FOREWORD

Over the past few years there has been an increase in fluid injection injuries from the use of pressurised fluid power systems. Pressurised fluid power systems are used as an energy source on mechanical equipment in mines. Pressurised fluid power systems are a potential major hazard which may result in fatal injuries if uncontrolled.

This Guideline for Fluid Power System Safety at Mines has been compiled to assist in formulating a management system approach for the safe use of fluid power systems in mines. It should be used by designers, manufacturers, purchasers, owners, operators, site contractors and Industry & Investment NSW Mine Safety Operations when assessing the safety aspects of fluid power systems.

This Guideline provides a good industry benchmark for engineering standards and fit for purpose equipment. It can be considered good industry practice for mitigating and controlling the risks associated with the use of fluid power systems in mines at this time.

This is a ‘Published Guideline’.

The principles stated in this document are intended as general guidelines only for assistance in devising safety standards. Owners, operators and managers should rely upon their own advice, skills and experience in applying safety standards to be observed in individual workplaces. Adherence to the guidelines does not itself assure compliance with the general duty of care.

The State of New South Wales and its officers or agents including individual authors or editors will not be held liable for any loss or damage whatsoever (including liability for negligence and consequential losses) suffered by any person acting in reliance or purported reliance upon this Guideline.

The constructive evaluation and input provided by Mine Mechanical Engineers and manufacturers of fluid power systems is gratefully acknowledged in the development of this Guideline.

This version (version 1.0) reflects the prepublished draft document. A new version will be released in 2011 to reflect the most recent updates.

The MDG 41 Guideline for Fluid Power Safety at Mines was distributed to industry for consultation and through the Coal Safety Advisory Committee, Metalliferous Safety Advisory Committee and Extractive Industries Safety Advisory committee.

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Mine Safety Operations
Industry & Investment NSW
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SECTION 1  PURPOSE AND SCOPE

1.1 SCOPE
This guideline ‘Fluid Power System Safety at Mines’ provides guidance material to assist in managing the risks associated with fluid power systems.

This guideline describes the process to be employed, the standards to be references and the issues to be addressed in developing a management plan for the management of fluid power systems in mines.

This guideline covers the lifecycle of fluid power systems including design, installation, commissioning, operation, maintenance, repair and decommissioning in the context of use within the minerals industry.

NOTES:

1. Pressurised fluid systems present a range of unique safety hazards; one of the most dangerous of all is being struck by high pressure fluid escaping to atmosphere at high velocity. Almost every fluid system in existence has the potential to cause high-pressure injection injuries. Anyone working around these systems could face such dangers. The affect on its victim ranges from; minor to severe burns, lacerations and amputations, eye injury and blindness and in some cases death.

2. This guideline is intended to assist in the evaluation of risk and may not comprehensively cover all safety related aspects of fluid power systems.

3. This guideline does not generally give quantitative information as it is not the intent to restrict innovative design.

4. This guideline is not intended for water supply reticulation which is covered by Australian Standards and local government regulation.

1.2 OBJECTIVE
The objective of this guideline is to minimise risks to the health and safety of people where fluid power systems are being used in the minerals industry.

1.3 APPLICATION
This guideline applies to all fluid power systems being used on equipment at mines in NSW.

This guideline should be used for all mining equipment such as; mobile plant (open cut and underground mines), development equipment, longwalls, fixed installations, compressed air systems, etc.

This guideline should be considered when equipment incorporating fluid power systems is:

   a) Designed or purchased (new or 2nd hand)
   b) Operated
   c) Maintained, repaired or overhauled, or when
   d) Site contracts are being considered

1.4 ALTERNATIVES
Alternative methods of providing safety based on risk assessment may be used provided that the level of safety offered by alternatives is at least equal to or better than that provided by the methods given in this guideline.

1.5 REFERENCES
A partial list of associated documents is included in Appendix 9.1 for reference.
1.5.1 Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>AS</td>
<td>Australian Standards</td>
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<tr>
<td>AS/NZS</td>
<td>Australian / New Zealand Standard</td>
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<td>DIN</td>
<td>German Standard</td>
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<td>FRAS</td>
<td>Fire Resistant and Antistatic</td>
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<td>ISO</td>
<td>International Organisation for Standardisation</td>
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<td>ITP</td>
<td>Inspection and Test Plan</td>
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<td>JIC</td>
<td>Joint International Conference</td>
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<td>JSA</td>
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<td>MSDS</td>
<td>Material Safety Data Sheet</td>
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<td>NCR</td>
<td>Non Conformance Report</td>
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<td>PPE</td>
<td>Personal Protection Equipment</td>
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<td>SAE</td>
<td>Society of Automotive Engineers</td>
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<td>SI</td>
<td>System International</td>
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<td>SWP</td>
<td>Standard Work Procedure</td>
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1.6 DEFINITIONS

For the purpose of this document the definitions below apply.

1.6.1 Competent Person

A person who has acquired through training, qualifications or experience, or a combination of them, the knowledge and skills to carry out that task.

1.6.2 Defect Management System

A system that outlines the actions to be taken when a defect is identified.

A defect management system documents actions to be taken when a defect is identified and how the details of the defect and actions taken are recorded.

1.6.3 Engineering Standards

A set of engineering standards that is applied to the mine to ensure equipment is safe to use.
Includes competency of persons, design, installation, commissioning, operation, maintenance and decommissioning

1.6.4 Fit For Purpose

Meeting adequate standards for the intended outcome over the equipment lifetime

1.6.5 Fluid Power Systems

Includes pressurised hydraulic and pneumatic compressed air systems for the transmission and control of energy. These include, but are not limited to:- fluid power medium hydraulic mineral oil, air, emulsion oil, diesel fuel, water etc

1.6.6 Fluid Injection

Fine streams of pressurised escaping fluid, which penetrate the skin and enter the human body. These injections of fluid may cause death, severe tissue damage and loss of limb.

1.6.7 High Risk Area

Any area where fluid power pressure exceeds 5MPa or the temperature of the pressurised fluid exceeds 60°C and where a hose, fitting, adaptor or connection could break, burst or fail and expose people in the vicinity of the area to the pressurised and/or hot fluid creating a risk to health and safety.

Note: The higher the pressure, the higher the risk i.e. a system operating at 32MPa is a higher risk than a system operating at 5MPa
1.6.8 Hose assembly
A hose with its hose ends attached.

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

1.6.10 Hose Service Life
Is the effective lifespan of the hose whereby the hose meets the required factor of safety and the required likelihood of failure.

Note: Generally this does not exceed 8 years in ideal conditions but is reduced due to operating and environmental conditions refer 3.7.3

1.6.11 Impulse Life
The set number of impulse cycles that a given component, for example hose assembly, fitting, etc, must be able to withstand under controlled test conditions.

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

1.6.13 Matched System
Where the hose and fittings (insert/ferrule) are from the same manufacturer are assembled and crimped using the method as specified by that manufacturer

1.6.14 Mine
In the context of this document means all mining operations within the minerals industry, including coal, metal and extractive mines or quarries.

1.6.15 Must
Indicates a statement is ‘mandatory’

1.6.16 Plant
Includes and machinery, equipment or appliance

1.6.17 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 cause by excess load, blockage of annulus areas, etc.

1.6.18 Shall
Indicates a statement is ‘strongly recommended’

1.6.19 Should
Indicates a statement is ‘recommended’
SECTION 2   GENERAL REQUIREMENTS

2.1   OCCUPATIONAL HEALTH AND SAFETY

2.1.1   Legislative Framework

The Occupational Health and Safety legislative framework for mechanical engineering safety on mine sites is represented by the diagram in Appendix 9.2.

This diagram highlights the hierarchy of legislation and the legislative considerations when managing mechanical engineering safety on a mine.

2.1.2   OHS Act 2000 and OHS Regulation 2001

The OHS Act 2000 and the OHS Regulation 2001 requires:

⇒ designers, manufacturers, and suppliers of plant to identify any foreseeable hazards that have potential to harm health or safety, assess the risks and take action to eliminate or control the risks and to provide adequate information for the safe use of plant.

⇒ employers to address workplace health and safety through a process of risk management and consultation.

To effectively implement this guideline, designers, manufacturers, suppliers of plant and employers need to be aware of these requirements and have systems and procedures in place to apply them.

Designers, manufacturers and suppliers of plant and employers are advised to consult the OHS Act 2000 and the OHS Regulation 2001, particularly Chapter 5 ‘Plant’, for details of these requirements.

This guideline provides guidance on how these requirements can be met.

2.1.3   Control of Risk

The OHS regulation requires risks (that cannot be reasonably eliminated) to be controlled in the following order:

a) Substitute the hazard for a hazard of lesser risk

b) Isolate the hazard from people

c) Minimise the risk by the use of engineering measures

d) Minimise the risk by the administrative means, eg SWP

e) Use of PPE

2.1.4   Consultation

Employers are required by the OHS Act 2000 to consult with employees when taking steps to assess and control workplace risks.

Further guidance can be obtained in the ‘OHS Consultation’ Code of Practice 2001 by Workcover NSW

2.2   STANDARDS FOR FLUID POWER SYSTEMS

All fluid power systems should be designed, manufactured, operated and maintained in accordance with the manufacturer’s recommendations and relevant Australian, ISO DIN or SAE standards, refer Appendix 9.1.

AS 2671, AS 2788 and SAE J1273 should be read in conjunction with this guideline.
2.3 MANAGEMENT OF FLUID POWER SYSTEMS

The management of fluid power systems should be an integral part of the mines Health and Safety Management System which should comply with AS 4801.

Designers, manufacturers, and mines must be able to demonstrate that the each of the following has been addressed:

1. Hazard identification
2. Consultation
3. Risk assessment
4. Risk management procedures (eg JSA, SWP, SWMS)
5. Information to be collated (e.g. manufacturers instructions, MSDS)
6. Instruction and training
7. Supervision
8. Monitoring
9. Review
10. Revision

2.3.1 Hazard Identification

All hazards must be identified and dealt with so they are eliminated or controls established to minimise the risk. This should be carried out for every stage of the plant in its lifecycle.

Specific hazards associated with fluid power systems which may lead to personal injury and property damage may include but not be limited to:

a) Uncontrolled release of pressurised fluid resulting in
   i) Fluid injection
   ii) Burns from conveyed fluid
   iii) Fires being fuelled.
   iv) Ignition or explosion

   Note: Escaping fluids from pressurised system may cause a fine mist which can ignite or explode when in contact with a hot surface

b) Harmful exposure to hazardous fluids resulting in
   i) Exposure to toxic vapours
   ii) Exposure to hazardous substances
   iii) Chemical burns
   iv) Disease e.g. skin irritation/contact dermatitis (refer fluid MSDS)

c) Catastrophic failure of pressurised systems resulting in
   i) Persons being struck by projectiles (flying materials)
   ii) Fluid injection
   iii) Whipping hoses
   iv) Mechanical movement (actuator, motor, pump, steering, brakes, etc)

d) Pressure intensification resulting in
   i) Fluid injection
   ii) Catastrophic failure
e) Excessive noise exposure
f) Excessive temperature exposure
   i) Operating temperature and surface temperatures
   ii) Hot and cold
g) Electrical conductivity resulting in
   i) Static electric discharge initiating a fire or explosion of the environment
   ii) Electric shock
h) Uncontrolled mechanical movement from
   i) Fluid power control system failure
   ii) Catastrophic failure

This is not an exhaustive list and there may be other hazards present.

2.3.1.1 Unforeseen Hazards

Unforeseen hazards may include:

   a) Human error factors
   b) Accidental misuse, abuse of pressurised systems
   c) Pin holes in hydraulic hoses which may cause fluid injection
   d) Potential hazards due to the environment
   e) Failure / incompatibility of pressurised systems
   f) Unsupported pressurised hoses and fittings
   g) Corrosion and excessive wear
   h) Poor work practices in diagnosing system faults and poor maintenance resulting in ignorance of potential dangers
   i) Fluid contamination

2.3.2 Consultation

All stakeholders, including designers, manufacturers, owners and employees should be consulted when:

   a) Identifying fluid power system hazards and assessing or reviewing their risks
   b) Decisions are made about measures to control those risks
   c) Introducing or altering the procedures for monitoring those risks
   d) Changes, defects or incidents occur

2.3.3 Risk Assessment

Designers, manufacturers and suppliers shall carry out a risk assessment to identify all risks and implement appropriate risk controls prior to the supply of fluid systems.

This risk assessment should be reassessed and an operational risk assessment carried out whenever variations in design, use, conditions or environment could change the risk.

An operational risk assessment should be carried on the use of the fluid power system and for all large fluid power installations (e.g. longwall).

Risk assessments shall be in accordance with MDG 1010, AS 4360, or equivalent recognised standards such as the ‘National Minerals Industry Safety and Health Risk Assessment Guideline’ and shall address the following as a minimum:

   a) Identify the risk to health and safety of people in the vicinity of fluid power systems
Note: Most injuries occur when people are working close to fluid systems and there is a component failure, e.g. hose, fitting, pressure vessel. Additional hard barriers should be considered where people are required to work in close proximity to fluid systems.

b) Identify the risk to health and safety of people operating, maintaining and repairing the fluid power systems

c) Identify the risk to property, production and the environment

d) Identify all high risk areas

e) Control identified risks to an acceptable level, refer 2.1.3

f) Determine additional safeguards that may be required for specific circumstances

g) To determine if the recommendations of this guideline should be applied or rejected

h) Ensure the equipment is fit for purpose

i) Develop safe work procedures

j) Maintenance requirements to ensure the fluid power system is safe to use

2.3.4 Risk Management Procedures

Jobs Safety Analysis (JSA), Safe Work Procedures (SWP), Safe Work Method Statements (SWMS) and the like shall be prepared for activities on fluid power systems, where there is a risk to the safety to people unless the risk is addressed by other means.

NOTE: The level of criticality of the risk may determine whether the level of risk requires a full analysis.

Risk management procedures should be supplied by the designer/manufacturer. Theses procedures should be reviewed and new procedures developed/maintained by the Owner of the fluid system relevant to site specific conditions.

2.3.5 Instruction, Training and Competencies

All persons involved with fluid systems including designers, supervisors, operators and maintenance personnel should be trained and assessed as to their competence.

The minimum acceptable competencies for particular types of work should be nominated. For example: replacing a burst hose, replacing a hydraulic cylinder, working with high pressure hydraulics, etc.

Records of training and assessments should be maintained and available for audit.

Persons with appropriate knowledge, skills and experience should carry out training.

2.3.5.1 Training

Training and assessment of competencies should include, but not be limited to:

a) Knowledge and understanding of hazards and the required controls

b) Safety procedures, including emergency procedures

c) Operating, maintaining and repairing of the fluid system

d) Energy isolation and depressurisation

e) Inspection and testing of the fluid system

f) Understanding the purpose and function of safeguards that protect personnel

g) Reporting of faults and defects

h) Use of protective equipment

NOTE: Training may vary depending on the hazard levels associated with the task being undertaken.
2.3.6 **Supervision**

All employees who work on fluid systems should be adequately supervised according to their competencies and the task at hand.

2.3.7 **Audit, Monitor & Review**

Fluid systems should be audited, monitored and reviewed at appropriate periodic intervals and in the advent of an incident for compliance to the design standard and this guideline.

2.4 **DOCUMENTATION**

Pressurised fluid systems should be fully documented. These records should be maintained in a safety file over the life of the system, particularly:

- a) Design specifications, functions, drawings and other documents
- b) Hazard identification and risk assessment documents
- c) Risk control methods
- d) Consultation records
- e) Commissioning and test results
- f) Maintenance records, safety inspections and test reports
- g) Monitoring, audit and review reports
- h) Reports of accidents, incidents and safety statistics
- i) Training and competency records
- j) Equipment modifications

2.5 **EMERGENCY PREPAREDNESS**

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 (Refer MDG 1016).

An emergency management plan should include actions to be taken in the event of a fluid injection injury. Refer fluid injection protocol, refer Appendix 9.5.

**NOTE:** Do not delay or treat as a simple cut specialist treatment is urgently required.

2.6 **ACCIDENT REVIEW**

A co-operative approach between manufacturers, statutory authorities and mine operators is required to eliminate further fluid power incidents.

