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TECHNICAL REFERENCE GUIDE

HOT WORK (CUTTING AND WELDING) AT MINES AND PETROLEUM SITES

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Contents

1. Introduction

1.1. Purpose

This technical reference guide provides information that will assist mine or petroleum site operators to manage the risks to health and safety of people where hot work activities are being carried out on a mine or petroleum site.

This guide replaces *MDG 25 – Guideline for Safe Cutting and Welding at Mines* (2003) and *MDG 25 TR – Technical Reference Material for Safe Cutting and Welding at Mines* (2003).

This guide covers hot work, including welding, brazing, soldering, heating, cutting or grinding where a surface temperature of more than 150 degrees Celsius is likely to be generated. This includes activities such as thermal or oxygen cutting or heating, and related heat-producing or spark-producing operations, including buffing.

This guide does not cover vulcanising.

Note: For the purposes of this guide, the term 'lead' is used on the welding side for connections to the welding job. The term 'cable' is used for the mains supply to the actual welding machine.

This guide sets out risk reduction information to assist management in formulating a management system approach for the hot work activities at mines and petroleum sites, including product processing plants.

The management system for hot work (referred to in this guide as a hot work management system[1], HWMS) should be an integral part of the mechanical and electrical engineering control plans (MECP and EECP) and the health control plan contained in the mine or petroleum site's safety management system. Hot work should also have links with the ventilation control plan, fire or explosion principal hazard management plan (PHMP), air quality or dust or other airborne contaminants PHMP and the emergency plan (refer to Table 1 *Summary of requirements in WHS (MPS) Regulation for managing hot work*).

This guide should be read in conjunction with the *SafeWork NSW Code of Practice - Welding Processes.* While the code of practice is comprehensive in the information for managing welding processes, it does not address other aspects of hot work conducted at mines or petroleum sites. Therefore, this guide should also be used to manage risks associated with hot work activities at mines (particularly underground mines) and petroleum sites.

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[1] The term *Hot Work Management System* (HWMS) is not a term used in the WHS (MPS) laws. It is a term used in this guide to describe a systematic approach for the use of cutting and welding activities. The extent of the system will depend on the hazards at the mine or petroleum site. A HWMS should be an integral part of the mine's overall safety management system and need not be a standalone document.

Note: This guide provides information for the development of the mine or petroleum site's safety management system and may be used as a reference in association with the risk assessment processes. Hot surfaces that result from the cutting or drilling of stone and coal strata are addressed in other guidelines.

1.2. Application

This guide applies to all mines and petroleum sites. It describes the processes to be employed, the standards to be referenced and the issues to be considered in developing a HWMS. The intention is to allow mines and petroleum sites to formulate a comprehensive and integrated management system approach for undertaking of hot work activities. This may include, but not necessarily be limited to, hot work activities in locations, such as:

- designated hot work areas including workshops and welding bays
- product processing plants
- remote locations such as storage or tailings dams and ventilation fan sites
- wet areas
- outdoor areas
- chemical and fuel storage or other hazardous areas
- confined spaces
- working in, on or near enclosed spaces
- working at heights
- reclaim tunnels
- underground coal mines in locations and circumstances including:
    - non-hazardous zones, such as designated underground workshops
    - hazardous zones.

This guide does not address all hazards associated with the design and construction requirements for underground workshops.

1.3. Legislative requirements for managing hot work

1.3.1. Legislation

The *Work Health and Safety Act 2011* (WHS Act) and Work Health and Safety Regulation 2017 (WHS Regulation) apply to all workplaces in NSW, including mines and petroleum sites. They impose a general obligation to ensure the health, safety, and welfare of people at work through a process of identifying hazards, identifying and assessing risks and eliminating or minimising risks.

Section 19 of the WHS Act imposes a primary duty on the mine or petroleum site operator (and other PCBUs) to ensure, so far as is reasonably practicable, that workers and other people are not exposed to health and safety risks arising from the business or undertaking. This includes ensuring, so far as is reasonably practicable:

- provision and maintenance of a work environment without risks to health and safety
- provision and maintenance of safe plant and installations
- safe use, handling, and storage of plant and substances
- provision of information, training and instruction
- supervision.

The *Work Health and Safety (Mines and Petroleum Sites) Act 2013* (WHS (MPS) Act) and the Work Health and Safety (Mines and Petroleum Sites) Regulation 2014 (WHS (MPS) Regulation) also apply to all mines and petroleum sites in NSW. They support the WHS Act and WHS Regulation and provide additional provisions for WHS issues unique to mines and petroleum sites.

Refer to Table 1 below for a summary of the requirements in the WHS (MPS) Regulation for managing hot work.

Table 1 Summary of requirements in WHS (MPS) Regulation for managing hot work

TOPIC AND CLAUSE	SUMMARY OF REQUIREMENT RELATING TO HOT WORK
Managing risks Part 2, Division 1, Subdivision 1	The effective management of hot work at a mine or petroleum site is reliant on the principles derived from Part 3.1 of the WHS Regulation that define the general obligations for managing risks to health and safety. Additional general obligations for the management of risks at mines and petroleum sites are contained in Part 2 Division 1 Subdivision 1 of the WHS (MPS) Regulation.
Fire or explosion PHMP Schedule 1, Part 2, clause 6, subclauses (1)(b), (2)	The potential sources of ignition, fire or explosion, including plant, electricity, static electricity, spontaneous combustion, lightning, light metal alloys, hot work and other work practices, must be considered in developing the control measures to manage the risks of fire or explosion. The details of any procedures to be used for carrying out hot work at the mine or petroleum site are to be included in a PHMP that addresses fire or explosion.
Mechanical engineering control plan Schedule 2, clause 2, subclauses (2), (3)(n)	Undertaking hot work must be taken into account when developing control measures (which must be set out in the mechanical engineering control plan) for the following health and safety risks associated with the mechanical aspects of plant and structures at the mine or petroleum site: ▪ Injury to people caused by the operation of plant or by working on plant or structures. ▪ The unintended initiation of explosions. ▪ The unintended operation of plant. ▪ The unintended release of mechanical energy. ▪ The catastrophic failure of plant or structures. ▪ Uncontrolled fires being initiated or fuelled by plant. ▪ The exposure of people to toxic or harmful substances.
Electrical engineering control plan Schedule 2, clause 3, subclauses (2) and (3)(n)(i)	The procedures for the use of electrical welding plant must be taken into account when developing control measures (which must be set out in the electrical engineering control plan) for the following health and safety risks associated with electricity at the mine or petroleum site:

TOPIC AND CLAUSE	SUMMARY OF REQUIREMENT RELATING TO HOT WORK
	■ Injury to people caused by direct or indirect contact with electricity. ■ Injury to people caused by working on electrical plant or electrical installations. ■ The unintended initiation of gas or dust explosions. ■ The unintended operation of plant. ■ The occurrence of uncontrolled fires.
Health control plan Clause 26(3) and Schedule 2, clause 1	The health control plan should set out the means by which the mine or petroleum site operator will manage the risks to health associated with hot work.
High risk activity – hot work in a hazardous zone Clause 33 and Schedule 3, Part 3, clause 11	The conduct of hot work in a hazardous zone is identified as a high-risk activity and is subject to the provisions of clause 33. The operator of a mine or petroleum site must not carry out any hot work in a hazardous zone unless the operator has given notice of the activity to the regulator; the waiting period has elapsed, and the activity is carried out in the manner specified in the notice.
Exceptions to explosion-protection requirements Clause 79, subclause (2)	Despite clause 78(1), electrical equipment associated with hot work may be used in the hazardous zone of an underground coal mine if the mine operator has complied with the requirements of clause 33 (Notification of high-risk activities).
Prohibited items and substances Schedule 4, clause 3, subclause (1)(a)	Ignition sources (such as lighters, matches and naked flames) must not be used at an underground coal mine (except when used to carry out a high risk activity in accordance with the WHS (MPS) Regulation or when used to carry out hot work outside a hazardous zone in accordance with control measures developed under the mechanical engineering control plan).
Ventilation control plan Clause 62, subclause (3)(f)	The ventilation control plan must include — arrangements for managing risks to health and safety associated with ignition sources in the event that the main ventilation fans fail to adequately ventilate the mine.
Air quality or dust or other airborne contaminants PHMP Schedule 1, Part 2, clause 5	The PHMP for air quality or dust or other airborne contaminants should provide for the management of risk control in relation to hot work, for example the risk of welding fume exposure and toxic gases.

1.3.2. Codes of practice

The following codes of practice relate to hot work hazard identification and risk controls:

- NSW code of practice: Electrical engineering control plan.
- NSW code of practice: Mechanical engineering control plan.
- NSW code of practice: Safety management systems in mines.
- NSW code of practice: Welding processes.
- NSW code of practice: Work health and safety consultation, cooperation and coordination.

1.4. Recognised published Standards

Unless otherwise specified, the appropriate amended and updated Australian Standards should apply as a minimum. Where Australian Standards have not been published, the appropriate international standards such as International Organization for Standardization (ISO), International Electrotechnical Commission (IEC) or Society of Automotive Engineers USA (SAE) Standards should apply.

