupational Health and Safety Management Systems
AS 5062	AS 5062:2016 Fire protection for mobile and transportable equipment
AS/NZS ISO 31000	AS/NZS ISO 31000:2009: Risk Management Set – Principles and guidelines
AS 61508.1	AS 61508.1-2011: Functional safety of electrical/electronic/programmable electronic safety-related systems - General requirements
AS 62061	AS 62061-2006: Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems
AS 6401	AS 6401- 2003; Gate valves for waterworks purposes
AS/NZS ISO 45001	AS/NZS ISO 45001:2018: Requirements with guidance for use Occupational health and safety management systems – Requirements with guidance for use
ACARP C17020	The Australian Coal Industry's Research Project Stage Two: Performance Based Specifications For Longwall Hose Assemblies
SA/SNZ HB 89	SA/NZS HB 89 Risk management – Guidelines on risk assessment techniques

	Reference to 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 1219-2	ISO 1219-2:2012: Fluid power systems and components - Graphical symbols and circuit diagrams - Part 2: Circuit diagrams
ISO 1436	ISO 1436:2009: Rubber hoses and hose assemblies – Wire-braid-reinforced hydraulic types for oil-based or water-based fluids – Specification
ISO 3457	ISO 3457:2003: Earth-moving machinery – Guards – Definitions and requirements
ISO 3862	ISO 3862:2009: Rubber hoses and hose assemblies – Rubber covered spiral-wire-reinforced hydraulic types for oil-based or water-based fluids – Specification
ISO 4079	ISO 4079:2015: Rubber hoses and hose assemblies – Textile-reinforced hydraulic types for oil-based or water-based fluids - Specification

ISO 4406	ISO 4406:1999: Hydraulic fluid power - Fluids - Method for coding the level of contamination by solid particles
ISO 4413	ISO 4413:2010: Hydraulic fluid power - General rules and safety requirements for systems and their components
ISO 4414	ISO 4414:2010: Pneumatic fluid power - General rules and safety requirements for systems and their components
ISO 4520	ISO 4520:1981: Chromate conversion coatings on electroplated zinc and cadmium coatings
ISO 6605	ISO 6605:2002: Hydraulic fluid power – Hoses and hose assemblies – Test methods
ISO 6802	ISO 6802:2005: Rubber and plastics hoses and hose assemblies with wire reinforcements – Hydraulic impulse test with flexing
ISO 6803	ISO 6803:2005: Rubber or plastics hoses and hose assemblies – Hydraulic pressure impulse test without flexing
ISO 6805	ISO 6805:1994: Rubber hoses and hose assemblies for underground mining - Wire-reinforced hydraulic types for coal mining - Specification
ISO 7751	ISO 7751:1991/Amd 1:2011: Rubber and plastics hoses and hose assemblies - Ratios of proof and burst pressure to maximum working pressure - Amendment 1: Replacement of "design working pressure" by "maximum working pressure" throughout text
ISO 8030	ISO 8030:2014: Rubber and plastics hoses – Method of test for flammability
ISO 8031	ISO 8031:2009: Rubber and plastics hoses and hose assemblies - Determination of electrical resistance and conductivity
ISO 8331	ISO 8331:2014: Rubber and plastics hoses and hose assemblies - Guidelines for selection, storage, use and maintenance
ISO 9001	ISO 9001:2015: Quality management systems – Requirements
ISO 11237	ISO 11237:2010: Rubber hoses and hose assemblies – Compact wire-braid-reinforced hydraulic types for oil-based or water-based fluids - Specification
ISO 13732-1	ISO 13732-1:2006: Ergonomics of the thermal environment - Methods for the assessment of human responses to contact with surfaces - Part 1: Hot surfaces
ISO 13849-1	ISO 13849-1:2015: Safety of machinery -- Safety-related parts of control systems -- Part 1: General principles for design
ISO 16889	ISO 16889:2008: Hydraulic fluid power - Filters - Multi-pass method for evaluating filtration performance of a filter element