The owners and operators of fluid systems should provide to the equipment manufacturer details of relevant fluid power incidents in relation to the equipment.

The manufacturer should notify all owners and operators of any safety related incidents that they become aware of from time to time and their recommendation to rectify such defect. (e.g. Safety Alerts, Technical Bulletins, etc.)

2.7 **ENERGY ISOLATION AND DISSIPATION**

Procedures shall be supplied by the designer/manufacturer and maintained and developed by the owner for the safe energy isolation and dissipation of the system. They shall be available for all activities associated with the installation, commissioning, operation and maintenance of the fluid power system.

A person shall not carry out repairs to fluid systems unless the energy source is isolated and dissipated and cannot be reenergised inadvertently.

The system of energy isolation and dissipation adopted shall incorporate a locking system, a tagging
system or permit system and in any case should also include a method for ensuring that energy isolation and dissipation is effectively established.

NOTE: Best practice is to use lockout systems where main fluid power isolation is required.

Energy isolation and dissipation should be carried out in accordance with MDG 40 and AS 4024.
SECTION 3 DESIGN, MANUFACTURE & INSTALLATION

3.1 GENERAL
Fluid systems shall be designed, manufactured, constructed and tested using good engineering principles to ensure that the fluid power system is fit for purpose for the required duty and encompasses all aspects of the equipments lifecycle.

Hydraulic fluid systems shall be designed, manufactured and installed in accordance with AS 2671.

Pneumatic fluid systems shall be designed, manufactured and installed in accordance with AS 2788.

All fluid systems should comply with AS 4024 where applicable.

Materials used in fluid systems should be appropriate and compatible for the intended application and the environment likely to be encountered in service.

The design of the system should allow reasonable access to all parts that require adjustment cleaning or service.

3.1.1 Hazard identification, Risk Assessment and Control

3.1.1.1 General
All foreseeable hazards should be identified at the design and manufacturing stage, refer 2.3.1 for partial list.

A risk assessment shall be carried out at the design stage.

The designer and manufacturers should evaluate all risks to the safety of people from the use and maintenance of the fluid power system. The designer and manufacturer should identify the design requirements and any other actions as required to control the risk in accordance with the hierarchy of risk controls, refer 2.1.3.

All design controls necessary for the safe operation of the fluid power system shall be supplied to the user.

3.1.1.2 Safety Critical Component Integrity
The design risk assessment should also include:

a) An analysis to determine safety critical components of the system and the required integrity of these components, refer 4024

b) A failure mode and effects analysis or other systematic type analysis to verify the integrity of the control circuit

3.2 OPERATING ENVIRONMENT
Fluid systems shall be suitably selected and rated to suit the intended operational environmental conditions. The operating environment that the fluid system is designed to operate in should be stated.

Examples of typical environmental issues in mines which should be considered include:

a) Fluid medium properties e.g. fire resistance, mineral oil.
b) Ambient temperature range and fluid operating temperature
c) Sources of vibration
d) Contamination and dusty atmosphere’s
e) Abrasive materials
f) Corrosive environments (acidity/alkalinity/salinity)
g) Likelihood and severity of fire
h) Ventilation
i) Ease / standards of maintenance
j) Access for maintenance and use

3.3 DESIGN DOCUMENTATION

3.3.1 General

The design of the fluid system should be fully documented, for the ‘As Built’ system. Design documentation should contain sufficient detail to enable an evaluation of the fluid system against this guideline by a competent person other than the designer. Documentation should be immediately revised and updated whenever a design change has occurred.

When alterations are being made to the system, documents should be updated as soon as practicable and details distributed to minimise the likelihood of hazards being created by the use of incorrect information.

All design documentation should identify system parameters, such as pressure and flow, in System International (SI) units in accordance with AS ISO 1000.

Note:

1. Misinterpretation of system parameters has caused fatalities in the past.
2. The documentation may in addition to SI units show other commonly used units

Design documentation should be maintained and should include:

a) Synopsis of plant
b) System design requirements
c) Circuit diagram
d) Installation testing and commissioning data
e) Operation and maintenance data

3.3.2 Synopsis of Plant

The manufacturer and supplier should provide to the owner a synopsis on the fluid power system as follows:

a) System operating limits and capacities
b) General arrangement drawings showing the physical dimensions
c) Hydraulic and pneumatic circuit diagrams
d) Schematic and logic drawings of power and control facilities
e) Detailed parts lists of all components including reorder codes
f) Transport and lifting requirements

3.3.3 System Design Requirements

The designer should document all system design requirements including but not be limited to:

a) The purpose of the fluid system
b) Intended operations
c) Intended service lifecycle of the system and its components
d) Design parameters and assumptions made
e) Operating duty / cycle of the system and its components
f) Functional specifications and control logic for control of the system
g) Operating environment
h) Maximum operating pressures and temperatures
i) Fluid types
j) Emergency and safety requirements
k) Information from manufacturers design and engineering, risk assessment

3.3.4 Circuit Diagrams

Circuit (schematics) diagrams should be provided and should comply with the requirements of AS 2671, 2788 and ISO 1219.2.

All hydraulic and pneumatic symbols should be in accordance with AS 1101.1 or ISO 1219.1.

The following information should be identified on the circuit diagram:
   a) All system components, including electro-hydraulic and item identification
   b) All pressures settings
   c) All flow rates
   d) Any other devices

3.3.5 Hosing Diagrams

Hosing diagrams should be provided and should identify the following items as a minimum:
   a) Hose type and rating
   b) Hose/pipe routing
   c) Hose/pipe size and length
   d) Accessories, such as sleeves, clamps, colour coding
   e) Adaptors
   f) Components

3.3.6 Installation Testing and Commissioning Data

Installation, testing and commissioning procedures should be provided and should not be limited to:
   a) Identification of hazards and appropriate controls associated with the installation, testing and dismantling of the fluid system
   b) Testing, inspection and commissioning to be carried out
   c) Safework procedure associated with the installation, testing and dismantling of the fluid system

3.3.7 Operation and Maintenance Instructions

Operation and maintenance manuals should be provided. These manuals should contain the following information categorised in appropriate sections:
   a) Recommended preventative maintenance requirements to maintain the fluid system in a safe operating condition
   b) Recommended inspection and tests, to check if the equipment is safe to operate
   c) Identification of any hazards involved in maintaining and operating the equipment
   d) Identification of all high risk areas
   e) Energy isolation, dissipation and control
   f) Safework procedures to carry out maintenance on the system, including setting of controls
   g) Protective equipment requirements
3.4 SYSTEMS DESIGN

3.4.1 General
Fluid systems shall be designed and components selected to provide safe operation over the intended design life cycle of the systems.

The fluid system should fail to safety in the event of loss of pressure and be designed to minimise surge, dynamic and intensified pressures.

Seals and sealing devices should be compatible with the fluid used, adjacent materials, working conditions and environment.

Fluid systems should be designed to minimise excessive heat generation.

3.4.1.1 Components
Components should be selected, applied and installed in accordance with the suppliers’ recommendations and AS 2671 or AS 2788. All components of the system should:

a) Be designed to withstand surge, dynamic and intensified pressures from the normal operation of the fluid power system

b) Be selected to operate reliably over the lifecycle of the system

c) Operate within their rated limits, in particular the operating pressure and allowable fluid contamination level

3.4.1.2 Factor of Safety
All fluid power hose assemblies shall have a factor of safety of at least 4:1, on rated working pressure to burst pressure.

All fluid power adaptor fittings should have a factor of safety of 4:1, on rated working pressure to failure of the component to perform its function.

All other fluid power components should have a minimum factor of safety of at least 2.5:1 on rated working pressure to bursting pressure

Note: Where the above safety factors are reduced, appropriate cycle and endurance testing and engineering analysis, eg Finite Element Analysis (FEA) shall be carried out and documented.

3.4.2 Design Issues
The design of the fluid system should consider all possible methods of failure of the fluid system. The system should be designed such that the failure of a component does not affect the health and safety of people operating, maintaining or are in the vicinity of the system.

Typical failure methods for fluid system components, which should be considered include, but be not limited to:

a) Hose / pipe / fitting failure

b) Fluid leakage

c) Physical damage from people standing on components

d) Physical damage from fallen material

e) Pressure intensification and pressure pulsation’s

f) Over pressurisation / excessive flow

g) Electrical control system failure
h) Leakage (internal or external)
i) Hydraulic/pneumatic control system failure
j) Fluid contamination
k) Wear
l) Fatigue
m) Corrosion
n) Mechanical movements
o) Excessive temperature of the systems or environment
p) Overload and high external loads
q) Misuse
r) Inadvertent operation due to the failure of any fluid power component within the system
s) Working pressure and flow, temperature and load changes
t) Human error
u) Blockages, pressure drops or leaks which affect the operation of components.
v) Loss of pressure
w) Failure of power supply, either hydraulic, pneumatic or electric
x) Actuator failure
y) Inappropriate hose/pipe installation

3.4.3 Marking and Identification
Where appropriate, permanent markings, signs and identification plates should be in accordance with
AS 1318 and AS 1319.

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

All systems components should be labelled to enable clear identification to the circuit diagram.
All pressure should be in standard SI units in accordance with AS ISO 1000.

NOTE: This is required to prevent human errors in the interpretation of pressures.

3.4.3.1 Construction & Location
Markings, signs and labels should be installed or positioned and maintained so that they are clearly
visible to maintenance and operational personnel.

Markings, signs and labels should be of durable construction and be permanently attached.

Note: It is preferable for signs and labels to be constructed of engraved brass, stainless steel, ‘Traffolyte’ or
similar.

3.4.4 Trouble Shooting
All fluid systems should have provision for test points to indicate pressure in that part of the circuit.
Pressure gauges should also be provided as appropriate.

Appropriate provisions for testing and condition monitoring to facilitate maintenance and trouble
shooting should be provided.

NOTE: Test points should be provided to limit the need for dismantling the system for regular testing.

3.4.5 Excessive Pressures
A means or device should be provided to protect the circuit against excessive pressures refer AS 2671
and AS 2788 e.g. relief valve.

The device should be:

a) Adequately supported and mechanically protected from damage in high wear or impact areas
b) Positioned for access for maintenance purposes
c) Positioned to reduce the ingress of dirt and coal dust from the environment

3.4.6 Pressure Intensification
A means should be provided to prevent pressure intensification on all fluid power systems in particular all hydraulic cylinders should be protected.

3.4.7 Vent Ports
The vent port from devices which release pressurised fluid should be diffused, positioned or protected to prevent injury to people in the vicinity of the fluid being ejected.

3.4.8 Fluids
Fluids should be compatible with the systems components.

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

Compatibility of materials and component should be checked before using fire resistant fluids.

Material safety data sheet MSDS’s should be supplied. Additional information on the toxicity, fire effects, handling requirements and degradability should also be provided where appropriate.

Fluid reservoirs should be designed in accordance with AS 2671.

3.4.9 Fluid Injection
The design shall minimise the risk of fluid injection to operators and maintenance personnel, see AS 2671.

A device should be provided to divert the fluid in high risk areas.

NOTES:
1. It is preferable for hoses in high risk areas to be re-routed, refer 2.1.3.
2. It is not considered acceptable to use PPE where in a high risk areas.
3. For treatment of fluid injections see Appendix 9.5.
4. See 3.6 for isolation and energy dissipation.

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

The degree of filtration required should be consistent with the filtration requirements for all system components with consideration to the environmental conditions.

NOTE: Refer ISO 4406 for filtration ratings and ISO 16889 for evaluation of filter performance.

The effect on the control circuit when the filter is blocked should be considered. Where a hazard exists, a pressure sensor or bypass in the return line should be installed.

Consideration should be given to duplicated filters on all control circuits. All filters should be equipped with a device to indicate when the filter needs servicing.

Note: Block or restrict filters fitted in the return line cause back pressure and may cause inadvertent movement.

3.4.11 Maintenance Requirements
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 vent stations, oil draining stations or points and sampling points.

3.4.12 Other System Components

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

All system components should be labelled consistent with the circuit diagram.

Components should be installed so they are either accessible from ground level or access platform conforming to AS 1657.

3.4.13 Valves

Valves should be designed in accordance with AS 2671 & AS 2788.

All valves should be labelled consistent with the circuit diagram.

All manual valves should be labelled with the valves function and explanation of operation.

All valves should be securely mounted.

Valves used for isolation shall be lockable.

3.4.14 Load Bearing Actuators

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

a) Safety devices to protect against the effects of failure of a hose or any other hydraulic component
b) Devices to prevent over pressurisation of the actuator
c) A device, such as a load lock, that will stop the movement in the event of a hose rupture or pipe fracture
d) 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 bursting pressure for the whole construction should be at least 2.5 times the maximum working pressure

Load locking valves should be designed in accordance with MDG 10.

3.4.15 Pumps & Pump Stations

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

a) Adequately supported when installed
b) Mechanically protected from predictable damage in high wear or impact areas
c) Positioned for access for maintenance purposes with sufficient space around each pump
d) Positioned guarded or cooled to eliminate the likely event of injuring a person
e) Positioned to allow easy access for maintenance work
f) Able to be isolated and dissipate stored energy individually
g) Be suitably guarded in accordance with AS 4024

3.5 FLUID POWER CONTROL CIRCUITS

3.5.1 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 system failure methods, refer 3.4.2 and appendix 9.6.
Adjustable control valves should be fitted with a tamper resistant device or tools where the adjustment of controls may create a hazard.

Clear indication of the fluid systems current operational status should be provided, for example pressure indication with gauge.

Hydraulic / pneumatic control systems should cause the machine to fail to safety in the event of any fluid system failure.

### 3.5.2 Safety Control Circuits

The integrity of all safety control circuits and safety interlocks should be assessed for compliance with the appropriate safety category and integrity level in accordance with AS 4024 parts 1501 & 1502, AS 62061 or AS 61508 as applicable.

A risk assessment on the failure modes and affects of all safety critical control circuits should be carried out. In addition to the failure modes of each particular device, failure methods as listed in 3.4.2 and appendix 9.6 should be considered.

### 3.5.3 Pilot Circuits

The pilot circuit return line shall be designed to minimise back pressure on the pilot circuit. The design risk assessment shall analysis all control circuits to determine effects associated with excessive backpressure.

Note:

1. Numerous unplanned movement incidences have occurred from main return line blockages causing excessive back pressure on the pilot circuit
2. One method of achieving this may include a dedicated return line to the tank and be a separate circuit to the main return line.

### 3.5.4 Fire Hazard

Where a fluid spill could cause a fire hazard the systems should be designed to shut down automatically if a component ruptures, where practicable.

### 3.5.5 Manual Controls

#### 3.5.5.1 General

Controls should be designed such that accidental operation cannot cause a hazardous condition. Were the operation of the control may create a hazard, the system shall be safe guarded in accordance with AS 4024.

All controls should be accessible for maintenance.

#### 3.5.5.2 Ergonomics

An ergonomic assessment on the layout of all fluid power controls and operator gauges should be carried out. The assessment should be carried out by a suitably competent person.

Note: Guidance for ergonomics in the workplace can be found in AS 4024 and “Practical Ergonomics” by Barbara McPhee, available through the Coal Services Health and Safety Trust, [www.coalservices.com.au](http://www.coalservices.com.au)

#### 3.5.5.3 Direction of Movement

The direction of movement for manually operated levers should be consistent with the direction of operation of the actuator, i.e. lever up raises actuator, refer Figure 1 below.

The direction of manual control lever should not be confusing. Manual controls should be clearly and permanently identified.
The location of manual controls should:

a) Place the control 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

b) Not require the operator to reach past rotating or moving devices to operate the control

c) Not interfere with the operator’s required working movements

3.5.6 Emergency Stop

An emergency stop or stopping system complying with AS 4024 should be provided at each workstation. In addition at least one button should be remotely located to stop the system in the event of an emergency.

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

3.5.7 Pressure Gauges

Permanent pressure gauges should be installed on all circuits at relevant locations. A snubber should protect the gauges. The upper limit on the gauge should exceed the maximum working pressure by 25%.