Refer to Appendix A for a list of Standards noted in this guide.

Note: All Standards referred to in this guide relate to the current revision of the Standard, as amended from time-to-time.

1.5. Acknowledgements

The NSW Resources Regulator would like to thank Weld Australia for their contribution to the development of this TRG and acknowledges that some content in this document has been extracted from *Weld Australia's Technical Note No. 7 Health and Safety in Welding.*

2. Hot work management

2.1. General

The mine or petroleum site operator must consider all hot work activities that may occur on-site. It is essential that any risk management process be undertaken having regard to the specific circumstances or context in which the risk is being considered.

The HWMS should include arrangements for undertaking hot work safely, including:

- the provision of fit-for-purpose equipment for carrying out the hot work

- adequate ventilation and air movement
- appropriate work system and competent people
- fatigue and heat stress management with regard to the fitness, health and other physiological characteristics of each worker
- controls to ensure accidental ignition and other hazards are minimised, such as restrictions or arrangements for where hot work can be carried out and management of potentially flammable or explosive substances in the vicinity of hot work.

The HWMS should address:

- hazard identification
- consultation
- risk assessment
- risk management process (e.g. could result in standard work procedures (SWPs))
- controls
- information to be collated (e.g. manufacturer's instructions, Safety Data Sheet (SDS))
- instruction and training
- supervision
- monitoring
- review
- revision
- maintenance and inspection
- emergency preparedness
- hot work permit system.

All hot work activities should be carried out in accordance with:

- NSW code of practice: Welding Processes
- AS 1674.1 Safety in welding and allied processes—Fire precautions
- AS 1674.2 Safety in welding and allied processes—Electrical

- Equipment manufacturer's safety instructions and recommendations
- Weld Australia TN 07 – Health and Safety in Welding
- Weld Australia TN 22 – Welding Electrical Safety.

Site operators may designate areas where hot work is carried out under controlled conditions such as at workshops. Additional controls may be required for hot work in fuel and hazardous chemical storage areas. In underground coal mines, methane or dust explosion risk from hot work requires careful consideration and implementation of effective controls. The MECP should set out the standards and processes for hot work in the various locations underground. Refer to section 11 for information about the management of hot work in underground coal mines.

2.2. Consultation

As part of managing the risks of hot work, the mine or petroleum site operator must consult workers when identifying hazards, assessing risks to health and safety, and when making decisions about ways to eliminate or minimise those risks (section 49 WHS Act).

The mine or petroleum site operator must, so far as is reasonably practicable, consult, cooperate and coordinate with other people who also have a duty in relation to the risks associated with undertaking hot work. This is critical in ensuring all risks associated with undertaking hot work are identified and managed in a consistent way. This includes people conducting a business or undertaking (PCBUs) (such as contractors) and their workers (sections 46 and 47 WHS Act).

General guidance on the duty to consult under the WHS Act can be found in the *NSW Code of Practice: Work health and safety consultation, cooperation and coordination,* and for mines specifically the NSW Code of Practice: Safety management systems in mines.

2.3. Common hazards of hot work

Analysis of incidents involving hot work showed one or more factors were involved, such as:

- inadequate hazard identification
- inadequate assessment of risk
- inadequate implementation of controls to address an identified hazard
- level of training not appropriate for the task
- work environment not adequately assessed

- flammable material not identified in work area, including dust, liquids or carbonaceous material
- inadequate equipment selection or maintenance
- poor working procedures, methods, or supervision
- personal protective equipment (PPE) not appropriate or maintained
- difficult work environment and failure to monitor changing working environment and conditions (e.g. damp clothing)
- flammable dust and gases
- molten metal, slag and sparks falling from work area (such as down a shaft, through grid mesh, onto conveyor belting or into adjacent work areas)
- working in adverse weather conditions e.g. rain, heat, high humidity[2], low air movement, fog or snow.

The following is not an exhaustive list of hazards. In addition to the hazards the hot work operator is exposed to, supervisors, bystanders and others in proximity to the hot work activity may also be exposed to the following hazards:

- **Electric shock** – contact with electrically live components on both primary and secondary circuits of cutting and welding power sources[3], grinders and low voltage (LV) power cables (415V and 240V).

Note: Both the likelihood and the severity of electric shock increases in the presence of moisture. Refer to clause 4.10 and to AS 1674.2 for information on the classification of welding environments and the selection of suitable equipment and control measures to minimise the risk of electric shock.

- **Radiation burns** – burns to the eyes or skin due to the welding arc – high intensity infrared (IR) and ultraviolet (UV) energy from arcs generated by welding power sources.
- **Thermal burns** – burns to the body due to weld spatter or contact with hot or molten materials, or due to ignition of clothing etc. especially in oxygen-enriched atmospheres.

[2] The mine or petroleum site operator should undertake a risk assessment to establish a pre-determined value for 'high humidity' depending on the location. This pre-determined value should form part of a Trigger Action Response Plan (TARP) if it is exceeded. Humidity is easily and quickly measured using commercially available hand-held or static devices.
[3] **Welding power source** is the terminology used in this document to describe a **welding machine** used for electric welding processes.

- **Fire** – fire in the surrounding environment due to flammable materials, gases or liquids and particles due to hot metal, arc, flame, sparks, or spatter or electrical faults.
- **Explosion** – explosion of gases and vapours in the environment, flammable gases and vapours contained within or flammable gas mixtures created within containers during hot work ignited by arcs, flames, sparks, hot metal or spatter or electrical faults in combination with flammable materials, gases or liquids.

Note: This includes explosions initiated by hot work on tyre and rims assemblies where pyrolysis of compounds within the tyre is involved.

- **Eye injury** – radiation – excessive visible, IR or UV radiation, fume and foreign matter such as high-velocity particles and falling dusts can cause injury.
- **Respiratory problems** – may result from inhalation of fume from cutting, welding, brazing, soldering or metallising and may be exacerbated by surface coatings and contaminants on the material being dealt with, from breakdown of contaminants such as residual chemicals in drums, paint or plastic bonded to metals.

Note: Refer to Appendix H for more information about the health effects from welding fume.

- **Asphyxiation** – displacement of oxygen by non-toxic gases can be dangerous, particularly in environments with limited ventilation, or confined space environments
- **Exposure to gases**
  - Inhalation of potentially harmful gas constituents (toxic gases)
  - Skin dermatitis from nickel and chromium welding fumes
  - Inhalation of dusts and particles
- **Toxic materials**
  - Skin contact with residues of materials used in surface preparation such as solvents, cleaners, fluxes or residues of coatings, lubricants, etc. on surfaces affected by hot work
  - Ingestion of chemicals, dust and particles from residues on hands and face

- **Hearing impairment** – excessive noise generated by the hot work process (air-arc gouging, grinding, etc) or transmitted to the operator by surrounding metal[4] [5]
- **Physical injuries**
  - Muscular skeletal injuries – particularly when working in situations that are poorly ergonomically designed

Note: Hot work is often required in cramped, confined and awkward positions and often requires holding or manipulating equipment in ergonomically challenging situations.

  - Slips and trips – crowded and confined work locations increase the risk of slips and trips

    High-velocity particles – grinding, chipping slag

  - Striking injuries – there is a risk of physical injury when using any form of mechanised or robotic welding
  - Pinch points – some older wire feeders are poorly guarded against personnel interaction with moving parts
  - Falling objects – striking injuries from objects
- **Falls** – working at heights or above openings increases risk. Refer WHS Regulation Part 4.4 'Falls'.
- **Delayed emergency response** – ability to reach, treat or rescue an injured person in an appropriate timeframe.
- **Changes** – in work environment, working conditions or the equipment.
- **Heat stress and fatigue** – heat rash, headaches, nausea and fatigue resulting from a combination of the person's metabolic work rate and environmental conditions in the work area such as air temperature, humidity, air movement, radiant heat and clothing worn.
- **Other hazards** – those typically found in general engineering or in special areas e.g. radioactive non-destructive examination (NDE) materials.

[4] AS/NZS 1270 *Acoustics – hearing protectors*
[5] AS/NZS 1269.3 *Occupational noise management – Hearing protector program*

2.4. Risk assessment

A risk assessment should be conducted prior to the use of hot work equipment at a mine or petroleum site. The risk assessment must be in accordance with Part 3.1 of the WHS Regulation, and clause 9 of the WHS (MPS) Regulation, and should address the following items as a minimum:

- Identify the risk to health and safety of people associated with the undertaking of hot work activities, including the use of equipment.
- Identify the risk to health and safety of people in the vicinity or that may be affected by the undertaking of hot work activities.
- Identify the risk to plant and equipment.
- Assess each location where hot work activities are being carried out.
- Eliminate or, where this is not practicable, minimise the risk so far as is reasonably practicable using the hierarchy of controls.
- Determine any additional controls that may be required for a particular mine or petroleum site or a specific site within a mine or petroleum site.
- Determine any additional criteria that may be required for a specific task that is considered to be hazardous for example, the level of supervision required.
- Determine the need for any safe work procedures for example, to ensure equipment is fit-for-purpose and in a safe condition to use.
- Assessment and monitoring of the environment (including temperature and humidity) to ensure if it is suitable for hot work.
- Identify the need for an observer/firewatcher to cover the safety of the person doing the hot work, including the duties of the observer/firewatcher.
- Identify the need for an observer/firewatcher to monitor the work area after completion of the hot work activity.