ISO 17165-1	ISO 17165-1:2007: Hydraulic fluid power - Hose assemblies - Part 1: Dimensions and requirements
ISO/TS 17165-2	ISO/TS 17165-2:2013: Hydraulic fluid power - Hose assemblies - Part 2: Practices for hydraulic hose assemblies
ISO 18752	ISO 18752:2014: Rubber hoses and hose assemblies - Wire- or textile-reinforced single- pressure types for hydraulic applications – Specification

	Reference to SAE standards
SAE J343	Test and Test Procedures for SAE 100R Series Hydraulic Hose and Hose Assemblies
SAE J517	Hydraulic Hose
SAE J1065	Nominal Reference Working Pressures for Steel Hydraulic Tubing
SAE J1273	Recommended Practices for Hydraulic Hose Assemblies
SAE J1467	Clip Fastener Fitting
SAE J1927	Cumulative Damage Analysis for Hydraulic Hose Assemblies
SAE J2006	Marine Exhaust Hose

	Reference to MDGs

MDGs are found on NSW Resources Regulator website.

Documents located in the NSW Resources Regulator’s historical catalogue may contain outdated material but include guidance material still useful and/or relevant.

MDG 1	MDG 1 *Guideline for Free-Steered Vehicles*
MDG 15	MDG 15 *Guideline for mobile & transportable equipment for use in mines*
MDG 40	MDG 40:2007 *Guideline for Hazardous Energy Control (Isolation or Treatment)*
MDG 41	MDG 41 *Guideline for fluid power systems safety at mines*
MDG41TR	MDG41TR *Technical Reference 1 – 420 Bar Super Staple-lock Fittings and Adaptors for Hydraulic power-transmission*
MDG 3007	MDG 3007: 2018 *Guideline for Hydraulic Safety*
MDG 3608	MDG 3608:2012 *Guideline for Non-metallic materials for use in underground coal mines*

17.2 Appendix B: Fluid power system hazards

A list of primary hazards and potential consequences associated with fluid power systems is shown in Table B1.

Table B1 – Common hazards and consequences for fluid power systems.

Energy/Hazard	Unwanted event	Potential consequence
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 • Release of compressible gas	• Direct fluid injection injury • Struck by projectile debris • Struck by whipping hoses • Burns from contact with eyes or skin • Injury to sensitive areas of body, e.g. eye injury • Catastrophic failure of pressurised components • Reduced component life • Loss of production/downtime
Fuel source - hydraulic oil or other	• Exposure to heat or explosion after ignition of uncontrolled release of fuel energy (fire or explosion). For example: A leak under pressure results in fluid contacting an ignition source.	• Burns • Asphyxiation • Equipment and production losses
Toxic chemical or substance	• Uncontrolled release of toxic chemical or substance. For example: fluids such as phosphate esters.	• 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. pumps and motors, electric motors, cavitation, etc • Exposure to discontinuous operation noise ie hammering, operation of functions etc • Noise from rapid expansion of gases	• Loss of hearing (short term) • Loss of hearing (long term)
High temperature	• Development of high temperatures on equipment components from energy being converted into heat within the hydraulic system. Ignition of fluid or vapour	• 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 • Equipment and production losses

Electrical energy sources	• Earth or other faults of the electrical system.	• Electric shock
Static electricity	• Discharge of electrical energy causing ignition of fluid or vapour	• Burns • Asphyxiation • Equipment and production losses
Potential or kinetic energy driven by gravitational or hydraulic forces	• Unplanned movement (by failure to control motion of machine or failure to support suspended load)	• Crush injury (between fixed and moving components) • Crush injury (falling load or roof) • Equipment and production losses

The list below identifies some latent and other specific risks for fluid power systems that should be considered. Many of the potential consequences listed in Table B2 are relevant to latent and specific risks.