Green zones should mark correct operating pressure range on pressure gauges of hydraulic and/or pneumatic systems.

For dial type pressure gauges, the indicating needle should be between 9 o’clock and 2 o’clock on the dial, under normal system pressure.

All pressure gauges should be in standard SI units in accordance with AS ISO 1000.

NOTE: This is required to prevent human errors in the interpretation of gauges.

Gauges should be adequately supported and mechanically protected from damage in high wear or impact areas.

Gauges should be located where the operators can clearly read the gauge. Gauges should be labelled.

3.6 ISOLATION AND ENERGY DISSIPATION

The 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 when maintenance
activities are being carried out. Isolation points shall 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 and energy dissipation should be in accordance with MDG 40 and AS 4024.

3.7 HOSE ASSEMBLIES

3.7.1 General

The selection, assembly and installation of hoses should be in accordance with SAE J1273, ‘Recommended Practices for Hydraulic Hose Assemblies’.

Hose assemblies should not be used at pressures exceeding the hose manufacturer’s recommendations.

3.7.2 Hose Selection

3.7.2.1 General

The following is a list of considerations that should be analysed to allow a final hose selection to be made.

a) Hydraulic hose shall comply with the provisions of ISO 6805 or SAE J517, except hoses for use in underground coal mines shall comply with ISO 6805.

   Note:
   1. AS 3791 has not been revised since 1991 and is not as current as ISO 6805 or SAE J517.
   2. SAE J517 does not have testing criteria for flame resistance or electrical resistance as required for underground coal mines

b) Hose assemblies should be suitable for the fluid used and the maximum system pressure and temperature

c) The rated hose assembly factor of safety shall be a minimum of 4 to 1 based on burst pressure to maximum working pressure for the maximum operating temperature

d) Hoses for conveying air, water or stone dust for use in underground coal mines shall be in accordance with AS 2660, except where hydraulic hose is used to convey air, and then the hose should be FRAS in accordance with 3.7.2.9 and 3.7.2.11 as applicable.

   Note: It is recommended that all air/water conveying hoses at coal mining sites be FRAS to prevent accidental use of non-FRAS hoses in underground coal mines

e) Air hoses for mine sites other than underground coal should be in accordance with AS 2554

f) The effect of static electric discharge should be considered

g) Hoses should be adequately sized to minimise pressure loss and avoid damage from heat generation due to excessive internal velocity, refer Appendix 9.3

h) Where the specification does not cover the application then additional testing should be carried out and documented

i) Hose should be ozone, weather, abrasion and heat resistant as applicable for the application

j) Hydraulic oil hoses in underground coal mines shall be fire resistant, refer 3.7.2.9

3.7.2.2 Pressure/Suction

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.

The rated hose assembly should be at least rated to, or greater than the maximum system pressure.

Suction hoses should be selected to withstand both the negative and positive pressure imposed by the fluid system.
NOTE:

1. Where hose is subject to system spikes and or irregular pressure variations higher than its rated working pressure its life expectancy is reduced and should be evaluated, refer SAE J1927

2. Surge pressures are rapid and transient rises in pressure. Surge pressure may not be indicated on many common pressure gauges and can best be identified on electronic measuring instruments with high frequency response.

3.7.2.3 Temperature

Hoses should be selected such that both the fluid and ambient temperatures do not exceed the temperature rating of the hose. Hoses near external heat sources, eg exhaust manifolds, should be adequately shielded or covered with heat resistant sheathing to prevent the hose coming into contact with the hot surface.

3.7.2.4 Environment

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

3.7.2.5 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.

3.7.2.6 Abrasion Resistance

All hoses should meet the abrasion resistance requirements of ISO 6805 as a minimum.

Note: Some hose manufacturers have hoses with greater abrasions resistance for specific applications

3.7.2.7 Corrosion Resistance

All steel hose ends and hose adaptors should achieve a minimum of 200 hours (red rust) when subjected to a salt spray test in accordance with ASTM B117 or ISO 4520.

Note: Some hose manufacturers have products with greater corrosion resistance for specific applications

3.7.2.8 Hose Energy Diffusion Devices

A hose energy diffusion device should be considered for hoses where there is high potential harm to people in the event of a hose failure, refer 3.4.9.

The hose energy diffusion device should be able to diffuse the energy in the oil, if the hose blows, to a level where fluid injection will not occur.

Where a burst suppression sleeve type device is used the sleeve should be manufactured from high abrasion, ozone, heat resistant material and should be suitably attached.

For underground coal mines this sleeve should have a fire resistant cover.

3.7.2.9 Fire Resistance Hose

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

The requirements for flame resistance should be in accordance with:

a) When tested to AS 1180-10b or ISO 8030 the average duration of the flaming and glowing shall not exceed 30 seconds, or

b) Satisfy the flame test requirements of the U.S.A. Code of Federal Regulations Title 30 Part 18 Section 18.65 (MSHA), or

c) Comply with type 1 or 3 hose specifications as listed in ISO 6805, or

d) An equivalent level of fire resistance provided.
3.7.2.10 Fire Proof Hose

All brake, turbo lube hoses and fire suppression system hoses should be fire proof. As a minimum they shall be fire resistant.

The requirements for flame proof hose should be in accordance with:-
   b) The operating limit for this hose is -54° C to +232° C, or
   c) An equivalent level of fire proofing provided

3.7.2.11 Antistatic Hose

Hose which is required have antistatic properties should be tested in accordance with AS 1180.13A, using the flexible ring electrodes for the external surface and the plug electrodes for the internal surface.

The electrical resistance shall be not greater than 1 MΩ/m.

3.7.2.12 PVC Piping

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

3.7.2.13 Specific Applications

Elastomeric (rubber type) hose should not be used on a delivery line between an air compressor and air receiver. Fit for purpose Teflon with steel braid is satisfactory. All delivery hoses should be heat resistant.

3.7.3 Hose Service Life

The following hose life considerations should be considered in the design, selection and installation of hose assemblies in order to maximise the effective service life

3.7.3.1 Impulse life

Typical factors that affect the impulse life, assuming that the hose has been assembled correctly, include:
   a) Bend radii (static and dynamic)
   b) Bend angle adjacent to the end fitting
   c) Mechanical flexing
   d) Pulse frequency
   e) Pulse pressures (normal and transient spikes)
   f) Twisting
   g) Mechanical damage

NOTE: Although hose assemblies are rated with a minimum impulse life, there are a number of factors that will affect the nominal rated impulse life of a hose assembly. Most factors will tend to reduce the impulse life, and the impulse life will only be extended when the impulse pressures are significantly lower than the maximum operating pressure of the hose assembly. Refer SAE J1927

3.7.3.2 Service Life

In addition to the above, typical factors that reduce the in-service life of a hose assembly include:-
   a) External cover damage (abrasion, impact, rubbing, gouging etc)
   b) Environmental factors (temperature, UV, Ozone, chemicals etc)
c) Mechanical loads - vibration, tensile, shear

d) Installation/routing (orientation, clamping, vibration, mechanical loads, equipment extension, securing methods etc)

e) Corrosion of end fittings and reinforcement wires

f) Hydraulic fluid – temperature, velocity, contamination

3.7.3.3 Maximising Effective Service Life

In order to maximise the effective service life of hose assemblies, design and installation should be carried out in accordance with SAE J1273.

NOTE: The reduction of effective service life of the hose assembly is predominately contributable to poor installation and design.

In addition consideration may be given to:-

a) External cover protection that may be exposed to abrasion or impact damage

b) Shielding to protect hoses from heat sources such as manifolds, exhausts, etc

c) Accidental damage caused by: rock fall, vehicle collision, tensile load, shear load, crushing, fire

d) Corrosive spillage, molten metal, pressure surge

e) Heat generated internally and externally to the hose assembly

3.7.3.4 Hose Shelf Life and Storage

Hoses should be re-proof tested after 5-8 years from their cure date and discarded after 8 years unless recommended by the hose manufacturer. The hose should then be clearly remarked.

Storage areas should be relatively cool and dark, as well as free of dust, dirt, dampness and mildew

Note: Shelf life is dependent on the hose being stored under cover away from direct sunlight, away from physical damage and in a clean dry environment. Hose products in storage can be affected adversely by temperature, humidity, ozone, sunlight, oils, solvents, corrosive liquids and fumes, insects, rodents and radioactive materials.

3.7.4 Hose Safety Issues

Hose safety considerations that may lead to personal injury and/or property damage, refer SAE J1273 include:

a) Fluid injections

b) Whipping hose

c) Burns from conveyed fluids

d) Fire and explosion from conveyed fluids

e) Fire and explosion from static electric discharge

f) Electrical shock

g) Mechanism controlled by fluid becoming dangerous after hose failure

h) Sharp edges

i) Exposed wire

j) Different rated hoses in a common system

k) Hose end and hose incompatibility

3.7.5 Markings for Identification

Markings should be designed to last for the life of the hose and be placed on both ends of the hose assembly.
Hose, hose end, hose assemblies and adaptors should be labelled as follows:-

3.7.5.1 Hose
   a) Manufacturer’s name or mark
   b) Class/type of hose
   c) Month & year of manufacture
   d) Hose description, e.g. 10 mm, 13 mm etc.
   e) Batch code
   f) Maximum working pressure

3.7.5.2 Hose Ends
   a) Manufacturer’s name or mark
   b) Date code or batch code, where practicable
   c) Part number, where practicable

3.7.5.3 Hose Assemblies
   a) Supply company name (or Logo)
   b) Hose assembly part number or description
   c) Test certificate number, refer 3.7.7.4
   d) Date of assembly
   e) Working pressure
   f) For hoses in high risk areas and accessible to personnel additional information could be included as a warning for consideration such as “Warning – Fluid injection injury” or symbol similar to one below

![Warning Sign]

3.7.5.4 Adaptors
   a) Manufacturer’s name or mark
   b) Working pressure (Where practicable) See Appendix 9.8
   c) Part-Number, where practicable
   d) Date code or Batch Code, where practicable

3.7.6 Hose & Hose Assembly Manufacturer

3.7.6.1 General
   a) Competent people should carry out hose assembly in accordance with the hose and hose end manufacturer’s assembly instructions
   b) Tolerance on overall hose lengths should be +/- 1%
c) Hose assemblies should be cleaned and flushed for removal of cuttings

d) When lubrication is required for assembly it should be compatible with the system the hose is being used in

e) An inspection and test plan (ITP) should be carried out during all phases on hose assembly

f) Each hose assembly should be proof tested to two times the rated working pressure, refer 3.7.7.1

g) The hose assembly rated working pressure may be limited by hose ends, refer Appendix 9.8

h) Non-standard adaptors should be designed and assessed to SAE J1065 and proof tested to ISO 6605 or SAE J343 or AS 1180.5 as a minimum.

i) For threaded type hose assemblies the final hose length should be specified from the tip of the seat of one hose end to the tip of the seat of the other hose end, refer SAE J517 and Appendix 9.8

j) For staple type hose assemblies the final hose length should be specified from the overall length, refer Appendix 9.9.

k) Hose assemblies shall only be carried out using “matched” hoses and fittings.

Note: This means that the hose dimensions and tolerances are compatible with the dimensions and tolerance of the fittings to ensure that the joint meets the standard test requirements (impulse and burst) for the hose assembly. The use of fittings that are not matched to a hose may result in hose/fitting separation or other premature catastrophic failure. Although a hose assembly fabricated using non-matched fittings may achieve the required burst test pressure, it will most likely fail the required impulse testing. Suppliers of manufactured hydraulic hose assemblies must be able to guarantee that the hose and fittings used are matched.

3.7.6.2 Hose Ends

Hose ends shall not be interchanged and shall be properly matched with the hose.

Note: Only select hose ends compatible with the hose for the application. The fitting and hose manufacturer’s recommendations shall be strictly followed.

Hose ends, adaptors and flanges should be in accordance with a recognised standard, refer 9.9.

Note: For staple or pin type connections DIN 20043 is not considered suitable for hydraulic application as the working pressures for the fitting may be as low as 2.5:1. The pressures listed for staple fittings in appendix 9.9 have been adjusted to provide a 4:1 safety factor. There is no satisfactory standard for these types of fittings.

Pressure rating of the hose assembly may be limited by the hose end selection.

Corrosive resistance should be in accordance with 3.7.2.7

Threads on all hose ends and adaptors should be uniform throughout the system so they cannot be mismatched, for example BSPP and BSPT

3.7.6.3 Non-Standard Type Hose Ends and Adaptors

Hose ends and adaptor, such as staple or pin type connections and other proprietary type fitting, which do not comply with a recognised standard shall meet the following:

1. Be certified by the manufacturer as designed and assessed to SAE J1065 and proof tested to ISO 6605 or SAE L343 or AS 1180.5 as with a 4:1 FOS as a minimum. Testing to ISO 6802 or ISO 8032 is preferred.

2. Be designed such that the use of other manufacturers proprietary fitting / components cannot easily be mistaken and used in the wrong system creating a hazard to the end user.

3. Be fit for purpose for the intended application over the fitting lifecycle such that the fitting does not fail due to fatigue, cyclic loading, contamination from the intended operating environment or removal and assemble for maintenance.
3.7.6.4 Procedures for Hose Assembly Manufacture

The hose assembly shall be assembled strictly in accordance with the hose/hose end manufacturer’s procedures which should cover:

a) Material supply verification - product compatibility, material quality
b) Hydraulic hose cutting - calculate cut length, cutting of hose, cleanliness
c) Skiving or buffing – skiving, buffing, cleaning
d) Coupling assembly – depth, lubrication, verification
e) Crimping
f) Final assembly inspection
g) Quality plan

3.7.6.5 Quality Plan

The process of hose manufacture, from raw materials shall comply with ISO Standards 9001, 9002 and shall be batch tested for conformance and recorded. The hose end assembly manufacture should hold third party accreditation.

Completed hose assemblies should be certified and tested in accordance with 3.7.7.1.

3.7.6.6 Competence

Persons fabricating hose assemblies shall be competent and trained in the proper use of equipment, materials, assembly procedures and testing. People should be assessed in their competence for hose assembly and the assessment should be recorded.

Note: Proper assembled fittings are vital to the integrity of a hose assembly

3.7.6.7 Cleaning & Packaging

Hose assemblies should be supplied free from water, debris, metal shavings, dirt or any other foreign material. A cleaning projectile should be shot through the hose assembly in both directions.

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.

3.7.7 Testing and Certification of Hose Assemblies

3.7.7.1 Individual Hose Assembly Proof Testing

Hose testing should be carried out in accordance with ISO 6605 or SAE J343 & AS 1180-5.

All hoses assemblies which are located in a high risk area shall be proof tested at two times the rated working pressure.

Note: Consideration should be given to proof testing all hose assemblies to two times the rated working pressure depending on the risk of injury to people upon failure of the hose.

The test pressure should be held for a minimum of 30s and maximum of 60s. There should be no indication of failure or leakage.

Proof testing should be carried out using compatible hydraulic fluid rather than with compressed gases.

Teflon type hose shall be tested with water.

3.7.7.2 Type Testing of Hose Assemblies - Dynamic Cycle Testing

The matched hose and hose end shall be dynamically type tested at the pressure and to the number of test cycles specified in ISO 6805 in accordance with ISO 6803, hydraulic pressure impulse test without flexing to minimum bend radius.

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, to 80,000 cycles at 120% of the working pressure.

In applications of high dynamic cycling twisting and flexing consideration should be given to type testing the hose assembly in accordance with ISO 8032, flexing combined with hydraulic impulse test - Half Omega Test (impulse and flexing in three dimensions), to 40,000 cycles at 120% of the working pressure.

Note: Refer Appendix 9.10 for layout of test rigs

3.7.7.3 Visual Inspection

All hose assemblies should be visually inspected before dispatch and inspections recorded.