Note: Refer to clause 6.2 for information about task specific risk assessments.

Note: Refer to clauses 11.1.3 and 11.1.4 for information about risk assessments applicable to conducting hot work in an underground coal mine.

2.4.1. Introduction of additional risks

Welding on some components or plant introduces additional risks. The criticality and complexity of the repair should be considered. Preference should be given to returning damaged items to a suitable repairer as opposed to conducting the work on site. Some items require specific competency and detailed procedures to ensure a safe outcome. Examples include (but are not limited to):

- wheel rims
- ball studs
- forklift tynes
- shafts
- pins
- hydraulic cylinders and rods
- specific components as nominated by the OEM (e.g. steering arms).

2.5. Controls

The controls detailed in clause 2.5 may apply to all hot work activities, whereas sections 3 – 11 of this guide details specific controls for the equipment and the environment in which the hot work is to be performed.

2.5.1. General

All hazards must be identified and dealt with so that they are eliminated if reasonably practicable to do so, or controls established to minimise the risk so far as is reasonably practicable prior to commencing hot work.

The controls identified from the risk assessment should be used to formulate the basis of the HWMS.

The effects of hot work on other work groups should be considered during the planning of work activities. This includes giving consideration to effects such as noise from grinding or gouging activities, slag and sparks from cutting and gouging activities and light and UV radiation associated with welding. Where these may have adverse effects on other work activities additional control measures may need to be implemented or activities rescheduled.

2.5.2. Dedicated hot work area

Sites should consider having a dedicated area where hot work can be performed (e.g. workshops, welding area). The dedicated hot work area should be inspected prior to undertaking hot work to verify the equipment is in good condition, fit-for-purpose and that there are no other hazards present in the vicinity where the hot work is to be conducted.

The dedicated hot work area should be assessed against the Category environment level (refer clause 4.10 and AS 1674.2) with the appropriate controls in place. In the absence of an assessment and suitable risk minimisation strategies, the dedicated hot work area should be regarded as a Category C environment. This may be reduced to Category B or even Category A depending on the risk control measures implemented and the type of work to be undertaken .

2.5.3. Ventilation

Effective ventilation should be provided in a hot work area. This may be achieved through either natural ventilation or forced ventilation.

The HWMS should detail the actions to be taken if ventilation quantities and/or gas levels deteriorate, or any other abnormal circumstance eventuates. For an underground coal mine, such actions would include the cooling of any heated metal to a temperature which cannot ignite methane prior to the migration of methane to the hot work area.

2.5.4. Barriers and signage

The use of protective guards (screens) to barricade off the hot work area should be considered to protect other workers in the vicinity[6]. These guards should be fire resistant and shield other people from the effects of radiation.

Adequate warning signs should be provided where there is a risk of exposure of workers to hazards associated with hot work.

2.5.5. Personal protective equipment

Personnel (including other welders) working in the vicinity of arc welding operations should wear safety glasses with side shields to limit the adverse effects of accidental exposure to UV radiation from stray arcs and arc flash.

[6] AS/NZS 3957 *Light-transmitting screens and curtains for welding operations*

Appropriate PPE should be worn at all times to protect the health and safety of all workers. Examples include (but are not limited to):

- helmets, hand shields, goggles or face masks (shield) with the correct shade of filter[7]
- suitable protective equipment that should be worn i.e. gloves[8], spats, aprons, shoes (boots)[9]
- suitable protective clothing that should be worn e.g. overalls, industrial clothes[10]. Avoid clothing that has the potential to capture hot sparks and metals, for example in pockets or other folds. Clothing should be made of natural fibres. Clothing made from polyesters should not be used due to their flammability e.g. the suitability of nylon vests and clothing with reflective stripes should be considered in the site's risk assessment.

Note: It is important that the hot work operator's clothes remain dry. In hot and humid environments, especially in confined spaces, spare dry PPE and clothing should be provided in the vicinity where hot work is required to be done.

- cooling vests may be appropriate in certain circumstances
- appropriate respiratory protection should be worn when working on lead, lead-bearing materials, steel coated with lead paints, cadmium-coated materials, zinc-coated materials or any objects containing material which may give off toxic fumes (refer AS/NZS 1715, AS/NZS 1716).
  - A Powered Air Purifying Respirator (PAPR) with the appropriate filters; and local exhaust ventilation (LEV) (extraction) systems should be used.
  - A disposable P2 mask may be used for welding tasks of less than one-hour duration in a well-ventilated area for welding tasks that do not generate high concentrations of airborne gases, provided a face-fit test or respiratory-fit test confirms an adequate facial seal is achieved.

Note: Refer: *Safety Bulletin SB 18 – 17 Welding processes declared a carcinogen (November 2018)*[11]; *AIOH Breathe Freely Australia – RPE Program for Welders*[12].

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[7] Refer AS/NZS 1336, AS/NZS 1337 (series), AS/NZS 1338 (series)
[8] Refer AS/NZS 2161 (series)
[9] Refer AS/NZS 2210 (series)
[10] AS/NZS 4502 (series) *Methods for evaluating clothing for protection against heat and fire* and ISO 11611 *Protective clothing for use in welding and allied processes*
[11] See https://www.resourcesregulator.nsw.gov.au/__data/assets/pdf_file/0006/840435/SB18-17-Welding-fume-safety.pdf
[12] Refer https://www.breathefreelyaustralia.org.au/welding/rpe/

Table 2 Example of the minimum PPE for different hot work processes

PROCESS	HAZARD	MINIMUM PPE REQUIRED
Gas cutting and welding	• radiation • burns • fumes	goggles or face shield (P2 disposable mask minimum) suitable clothing, gloves, footwear suitable headwear for overhead cutting
Arc welding (manual)	• burns • radiation • electric shock • fumes	full-face shields ventilation suitable fume extraction or appropriate respiratory protection (PAPR preferred or P2 disposable mask minimum) dry clothes, gloves and footwear
Grinding and chipping	• hard and/or hot particles • fumes	goggles and appropriate respiratory protection (P2 disposable mask minimum) suitable clothing, gloves, footwear hearing protection
Plasma cutting	• fumes • radiation • electric shock • burns	full-face shields and appropriate respiratory protection (PAPR) suitable clothing, gloves, footwear suitable headwear for overhead cutting hearing protection
Cutting and welding (zinc or cadmium coated plate, coated plate, uncoated plate fasteners etc.)	• toxic fumes	goggles or face shield with appropriate respiratory protection (P2 disposable mask minimum) ventilation e.g. fume extraction suitable clothing, gloves, footwear

2.5.6. Fire protection

2.5.6.1. Fire hazard controls

The risk of fire is always present in hot work operations. A fire risk in the workplace for hot work equipment carries consequences of fire or explosions resulting in possible injury and death. For a fire to survive there must be **oxygen**, **fuel** and **heat** present. If any of these are removed the fire will extinguish.

Fire precautions should include the following:

- Inspect every location within a minimum radius of 15 metres of the location of the arc or flame before cutting and welding commences to ensure the potential for a fire to occur is eliminated.
- Firefighting facilities are adequate and available at the work area and workers know where they are located and know how to use them (e.g. fire extinguishers, firefighting water hose charged ready to operate, fire depot near a hydrant, fire blankets, sand or stone dust).
- Work areas are cleared of all rubbish and flammable material such as rags, oil etc. These materials should be removed to a safe distance before cutting and welding.

Note: Oil or grease in the presence of oxygen may ignite spontaneously and burn violently or explosively.

- Remove and/or protect flammable material e.g. wetting the surrounding area, covering with fire blankets or in the case of underground coal mines – use of stone dust.
- Clear the area around the hot work site of dry grass and scrub. Check for total fire bans when working outdoors.
- Operators should check their clothing is not impregnated with oil or grease.
- Conveyor belting or other combustible materials (removal is preferred) should be suitably protected from hot work and its sparks.
- Inspect the site after hot work has been performed to ensure that a fire does not occur e.g. check for hot embers.
- Isolate electricity, where possible, and protect leads and cables.

Note: When using water, care should be taken not to impair the safe operation of electrical equipment.

2.5.6.2. Fire extinguishers

As a minimum, fire extinguisher(s) should be:

- located in the vicinity of the work area (within 10 m) and ready for immediate use
- of a suitable type and capacity as appropriate to the fire risk
- maintained in accordance with AS 1851
- selected in accordance with AS 2444.

2.5.7. Asphyxiation and fume management

The HWMS should include fume management practices.

Asphyxiation can occur when there is a build-up of gases in the workplace. Precautions include:

- ensuring the area is adequately ventilated
- testing of the atmosphere (monitoring for toxic gases/fumes and personal exposure).

There should also be adequate ventilation for toxic fumes to escape from the vicinity of the hot work operator and other people at the mine.

Natural ventilation can be inadequate and mechanical ventilation or local exhaust extraction including portable fume capture systems may be required.