Table B1 – Consequences of some latent and other specific fluid power system risks.

a) fluid leakage due to hose/pipe/fitting failure (including pin holes)
b) physical damage from people standing on components
c) physical damage from fallen material
d) pressure intensification and pressure pulsation's
e) over pressurisation/excessive flow or loss of pressure
f) electrical/hydraulic/pneumatic control system failure
g) fluid contamination
h) wear, fatigue, corrosion and age
i) excessive temperature of the systems or environment
j) overload and/or high external loads
k) unplanned movement due to component failure. For example, blockages, pressure drops or leaks which affect the operation of components
l) working pressure and flow, temperature and load changes over time
m) failure of power supply, either hydraulic, pneumatic or electric
n) actuator failure (structural or functional)
o) inappropriate hose/pipe installation
p) potential hazards due to the environment; a. explosive dust or gas mixtures b. water level or rainfall c. release of gas from oxy/acetylene bottles d. UV light exposure
q) system integration and potential incompatibility
r) poor work practices in diagnosing system faults and poor maintenance resulting in ignorance of potential dangers
s) failure to implement change management procedures (ie different scale pressure gauges)

17.3 Appendix C: Safety Alerts and Bulletins

Safety alerts and bulletins published by Resources Safety & Health Queensland (RSHQ) relating to fluid power systems can be found at https://www.rshq.qld.gov.au/safety-notices and include:

	RSHQ safety alerts
SA-001	Failure to isolate compressed air line
SA-031	Incorrect removal of hydraulic hoses
SA-060	Failure of high-pressure hydraulic fitting
SA-063	Plunger from hydraulic cylinder becomes an 18kg projectile
SA-093	Operation of hydraulic controlled lighting plants
SA-099	Steering tie-rod failure in dump truck
SA-101	Quick release pipe couplings without safety clips could be deadly
SA-160	Compressed air pipeline failure
SA-196	Mine worker suffers chemical burns to eyes due to high pressure fluid release
SA-241	Rupture of high-pressure hydraulic line
SA-267	Incorrect use of Victaulic flexible coupling SC 77
SA-271	Longwall fluid-injection injury
SA-273	Hydraulic hoses fail on excavator booms
SA-286	Coal mine worker hit by loose discharge hose
SA-321	High pressure water jet injection injury
SA-323	Worker injured by a discharging fire suppression cylinder
SA-332	Abrasive blasting incident
SA-344	Worker injured due to ineffective isolation
SA-346	Slurry pump explosion

	RSHQ safety bulletins
SB-001	Off-highway trucks: Low brake pressure and low brake fluid warnings
SB-011	Use of restraining devices on hoses

SB-041	Working on compressed air lines
SB-049	Isolation of plant containing stored energy
SB-067	Managing high pressure fluids and gases
SB-070	Hazards of stored energy
SB-074	Isocyanates from 2-pack paints and use of polyurethane resins in mining
SB-139	Risk management of high-pressure fluids and gases
SB-158	Fixed plant and mobile equipment fires on surface coal mines

NSW Safety Alerts

	NSW Safety alerts & bulletins
SA98-08	Injection of High Pressure Hydraulic Oil
SA06-16	Fatal high pressure hydraulic injection
SA06-18	Longwall staple failures Non-standard type hose ends and adaptors
SA10-01	Longwall hydraulic system over- pressurised.
SB-19 – 04	Workers injured by high pressure fluid

17.4 Appendix D: Human Error

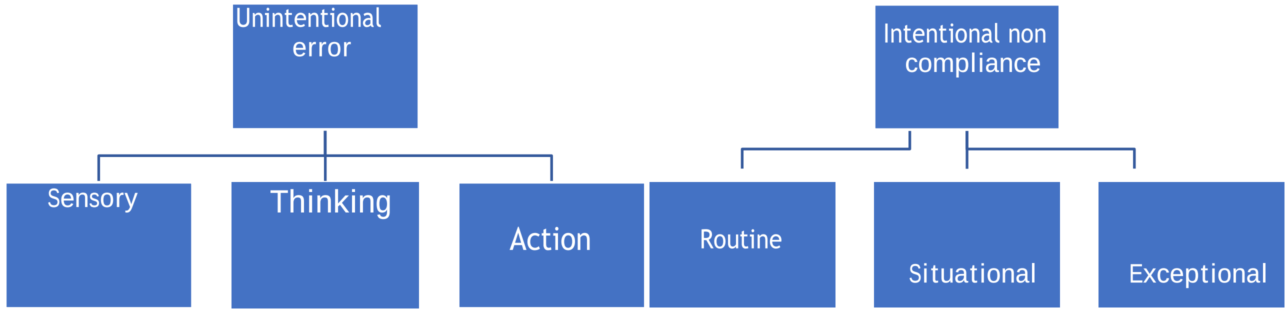
Human factors are often contributing factors in the failure of risk controls. The reduction of human factor potential should therefore be considered for the lifecycle of the fluid power system