The inspection should include:-

a) Labelling is true and correct
b) Assembly condition is free from kinks, loose covers, bulges or ballooning, soft spots, cuts, broken or protruding wires, any other obvious defects, also refer 9.6.2 for used hose assemblies
c) Fittings and attachments are; securely crimped or fastened, correct for hose size, series or type, free from cracks, not cocked, free from bulges where they join the hose, free to swivel, free from rust
d) The assembled hose corresponds to the order – verification
e) The assembled hose is free from contaminants, hose ends are capped, plugged and the hose is packed correctly for transport

Note: Where practical the person carrying out the visual inspection should be different to the person who assembled the hose

3.7.7.4 Individual Hose Assembly Test Documentation

Each test certificate should bear a unique number for traceability. Test certificates should include the following information as required:

a) Test certificate number
b) Testing location and name
c) Test procedure reference number
d) Assembler’s name
e) Fabrication number
f) Hose assembly part-number and or serial number(s)
g) Hose assembly details including length, type of hose and size
h) Hose assembly standard
i) End fitting details with types of ferrules and seals used
j) Test date
k) Confirmation that the hose assembly consisted of matched hose and hose ends
l) Hose end information and check for correct matching of hose ends to hose
m) Test pressure
n) Pass / fail
o) Signature of person inspecting

3.7.7.5 Batch Certificate of Conformance

A certificate of conformance should be supplied when requested. The certificate of conformance
should have the following information, if applicable:

a) Customer's name, address, purchase order, contact details
b) Specification, drawings and standards the assembly conforms to
c) Supplier's name, address, purchase order, contact details
d) Supplier's order number
e) Description and quantity of supply
f) Additional information as requested
g) Supplier's authorisation Signature
h) Date of supply

3.7.8 Hose Assembly Installation

3.7.8.1 General

The hose assembly installation should:

a) Be secure and be adequately supported along the entire length
b) Be supported in such a way that external loads are not transferred to the hose end or adaptor
c) Be supported if the weight of the hose assembly could cause undue strain on the hose end
d) Be neat and tidy, with minimal crossover to eliminate rubbing, refer to MDG 15 for guidance on mobile equipment
e) Be mechanically protected from damage in high wear or impact areas
f) Be connected to adaptors which allow for full articulation for the intended movement
g) Be the correct length as required for the intended movement
h) Be routed to prevent coming into contact with sharp edges or other surfaces that may wear the hose cover
i) Be restrained near people to eliminate whipping of a blown hose
j) Not be positioned where stone, coal or mud is likely to build up causing abrasion
i) Not be subject to shock, surge pressures which exceed the manufacturer’s recommendations
j) Have a length necessary to avoid sharp flexing and straining of the hose during operation
k) Not be bent at a radius smaller than those recommended by the manufacturer
l) Minimal torsional deflection during installation and use, e.g. as a result of a fitting jammed
m) Be located and be protected to minimise abrasive rubbing on the hose cover
n) Be cleaned during manufacture and prior to installation

3.7.8.2 External Loads

External mechanical loads should be minimised during the installation of a hose.

Swivel type fittings or adapters should be used to ensure no twist is put into the hose. In some applications live swivels may be necessary, e.g. two rotating components.

Note:

1. 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
2. Mechanical loads include; flexing, twist, kinking, tensile or side loads, bend radius and vibration (amplitude and frequency).
3.7.8.3 **Length**

Only correctly sized hose lengths should be used.

Note:

1. Hose length varies due to motion, pressure variations and equipment tolerances
2. Hoses that are too short stress hose ends and induce premature failure

3.7.8.4 **Installation/Routing**

Hoses should be correctly routed to avoid undue external stress from, refer Appendix 9.7)

a) Mechanical loads, tensile, side loads
b) Abrasion and rubbing from insufficient clearance
c) Flattening
d) Kinking and minimum bend radii
e) Twisting
f) Thread and seal damage
g) Equipment mobility

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.

Note: To prevent vibration and pulsation causing fretting between services leading to hose and cable failure

3.7.8.5 **Abrasion**

The hose cover should be protected from abrasion, erosion, snagging and cutting. Hoses should be routed in order to reduce abrasion from hose rubbing other hose or other objects that may abrade it.

Exposure of the hose reinforcement reduces hose life significantly. The use of a hose cover protection should be considered, refer 3.7.2.8.

3.7.8.6 **Competence of Hose Installers**

People installing hose assemblies should be competent and trained in the following areas:-

a) Safe working practices and energy dissipation and isolation
b) Hose and fitting selection, construction and identification
c) Hose specification and standards
d) Hose working pressures
e) Hose assembly lengths
f) Hose cleanliness and system contamination
g) Hose assembly storage
h) Hose outer protection
i) Hose end fittings and coupling identification
j) Fluid compatibility
k) Installation/routing, refer 3.7.8.4
l) Mechanical loads
m) Physical damage to hose and hose end couplings
n) When to change a hose assembly
GUIDELINE FOR FLUID POWER SYSTEM SAFETY AT MINES

- Anti-seize application methods and its benefits
- Seals and seal replacement
- Sealing or seating face damage
- Importance of environment conditions

3.7.8.7 Inspection

The installed hose assembly should be inspected for, refer 9.6.2:-

- Visual evidence of leaks along the hose or around the hose ends
- Damaged, abraded, or corroded braid; or broken braid wires
- Cracked, damaged, or badly corroded hose ends
  
  Note: Excessive corrosion levels can be determined by following the basic rule “if the crimp marks are not evident after cleaning the ferrule, replace the hose”
- Other signs of significant deterioration
- Wrong bend radius
- Outer sheath damage
- Incorrect hose routing
- Incorrect length of hose
- Kinked crushed or flattened hose
- Hard, stiff, charred, blistered, soft, degraded hose
- Fitting thread is damaged
- Any signs of exposed wire
- Functional testing of devices

If any of these conditions exist, the hose assemblies should be replaced.

The period of inspections should be consistent with the hose duty and operating environment but should not be less than 12 months.

3.8 PIPEWORK & ADAPTORs

3.8.1 General

- All pressure piping shall be designed, manufactured and tested in accordance with AS 4041 to meet all dynamic, shock and environmental loads
- Pipework should be designed, selected and installed in accordance with AS 2671 and AS 2788
- Pressure pipe adaptors and flanges should be accordance with a recognised standard, refer 9.9.
- Non-standard or staple type adaptors which do not comply with a recognised standard shall comply with 3.7.6.3
- 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 pipe and connectors should be at least equal to or greater than the system operating pressure
- Threads on all pipework and adaptors shall be uniform throughout the system so they cannot be mismatched, for example BSPP and BSPT

3.8.1.1 Colouring Systems

Main reticulation pipework and services should be coloured and labelled in accordance with AS 1345.
Where machine based fluid colouring systems are used then the colours\(^2\) should be:

a) ‘High Pressure lines’ – Yellow, Red on Tan
b) ‘Pressure lines’ – Red on Tan
c) ‘Pilot lines’ – Green on Tan
d) ‘Return lines’ – Blue on Tan

3.8.2 Adaptors

a) Corrosive resistance should be in accordance with 3.7.2.7
b) All adaptors should be designed to withstand the maximum normal operating pressure of the system
c) All batches of adaptors should be type tested to 4.0 times the working pressure to ISO 6605 or SAE J343 or AS 1180.5 as a minimum.
d) Adaptors 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,
   Note: Some thread type fittings may not be suitable for swivel applications and high pressures for larger diameters
e) Multiple adaptors (Christmas tree fittings) should be minimised by utilising fit for purpose designed and tested manifolds
f) Incompatible adaptors combinations such as BSPP and BSPT, shall not be used
g) Home made or fabricated adaptors should not be used, unless they have been designed by a qualified engineer, tested and certified, refer SAE J1065. Where a special adaptor is required it should be provided with full certification stating the working pressure, test pressure and safety factor.
h) All adaptor fittings shall be manufactured in one piece either from bar stock (straight fittings), or from fully forged adaptor blanks (shaped fittings)
i) Where welding is unavoidable then it shall be supervised and carried out strictly in accordance with AS 4041
   Soldering, brazing, copper loading or other similar processes shall not be used in pressurised hydraulic circuits.
j) Galvanised water type fittings shall not be used in pressurised hydraulic circuits

3.8.3 Support and Installation

Pipe and adapters should be:

a) Mounted to minimise installation stresses from vibrations, pulsation’s, thermal expansion and its own mass
b) Located and guarded against foreseeable environmental damage
c) Located such that it is not readily accessible for people to stand on unless:
   • guarded or
   • robust enough to carry a vertical load of 1.5KN without permanent deformation or damage
d) Securely supported at appropriate intervals along its length, refer AS 2671 & AS 2788
e) Run in a neat and tidy manner
f) Mechanically protected from damage in high wear areas

\(^2\) See AS 2700 for colour chart
g) Routed to prevent coming into contact with surfaces that may wear or rub the pipe work or fittings

h) Guarded where people continually work such as workstations, longwall boot end valve bank

i) Accessible for maintenance without disturbing adjacent hoses and components.

Note this may not be practical due to space constraints

3.9 PRESSURE EQUIPMENT

3.9.1 General

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

a) AS 1200, ‘Pressure Equipment’
b) AS 1210, ‘Pressure Vessels’
c) AS 2971, ‘Serially Produced Pressure Vessels’
d) AS 3788, ‘Pressure Equipment - In Service Inspection’
e) AS 3873, ‘Pressure Equipment - Operation and Maintenance’
f) AS 3892, ‘Pressure Equipment – Installation’
g) AS 4037, ‘Pressure equipment - Examination and testing’
h) AS 4343, ‘Pressure equipment - Hazard levels’
i) AS 4458, ‘Pressure equipment – Manufacture’
j) AS 4481, ‘Pressure equipment - Competencies of inspectors’

The Manufacturer shall provide a current ‘Certificate of Inspection’ and design registration documents 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.

3.9.2 Hydraulic Accumulators

a) Hydraulic accumulators should be securely installed and protected from damage by falling objects

b) The attachments to the accumulator should be by means of a minimal length adapter and flexible hose for mobile plant

c) 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

d) A manual bleed valve should be fitted to allow pressure relief for maintenance purposes. The fluid should return to tank and the tank depressurised

e) A safety relief should be included in the manual gas charging circuit when gas-charging accumulators are installed

f) Gas charged accumulators should be in accordance with AS 2671

g) Spring type accumulators should be labelled with a warning informing the content is under spring pressure

h) A guard should be installed between accumulators and any personnel for mobile equipment. Accumulators should be installed within the envelope of the equipment where practicable.

i) Accumulators should be fitted with a pressure gauge

j) Warning sign to identify accumulators in the hydraulic system and to depressurisation before maintenance work should be installed. (Generally be located at the main isolation points and on
the hydraulic circuit/drawing)
SECTION 4  SITE INSTALLATION

4.1  GENERAL
This section applies to the installation of fluid systems, including pumps, hoses, valves, gauges, components, accumulators and actuators at the mine site.

Fluid power systems should be installed in accordance with the design documentation which should identify the exact location and route of all components and hoses.

Prior to the installation of a large fluid power system in the mine environment the mine’s health and safety management system should identify:
   a) The installation programme (schedule)
   b) All hazards, risks and controls associated with the installation
   c) When a risk assessment is required
   d) Tasks which require an installation procedure or safe work procedure (SWP)
   e) Tasks which can be covered by people’s competencies
   f) Training requirements prior to or during installation
   g) Change management, auditing and review requirements

4.2  SAFE WORK PROCEDURE (SWP)
A SWP should include:
   a) Isolation, depressurisation and re-energising instructions
   b) Change of shift or hand over procedures
   c) Testing procedures
   d) Competencies to complete the task safely
   e) Tools and equipment required

4.2.1  Input
A SWP should be prepared from:-
   a) Equipment manufacturer’s and designers recommendations
   b) Site risk assessments, risk reviews and job safety analysis’s
   c) Safety Alerts
   d) Relevant standards and guidelines
   e) Site knowledge through employee consultation
   f) Other site specific requirements

4.2.2  When
A SWP should be prepared or revised when:-
   a) Equipment is new or modified or the system is changed
   b) The hazards create a risk to health and safety of employees and equipment
   c) The task is complex in its nature
   d) A task is done infrequently
   e) An accident or incident occurs
f) There is a change in the environment or application

g) Recommendations from employees are made

When a SWP is not required other systems to identify hazards, access risks and implement controls should be implemented, for example; 5 x 5, Job Safety Map, JSA, etc.

4.2.3 Standard

The SWP should comply with:-

a) The mine’s site standard

b) The fluid power system design specifications

4.3 COMMUNICATIONS / CONSULTATIONS

Prior to the installation of a fluid power installation employees should be consulted with:-

a) Foreseeable hazards, risk assessments, risk controls, JSA, SWP, etc

b) Design documentation relevant to the installation such as hydraulic circuit, function and layout, hose/pipe routes, etc

c) Safety instructions such as; no standing zones, PPE, set down areas for the equipment, specific isolation procedures, emergency stops locations

d) Emergency response (including fluid injection response)

e) Supervision

f)Competencies required

g) Change management procedures, such updating of drawings, designs, specifications, training, procedures etc

A debrief meeting with employees should occur to review the process and identify the areas where improvements can be made.

Employees should have the ability to suggest improvements of the system and procedures.

4.4 INSPECTION AND TEST PLAN (ITP) - VERIFICATION

An Inspection and Test Plan (ITP) should:-

a) Be developed to identify all critical inspections, stops and checks during the installation

b) Verify the system is installed in accordance with the design documentation and the site standards, for example routing of hoses, component locations, etc

c) Be completed prior to the normal operation of the system

d) Be carried out by a person independent to the person that installed the system

e) Raise a non-conformance report (NCR) where defects or non-conformances are identified

4.5 INSTALLATION RECORDS

‘As Built’ installation records should be documented with the relevant drawings and manuals updated.

The mine should maintain as built records.

4.6 LONGWALL INSTALLATIONS – UNDERGROUND COAL MINES

Longwall installations or relocations in underground coal mine’s should consider:

a) Pump installation, routing of the hydraulics hoses to the face and retention of the hoses

b) Reducing the installation pump pressure to the lowest practicable pressure, for example 35MPa to 10MPa during the installation phase
c) The location and function of remote emergency stops

d) How the hoses are installed and connected
   
   Note: A screwed adaptor should not be installed on in a dynamic application where the movement may cause the end fitting to loosen or become dislodged.

e) Remote operation for roof supports during recovery and installation

f) Alterations or changes to existing high pressure supply including venting of any installation/recovery system, the labelling and training.

g) 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

h) How the temporary pump station and hydraulics should be installed
SECTION 5 SITE COMMISSIONING

5.1 GENERAL
This section applies to the commissioning of the fluid systems, including pumps, hoses, valves, gauges, accumulators, filters and actuators at the mine site.
Fluid power systems should be commissioned in accordance with the design documentation and AS 2671 and AS 2788 as applicable.

5.2 COMMISSIONING PLAN
A commissioning program should be developed for the fluid system. The commissioning plan should consider:

a) Potential hazards and risks associate with commissioning the fluid power system
b) Commissioning in accordance with the designer’s, manufacturers and site specific requirements
c) Initially commission each part of the system at a lower pressures where practicable
   Note: This allows functional operation of the system with reduced risk of component failure
d) Examination and tests to prove the correct operation and installation of all safety devices
e) All air is expelled prior to pressure testing
f) Pressure testing each component of the system at the designed working pressure
g) A testing schedule to check, test and operate all functions in a safe manner with consideration to the electrical commissioning checks.
h) Documenting results of commissioning checks
i) A system to identify commissioning is complete and the system is ready for normal operation

5.2.1 Commissioning Criteria
Commissioning should test the installation against the design specifications.
Commissioning criteria should be quantifiable and set pass failure limits for each test.
Commissioning criteria compare the system performance when compared against the design criteria or functional specification and should include, but be not limited to:

a) Circuit pressure, restrictions and flows
b) Completeness of circuits to drawings, identification and labelling of components
c) Discharge patterns and performance criteria (number of operations from an accumulator)
d) Control device functionality and operability
e) Emergency stop functions
f) Isolation points
g) Timing of component movement (speed of function) and full extent of movement. Eg time to extend a cylinder.
h) Hose layouts and routes (Wear points, hose bend radius, movement range)
i) Software functionality
j) Protection devices settings and alarms as applicable
k) Fluid leakage rates
l) Temperature, vibration and noise  
m) Cleanliness of the hydraulic fluid  
n) Hydraulic fluid specification  
o) Air entrapment in the system

5.2.2 Commissioning Procedures

Commissioning procedures should be developed within the overall-commissioning plan.