Local extraction systems with moveable arms may not be effective unless they are positioned close to and directly over the source of the welding fumes. Other types of extraction, such as welding benches and on-gun extraction for MIG welding, are also readily available and, depending on the type of job, these are better options for many types of work.

If the welder's head cannot be kept out of the plume, additional protective measures including PAPR or a P2 mask may be required. While all welding processes generate fume, the plume may not be visible to the welder, or with some processes, the observer.

Note: 1. Refer Weld Australia Technical Guidance Note Fume Minimisation Guidelines: Welding, Cutting, Brazing and Soldering.

Note: 2. Refer NSW Resources Regulator Safety Bulletin SB18-17 Welding processes declared a carcinogen (November 2018).[13]

Note: 3. Refer Breath Freely: An introduction to welding: Why do welders need protecting?[14]

[13] See https://www.resourcesregulator.nsw.gov.au/__data/assets/pdf_file/0006/840435/SB18-17-Welding-fume-safety.pdf

[14] Refer https://breathefreelyaustralia.org.au/wp-content/uploads/2019/05/An-introduction-to-welding-AIOH.pdf

2.5.7.1. Health effects

The health control plan (refer clause 26(3) of the WHS (MPS) Regulation) should set out the means by which the mine or petroleum site operator will manage the risks to health associated with hot work.

In 2017, the International Agency for Research on Cancer (IARC)[15] declared welding fumes and UV radiation a Group 1 carcinogen to humans. As such the risk of welding fume exposure and UV radiation from welding must be controlled. Consequently, awareness, minimising exposures with suitable protection and safe work practices are required to protect a hot work operator's health. Refer*: Safety Bulletin SB 18 – 17 Welding processes declared a carcinogen (November 2018)*[16]*.*

Note: Refer to Appendix H for more information on the health effects of welding fume.

Other components when heated or burned may release fumes that pose additional risk (e.g. melting/burning of bearing cages and seals). These fumes may be highly noxious and may have greater health impacts than welding fumes.

2.5.7.2. Workplace exposure standards

Clause 49 of the WHS Regulation requires the mine or petroleum site operator to ensure that no person at the workplace is exposed to a substance or mixture in an airborne concentration that exceeds the exposure standard for the substance or mixture.

Safe Work Australia lists the workplace exposure standard for welding fume (not otherwise classified) as a TWA (8 hour) 5mg/m^3. Additional contaminant-specific exposure standards are also listed for the various components found in welding fume and gases (e.g. aluminium, iron oxide, zinc oxide, magnesium, manganese, copper etc).

2.5.7.3. Air monitoring – mitigating control

To determine worker exposure to airborne contaminants from welding processes, air monitoring must be conducted in accordance with clause 50 of the WHS Regulation. Air monitoring is a specialist activity. It may be identified as a control from a risk assessment, as a periodic check on the effectiveness of controls and to assess compliance with relevant workplace exposure standards, or where there has been a failure in a control (for example if a worker reports respiratory symptoms).

A competent occupational hygienist can ensure air monitoring is carried out to recognised methods and assess and provide feedback on the results.

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[15] Refer https://www.iarc.fr/
[16] See https://www.resourcesregulator.nsw.gov.au/__data/assets/pdf_file/0006/840435/SB18-17-Welding-fume-safety.pdf

Personal exposure monitoring of workers should be undertaken in accordance with AS 3853.1[17] and AS 3853.2[18] or ISO 10882-1[19] and ISO 10882-2[20]. These are the standards against which personal exposure monitoring of welding fume is conducted.

2.6. Information to be collated

2.6.1. Documentation

Records should be kept in accordance with the records management procedures set out in the site's safety management system, which include:

- equipment safety file, purchase specifications, OEM manuals and safety bulletins
- risk assessment documents
- permits and authorisations issued
- maintenance records, safety inspections and test reports
- audit and review reports
- reports of accidents and safety statistics
- training and competency records
- consultation records
- control procedures
- reports covering hot work in underground coal mines where the hot work is outside a dedicated underground workshop.

The records should be stored and maintained in such a way that they are readily retrievable and protected against damage, deterioration or loss.

[17] AS 3853.1 *Health and safety in welding and allied processes – Sampling of airborne particles and gases in the operator's breathing zone – Sampling of airborne particles*
[18] AS 3853.2 *Health and safety in welding and allied processes – Sampling of airborne particles and gases in the operator's breathing zone, Part 2: Sampling of gases*
[19] ISO 10882-1 *Health and safety in welding and allied processes – Sampling of airborne particles and gases in the operators breathing zone – Part 1: Sampling of airborne particles*
[20] ISO 10882-1 *Health and safety in welding and allied processes – Sampling of airborne particles and gases in the operators breathing zone – Part 2: Sampling of gases'*

2.7. Personnel

All people involved with hot work activities should be trained and assessed for their competencies. Records of training and assessments should be maintained and available for audit. The training and assessment of competencies extends to all levels including senior management and contractors.

2.7.1. Competencies

The safety management system should address the minimum acceptable competencies for particular types of work. For example:

- heating, cutting and grinding
- general welding
- structural welding
- welding in confined spaces, hazardous areas or other specialised work
- specialised work including dragline, excavator booms, pressure vessels and coal bins
- observing/monitoring of the person doing the hot work
- thermal lancing.

2.7.2. Responsibility and accountabilities

All people associated with hot work activities should understand their areas of accountability and responsibility. This includes contractors.

2.7.3. Training

Personnel who are to undertake hot work should be trained to enable them to act on their own authority within their area of responsibility. Training should address the total skill set required for a particular area of activity. Having a trade certificate does not mean a person is competent to perform the task. Comprehensive knowledge extending across processes and reflecting the latest status of technical and scientific development is necessary to achieve the best outcomes. Consideration should be given to developing special training and advanced training measures geared to the specific requirements of the hot work personnel (welders, machine operators, hot work supervisory personnel and observers/firewatchers).

Training and assessment of competencies for personnel who use hot work equipment should as a minimum include:

- safe operation, inspections, testing and checking of the hot work equipment
- maintenance and repairing of the equipment or as a minimum identification of the limitation of their competence. For example, a welder should not be expected to repair an electric welding set
- prerequisite of a trade qualification e.g. boilermaker, metal trade etc
- specialised training in certain areas such as structural welding, pressure welding and thermal lancing.

2.7.4. Authorisations

The mine or petroleum site operator should consider a process of authorising competent people to carry out hot work. This process of authorising will vary based on the nature, complexity and location of where the hot work is to be carried out.

2.8. Supervision

All employees should be adequately supervised according to their skills, competencies and the level of risk of the activity to be conducted.

This person should have sufficient control to ensure that before hot work is commenced the following items have been taken into consideration:

- The hazards of the location have been identified and the risks assessed.
- Controls are in place to eliminate or reduce risk.
- The equipment being used has been inspected, is fit-for-purpose and safe to operate.
- The hot work operator is aware of potential hazards.

2.9. Audit, monitor and review

The potential risks to health and safety should be continually assessed and actions taken to reduce the risk.

Hot work activities should be audited at regular intervals for compliance with the HWMS.

All issues associated with hot work should be recorded and actions taken to prevent recurrence of the issue.

The HWMS should be audited, monitored and reviewed at regular intervals not exceeding three years. This should include assessment against:

- legislative requirements
- this TRG
- industry benchmarks
- original equipment manufacturer (OEM) service bulletins
- safety alerts, bulletins and incident reports.

For guidance on how to undertake a review of a HWMS, refer to Appendix B *Assessment for hot work management system* and Appendix C *Assessment for HWMS for hot work in underground in coal mines*.

2.10. Revision

The HWMS should be revised after an audit or review has taken place. The procedures for revision should be documented.

2.11. Maintenance and inspections

An appropriate examination, inspection, testing and maintenance system should be developed and implemented to ensure all hot work equipment is fit-for-purpose, safe and without risks to worker health when properly used.

The following references should be used along with relevant OEM documentation to develop specific hot work equipment maintenance and inspection requirements:

- Appendix D Gas cutting, heating and welding equipment maintenance inspection schedule.
- Appendix E Recommended oxy-fuel gas daily inspection and pre-start check list (Weld Australia TGN-SW07).
- Appendix F Electric welding equipment inspection schedules.

2.11.1. Equipment inspections

Equipment inspections are necessary control measures to monitor the safe condition of the equipment in the workplace and prevent fire, explosions or electric shock which could result in injury and possibly death. Examination and inspection of equipment should be made at regular intervals in accordance with the appropriate Australian Standards and manufacturer recommendations.

The frequency of these inspections should be such that the equipment is kept in a safe condition for use, and faulty items reported and replaced immediately. These inspections should be recorded and detail the condition of each item inspected.

Items of equipment to inspect should include as a minimum, e.g. pre use inspection:

- cylinder regulators
- flashback arresters
- hoses and couplings
- torches and tips
- welding leads and connections for cuts, areas of wear, exposed metal, being clean and securely connected
- electrode holders for cracks, missing insulators, broken pieces
- PPE e.g. gloves, cloths for moisture and condition of PAPR
- hazard-reducing device (HRD) i.e. trigger switch or voltage-reducing device (VRD)
- output circuit safety switch (see definition in Appendix A).