Human errors may be described by the unsafe acts listed below:

- errors (unintentional behaviours)
- decision errors
- skill-based errors (lacked the knowledge to do the right thing)
- perceptual errors (decision made based upon faulty information)
- violations (wilful disregard of the rules and regulations)
- routine (known to be wrong but is an accepted way of doing things)
- exceptional (misuse or abuse)
- Incident data

Human factors are often contributing factors in the failure of risk controls. The reduction of human factor potential should therefore be considered for the lifecycle of the fluid power system. Human failures may be described as;

- Unintentional error is whereby the person can explain how the failure occurred but not why. The individual is puzzled by their own actions.
- Intentional noncompliance is the individual announcing their intention to behave in a certain way. It can also be demonstrated the person knew what should be done. Usually, intentional noncompliance is well meaning but misguided.



17.5 *Appendix E: Information Management*

Safety-related aspects of fluid power systems should be fully documented and be readily available to those involved. These records should cover the lifecycle of the power fluid systems and be stored and maintained in such a way that they are readily retrievable and protected against damage, deterioration and loss.

The documentation should be created by the designer and maintained by the person in control of the fluid power system.

The following information should be included in these records:

- design specifications, performance and operational conditions
- design documentation
- as built schematic
- installation requirements
- hazard identification and risk assessment documents
- risk control methods
- identification of all safety-critical systems and their safety category or integrity level
- consultation records
- commissioning and test results
- Operator and trade training manuals
- Inspection, repair and replacement manuals

- Troubleshooting guides
- maintenance records, safety inspections and test reports
- change of procedures, monitoring, audit and review reports
- reports of incidents, accidents and safety statistics
- fluid system alterations
- Review of past incidents

The documentation file may not necessarily be one complete document and may refer to where the information can be obtained.

The information should be kept and maintained for the life of the fluid power systems.

People in control of fluid power systems should provide the plant designer/manufacturer/supplier with details of relevant incidents and include these alongside the record(s) for the specific fluid power systems.

The designer should to each person provided with the design, provide information on safety-related incidents that they become aware of and their recommendation to rectify such defects (e.g. safety alerts, technical bulletins and similar).

17.6 Appendix F: Emergency response plans – high pressure fluid injection

The mine must develop and implement emergency response procedures to deal with high pressure fluid injection injuries or suspected fluid injections.

> **Note: These patients require urgent transfer to medical facilities with surgical capability. There are some situations, due to the isolation of the patient, a clinician may wish to liaise with Queensland Ambulance Service and/or Retrieval Services Queensland for advice about the transfer.**

Considerations when developing an emergency response plan:

- **The suspected high pressure injection or high pressure injection of a fluid such as hydraulic oil, diesel, grease, or paint constitutes a medical and surgical emergency. This requires rapid access to appropriate specialist surgical review.**
- **The injury is frequently worse than it will initially appear, and coal mine workers and emergency responders must have a high level of suspicion of injury.**
- Patients suspected of having sustained a fluid injection injury should not be administered fluids or food. The patient should remain fasted in anticipation of anaesthesia and surgery potentially being required.
- If a high pressure injection is suspected, contact the ambulance service, and request

their attendance on site.