Consultation should be carried out between all relevant stakeholders such as mechanical, electrical and operational departments to determine the commissioning sequence.

Commissioning Procedure (checklist) should identify areas required to be tested. All results should be documented.

Note: These procedures could be for the entire system or could be a number of procedures for individual components of the system

5.2.3 Commissioning Records

Commissioning records should be maintained and stored for future reference. As built drawings and specifications should be updated.
SECTION 6 SITE OPERATION

6.1 GENERAL

This section applies to the operation of fluid power systems.

6.2 OPERATIONAL PROCEDURES

Operational procedures should be developed and should outline:-

a) How the fluid power system is operated in a safe manner
b) The designed operational envelope
c) The operational functions and expected response to controls
d) Normal operations conditions such as pressures, temperatures, flows, actuator positions, etc.

6.3 DEFECTS

Defects identified during operation should be reported and dealt with in accordance with the mines defect management system.

Variances to the normal operating condition should be reported.

6.4 TRAINING

All operators should be trained in:-

a) The operational procedures
b) All operational functions
c) Understanding the indicating devices, which indicate the equipment operating condition (eg flow, pressure, error messages, motor current and voltage)

6.5 PREOPERATIONAL CHECKS AND INSPECTIONS

Preoperational checks and inspections should be carried out on a regular basis, typically daily and should include:-

a) Normal operation of all functions
b) Functionality/status of indicating devices and warning alarms such as:
   - Hydraulic Pressures
   - Hydraulic Flow
   - Water Pressure and Flow
   - Filter condition (filter monitor)
   - Fluid levels and fluid leaks
c) Time to carry out a specific operation
d) Fluid leakage, visually and over a period of time
e) Guarding is in place and functional
f) Suspect hosing that is physically damaged or leaking
g) Unusual increases in temperature, noises and smell from the system
6.6 EMERGENCY REPAIRS

A system should be developed to:-

- Carry out emergency repairs in a safe manner
- Set minimum standards for emergency production repairs

All repairs should be carried out by competent people.

Hoses should not be repaired on site unless inspected in accordance with 3.7.7.3 and Appendix 9.6.2. In addition, hoses in high risk areas should be tested in accordance with 3.7.7.1.

Note: Consideration should be given to testing all hose assemblies depending on the risk of injury to people upon failure of the hose.

Where emergency temporary repairs are carried out to allow continued operation, then permanent repairs should be carried out at the next maintenance shift.

For example if a 1m hose fails during operation and a 3m hose is used as its temporary replacement, then the correct hose should be installed and correctly routed on the next available maintenance shift.

These repairs should be documented and recorded against the equipment.
SECTION 7 INSPECTION, MAINTENANCE AND REPAIR

7.1 FLUID POWER SYSTEMS

7.1.1 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 extend to:-

a) Verifying the functionality of the circuit
b) Systematically inspecting and maintaining all components of the system in accordance with the manufacturer recommendations, refer 3.3.7
c) Periodically checking safety critical functions and warning devices
d) Only using competent persons familiar with the particular fluid power system

7.1.2 Training

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

Training of maintenance personnel should include:-

a) System functional requirements and operating parameters
b) Troubleshooting and individual component testing
c) Safe energy isolation and dissipation in accordance with the mines Isolation Management Plan
d) Electrical / fluid power interfaces and control circuitry
e) Hose management
f) Importance of cleanliness

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

7.1.3 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.

SWP should be available for all abnormal maintenance activities and replacement of any item that may cause a significant risk if removed or installed incorrectly i.e. (hazardous task)

7.1.4 Inspection and Maintenance Schedules

Periodic inspections and maintenance schedules (daily, weekly, monthly, six monthly, annual, etc) should be developed and implemented in accordance with:-

a) The designer’s / manufacturer’s recommendations
b) Consultation with site personnel

tese schedules should include the inspection of hose condition.

7.1.5 Safe Working With Fluid Power Systems

When working with fluid power systems:-

a) Never feel for leaks
b) Never vent hydraulic fluid to atmosphere unless it is controlled into collection drums/trays or
visible way to determine loss of pressure

c) Never disconnect any line that has not been de-energised and tested for de-energisation

d) Always apply Lockout/Tagout procedures

7.1.6 Pressure Intensification

Any component with the potential for intensification shall be supplied with plastic caps that will blowout in the event of the component being pressurised and the cap not being removed.

Note: Fatalities have occurred because the component has been supplied with steel caps allowing the component to be intensified.

7.1.7 Filtration

Fluid power system filtration and replacement should be considered in the maintenance schedule.

Special attention should be paid to pilot control system to verify the oil is filtered to the correct cleanliness and does not induce excessive back pressures.

At no stage should the fluid power system operate without filtration.

7.1.8 Pipe Fittings and Components

Pipes should be correctly matched and rated.

Galvanised water pipe shall not be used in any hydraulic circuits including return lines.

Threads should be capable of withstanding the pressure in the system, refer 9.9

Only matching threads and fittings of the same pattern should be used.

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

7.2 ISOLATION AND ENERGY DISSIPATION

The mines Isolation Management Plan, refer MDG 40, should extend to all energies associated with fluid power systems such as:

a) Fluid under system pressure

b) Accumulators which may discharge

c) Suspended weights

d) Unexpected movement of linear and rotary actuators

All SWP should identify the specific areas for energy isolation and dissipation.

Note: Best practice is to utilise both text and pictures to show the correct isolation procedure

Reenergising fluid power systems should be carried out at a low pressure to minimise risk and verify system integrity where practicable. The area should also be restricted access to people until verification of system integrity is confirmed.

7.3 REPAIRS & DEFECTS

SWP 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, for example correct micron rating on the filters, correct pressure rating, etc.

When replacing components they should be kept clean and without damage.

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.
7.4 AUDITS
All site inspection, maintenance and repair activities should be periodically audited against the:-

   a) Mines inspection and maintenance system
   b) Designers/manufacturers recommendations
   c) Keeping of records
   d) Appropriateness and currency of competencies

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

7.5 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, maintenance or duty should be recorded and appropriate changes implemented.

7.6 HOSE MANAGEMENT
7.6.1 General
A hose management program should be developed, implemented and maintained. The hose management program should be integral with the mines maintenance system and the site specific maintenance strategies.

Note: A hose management program will reduce equipment downtime, maintain peak operating performance, and reduce the risk for personal injury and/or property damage.

The hose management program should include:

   a) A database of the range of hose assemblies on the mine site, including the hose size, length and working pressure
   b) A maintenance schedule such that all hose assemblies are inspected at a frequency as required for their risk to safety and equipment operation
   c) Old hose assemblies previously used not being reinstalled unless tested and certified in accordance with 3.7.7
   d) The hoses being cleaned and labelled in readiness for reuse
   e) Hose failure mode analysis

7.6.2 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.
Typically the failure of hose assemblies is by either of the following two mechanisms:-

- Excessive mechanical damage (such as abrasion, cuts, crushing etc),
- Corrosion (of both fittings and hose wire reinforcement)
- Degradation (age, chemical, cracking, overheating, fatigue etc)
- Leakage
- Burst
- Hose/ hose end separation
- Pinholes

The mines 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.

Note:
1. Failure by mechanical damage, deterioration and corrosion all significantly reduce the operational safety factor
2. In service catastrophic failures affect people safety and system performance
3. Hose assemblies discarded during in-service inspections can be changed during scheduled maintenance
4. Anything more than a ‘dampness’ should indicates the high pressure fluid is no longer being safely constrained and may be an indicator of imminent catastrophic failure

There are multiple potential causes for each type of failure mode, some typical examples of common failures and their possible causes are provided in Appendix 9.6.1.

7.6.3 Hose Failure Inspections

7.6.3.1 General

All hose assemblies and adaptors should be rigorously inspected periodically, in accordance with the mines 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 functional tested 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.

7.6.3.2 In-service Inspections

In-service inspection of hose assemblies should only be carried out by competent personnel, who are capable of making 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
The hose inspection should include but be not limited to all those in service inspections checks listed in Appendix 9.6.2

7.6.3.3 Hose Discard 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.

Hoses should be discarded if the inspection finds damage and is no longer fit for purpose as a result of the in service inspections, refer, 9.6.2 or:

7.6.4 Hose storage

Hose assemblies should be stored in a cool, dark, dry area with plastic end caps fitted. When storing care should be taken not to damage or shorten the hose service life, refer 3.7.3.4

7.6.5 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 (operating environment), refer 3.7.3 and the site hose management plan.

Where hoses in high risk areas have been in service for a period of greater than 8 years then they should be replaced unless:

a) A sample of hoses have been inspected and tested in accordance with 3.7.7, and

b) An assessment based on service history and condition is made to justify an extended period

Note: Consider 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

When hoses are replaced the hose assembly should be installed to the correct installation standard. The hose should be properly supported, routed and protected in the correct manner, refer Appendix 9.7.

The replacement hose assembly should be at least rated to, or greater than the maximum system pressure.

Maintenance issues, which should be considered, include:-

a) Use of correct hose design and material for the replacement hose

b) Use the correct fitting configuration for the duty and use of matched hose and fittings.

c) Maintain proper cleanliness at all times prior to installation

d) Use adequately sized hose for the duty

e) Ensure correct length of hose to minimise tension forces

f) Ensure the minimum bend radius of the hose is not exceeded

g) Ensure that no twisting remains in the installed hoses

h) Secure the hose assembly as per the design documentation using the correct mounting points

i) Protect the hose from impact or abrasion damage while in service

j) Ensure staple type fitting are not being dislodged during in service use.
SECTION 8  DECOMMISSIONING

8.1  GENERAL

Where the fluid system is to be decommissioned, relocated and re-commissioned, then a risk assessment on the decommissioning process should be carried out.

Standard work procedures should be developed and followed.

In particular 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:

a) Environment (U/G & or Surface)

b) Pressure intensification

c) Access to the equipment

d) Cleanliness of the hydraulic system

e) Storage of fluids

f) Corrosion protection

g) Handling during and after storage (associated equipment)

h) Visual impact

i) Long term care and maintenance

j) Disposal procedures

k) Contractor Management
## SECTION 9 APPENDICES

### 9.1 APPENDIX A – ASSOCIATED DOCUMENTS

The following partial list of documents is related to fluid power system safety. This list is provided for information only and it is not a full and comprehensive list of all documents that may be applicable.

#### 9.1.1 Australian Standards

- **AS 1000** The international system of units (SI) and its application
- **AS 1101.1** Graphic symbols for general engineering - Hydraulic and pneumatic systems
- **AS 1180** Methods of test for hose made from elastomeric materials
- **AS 1200** Pressure equipment
- **AS 1210** Pressure vessels
- **AS 1318** Use of colour for the marking of physical hazards and the identification of certain equipment in industry
- **AS 1319** Safety signs for the occupational environment
- **AS 1345** Pressure piping
- **AS 1657** Fixed platforms, walkways, stairways and ladders - Design, construction and installation
- **AS 1683.21** Rubber Vulcanised – Determination of Abrasion Resistance using a Rotating Cylindrical Device.
- **AS 2554** Hose and hose assemblies for air
- **AS 2660** Hose and hose assemblies - Air/water - For underground coal mines
- **AS 2671** Fluid Power Hydraulic Systems and Components
- **AS 2700** Colour standards for general purposes
- **AS 2788** Pneumatic fluid power – General requirements for systems
- **AS 2971** Serially produced pressure vessels
- **AS 3788** Pressure equipment - In-service inspection
- **AS 3791** Hydraulic Hose
- **AS 3873** Pressure equipment - Operation and maintenance
- **AS 3892** Pressure equipment – Installation
- **AS 4024** Safeguarding of machinery
- **AS 4024-1** Safe Guarding on Machinery. General Principles.
- **AS 4037** Pressure equipment - Examination and testing
- **AS 4041** Pressure piping
- **AS 4343** Pressure equipment - Hazard levels
- **AS 4360** Risk management
- **AS 4458** Pressure equipment – Manufacture
- **AS 4481** Pressure equipment – Competencies of inspectors
- **AS 61508** Functional safety of electrical/electronic/programmable electronic safety-related systems
- **AS 62061**

#### 9.1.2 ISO Standards

- **ISO 11340** Rubber and Rubber Products – Hydraulic Hose assemblies – External Leakage classification for hydraulic systems
ISO 12151 Connections for Hydraulic Hose Power and General Use
ISO 1219 Fluid power systems and components - Graphic symbols and circuit diagrams
ISO 1436-1 Rubber hoses and hose assemblies - Wire-braid-reinforced hydraulic types - Specification – Part 1: Oil-based fluid applications
ISO 1436-2 Rubber hoses and hose assemblies – Wire braided reinforced for hydraulic applications – specifications – Part 2; Water-based fluid applications
ISO 16889 Hydraulic fluid power filters - Multi-pass method for evaluating filtration performance of a filter element
ISO 3862-1 Rubber hoses and hose assemblies - Rubber-covered spiral-wire-reinforced hydraulic types - Specification - Part 1: Oil-based fluid applications
ISO 3862-2 Rubber hoses and hose assemblies – Rubber-covered spiral-wire reinforced for hydraulic applications – specifications – Part 2; Water-based fluid applications
ISO 4079-1 Rubber hoses and hose assemblies - Textile-reinforced hydraulic types - Specification – Part 1: Oil-based fluid applications
ISO 4406 Hydraulic fluid power; Fluids; Method for coding level of contamination by solid particles
ISO 4520 Chromate conversion coatings on electroplated zinc and cadmium coatings
ISO 6605 Hydraulic power - Hoses and hose assemblies - Test methods
ISO 6802 Rubber and plastics hose and hose assemblies with wire reinforcements – Hydraulic impulse test with flexing
ISO 6803 Rubber or plastics hoses and hose assemblies – Hydraulic-pressure impulse test without flexing
ISO 6805 Rubber hoses and hose assemblies for underground mining - Wire-reinforced hydraulic types for coal mining – Specification
ISO 6945 Rubber hoses – Determination of abrasion resistance of the outer cover
ISO 8030 Rubber and plastics hoses – Method of test for flammability
ISO 8032 Rubber and plastics hose assemblies – flexing combined with hydraulic impulse test (half-omega test).

9.1.3 SAE Standards
SAE J343 Tests and Procedures for SAE 100R series hydraulic hose and hose assemblies
SAE J516 Hydraulic Hose Fittings
SAE J517 Hydraulic Hose
SAE J1176 External Leakage Classifications for Hydraulic Systems
SAE J1231 Formed Tube Ends for Hose Connections and Hose Fittings
SAE 1273 Recommended Practices for Hydraulic Hose assemblies
SAE J1405 Optional Impulse Test Procedures For Hydraulic Hose Assemblies
SAE J1927 Cumulative Damage Analysis for Hydraulic hose assemblies
SAE J1065 Nominal Reference Working Pressures for Steel Hydraulic Tubing
9.2 APPENDIX B – OH&S LEGISLATIVE FRAMEWORK FOR MINING IN NSW

The following diagram outlines the Occupational Health and Safety legislative framework for coal mines in NSW.
9.3 APPENDIX C – FLUID NOMOGRAPH

Selecting the Right Hose Size

With this nomograph, you can easily select the correct:

a) Hose ID size
b) Desired flow rate
c) Recommended flow velocity

If any two of these factors are known, the third can be determined.

To use this nomograph:
1. Pick the two known values.
2. Lay a straightedge to intersect the two values.
3. Intersection on the third vertical line gives the value of that factor.
Example:

To find the bore size for a Pressure Line consistent with a Flow Rate of 100 litres per minute (26 US or 22 Imperial gallons per minute), and a Flow Velocity of 4.5 metres per second (14.8 feet per second), connect Flow Rate to Flow Velocity and read Hose Bore on centre scale.

Answer: The line crosses Hose Bore between -12 and -16.