Note: Further guidance on equipment inspections is provided in Appendices D, E, and F.

2.11.2. Equipment maintenance

Electrical maintenance inspections should be carried out in accordance with AS 1674.2.

2.12. Emergency preparedness

It is the duty of the operator to prepare an emergency plan as per clause 88 and Schedule 7 of the WH S (MPS) Regulation.

The HWMS should consider actions to be taken in the event of an emergency, such as:

- fire over and around cylinders
- flashback or backfires (intermittent or sustained)
- leaking cylinders
- electric shock
- explosions

- fire associated with materials or gases in the area where hot work is being conducted
- means to prevent the products of combustion affecting the health and safety of people, particularly in underground mines.

2.12.1. Emergency response plan

Whenever work is carried out in an area with increased hazards there should be:

- an emergency response plan developed and implemented including recovering a welding operator from an electric shock or any other incident
- an observer who is outside the welding area and readily accessible and in communications with the hot works operator. This person should be trained in first aid, emergency procedures and disconnecting the power
- a whole current isolator, within the reach of the observer, that will cut off the supply to the welding machine, or have an output circuit safety switch to remove power between the handpiece and the welding operator if the welding machine is located outside the confined space.

The mine or petroleum site's emergency plan should provide for the management of incidents resulting from hot work activities. The emergency plan should be enacted whenever the HWMS is no longer able to maintain control of the work and the work environment. Refer to the NSW code of practice: *Emergency planning for mines*. The provisions of Part 2 division 6 Emergency Management of the WHS (MPS) Regulation are considered relevant.

2.12.2. Emergency removal of personnel from confined space

Where access to a confined space is limited, e.g. through a manhole, provisions are required to be made to allow removal of the operator in an emergency. This includes the following:

- Safety harnesses with lifelines are recommended and are a legal requirement in some instances.
- Care is required to ensure the operator's body will not jam in small exits. This includes the circumstance where the operator is unconscious. Where possible, an entry and an exit should be provided.

- A helper or observer with a pre-planned rescue procedure and suitable training should be stationed outside to observe the hot work operator at all times and to be capable of putting rescue operations into effect.
- The observer should be aware that an unprotected person should not enter a space where another person has collapsed before taking appropriate precautions.

2.12.3. Conducting hot work during an emergency situation

There may be times during an emergency where hot work is required to be carried out.

An emergency hot work procedure should be developed and maintained in the HWMS. This should take into consideration the outcomes of the hot work risk assessments that should have previously been carried out. In addition, the likely risks associated with undertaking hot work in an emergency should be clearly identified in the HWMS.

A task specific risk assessment should be carried out to address additional controls that may be used to minimise the hazard in the event of an emergency.

When hot work in emergency situations is required, it is likely that little time will be available to plan the activities in detail. However, the general situation should be considered beforehand and the fundamental practices and standards that apply should be determined in advance. The basic principle that underpins the use of hot work equipment in an emergency is that people assisting in the emergency are not to be exposed to a level of risk that might exacerbate the overall situation.

The site's HWMS should include but not necessarily be limited to the following:

- Any corporate permission/authorisation to be obtained, or notification to be given, before the emergency use of hot work equipment can be activated.
- The status and/or qualifications of the person (on any shift) who is responsible to inspect the site and determine that people performing emergency hot work operations are not being put at unacceptable risk or undertaking any activity that may compound the problem.
- The means by which this person can ensure that the appropriate controls in relation to hot work are put in place to the maximum extent possible in the limited time available. This may be in the form of a checklist that specifies a hierarchy of controls to be in place before emergency hot work is activated. This list may be separated into:
    - those controls that must be put in place, but may be enacted during the emergency hot work operation, and
    - those controls which are desirable if time allows but are not essential to achieve an acceptable level of safety of personnel operating in an emergency situation

- the location of any equipment that will be required to ensure the safety of people performing emergency hot work operations.

2.12.4. First aid considerations

Minimum requirements for provision of first aid equipment and facilities for administering first aid must meet the requirements of the WHS Regulation 2017 Part 3.2 Division 3 First Aid.

First aid equipment and instruction should be readily available on or near the site work. As hot work can be associated with an increased risk of electric shock, an automated external defibrillator should be considered as part of the first aid equipment.

At least one person in a hot work workgroup should be qualified and competent in first aid. Risks associated with the welding processes are detailed in Weld Australia's TN07, Chapter 13 "Precautions with various materials".

The address and telephone number of the nearest available medical service, hospital and ambulance service should be available on site as per the site's first aid and emergency response procedures.

2.13. Hot work permit system

Permit systems typically provide a proforma style checking system to assist in the undertaking of safe works. Permits should identify the specific controls required to manage risks while providing a supervisory review along with a documented sign on/off mechanism.

A hot work permit system should be developed and used when performing hot work in areas outside of dedicated hot work areas. The hot work permit system should ensure that safeguards are in place prior to, during, and after all hot work is performed and should be in accordance with AS 1674.1 and AS 2865.

A hot work permit system should incorporate the following as a minimum:

- Ensure a task specific risk assessment has been undertaken (refer clause 6.2).
- Identify appropriate controls for access, ventilation, electric shock and fire hazards.
- Ensure each workgroup member is conversant with the risk assessment hazards and the risk assessment controls are implemented.
- The mine or petroleum site supervisor has given all necessary authorisations.
- Any required inspections at nominated locations and frequency are conducted and recorded.

NSW Resources Regulator

3. Gas cutting, heating and welding equipment

3.1. General

Gases used in gas welding, cutting and allied processes are delivered to the point of use either from portable compressed gas cylinders, supplying generally only one application, or from reticulation systems supplying an entire workshop. Where cylinders are used, it is important that cylinders are secured at all times to prevent toppling. Gas cylinders have an external valving arrangement which when subject to impact can become damaged or torn off and result in excessive flammable gases, fire hazard/explosion in the workplace and the gas cylinder becoming a possible projectile which can do significant damage or harm.

Gas reticulation systems are either supplied from manifolded gas cylinders, large gas vessels or from mains supply. Workshops generally use single or manifolded cylinders[21]. Larger workshops may use special bulk installations of liquid oxygen or liquified petroleum gas (LPG)[22]. In all cases, it is important to ensure that any configuration complies with relevant statutory requirements. Manufacturer's recommendations where provided and relevant Australian Standards should also be followed.

3.2. Cylinder storage, handling, transport and use

All cylinders must be labelled, colour-coded and accounted for and should be removed from all active mining operations or petroleum sites after use and stored in accordance with the manufacturer recommendations and applicable standards.

Cylinders should generally comply with the following:

- Filled, inspected and maintained in accordance with AS 2030.1, .2, .4 and .5 as appropriate.
- Gas safety data sheets should be kept on site.
- Cylinder valves should be tightly closed when not in use or where cutting activities are stopped for a period of time e.g. lunch break.
- Empty cylinders should be disconnected from the welding equipment.

Cylinders and associated equipment should be located to prevent sparks, slag and molten material from falling on hoses or on the cylinders or attachments.

[21] Details of safe supply, usage, etc. are given in Weld Australia's TN 7-20 Chapter 5 clauses 5.3.3, 5.3.4 and 5.3.6
[22] General safety provisions are given in Weld Australia's TN 7-20 Chapter 5 clauses 5.3.2 and 5.3.5

3.2.1. Storage

All storage areas must comply with statutory requirements. All cylinders should be stored in accordance with AS 4332 and AS 1940. LPG cylinders should be stored in accordance with AS/NZS 1596. LPG cylinders in excess of 50 kg total capacity should not be stored within three metres of any other cylinders, including acetylene.

Cylinder storage areas should be well ventilated and away from sources of heat. External storage is preferred. Protection from weather is desirable but not at the expense of ventilation. Other products should not be stored with cylinders, especially oil, paints or corrosive liquids. Oxygen cylinders should be separated from fuel gas cylinders by a distance greater than three metres.

Cylinders should always be stored upright on a stable footing and restrained to prevent falling. Full cylinders should be segregated from empty ones and fuel gases from oxygen. "NO SMOKING OR NAKED LIGHTS" signs should be displayed where fuel gases are stored.

Cylinders should be stored at least 15 metres away from fuel bays and fuel outlets.

Storage areas should be fitted with lockable doors, level floors and should be raised at least 150 mm above the surrounding floor. Adequate ventilation should be provided at the top and bottom of storage areas to prevent a build-up of gases from a minor leak at a cylinder.

Dry powder extinguishers should not be positioned less than eight metres or more than 10 metres from the storage area.

Grease, oils or other combustible substances should not be in contact with the valves of cylinders containing oxygen, nitrous oxides or other oxidants. Oils and any fuels in the presence of oxygen may ignite spontaneously.

Note: A segregation panel between fuel and oxygen gas cylinders may achieve the intent of the separation distance.

3.2.2. Handling

Do not move cylinders with the cylinder valves open.

Do not subject a cylinder to abnormal mechanical shocks.

Cylinders should be lifted in a manner as recommended by the manufacturer.