- A copy of the Safety Data Sheet of the involved fluid is to be accessed and available for ambulance personnel.
- Site first aid treatment would generally consist of gentle cleaning of the affected area and immobilisation and elevation of the affected limb if a fluid injection is considered likely or possible.
- Due to the initially benign symptoms, these injuries are often complicated by a delay to seek medical assistance, often several hours.
- **Without adequate and timely treatment there is a high rate of amputation.**

Clinical features:

- The point of entry may look very small and may not bleed.
- The area of injury will usually be on the working surface of the hand. However, it may be located on any body area.
- Initially the patient may not complain of pain but may have a feeling of numbness, or increased pressure within the affected part.
- Damage in the early stage is normally related to the physical injury as well as damage from the chemicals in the injected material.
- The affected body part will progressively become irritated, with the patient complaining of throbbing pain.
- Dependent upon the entry pressures, injected fluid can travel a significant distance from the initial site of entry, resulting in more widespread tissue damage.
- After the initial injection, the fluid travels in a stream until resistance (eg from muscle or bone) is encountered. The fluid then rapidly disperses in all directions along tissue planes, potentially causing traumatic dissections and compressing neurovascular bundles, leading to vascular spasm, ischaemia and thrombosis. Furthermore, the presence of the fluid and subsequent tissue oedema, can cause a pressure build up, reducing perfusion and resulting in a form of compartment syndrome.
- Two additional issues are the chemical composition of the fluid, which can have cytolytic properties and infection, which can occur during the injection, or subsequent tissue damage and ischaemia.

Intact skin can be penetrated by pressure of 7bar (approx.100psi), but this typically requires direct contact. Much higher pressures exist within most mining machinery applications where infiltration of subcutaneous tissues can occur when the liquid is fired from a distance.

References:

Clinical Practice Guidelines: Trauma/Fluid injection injury

Queensland Ambulance Service, February 2021

17.7 Appendix G: Fluid power system isolation considerations

The fluid power system should be designed such that it can be positively isolated from the energy source and also enable energy dissipation of the pressurised fluid to prevent unexpected movement and verification of fluid power hazards.

Consideration should be given to:

- **keeping the system simple** - be easily identified, be simple to operate and easy to understand its functionality
- **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.
  - prevent the activation either directly or indirectly of equipment or the release of other energies that could be enacted because of the isolation process.
    - Note: There may be more than one source of electrical or hydraulic energy supply as well as gravity, all of which should be isolated.
- **provision of a means to isolate all identified energy sources** to prevent a possible state change. This includes:
  - purpose-built isolation point, dissipation point and gauges, isolation signposting, instructions for the isolation point identify a specific safe work method for the isolation process. Gauges which indicate when operational, normal working pressures and dissipated state
  - purpose designed isolation devices that are lockable.
  - using purpose designed mechanical stops to isolate against gravity where required.
  - Integrated isolation point for multiple or complex hydraulic systems, which includes isolation and dissipation functions for all pressure systems.
  - A double block and bleed isolation point, which includes double isolation and dissipation between the isolation devices.
- a **test and inspection plan** - provided to verify the safety integrity of the purpose-built isolation, dissipation system and isolation, dissipation and verification devices.
- clear **identification of all isolation and dissipation points**.
- 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.
  - Two-point verification of a dissipation event – Such as gauge, or gauges or vent to atmosphere through a diffuser that discharges safely and/or operates a system function.
  - The system must demonstrate dissipating stored energy the system shall not inadvertently re-pressurise
  - Dissipation should not be through unscrewing, removal of staples or loosening hoses and or fittings. Diffusion should be suitably directed and restrained to prevent any unsafe state from being initiated.

- **provision of a system that verifies that pressure has been dissipated**. (Test for dead or safe state)
- provision of **safe work methods** for the use of the isolation, dissipation and verification devices. Should include:
  - removal and restoration of energy.
  - Should be based on complexity and include areas of entrapped pressure such as load lock valves used on a cylinder, accumulators, intensification.
- information on **required people competence** to isolate, diffuse and verify isolation.
- Some equipment has a **maintenance mode** included in the hydraulic system which allows limited operation of the system. If this mode is to be used, the hazards associated with the power on operation of this mode should be fully understood, risk assessed and any necessary control measures to assure acceptable risk need to be applied. Seek manufacturer’s instructions and recommendations.