The velocity of the fluid should not exceed the range shown in the right hand column. When oil velocities are higher than recommended in the chart, the results are turbulent flow with loss of pressure and excessive heating. For long hoses and/or high viscosity oil, or if the flow of hydraulic fluid is continuous, it is recommended to use figures at the lower end of the Maximum Recommended Velocity range. For short hoses and/or low viscosity oil, or if the flow of hydraulic fluid is intermittent or for only short periods of time, figures at the higher end of the Maximum Recommended Velocity range can be used.
### 9.4 APPENDIX D – COMMON TYPES OF FLUID INJECTION INJURIES

<table>
<thead>
<tr>
<th>Fluid Injection / Near Miss</th>
<th>Description</th>
<th>Causal Effects</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid Injection in back of leg</td>
<td>A 3/8”BSPP fitting stripped on a 320Bar constant pressure line. Fitting had hoses, filters, tee piece etc hanging from the fitting and hoses were dragging on the ground. No guard or clamp to restrain the hose.</td>
<td>L/W: FFP</td>
<td>Relocate the hoses to have a hose end directly coupled to the valve bank. Remount the filters; tee piece etc back on the boot end. Guard the area around the valve bank to protect the operator. Install Emergency switch on the valve bank. Review the Risk Assessment hazard &amp; controls to identify if these areas are considered. Include the changes into the Mines Longwall Management Plan and / or Standards of Engineering Practice.</td>
</tr>
<tr>
<td>Longwall Boot End</td>
<td></td>
<td>Longwall high pressure This fitting not suitable for the function.</td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Fluid Injection in the hand O/C - Work area</td>
<td>The porta power hose had some damage near the end of the hose. The protection sheath had moved back from the hose end exposing the damaged section. When the pump applied pressure, oil escaped through a pinhole in the damaged section producing a jet of oil, which penetrated the operators gloved hand.</td>
<td>O/C: H&amp;F: M</td>
<td>Set up a maintenance and inspection program to identify the condition of the Porta Power equipment. Also set up a pre use inspection to check equipment before use. The hoses and fitting to be suitable for the duty. Up to 10 000 psi. Auditing of contractors equipment. Ensure appropriate training of inspection of hydraulic equipment porta powers. Review the Risk Assessment hazard &amp; controls to identify if these areas are considered. Include the changes into the Mines Longwall Management Plan and / or Standards of Engineering Practice.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The protection sheath had become dislodged and moved back from the end. The hose was damaged. Maintenance and inspection of the porta power equipment. The operator failed to identify the damage to the hose and sheath had become dislodged from its correct location.</td>
<td></td>
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<td></td>
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<tr>
<td>Fluid Injection to the buttocks area. U/G. Longwall roof support.</td>
<td>A 350 bar constant pressure hose blew off the hose end DN13 hose. The fluid was released as the hose was whipping around, and a chock operator received oil injection into the anus. The employee was dispatched to Hospital, OK.</td>
<td>L/W: H&amp;F: M</td>
<td>Full inspection / audit of all face hoses and their condition. Replace defective hoses. Remount pressure filters and side shield valve banks out of the coal fines. Regularly inspect the hose condition above there normal inspection, and monitor hose wear. Review the Risk Assessment hazard &amp; controls to identify if these areas are considered. Include the changes into the Mines Longwall Management Plan and / or Standards of Engineering Practice.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hose end and swage were badly corroded due to the hose end lying in damp coal fines. The hose was identified as being &gt; 5-6 years old. Pressure filters and side shield valve banks lying in coal fines not mounted.</td>
<td></td>
</tr>
<tr>
<td>Fluid Injection / Near Miss</td>
<td>Description</td>
<td>Causal Effects</td>
<td>Actions</td>
</tr>
<tr>
<td>----------------------------</td>
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</tr>
<tr>
<td>Fitter hit with Solcenic fluid at the pump station. U/G Longwall Pump Station</td>
<td>The mine planned to carry out a monorail section removal on the day shift. On the N/S this job was brought forward. The fitter and fed carried out a JSA (verbal) and isolated the electric’s on the pump station, water and air and hydraulics, the water and air were depressurised. The longwall hydraulics depressurisation was carried out on the chocks. When trying to remove the super stecko staple was difficult and very tight. They turned the valves on the pump outlet manifold and listen for any sounds. The fitter decided to check for hydraulic pressure at the pump outlet manifold, by removing the side cover from the manifold. On part removal the cover became partly dislodged allowing oil under pressure to escape, which fit the fitter in the rib and chest area. The fitter was dispatched to hospital for treatment.</td>
<td>L/W: I; HE: T; Op Adequate procedures not available to carry out the work. A change of the plan not managed in a controlled fashion. Fitter did not understand the longwall hydraulics and electric’s good enough, as the tranny power was stopped which activated the dump valve holding pressure in the monorail hoses. Isolation procedures not adequate for the task. Fitter was trained but could not remember the correct pump isolation as this job normally carried out on day shift.</td>
<td>Develop new operational procedure to include specific isolation steps to be followed. Information to be located on the equipment (pump station). Retrain the employees on the hydraulics and electric’s so they have a clear understanding of the operation. Develop function specification for the hydraulics to assist with the above training. Work instruction to be given by persons with the appropriate knowledge and skill for the work required.</td>
</tr>
<tr>
<td>Fitter hit with Longwall hydraulic fluid. U/G Longwall</td>
<td>A fitter was asked to replace a burst hose. The hose was in two sections with a physical break. The fitter started to remove one end, which was difficult due to corrosion and decided to remove the other end, by positioning himself on the other side of the leg. There were two hoses on the leg bottom port manifold. He removed the staple of the hose and the hose blew out spraying him with oil. The fitter noticed he received a cut, he was unsure if the cut was caused from the oil or the hose end etc? He was dispatched to hospital. The cut was not caused by fluid injection.</td>
<td>L/W: H&amp;F, M: I; HE. The fitter picked the wrong hose to remove on the cylinder leg. He was distracted &amp; frustrated he could not remove the first end. Hose inspection should have picked up the hose needs replacing. He did know the isolation procedure, which was demonstrated by a second fitter U/G.</td>
<td>Maintenance regimes to inspect the hose condition and identify any for replacement. Review the Risk Assessment hazard &amp; controls to identify if these areas are considered. Include the changes into the Mines Longwall Management Plan and / or Standards of Engineering Practice.</td>
</tr>
<tr>
<td>Near Miss oil sprayed into the walkway U/G Longwall</td>
<td>Oil sprayed out from the top (power down) port block on the leg cylinder. The oil sprayed / leaked out the welded area between the port block and the cylinder housing.</td>
<td>L/W; HE; M When the chocks were overhauled new port block was fitted to the cylinder by welding the block to the cylinder. Slag inclusion and insufficient fusion on the weld ends causing a pathway for the oil to escape.</td>
<td>When changes and improvements to equipment. Check the repairer has correct repair procedures and monitoring and inspection of the repair is carried out. Quality control procedures. Remember the time constraints the mine usually places on the repairer. Review the Risk Assessment hazard &amp; controls to identify if these areas are considered. Include the changes into the Mines Longwall Management Plan and / or Standards of Engineering Practice.</td>
</tr>
<tr>
<td>Near miss. The chock operator was</td>
<td></td>
<td>L/W; H&amp;F; M.</td>
<td>The hose routing to be improved to</td>
</tr>
<tr>
<td>Fluid Injection / Near Miss</td>
<td>Description</td>
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</tr>
<tr>
<td>-----------------------------</td>
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</tr>
<tr>
<td>Leg raise hose burst U/G. Longwall</td>
<td>advancing the chocks by adjacent controls. The chock became stuck and raised the pontoons. The operator then operated the chock in manual mode (on board the chock) lowering the chock to free the chock, as it was jammed into a lip in the roof. When lowering the front legs the power lower hose blew out</td>
<td>Hose route under the walkway covers and up to the power down leg port, the hose was wearing the outer cover and braiding causing a weak point in the hose. Also allowing water onto the braiding and allowing corrosion to start.</td>
<td>eliminate wear from the floor plate on the hose. Hose protection in this area and modifying the floor plate to eliminate the wear. Review the Risk Assessment hazard &amp; controls to identify if these areas are considered. Include the changes into the Mines Longwall Management Plan and / or Standards of Engineering Practice.</td>
</tr>
<tr>
<td>Fitting failure Longwall</td>
<td>A fitter was adjusting the unloader relief valve on a longwall pump station a fitting between the pump and the accumulator on the pump sled failed and the hose whipped around violently, hitting the fitter.</td>
<td>Unloader adjustment procedure. Layout of the hoses, accumulator set up on the sled encouraged people walking on the hose causing stress to the fitting. Fitting material suspect. Hose and fitting not supported / mounting.</td>
<td>Replace all suspect hoses and fittings and to remount the hose end manifolds. Procedure required replacing and adjusting the relief and unloader valve. Unloader valves to be overhauled and preset. Guard and protect the accumulator fittings. Review the Risk Assessment hazard &amp; controls to identify if these areas are considered. Include the changes into the Mines Longwall Management Plan and / or Standards of Engineering Practice.</td>
</tr>
<tr>
<td>Fitter hit by hose under pressure. O/C Steering accumulato r hose on a dump truck</td>
<td>A fitter was working on the steering circuit of a dump truck. The truck had been shut down using the emergency stop and isolated and locked on the previous shift. The fitter removed the hose going to the accumulator and he was hit with the hose and fluid under pressure.</td>
<td>Normally a timer drains off the steering pressure after say eg 30sec. As the truck was shut down on emergency stop this also disabled the electrics and the timer trapping pressure in the steering circuit. The fitter did not verify the isolation and dissipation of hydraulic energy.</td>
<td>Review and update the isolation procedures. Reinforce the training on hydraulic circuits to include the depressurising the hydraulic circuit and testing for residual pressure in the accumulator circuit. Review the Risk Assessment hazard &amp; controls to identify if these areas are considered. Include the changes into the Mines Longwall Management Plan and / or Standards of Engineering Practice.</td>
</tr>
<tr>
<td>Leg intensificati on L/W Chock Leg intensificati on splitting the cylinder.</td>
<td>A chock operator noticed oil leaking from the behind the rear cylinder leg. A fitter investigated the oil leak and found the second stage leg split for approx 300mm x 20mm wide.</td>
<td>The cylinder leg was manufactured with different material than the OEM spec. The return port was blocked by a poppet jammed and a broken spring. Maintenance not sufficient to identify the poppet and spring problem. These areas have not been considered for maintenance. Leg cylinders have a low Factor of Safety on the hoop stress.</td>
<td>Strip inspect all manifold block to inspect and renew suspect poppets and springs. Set a maintenance inspection of the poppets and spring and hydraulic controls. Install yield valves set to 420 bar relief on the power down (top port) side of the cylinder leg, in addition to the durst disc / hydrafuse. Conduct a FMEA on the hydraulic circuit to identify similar circumstances as above. Test the hydraulic circuit (cylinder leg fitted with yield valve and hydrafuse then intensify in a</td>
</tr>
</tbody>
</table>
### Fluid Injection / Near Miss

<table>
<thead>
<tr>
<th>Description</th>
<th>Causal Effects</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>A burst disk was installed on the cylinder leg.</td>
<td>controlled environment) to prove that the legs and employees are protected.</td>
<td>Replace old equipment with newer equipment, and new technology. Review the Risk Assessment hazard &amp; controls to identify if these areas are considered. Include the changes into the Mines Longwall Management Plan and / or Standards of Engineering Practice.</td>
</tr>
</tbody>
</table>

### Incident Location:

- **L/W.** Longwall: 10
- **O/C.** Open Cut Mine: 2

### Common Causes:

- **H&F.** Hose & Fitting failure: 6
- **I.** Isolation: 4
- **HE.** Human Error: 5
- **M.** Maintenance: 7
- **FFP.** Fit for Purpose: 5
- **T.** Training: 2
- **Op.** Operational: 2
9.5 APPENDIX E – FLUID INJECTION PROTOCOL

SAFETY, HEALTH & ENVIRONMENT PROCEDURE

FLUID INJECTION PROTOCOL

Document No.:

Issue: 001

Number of Pages:

Date Printed:

File Name:

Approved by:

WARNING: Failure to act appropriately may result in death of patient, or the need to amputate the affected limb.
1.0 PURPOSE
This procedure defines the protocol to follow for a person who receives fluid injected through the skin. This protocol establishes a minimum level of treatment for any person who has received fluid injected through the skin. This procedure to go with the Patient and to the Doctor / Hospital.

2.0 SCOPE
This procedure applies to any person reporting to the Medical centre after receiving fluid injected under the skin, regardless of how minor the contact may appear upon reporting.
This procedure applies to all employees, contractors and visitors on the site.

3.0 REFERENCES
Safety Alerts. SA 00-02, SA 98-08 and SA 02-14.
MDG 1016 First Aid Guideline.

The intention of this document is to make all persons aware that delayed effects can still occur, in some cases several hours or days after a fluid injection under the skin.

4.0 DEFINITIONS
   Feel near the cut or puncture wound: Severe pain, throbbing, or numbness?
2. When any fluid has punctured the skin and likely to have injected the fluid under the skin of a person.
3. Look for entry wound / site.

5.0 RESPONSIBILITIES
Site Manager
Authorise persons to carry out this procedure.

Department Managers
Ensure that all employees (including contractors and visitors) working under their control are aware of the need to follow this procedure.

Managers of Contractors
Ensure that all employees (including sub-contractors and visitors) workings under their control are aware of the need to follow this procedure.

Contractor Companies
Ensure that all employees (including sub-contractors and visitors) workings under their control are aware of the need to follow this procedure. Contractor companies are responsible for their own employee’s costs associated with any incident.
6.0 PROCEDURE

Any person (whether employee or contractor or visitor) receiving fluid injected under the skin, no matter how small, during the course of their work is required to follow the procedure listed below.

**Step 1:**

The employee should, if possible, make the area safe to prevent other employees from also receiving a fluid injected injury.

Call for an ambulance to transport the employee to hospital.

First Aid treatment given at the mine would consist of gentle cleaning of the injured part, immobilise and elevate the affected limb to a comfortable position.

Rest the patient to avoid anxiety.

The patient should NOT be given food or fluids as they must remain fasted in anticipation of anaesthesia and surgery being required.

**Step 2:**

Transport the causality to the surface first aid room.

Attach the following documents to the patient and a copy to the ambulance.

- Dear Doctor Letter.
- Additional Information from Sydney Hospital, “High Pressure Injection Injury of a Hand”.
- Injuries involving High Pressure Injection.
- Material Safety Data Sheet of the fluid involved eg hydraulic oil safety data sheet.

**Step 3:**

The employees must not be left alone or allowed to drive themselves to the medical facility. Repeat baseline observation every 20-30 minutes especially if suspicious of systemic infection (into blood stream).

**Step 4:**

Upon arriving at the hospital, the employee should report that “I’m an employee of (...company...) at (...location ...) where I received a fluid injection injury about XX minutes ago. I’m here for a medical assessment”.

**Step 5:**

When the doctor arrives, the employee should hand over the INFORMATION KIT for HIGH PRESSURE INJECTION INJURIES and “Dear Doctor” form for the doctor’s information and assessment. A medical check of the injury will be performed. If considered necessary, the doctor may require the person to be admitted for observation or surgery if required. The medical facility should then advise the injured employee’s family of the situation.

**Step 6:**

If following the medical examination and investigations the patient is not admitted they will be driven back to work.

**Step 7:**

Upon arrival back at work, the person should report to the Medical Centre and advise the Supervisor of the results of the investigation.

7.0 DOCUMENTATION

All proposals to modify this procedure should be sent to the Mines Corporate SH&E Manager.
8.0 ATTACHMENTS

8.1 LETTER TO THE DOCTOR

“Dear Doctor …” form (Works Site)

WORKS NAME

Road
Suburb
Town, NSW
P.O. Box **,
Suburb, NSW 2***
Phone
Fax:

Date: _______________________

Dear Doctor,

The patient __________________________ you are assessing has a fluid injection injury.

(PLEASE PRINT NAME)

He/she received a fluid (oil) injection injury at ..........am/pm ....../..../...... The mines First Aid Management System require our employees to have a medical assessment to check for any medical complications regarding this incident.