Use a cradle when lifting cylinders by crane. Never lift a cylinder with magnets, chains or slings. Never sling or lift a cylinder by the valve cap. All cylinders should be secured and moved with the aid of a purpose built trolley or specifically designed personal lifting devices.

Use a trolley for manual handling. Never roll a cylinder along the ground. This damages the identification labels and may cause the valve to open.

Where a fuel and oxygen cylinder are stored together on a trolley, the trolley should incorporate a separation barrier because of the proximity of the fuel gas to the oxygen cylinder. All cylinders should be secured to the trolley.

3.2.3. Transport – general

Transportation of dangerous goods by either road or rail must comply with the Australian Dangerous Goods Code (ADGC) which is applicable to every state and territory in Australia. When it comes to transporting liquids and gases for the use of cutting equipment for 'tools of trade', mines and petroleum sites would generally do this on the back of a light vehicle to take to the job site as required and therefore may be exempt from transport legislation. However, if there is any doubt, you should refer to the Competent Authorities[23] for Road and Rail Transport in Australia for further information.

When transporting cylinders, the following should be considered:

- Cylinders should be secured and retained to a rigid support.
- Acetylene and LPG cylinders should be transported upright. This ensures that the safety device is in contact with vapour and not the liquid within the cylinder.
- Open vehicles should be used wherever possible. If closed vehicles are the only option, the following precautions should be taken:
  - Ensure maximum ventilation at all times.
  - Ensure all valves are fully closed and that there are no leaks
  - Secure cylinders against movement within the vehicle
  - Do not allow any part of the cylinder to protrude from a vehicle
- Disconnect all equipment (e.g. pressure regulators) from cylinders.
- Cylinder valve guards should be used during transport.
- Where possible, an appropriate trolley or cradle for moving cylinders should be used, even over short distances.
- Cylinders should not be rolled along the ground.
- Cylinders should never be transported by laying them across forklift tynes.

[23] Refer to www.infrastructure.gov.au/transport/australia/dangerous/str_compauth.aspx

3.2.4. Transport – low headroom

Where it is impractical to transport cylinders safely in the upright position, they should only be laid down for the minimum time practicable and the cylinder should be protected against shock. Reduced sized cylinders should be considered over the need for full size cylinders before considering laying down a cylinder.

When the cylinders are in position for use, they should be placed in the upright position. Acetylene cylinders should be left standing before use for sufficient time to allow the acetone to settle and the vapour space to reform at the neck of the cylinder. Acetylene cylinders should be left standing before use for the same period of time as they were laid down during transport. OEM data may indicate shorter times are suitable.

3.2.5. Cylinder use

The manufacturer's instructions and recommendations should always be followed. Factors that warrant mention are:

- Never open ("crack") a fuel gas or oxygen cylinder valve. Uncontrolled release of fuel gases or oxygen can result in fires or explosion.
- Opening of cylinder valves should only be carried out with approved keys or hand wheels. Do not use excessive force or extension key to open or close cylinder valves.
- Damaged valves or regulators or those suspected to be damaged should not be used until checked by a competent person.
- Cylinders should never be used as rollers to assist moving other objects.
- Acetylene and LPG cylinders should always be in the vertical or near-vertical position when in use.
- Acetylene can only be used to a maximum pressure of 150 kPa (gauge). With increasing pressure, explosion may occur due to instability of this gas.
- The draw off rate of an acetylene cylinder should never be exceeded. Doing so may damage seals and equipment and can lead to flashbacks.
- Acetylene valves should not be opened more than about one and a half turns. One turn is preferable to allow for quick closing in an emergency.
- Empty cylinders should not be left connected to welding equipment.

- Empty cylinders should have the valves closed, protective caps fitted and be suitably identified e.g. "MT" in chalk.
- Always leave cylinders with the valve closed and slight positive pressure to ensure air does not enter.
- All cylinders should be kept upright and away from any sources of heat, electrical circuits and oil or grease during use.

3.2.6. Connection to regulators and hoses

It is imperative to minimise the risk of leaks at connection points of cylinders. This will in turn minimise the risk of gas escape which could result in potential fire incidents. Keep the cylinder valve clean, especially its outlet connection. No grit, dirt, grease, oil or dirty water should be present. Particles of dirt and residual moisture may be removed by wiping with a clean dry cloth or blowing out with clean dry compressed air. The old practice of “cracking” open the valve momentarily and then closing it has led to a number of incidents and is now a prohibited practice at many worksites.

Make sure the pressure regulator is suitable for the gas and pressure in the cylinder and that its inlet connection is the same thread as that in the cylinder valve. Fuel gas connections have left-handed threads. Never force any connection that does not fit.

Open the cylinder valve slowly using its hand wheel or a suitable key for key-operated cylinder valves. Do not over-tighten the spindle when shutting off the valve as this will destroy the soft seating material in the valve. If the valve spindle is too stiff to turn with the hand wheel or the correct key, do not increase the leverage on the spindle. If the cylinder or valving is found to be damaged or defective the cylinder should be returned to the gas supplier for repairs.

3.2.7. Portable and mobile cylinder trolleys and cradles

To minimise the potential for cylinders to be handled or used in a dangerous position, the following should apply:

- Portable and mobile systems for gas cutting, heating and welding equipment should be in accordance with the requirements of AS 4839.
- Portable and mobile cylinder trolleys should be of a design that enables the cylinders to be returned to the upright position when in use.
- Cylinder trolleys should provide a suitable platform with secure non-flammable restraints for operation and transport. Trolleys should enable safe and stable transport of cylinders to the work location. A maximum of one cylinder of each of oxygen and fuel should be used on a

trolley. Acetylene cylinders must be upright at all times in operation. A heat shield between the cylinders is strongly recommended. This minimises the potential for fire at one cylinder to spread to adjacent cylinder.

- Cylinders should be located on the trolley such that outlets are directed away from the other cylinder/s in the event of a possible release from a cylinder safety device to allow unimpeded release of gas. The maximum and minimum size cylinder allowed by the design should be stated on a permanent label on the trolley.
- The height to base widths and centre of gravity of any transport trolley or cradle should be such that the stability of the system is suitable for rough ground conditions.
- At some mines the transport of cylinders may be carried out at steep gradients (for example, gradients of up to 1-in-3 can be encountered in underground mines) hence the cylinder transport system needs to be suitable for these conditions.

3.2.8. Piping and manifolds

Where gas requirements exceed the delivery achievable from a single cylinder or uninterrupted supply is required, or cylinder handling is to be avoided, manifolding of cylinders and piping gas to the point of use is widely adopted.

AS 4289 applies to oxygen-acetylene systems and AS/NZS 1596 to LPG systems. Regulatory requirements may also apply.

Care is required in design, choice of materials, location of piping etc. as outlined below:

- Design of systems should only be carried out by qualified people and in accordance with appropriate design rules and regulations. The gas supply organisation will generally be responsible for this.
- Manifolds should be located in environments free of oil, grease and dust and should be compatible with the filling pressures of the cylinders to be connected, especially in the case of oxygen.
- Components such as regulators, pressure gauges and connections should comply with AS 4267 and be of a satisfactory type for the gas type and operating pressure.
- Materials should be of a suitable type and have adequate resistance to the chemical action of the gas under operating conditions. Particular attention is drawn to the fact that alloys of a higher copper content (greater than 70% copper) cannot be used in applications involving acetylene due to the possibility of formation of explosive copper acetylide. Acetylene piping is usually of the seamless steel or stainless steel type.

- Location should be chosen to avoid damage to piping and allow ease of repair (e.g. use ducting).
- Piping should be clearly labelled at inlet and outlet ends and along the length to identify the contents. Identification marking should be in accordance with AS 1345.
- Piping should never be used as an earth for electrical equipment or as a work return path for welding due to the risk of explosion, fire or corrosion damage to the pipe.
- Operating instructions should be available and safety-warning notices prominently displayed.
- Installation should only be carried out by qualified people experienced in the requirements for oxygen and fuel gas pipelines. Internal surfaces of piping and fittings should be free of foreign matter and the completed system should be fully tested prior to commissioning.

Note: The above requirements are also applicable to portable outlet headers.

- Outlet points for use with oxygen-fuel systems should comply with AS 4289 e.g. incorporate a shut-off valve and a flashback arrester as a minimum.

3.3. Safety devices

3.3.1. Recommendations

Safety devices should always be used in oxygen-fuel systems to prevent potential fires or explosions. Safety devices such as flashback arrestors should comply with AS 4603.

3.3.2. Fitment of safety devices

Safety devices should be used in all oxy-fuel systems in accordance with AS 4839. As a minimum, one non-return valve and flashback arrestor per gas line should be used with due consideration to the pressure drops experienced in all components of the assembled system at the rated flow capacity of the tip or nozzle in use.

During a flashback the flame can extend beyond the blowpipe into the hoses, regulators and may also reach the cylinder.

AS 4839 specifies there must be at least one safety device e.g. a flashback arrestor, to protect each line of oxygen and fuel gas. Flashback arrestors should comply with AS 4603. Additional devices should be fitted whenever practicable[24]. If a flashback occurs, immediately close the oxygen valve followed by the fuel valve.

Flashback arrestors with non-return valves complying with AS 4603 should be used on all handpieces and cylinders. They should not unduly restrict gas flow.

Note: Flashback arrestors should be sized to suit the maximum gas flow. These devices may restrict gas flow if they become contaminated. Flashback arrestors that incorporate a pressure sensitive flow cut-off valve and pressure relief safety valve should be considered.

Flashback arrestors should be fitted at both hose ends (handpiece and cylinder end) (optimum protection) on the fuel hose and oxygen hose.

If a flashback occurs, testing is vital because flashback arrestors can be damaged by repeated flashbacks, thereby losing effectiveness.

After any flashback incident, flashback arrestors, gas hoses and fittings should be removed, inspected by a competent person and if necessary either discarded or repaired according to the manufacturer's specifications or the applicable Australian Standard.

The use of safety devices like non-return valves or flashback arresters does not reduce the need to follow correct and safe operating procedures.

3.3.3. Flow capacity and operating pressure

The fitment of safety devices will result in reduced flow capacity. This reduced flow may be below the minimum required by the end heat output device or the mixer and may result in flame instability with increased probability of flashback. Once this point is reached, additional safety devices may reduce, rather than increase, the safety level due to the reduced flow capacity. Flashback arrestors with different flow capacities are available.

Acetylene cylinder draw off rates may be exceeded when using large cutting tips, gouging nozzles or heating nozzles. Cylinders may need to be manifolded together so the draw off rate is not exceeded when using large attachments.

Before the use of the gas system, the operator should:

- verify the operating pressure and flow of each gas recommended by the manufacturer for the tip or nozzle in use
- check that all pressure drops through the whole of downstream equipment have been taken into account

[24] Refer AS 4839 – 2001 clause 7.3

- ensure higher flow flashback arrestors are used for high flow applications (such as heating).

3.3.4. Maintenance of safety devices

Continued performance of safety devices is essential to safety performance. Safety devices should be included in any routine inspection and maintenance schedule and tested in accordance with manufacturers' recommendations and requirements of relevant standards.

Pre-use inspection should include a suitable means for detecting leaks as recommended by the manufacturer.

AS 4603 and AS 4839 state that all flashback arrestors must be tested by a competent person at least every 12 months, or in the case of a flashback occurring.

Alternatively, flashback arrestors may be replaced in lieu of testing.

3.3.5. Ignition safety devices

An ignition safety device (flint gun) for flame cutting and burning activities should be used at all times.

Matches, cigarette lighters, wicks, smouldering material, arcing of welding equipment against the workpiece and other similar devices should not be used to ignite a gas.

3.4. Hoses and fittings

3.4.1. Hoses

It is essential that hoses and fittings used on cutting or heating equipment are maintained in good working condition.

Hoses and fittings should meet the requirements, including colour coding, specified in AS/NZS 1335 and the additional requirements of AS/NZS 1869 for LPG.

For safety reasons, each hose should present the minimum practicable flow restriction i.e. be of the largest diameter and shortest length possible to minimise pressure drop and gas starvation at the tip or nozzle. The potential for flashback increases when gas starvation occurs at the tip or nozzle.

Hoses should be located and protected from heat, mechanical damage, traffic, sparks, slag and oil so that accidental damage such as piercing, burning or crush damage does not occur. Location of hoses over sharp edges or manifolds or under sparks or hot slag from welding or cutting should be avoided as these events could lead to inadvertent ignition of gases resulting in possible injury to those in the workplace.

When working at heights while conducting hot work activity, controls should be put in place to manage hoses, leads and cables. This includes working in mine shafts. Hazards such as entanglement, excess load on regulators and connection points exist due to the weight of long hoses that may be required to be used. One such suitable control is the use of automatic reeling systems. Damage sustained can result in leaks and fires.

If hoses are damaged or burnt in a flashback, they must be replaced.

Do not use hoses longer than necessary.

Hoses should be checked for damage before use, and for leaks at least daily.

3.4.2. Fittings

Fittings should be:

- as specified in AS/NZS 1335
- with dimensions as specified in AS 4267
- of an appropriate type
- with connections securely made and leak-tight.

Wire should never be used to fasten hose to fittings.

Care should be taken with compatibility of fittings to ensure correct sealing with other fittings and with the hoses themselves. Oxygen and shielding gas fittings have righthand threads, fuel gases have left-hand threads.

3.4.3. Length and diameter

Hose should be of a diameter suitable for the flows required by the intended application. Hoses should be of the minimum practicable length to avoid excessive pressure drop, kinks, accidental damage etc.

The maximum hose length should not exceed 15 metres for each gas, or such distance that will allow the operator of hand-held equipment to be in sight of all the supply gas cylinders, whichever is the smaller. Hoses should be single length, but where extended lengths are required, lengths of hose should only be joined using fittings that comply with AS/NZS 1335. If twin hose is not used, single oxygen and fuel gas hoses should be clipped together at about two-metre intervals using special clips available from the hose supplier, and the oxygen and fuel hoses to be the same length.

Common standard internal diameters are 5.0, 6.3, 8.0, 10.0, 12.5, 16.0, and 20.0 mm.

AS 4839 specifies the maximum length of hose "must" be 15 metres. The standard outlines two reasons for this:

- to maintain the supply cylinders (this obviously includes pressure regulators and regulator end safety devices) within view of the operator
- to ensure flow rates at the tip are adequate to ensure the gas flow rate is matched to the flame velocity.

The second point is referred to in clause 7.4 of AS 4839–2001. Insufficient gas flow or velocity in the tip is the prime reason for the flame to move back into the mixer of the blowpipe during a burnback or flashback. If flow velocity is too low the flame can "chase" the mixed gases back to the mixer. Maintaining a minimum velocity of the gas mixture as it leaves the tip is critical for stable operation and depends on the pressures of the fuel and oxygen set at the regulators, the length and diameter of the hoses and the cumulative flow restrictions in the system. Restrictions can develop in operation due to blocked or damaged tip orifices, accumulation of particles (build-up of soot) in safety devices, or kinked and pinched hoses.

If hoses longer than 15 metres are required in particular circumstances, pressure losses can be overcome by increasing the hose diameter. A 10 mm diameter hose, for example, carries four times the volume and therefore has a much lower pressure drop per unit distance at a given flow rate than a standard 5 mm diameter hose. Larger diameter hoses should be considered where the 15 metre restriction is impractical.

Advice should be sought from equipment manufacturers to ensure the correct high-flow safety devices are matched to higher capacity hoses.

Where published data or advice cannot be obtained from the manufacturer or manufacturers of components used in a system, AS 4839–2001 requires the user to ensure that the *"assembled system is safe to use and complies with this Standard."*[25]

Where it is necessary to use hose lengths greater than allowed by AS 4839 or OEM data, substitution of LPG for acetylene should be considered. LPG draw-off rates can be much higher than acetylene draw-off rates. There are no immediate safety concerns with use of high draw-off rates from LPG cylinders, however at very high rates the cylinders may "freeze", limiting the available gas.

[25] Refer to AS 4839 - 2001 clause 7.1.

3.5. Blowpipes and mixers

Blowpipes perform the gas control and mixing function with the aid of a gas mixer that may be integral to the blowpipe or a separate, compatible attachment. In any case, blowpipe and mixer must perform the mixing of oxygen and fuel gas with due consideration to potential back-flow of gases and flashback.

3.5.1. Requirements for blowpipes

- The inlet connections should be suitable for the welding hose fittings (see Appendix D 'Gas cutting, heating and welding equipment maintenance inspection schedule')
- The control valves should be clearly marked 'oxygen' and 'fuel' (e.g. by the full names or by the abbreviations 'O' and 'F'), and colour-coded blue for oxygen and red for fuel gas
- Only suitable mixers and other attachments should be fitted to a blowpipe
- The blowpipe and mixer should be operated in accordance with the manufacturer's instructions
- Particular attention should be paid to the recommended maximum and minimum operating pressures and flows for the blowpipe-mixer tip or nozzle combination. These should always be respected

3.5.2. Lancing equipment

Oxygen/thermal lancing is a cutting process which uses oxygen supplied through a consumable steel pipe to pierce holes in metallic and mineral workpieces. The lance is lighted and steadily consumed. It involves a number of steel wires packed into the steel tube.

The lancing process requires the appropriate equipment for safe use. Lancing processes should be considered as a specialist process and expert advice and OEM recommendations should be followed. Refer to Appendix G for more information on thermal lancing.

Refer to the following Resources Regulator resources[26] regarding an incident involving lancing processes:

- Investigation Information Release - Causal investigation initiated after worker injured by pin ejection under pressure (IIR19-09, August 2019)
- Causal Investigation Report - Pin Ejection Incident, Ravensworth Open Cut Mine

[26] These resources are available at www.resourcesregulator.nsw.gov.au/safety-and-health/incidents/investigation-reports

- Learning from investigations video resource: Worker injured by pin ejecting under pressure

3.6. Tips, nozzles and their attachment fittings

Tips, nozzles and their attachment fittings should be selected to ensure they are fit for use. An incorrect selection may result in flashbacks and cylinder explosions.