Their baseline observations at _____ am/pm were:

Pulse: ___________ Blood pressure: ____________ Temperature: __________

He/she is complaining of:

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________

1. Sydney Hand Unit Phone No: 02 9382 7201. (24 hour advice).  
   Note: If the employee is required to be admitted to the hospital for observation overnight, 
   please contact the company and advise of the situation.

2. Royal North Shore Hospital Phone No. 02 9926 7111.

3. …………..Mine Phone No:……………………
8.2 ADDITIONAL INFORMATION

INJECTION OF HIGH PRESSURE HYDRAULIC OIL:
ADDITIONAL INFORMATION RELATED TO
SAFETY ALERT No. SA98-08 (November 1998)

Background information
The high pressure injection of a fluid such as hydraulic oil, grease and paint constitutes a medical and surgical emergency, requiring access to appropriate specialist surgical expertise as soon as possible. This comment is consistent with the document "INJURIES INVOLVING HIGH PRESSURE INJECTION" which was attached to SA98-08 (distributed November 1998).

The injury sustained in a high pressure injection incident is usually worse than it will first appear. The injury is relatively rare and it may be that some medical practitioners or hospital services will not be alert to the severity of an injury of this type.

Dr lan Isaacs, Director of the Sydney Hospital Hand Unit, has provided advice on the response to ‘High Pressure Injuries of the Hand’, and this is included as Attachment 1.

The injured person will generally require specialist surgery or hand surgery services. Such services will usually be available through the Accident and Emergency Department at a major public health system teaching hospital or, as appropriate, through a specialist Hand Clinic. Urgent transport to the appropriate service is required. The locations of such services in NSW are indicated in Attachment 2.

Where Emergency Transport is required for a person working in a remote area, a local medical officer or service can usually arrange this more effectively than a work site representative or the injured individual. However, if establishing contact with a local medical officer or service entails any delay, contact can be made direct with the specialist services.

Issues for mine site consideration and management
Prevention
As indicated in SA98-08 personnel should be made aware of the potential dangers of fluids at high pressure.

Reporting a high pressure fluid injection injury
Mine site personnel should report any incident where they may have received a high pressure fluid injection.
ADDITIONAL INFORMATION

Response to an 'Injection of High Pressure fluid' incident

First aid response

As suggested in the attached advice of the Director of the Sydney Hospital Hand Unit.
In addition, there should be clear identification of the injected material, and its chemical constituents if possible, for the information of specialist medical services.

Access to specialist medical services

A person who has sustained a high pressure fluid injection injury requires emergency assessment and/or treatment at specialist medical units (Attachment 2).

Transport to the emergency medical service

The use of emergency medical transport to the specialist service is warranted with a high pressure hydraulic oil or other fluid injection injury. For people in areas remote from the specialist services, local medical officers or medical services may facilitate and speed up access to emergency medical transport.

Where mine sites have their own medical advisers this document and SA98-08 could be discussed with them as part of establishing the work sites' response to the high pressure injection of hydraulic oil or other fluids.

For NSW coal mines the Joint Coal Board doctors are available for discussion of the topic and the work site response if required.
8.3 SYDNEY HOSPITAL INFORMATION

ADDITIONAL INFORMATION
SYDNEY HOSPITAL & SYDNEY EYE HOSPITAL
Macquarie Street, Sydney, 2000
G.P.O. Box 1614, Sydney, NSW 2001

Our reference: IJI:ejh/II030299
Your reference: 3rd February 1999

Enquiries to:
The Mine Managers
New South Wales Department of Mineral Resources

re: High Pressure Injection Injuries of the Hand

The advice of Sydney Hospital Hand Unit has been sought in updating the protocols for the management of high pressure injection injuries occurring in the hand.

The information that has been distributed is by no means an over-statement of the problems that can arise as a result of such injuries. It needs to be emphasised that high pressure injection injuries to the hands are one of the very few injuries that require prompt and highly specialised treatment to minimise tissue damage and maximise restoration of function. The only effective treatment for high pressure injection injuries is surgical. This invariably will require extensive decompression of the area that has been affected by the injection injuries and this can involve a very extensive area beyond the apparent initial point of entry. The faster the injured worker is able to be transported to a centre that is able to perform this surgical treatment, the better the outcome will be.

The most important consideration at the work-site is the employer and employees to all be aware of these injuries and their potential problems. Prevention remains the best treatment and the safety procedures that you use within the mines, avoiding exposure to hydraulic lines and teaching employees the proper techniques in handling high pressure hoses and components, are paramount.

A high index of suspicion of this injury must be entertained when a worker reports an accident whilst handling such equipment. Make note that the point of entry may look very small and may not bleed. It will usually be on the working surface of the hand, that is, on the pulps of the fingers or towards the palm. The worker may not complain initially of pain but may have a feeling of numbness and tenseness within the affected part. Within a short period following this injury, however, the part usually becomes quite irritated with the worker complaining of throbbing pain which can seem out of proportion to what is visible to the naked eye. Once the diagnosis has been entertained, there is little to be done apart from expediting that worker's transfer to a surgical facility where he can get treatment with the minimum of delay.

The First Aid procedures would consist of gentle cleaning of the part, resting the patient to avoid anxiety, and elevating the affected limb in a comfortable position so that activity of the extremity is minimal. A resting splint applied gently to the wrist would be an advantage. The patient should not be given fluids or food as they must remain fasted in anticipation of anaesthesia and surgery being required.

The urgency of transfer is of the same degree as would be required for an amputation injury where replantation is being considered. In this regard there are some situations where, due to the isolation of the mine, the Occupational Health & Safety Officer at the site may wish to liaise directly with the Specialist Unit for advice re the transfer. The staff at Sydney Hospital Hand Unit would be available 24 hours a day for advice and assistance in expediting treatment of any of your workers suspected of having these injuries.

Ian J. Isaacs FRACS
Director
SYDNEY HOSPITAL HAND UNIT
FACILITIES OF THE SOUTH EASTERN SYDNEY AREA HEALTH SERVICE  DTP/283
SPECIALIST HAND UNITS AND MAJOR ACCIDENT AND EMERGENCY UNITS IN NSW

For a hand injury there are "Hand Clinics" at Sydney Hospital (02 93827201) and Royal North Shore Hospital (02 99267111). These services can be contacted by phone and advice sought when a high pressure fluid injection injury has occurred to a hand.

The Accident and Emergency Services at the major public hospitals are likely to be equipped to deal with high pressure fluid injection injuries. In NSW these hospitals are:

- Royal North Shore Hospital
- The Prince of Wales group of hospitals
- Royal Prince Alfred Hospital
- Westmead Hospital
- Liverpool Hospital
- Nepean Hospital
- Concord Hospital
- John Hunter Hospital
8.4 INJURIES

INJURIES INVOLVING HIGH PRESSURE INJECTION

High pressure injection injuries resulting from inadvertent contact with grease gun tips or leaking hydraulic pipes are a rare occurrence (150 reported cases in the 50 years to 1984 in the UK).

When they do occur the speed of treatment is probably the most important factor in limiting the ultimate severity of the injury.

Injury typically involves pressures well in excess of 1500 psi (10.342 bar) punching a hole in the skin and soft tissue. Pressures below 1000 psi (6.895 bar) are unlikely to be energetic enough to cause an injection unless skin has previously been broken or is healing from a recent injury. After the initial injection, the fluid travels in a narrow stream until a structure of sufficient density (i.e., muscle or bone) is encountered. The fluid then rapidly disperses in all directions. Dependent upon the entry pressure, injected fluid can travel a great distance from the initial site of entry.

Damage at this stage is normally related to physical phenomena such as compression, rupture and impact together with the chemical nature of the injected material.

With lesser injections only a small puncture hole may be apparent often with no bleeding and little or no pain. If the material is a low hydrocarbon such as white spirit or kerosene then local anaesthesia can result as fat and myelin nerve sheaths dissolve. With such injections injecting local anaesthetics will potentiate the effects and so must not be administered. With higher distillates such as those typically used as hydraulic mineral oils, the higher viscosity usually results in less lateral penetration but can be more difficult to remove.

After a short period of time, the body's natural defence mechanism is activated and local swelling, pain and heat is noticed. If the material consists of tissue irritants, as would be the case with soluble hydraulic fluids and to lesser extent with their emulsions, this reaction would be faster than if it were just mineral oil.

Urgent surgical treatment is required to reduce the long term implications of this type of injury. First aid treatment is very limited, being mainly restricted to comforting the casualty until qualified medical assistance can be obtained. The general treatment would include decompressive surgery and deep cleansing of the wound and affected tissues, removing as much of the foreign material as possible. Relief of pressure on tissues caused by swelling of damaged tissue is continued after the operation by the application of steroids. The wound is closed after cleaning out all necrotic tissue and debris, with loose sutures to help reduce internal pressure.

Obviously, the treatment of this type of injury is highly individualised, depending to a great extent upon the nature of the fluid (its viscosity, chemical nature, etc.) and the impact pressure. One would expect a greater risk of amputation with low viscosity substances but treatment can be over very extended periods (may be years) with greases. Information concerning systemic toxicity of any injected substance is very sparse and not generally of immediate concern in these instances. However, it is worth noting that certain fluids, namely soluble hydraulics, often contain biocides, alkaline anti corrosion inhibitors and other components, which can have a toxic effect.

Consideration of the quantity which is likely to be injected, however, and relating this to the proportion of toxic substance it can be seen that very little enters the body so, whilst the possibility of toxic effects cannot be discounted, the treatment of the more acute damage caused by the actual injection should be paramount.

It can't be emphasised too much that the eventual severity of the disability is strongly dependent upon the immediacy of treatment. With rapid, effective and educated treatment there is a reduced risk of amputation or loss of function of the limb. Therefore, personnel must be trained to inform supervisors of any injection injury as soon as it happens and to seek urgent immediate medical attention.
Operator of Integrated Tool Carrier Injected with Hydraulic Oil

Incident

A plant operator was changing the implements on an Integrated Tool Carrier at an underground metaliferous mine. While attempting to retract the locking pins far enough to allow the bucket to be removed, by moving the hydraulic valve lever backwards and forwards, a hose near his left hand ruptured. The oil discharging from the ruptured hose struck the operator’s left thumb, bending it backwards and causing severe pain. The operator was wearing gloves at the time and when he removed the glove from his left hand he noticed that his thumb was bleeding.

The initial injury report completed at the mine stated that there was a laceration, swelling to the left thumb and swelling to the left hand.

During a physiotherapy session eight days after the accident, when the thumb swelled up it was realised that hydraulic oil had penetrated the thumb.

Cause

Wire braiding on the hydraulic hose failed owing to a combination of corrosion and fatigue. At the point of failure the rubber protection was missing.

Comments and Preventive Action

- Operators of hydraulic machinery should be protected from any potential source of high pressure fluid release.
- It should be recognised that any fluid at high pressure has the potential to cause major injury when injected into the body. The chemicals in the fluid can cause infection as well as dissolve fatty tissue.
- This incident highlights the fact that there was no awareness by the medical profession of the potential for fluid injection when using hydraulically operated systems.
- All relevant personnel should be made aware of the potential dangers of fluids at high pressure and the procedure to be followed if an injection of fluids occur.

For additional information contact Mr. R. Johnson, Inspector of Mechanical Eng. on (08) 80800622.

G. Farrow
DIRECTOR MINES SAFETY AND ENVIRONMENT

Report No: SA98-08
Date: 28 November 1998
9.6 APPENDIX F – HOSE FAILURE MODES AND DISCARD CRITERIA

9.6.1 Hose Typical Failure Modes

<table>
<thead>
<tr>
<th>Failure Mode</th>
<th>Possible Causes</th>
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<tr>
<td>Hose rupture</td>
<td>• overload – pressure</td>
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<tr>
<td></td>
<td>• overload – mechanical</td>
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<tr>
<td></td>
<td>• deterioration of hose material</td>
</tr>
<tr>
<td></td>
<td>• twisting damage</td>
</tr>
<tr>
<td></td>
<td>• too sharp bends</td>
</tr>
<tr>
<td>Outer sheath wear</td>
<td>• too sharp bends</td>
</tr>
<tr>
<td></td>
<td>• inadequate abrasion protection</td>
</tr>
<tr>
<td></td>
<td>• incorrect material selection</td>
</tr>
<tr>
<td>Fitting failure</td>
<td>• overload – pressure</td>
</tr>
<tr>
<td></td>
<td>• overload – mechanical</td>
</tr>
<tr>
<td></td>
<td>• incorrect material selection</td>
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<td></td>
<td>• general wear and age maturity</td>
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<td></td>
<td>• fatigue and cyclic loading</td>
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<tr>
<td>Fitting corrosion</td>
<td>• inadequate corrosion protection</td>
</tr>
<tr>
<td></td>
<td>• incorrect material selection</td>
</tr>
<tr>
<td>Reinforcement wire corrosion</td>
<td>• inadequate abrasion protection</td>
</tr>
<tr>
<td></td>
<td>• incorrect material selection</td>
</tr>
<tr>
<td>Hose/fitting separation</td>
<td>• compression set of hose material</td>
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<tr>
<td></td>
<td>• loss of compression pressure on hose</td>
</tr>
<tr>
<td></td>
<td>• overload – pressure</td>
</tr>
<tr>
<td></td>
<td>• overload – mechanical</td>
</tr>
<tr>
<td></td>
<td>• mismatched components</td>
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<tr>
<td></td>
<td>• poor assembly practices</td>
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<tr>
<td>Outer layer’s of hose penetrated</td>
<td>• abrasion damage to hose by foreign material</td>
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<tr>
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<td>• hoses rubbing together</td>
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<tr>
<td></td>
<td>• inadequate hose cover material</td>
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<tr>
<td>Delamination of inner hose</td>
<td>• excessive vacuum conditions</td>
</tr>
<tr>
<td></td>
<td>• prolonged vacuum conditions</td>
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<tr>
<td></td>
<td>• material degradation</td>
</tr>
<tr>
<td></td>
<td>• incorrectly selected hose causing too high a velocity (refer to nomograph)</td>
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<tr>
<td>Fatigue failure of reinforcing mesh</td>
<td>• cyclic/random bending of hose</td>
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<tr>
<td></td>
<td>• cyclic/random pressure changes</td>
</tr>
<tr>
<td>Fatigue failure of hose material</td>
<td>• cyclic/random bending of hose</td>
</tr>
<tr>
<td></td>
<td>• cyclic/random pressure changes</td>
</tr>
<tr>
<td>Hose deterioration</td>
<td>• fluid/material computability</td>
</tr>
<tr>
<td></td>
<td>• ultraviolet radiation</td>
</tr>
<tr>
<td></td>
<td>• temperature</td>
</tr>
<tr>
<td></td>
<td>• ozone</td>
</tr>
<tr>
<td></td>
<td>• environmental surrounding hose</td>
</tr>
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<td></td>
<td>• solvents</td>
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</table>
9.6.2 Hose In-service Inspection Check Lists

The hose in-service checks should look for:-

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>Visual evidence of leaks along the hose or around the hose ends</td>
</tr>
<tr>
<td>b)</td>
<td>Degraded hose, hard, stiff, charred, blistered, soft, heat cracked</td>
</tr>
<tr>
<td>c)</td>
<td>Exposed, damaged, corroded or broken outer wire braid</td>
</tr>
<tr>
<td>d)</td>
<td>Corrosion, may be identified by small lumps in the hose</td>
</tr>
<tr>
<td>e)</td>
<td>Wear &amp; abrasion</td>
</tr>
<tr>
<td>f)</td>
<td>Bulges, blistered, soft, degraded or loose outer covers</td>
</tr>
<tr>
<td>g)</td>
<td>Outer cover sheath damage, cuts in the hose cover or cracked and heat affected</td>
</tr>
<tr>
<td>h)</td>
<td>Kinked, crushed, flattened or twisted hose</td>
</tr>
<tr>
<td>i)</td>
<td>Wrong bend radius</td>
</tr>
<tr>
<td>j)</td>
<td>Incorrect hose routing</td>
</tr>
<tr>
<td>k)</td>
<td>Incorrect length of hose</td>
</tr>
<tr>
<td>l)</td>
<td>Permanent or physical damage to the hose or hose ends, kinked crushed or flattened hose</td>
</tr>
<tr>
<td>m)</td>
<td>Hoses too close to heat sources.</td>
</tr>
<tr>
<td>n)</td>
<td>Hoses tangled with moving parts.</td>
</tr>
<tr>
<td>o)</td>
<td>Cracked, damaged, or badly corroded hose ends or adaptors</td>
</tr>
<tr>
<td>p)</td>
<td>Unsecured or loose hoses and fittings</td>
</tr>
<tr>
<td>q)</td>
<td>Fitting thread is damaged</td>
</tr>
<tr>
<td>r)</td>
<td>Inspection of staples (broken, twisting, cracked or “walking out”)</td>
</tr>
<tr>
<td>s)</td>
<td>Other sign of deterioration</td>
</tr>
<tr>
<td>t)</td>
<td>Hose exceeding shelf life before installation, refer 3.7.3.4</td>
</tr>
<tr>
<td>u)</td>
<td>Hose exceeding designed service life, refer 3.7.3</td>
</tr>
<tr>
<td>v)</td>
<td>Visual evidence of movement of hose and hose end fitting</td>
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</tbody>
</table>

If any of these conditions exist, the hose assemblies should be replaced.

9.6.3 Analysing Hose Installation Failures

A physical examination of the failed hose can often offer a clue to the cause of the failure. The following are symptoms to look for along with the conditions that could cause them:-

a) **Symptom**: The hose is very hard and has cracked

   **Cause**: Heat has a tendency to leach the plasticiser out of the tube. This is a material that gives the hose its flexibility or plasticity

   Aerated oil causes oxidation to occur in the tube. This reaction of oxygen on a rubber product will cause it to harden. Any combination of oxygen and heat will greatly accelerate the hardening of the hose tube. Cavitation occurring inside the tube would have the same effect.
b) **Symptom:** the hose is cracked both externally and internally but the elastomeric materials are soft and flexible at room temperature  

**Cause:** The probable reason is intense cold ambient conditions while the hose was flexed. Most standard hoses are rated to – 40 degrees C.

c) **Symptom:** The hose has burst and examination of the wire reinforcement after stripping back the cover reveals random broken wires the entire length of the hose.  

**Cause:** This would indicate a high frequency pressure impulse condition. SAE impulse test requirements should be followed but it is strongly recommended for underground conditions to be in accordance with 3.7.7.2.

d) **Symptom:** The hose has burst, but there is no indication of multiple broken wires the entire length of the hose. The hose may be damaged in more than one place.  

**Cause:** This would indicate that the pressure has exceeded the minimum burst strength of the hose. Either a stronger hose is needed or the hydraulic circuit has a malfunction, which is causing unusually high-pressure conditions.

e) **Symptom:** Hose has burst. An examination indicates the wire braid is rusted and the outer cover has been cut, abraded or deteriorated badly  

**Cause:** The primary function of the cover is to protect the reinforcement. Elements that may destroy or remove the hose covers are:  

- Abrasion  
- Cutting  
- Battery acid  
- Steam cleaners  
- Chemical cleaning solutions  
- Muriatic acid  
- Salt water  
- Heat  
- Extreme cold

f) **Symptom:** Hose has burst on the outside bend and appears to be elliptical in the bent section  

**Cause:** Violation of the minimum bend radius is most likely.

g) **Symptom:** Hose appears to be flattened out in one or two areas and appears to be kinked. It has burst in this area and also appears to be twisted.  

**Cause:** Torquing of a hydraulic hose will, tear loose the reinforcement layers and allow the hose to burst through the enlarged gaps between the braided plaits of wire strands. Use swivel fittings or joints to be sure there is no twisting force on a hydraulic hose.

h) **Symptom:** Hose type has broken loose from the reinforcement and piled up at the end of the hose. In some cases it may protrude from the end of the hose fitting.  

**Cause:** the probable cause is high vacuum or the wrong hose for vacuum service. No vacuum is recommended for double wire braid, 4 and 6-spiral wire hose unless some sort of internal coil support is used. It could also be that the hose diameter is too small for the return line flow.
Symptom: - Hose has burst about 150 mm to 200 mm from the end fitting. The wire braid is rusted. There are no cuts or abrasions of the outer cover.

Cause: - Improper assembly of the hose and fitting allowing moisture to enter around the edge of the fitting socket.

Symptoms: There are blisters in the cover of the hose. If one pricks the blisters, oil will be found in them.

Cause: - A minute pin hole in the hose tube is allowing the high pressure oil to seep between it and the cover. Eventually it will form a blister wherever the cover adhesion is weakest. A faulty hose can also cause this condition.

Symptoms: - Fitting blew off the end of the hose

Cause: - It may be that the wrong fitting has been put on the hose. Recheck the manufacturers’ specifications and part numbers.

In the case of a crimped fitting the wrong machine setting may have been used resulting in over or undercrimping. The die could also be worn beyond the manufacturers’ tolerances or the hydraulic pressure was incorrect.

The fitting may have been applied improperly to the hose. Check manufacturing instructions. The hose may have been installed without leaving enough slack to compensate for the possible 4% shortening that may occur when the hose is pressurised. This will impose a great force on the fitting. The hose itself may be out of tolerance.

The end ferrel may not have been pushed on the hose far enough during assembly or they totally forgot to crimp the end or there was insufficient crimping force

Symptoms: - The tube of the hose is badly deteriorated with evidence of extreme swelling. In some cases the hose tube may be partially “washed out”.

Cause: - Indications are that the hose tube is not compatible with the agent being carried.

Symptoms: - Hose has burst. The hose cover is badly deteriorated and the surface of the rubber is crazed.

Cause: - This could be simply old age. The crazed appearance is the effect of weathering and ozone over a period of time.

Symptoms: - The spiral-reinforced hose has burst and literally split open with the wire exploded out and badly entangled. Conical wire deformation.

Cause: - The hose is too short to accommodate the change in length occurring while it is pressurised

Symptoms: - The hose fitting has been pulled out of the hose. The hose has been considerably stretched in length.

Cause: - Insufficient support of the hose. It is very necessary to support very long lengths of hose, especially if they are vertical. The weight of the hose and the weight of the fluid inside the hose is being imposed on the hose fitting.
9.7 APPENDIX G – GOOD PRACTICES FOR HOSE INSTALLATION

Refer SAE J1273 for further guidance

Proper hose installation is essential for satisfactory performance. If hose length is excessive, the appearance of the installation will be unsatisfactory and unnecessary cost of equipment will be involved. If hose assemblies are too short to permit adequate flexing and changes in length due to expansion or contraction, hose service life will be reduced.

The following diagrams show proper hose installations which provide maximum performance and cost savings. Consider these examples in determining length of a specific assembly.

When hose installation is straight, allow enough slack in hose line to provide for length changes which will occur when pressure is applied.

When radius is below the required minimum, use an angle adaptor to avoid sharp bends.

Use proper angle adaptors to avoid sharp twist or bend in hose.
Reduce number of pipe thread joints by using proper hydraulic adaptors instead of pipe fittings.

Adequate hose length is necessary to distribute movement on flexing applications and to avoid abrasion.

Avoid twisting of hose lines bent in two planes by clamping hose at change of plane.

Prevent twisting and distortion by bending hose in same plane as the motion of the boss to which hose is connected.
Route hose directly by using 45° and/or 90° adaptors and fittings. Avoid excessive hose length to improve appearance.

To allow for length changes when hose is pressurised, do not clamp at bends. Curves will absorb changes. Do not clamp high and low pressure lines together.

High ambient temperatures shorten hose life so make sure hose is kept away from hot parts. If this is not possible, insulate hose.

To avoid hose collapse and flow restriction, keep hose bend radii as large as possible. Refer to hose specification tables for minimum bend radii.

When installing hose, make sure it is not twisted. Pressure applied to a twisted hose can result in hose
failure or loosening of connections.

Elbows and adaptors should be used to relieve strain on the assembly, and to provide neater installations which will be more accessible for inspection and maintenance.

Run hose in the installation so that it avoids rubbing and abrasion. Often, clamps are required to support long hose runs or to keep hose away from moving parts. Use clamps of the correct size. A clamp too large allows hose to move inside the clamp and causes abrasion.

When determining the length of hose assemblies, provide sufficient length to prevent bending strain from localising at the back of the coupling. In the diagram measurement “B” allows for a strain section of hose beyond the coupling to prevent concentration of bending strain. “T” designates the amount of travel. “A” indicates the smallest diameter to which hose should be bent.

**Overall length = B+1.57A+T**
TYPICAL DIMENSIONS FOR ONE & TWO WIRE BRAID HOSE

<table>
<thead>
<tr>
<th>DIN</th>
<th>INCH</th>
<th>DASH</th>
<th>&quot;B&quot; CONSTANT FOR STRAIGHT PORTION INCLUDING COUPLING</th>
</tr>
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<tr>
<td>06</td>
<td>1/4</td>
<td>-04</td>
<td>250mm</td>
</tr>
<tr>
<td>10</td>
<td>3/8</td>
<td>-06</td>
<td>250mm</td>
</tr>
<tr>
<td>12</td>
<td>1/2</td>
<td>-08</td>
<td>300mm</td>
</tr>
<tr>
<td>20</td>
<td>3/4</td>
<td>-12</td>
<td>350mm</td>
</tr>
<tr>
<td>25</td>
<td>1</td>
<td>-16</td>
<td>400mm</td>
</tr>
<tr>
<td>32</td>
<td>1.1/4</td>
<td>-20</td>
<td>450mm</td>
</tr>
<tr>
<td>40</td>
<td>1.1/2</td>
<td>-24</td>
<td>500mm</td>
</tr>
<tr>
<td>50</td>
<td>2</td>
<td>-32</td>
<td>500mm</td>
</tr>
</tbody>
</table>

Recommended minimum bend radius (Dimensions in millimetres)

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<tr>
<th>Nominal Bore</th>
<th>Minimum Bend Radius</th>
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<tr>
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<td>6</td>
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<tr>
<td>38</td>
<td>500</td>
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<td>51</td>
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9.8  APPENDIX H – HOSE LENGTH DIAGRAMS

9.8.1  Threaded Type Hose Assemblies

Locations for measuring hose lengths
9.8.2 Staple Type Hose Assemblies

Locations for measuring hose lengths
### 9.9 APPENDIX I – ADAPTORS AND THREADS MAXIMUM WORKING PRESSURE

| End Connection Description - Maximum Allowable Working Pressure (MPa) | SAE Flange Code 62 | SAE Flange Code 61 | ORFS (UNF) | SAE Inverted Flare | SAE Flareless | SAE J514 Part 2 | SAE J512 | ISO 1251-3-S-L | ISO 8434-3 | BS5520 | BS5520 | ISO 7 | SAE J476a | SAE J476a | BS8363 | BS8363 | BS5520 | BS5520 | BS5520 | BS5520 |
|---------------------------------------------------------------|-------------------|-------------------|----------|-------------------|--------------|---------------|----------|----------------|------------|--------|--------|------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Inch Fitting Size                                             | MPa               | MPa               | MPa      | MPa               | MPa           | MPa            | MPa      | MPa             | MPa        | MPa    | MPa    | MPa  | MPa    | MPa    | MPa    | MPa    | MPa    | MPa    | MPa    | MPa    | MPa    |
| 4                                                             | 4                 | 4                 | 4        | 4                 | 4             | 4              | 4        | 4               | 4          | 4      | 4      | 4    | 4      | 4      | 4      | 4      | 4      | 4      | 4      | 4      | 4      |
| 5                                                             | 5                 | 5                 | 5        | 5                 | 5             | 5              | 5        | 5               | 5          | 5      | 5      | 5    | 5      | 5      | 5      | 5      | 5      | 5      | 5      | 5      | 5      |
| 6                                                             | 6                 | 6                 | 6        | 6                 | 6             | 6              | 6        | 6               | 6          | 6      | 6      | 6    | 6      | 6      | 6      | 6      | 6      | 6      | 6      | 6      | 6      |
| 8                                                             | 8                 | 8                 | 8        | 8                 | 8             | 8              | 8        | 8               | 8          | 8      | 8      | 8    | 8      | 8      | 8      | 8      | 8      | 8      | 8      | 8      | 8      |
| 10                                                            | 10                | 10                | 10       | 10                | 10            | 10             | 10       | 10              | 10         | 10     | 10     | 10   | 10     | 10     | 10     | 10     | 10     | 10     | 10     | 10     | 10     |
| 12                                                            | 12                | 12                | 12       | 12                | 12            | 12             | 12       | 12              | 12         | 12     | 12     | 12   | 12     | 12     | 12     | 12     | 12     | 12     | 12     | 12     | 12     |
| 14                                                            | 14                | 14                | 14       | 14                | 14            | 14             | 14       | 14              | 14         | 14     | 14     | 14   | 14     | 14     | 14     | 14     | 14     | 14     | 14     | 14     | 14     |

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## Guideline for Fluid Power System Safety at Mines

<table>
<thead>
<tr>
<th>mm Fitting Size</th>
<th>DIN Light 'L' No O-ring 24° Cone</th>
<th>DIN Light 'L' with O-ring 24° Cone</th>
<th>DIN Heavy 'S' No O-ring</th>
<th>DIN Heavy 'S' with O-ring</th>
<th>Stecko</th>
<th>Super Stecko</th>
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9.10 APPENDIX J – HOSE DYNAMIC TEST RIGS

9.10.1 ISO 6802 - Impulse test and Flexing to Minimum Bend Radius

Hydraulic impulse test with flexing – Arrangement of test piece

9.10.2 ISO 8032 – Flexing Combined with Hydraulic Impulse (Flexing in Three Dimensions)

Flexing combined with hydraulic impulse test (half-omega test) – Arrangement of test piece
9.11 APPENDIX K - MDG 10 GUIDELINES FOR HYDRAULIC LOAD LOCK VALVES.

Design Guidelines for Hydraulic Load 
Locking Valves On Mobile Cranes

Design Guidelines For Hydraulic Load 
Locking Valves

Issue Date: 26th May, 1989 
File Reference No.: M81/0198

Note: This is an extract of the Mine Safety and Health Administration of the U.S. Department of Labour issued on 17th October, 1980

1. **Scope**

   All hydraulic cylinders used to elevate cutting heads and conveyor boom loading machines and continuous mining machines shall be equipped with hydraulic load locking valves meeting this criteria.

2. **Requirements**

   The hydraulic cylinder assemblies which elevate conveyor booms and cutting head shall be equipped with load locking valves to prevent unintentional fall of the boom or cutting head in the event of hydraulic circuit failure. If the boom or cutting head is elevated to more than one cylinder, each cylinder shall be equipped with a load locking valve capable of holding the boom or cutting head in position.

   Each cylinder load locking valve must meet the following requirements:

   1. The load locking valve must be attached directly to the cylinder port that is subject to the hydraulic pressure induced by the weight of the boom or cutting head.

   2. The rated working pressure of the load locking valve must be greater than the system operating pressure.

   3. If the load locking valve has over-pressure relief capability, the pressure needed to support the static weight of the boom.
4. If the load locking valve is pilot operated, the hydraulic system shall ensure that the residual pilot pressure will not hold the load locking valve open when the control valve (located in the operator's compartment) is in the neutral position.

L.J. Roberts
Senior Inspector of Mechanical Engineering
for Chief Inspector of Coal Mines
CONVEYOR BOOM ELEVATE CYLINDER WITH A PILOT-OPERATED CHECK VALVE ATTACHED TO CYLINDER

HEAD ELEVATE CYLINDER WITH A PILOT-OPERATED CHECK VALVE DIRECTED ATTACHED TO EACH CYLINDER

PILOT OPERATED CHECKS ATTACHED TO EACH CYLINDER

BOOM AND CUTTING HEAD ELEVATE CONTROLS IN OPERATOR'S COMPARTMENT

NOTE: P1, P2 = SYSTEM PRESSURE, MAX.

EXAMPLE: CONTINUOUS MINER WITH PILOT-OPERATED CHECK VALVES ON BOOM AND CUTTING HEAD ELEVATE CYLINDERS

MESL - 2 10/11/79