Tips and nozzles should be well identified and carry information relating to their use.

Tips and cutting nozzles appropriate to the particular fuel gas should be used. Sizes should be selected from the supplier's operating data or WTIA Technical Note 5 Flame cutting of steels.

Tips and nozzles operate safely and efficiently over a limited range of flows. Below a minimum flow the flame will recede into the tip or mixer with potential hazard of flashback. Manufacturer’s recommendations for correct operating pressures and flows should be followed.

Recommended operating pressures for tips and nozzles should take into account the pressure drop introduced by long lengths or small diameters of hoses and any added safety devices.

4. Electric welding

4.1. General

To minimise the potential for electric shocks and electrocution, the following should apply:

- All welding power sources should comply with AS 60974.1 or AS 60974.6.
- The welding input power cable and fitted plug is sufficient to meet the maximum input current rating for the power source.
- Welding leads should comply with AS/NZS 1995.
- Coupling devices for welding leads should comply with IEC 60974-12.
- Wire feeders should comply with IEC 60974-5.
- Electrode holders should be in accordance with IEC 60974.11 Type A but as a minimum should be Type B[27].
- Welding torches should comply with IEC 60974-7.

[27] Refer Weld Australia’s TN07 Chapter 4 *Electric Arc Welding, Cutting and Gouging*, clause 4.7 for more information on electrode holders.

- Liquid cooling systems for welding power sources should comply with IEC 60974-2.
- For manual metal arc welding (MMAW) equipment, the use of inverter based direct current (d.c.) welding equipment incorporating a built-in VRD is strongly recommended.
- MMAW VRD should limit the open circuit voltage (OCV) to 12V d.c. If the OCV is higher, an isolation switch should be fitted to the welding hand piece (or a separate in-line switch fitted to the work lead and operated by the welder or observer) to ensure 0 volts at the hand piece during electrode changes.
- The use of alternating current (a.c.) welding equipment should be avoided. These types of welding equipment have inherently higher open circuit voltages and therefore have a higher risk of electric shock and possible electrocution.
- The duty cycle of the welding equipment should match the duty cycle required of the welding activity.
- All welding equipment should be appropriately labelled.

4.2. Welding flash

'Welding flash' or 'arc eye' is a painful inflammation of the cornea, which is the clear tissue that covers the front of the eye. It occurs from exposure to bright UV light through the observation of the welding arc by the naked eye. Symptoms include pain that may be mild to very severe usually starting a few hours after the incident, bloodshot eyes, light sensitivity, watery eyes, blurred vision and the feeling of having something in your eye. The cornea can repair itself in one to two days and usually heals without leaving a scar however medical assistance should always be sought to ensure the correct treatment is received[28].

To minimise the risk of welding flash, an appropriately rated welding face shield in accordance with AS/NZS 1336, AS/NZS 1338.1 should be used to protect the welding operator. Suitable opaque screens or appropriate translucent screens in accordance with AS/NZS 3957 should be used to protect other personnel in the vicinity of the welding activities.

People working in the vicinity of arc welding should wear safety glasses with side shields at all times, which will minimise the risk of arc eye by reflecting or absorbing much of the UV from the arc welding operations.

[28] For more information visit www.betterhealth.vic.gov.au/health/conditionsandtreatments/eyes-flash-burns

4.3. Primary circuit

Welding power sources should only be connected to power outlets that have been installed in accordance with AS/NZS 3000. For older installations not fitted with RCD protection, it is recommended that a portable RCD safety switch is used with the welding power source.

Note: Additional primary circuit protection should be considered, such as mining specific cables and earth continuity protection, when a welding power source is used underground in mines.

4.4. Output circuit

Electric shock in welding occurs when a person's body is in simultaneous contact with any exposed part of the secondary circuit electrode conductor and any metal or conducting material connected to the work terminal.

To prevent electric shock from the secondary circuit, it is important that:

- the electrode lead is in good condition and suitably rated, located, protected and insulated, to contain all welding currents within the lead, and prevent any stray currents
- the work return lead is fastened as close as practicable to the welding location to avoid stray currents

Note: Gears, bearings, brushings, pipes, etc. should not be used to form part of the return circuit. This is to prevent damage to the equipment and arcing or sparking within the gearcases.

Particular care should be taken when using two or more welding machines in close proximity.

The lead connecting the welding machine to the work is called the "work return lead. This lead is commonly (incorrectly) called the earth lead. Deliberate or accidental connection of the work return lead to earth creates hazardous situations and allows stray currents of significant magnitude to be generated by welding circuits.

- the electrical connection between the work return lead clamp and lead is secure
- welding operators should ensure that no part of their body is placed in a position to effect a return path for the circuit
- electrode holders are not defective
- welding machines need to be switched off and isolated from supply before connecting and disconnecting leads
- when welding has stopped for a period of time, power should be turned off and the electrode removed from the holder in order to prevent inadvertent operation
- prevent bare skin contact with the workpiece and always use dry insulating gloves

- an output circuit safety switch, between the welding machine and the hand piece, is recommended and should be used whenever replacing electrodes
- ensure the electrode lead is connected to the electrode terminal and the work return lead is connected to the work terminal
- consideration should be given to the risk of electromagnetic induction with other circuits.

4.4.1. Welding leads

The welding leads should not be extended beyond nine metres in length without consideration of voltage drop in accordance with the requirements of AS 1674.2.

The current carrying capacity of the work return and electrode lead should be determined in accordance with:

- rated output of the welding machine
- duty cycle of the welding machine
- the distance of the work from the welding machine.

4.5. Multiple welding power sources[29]

Where two or more welding power sources are connected to the same workpiece, voltages between the electrode holders may increase to dangerous levels. With d.c. output welding power sources, if one electrode lead is connected d.c. negative and the other d.c. positive, then a voltage of twice the OCV (up to 226V d.c.) may occur between two electrode holders. A similar effect of twice the OCV (up to 160V AC) will be created with AC output welding power sources if the electrode lead and the work return lead connections are swapped on one power source relative to others.

If the primary of AC welding power sources are connected to different phases of the supply system, or their output connections opposed, a voltage of either 1.73 or 2 times that of the individual welding power sources (up to 160V AC) may occur between two electrode holders.

If it is not possible to ensure the supply connections and the output connections are correctly phased, fixed barriers should be installed so a person cannot gain access to multiple electrode holders at the same time.

[29] Refer to AS 1674.2 clause 4.4 and to Weld Australia's TN07 clause 14.8 for more information on the risks associated with multiple welding power sources,

4.6. Hazard reducing devices

Hazard-reducing devices (HRDs) are devices designed to reduce the hazard of electric shocks from a welding circuit. They operate to either eliminate or reduce to a safer level the open circuit voltage on a welding circuit when there is no welding taking place.

4.6.1. Handpiece trigger switches as HRDs

Where a hand-piece trigger switch is used as a HRD:

- the voltage of its control circuit should not exceed 35 Vdc peak or 25 Vac, and
- its switching mechanism needs to:
  - return to the OFF position immediately after the welding operator releases pressure on the switch
  - be easy to hold in the closed position, enabling the welding operator to carry out normal welding operations, without muscle strain
  - for MMAW and carbon-arc gouging, have a two-stage operation to move to the ON position so that there is a low probability of accidental closure of the switch during any hazardous operations (e.g. changing electrodes), and
  - automatically latch in the OFF position on release of pressure by the welding operator.

4.6.2. Voltage reducing devices (VRDs)

VRDs are a safety enhancement that greatly reduces the risk to welding operators of exposure to potentially hazardous voltages produced by a welding power source. The VRD function is to reduce the voltage from the electrode to a safe value when the welding machine is not being used.

A system (VRD or alternative) needs to be provided to reduce the no-load voltage or open circuit voltage (OCV) to a level of:

- 35V maximum for d.c. or
- 25Vrms maximum for a.c. circuits.

Note: For additional information about VRDs refer to AS 1674.2 or Weld Australia TN 22.

Alternative systems may include triggers, switches and open circuit safety switch being operated when changing electrodes.

Most equipment for gas metal arc welding (GMAW, MIG/MAG), flux cored arc welding (FCAW) and some gas tungsten arc welding (GTAW, TIG) complies with this requirement, because the current is switched with a trigger switch i.e. the voltage is zero when the trigger is not operated.

4.6.3. Response time for a VRD

The turn off time (reaction time) for the VRD to reduce the voltage to the low voltage state after the circuit resistance reaches or exceeds 200 Ohms needs to be less than 300ms for a.c. machine and 500ms for d.c. machines.

4.7. Diesel or petrol welding machines

To minimise the potential for electric shock and electrocution, diesel or petrol driven welding machines should be in accordance with AS 60974.1.

Socket outlets and residual-current devices (RCDs) fitted to combination welding machines and generators must comply with AS/NZS 3010.

Note: The preferred arrangement is to have separate welding machines and generators, not combination units. The concern is around faults occurring on one machine, affecting the safety and performance of the other.

4.8. Output circuit safety switches

An output circuit safety switch should be used when welding in confined spaces or electrically hazardous environments e.g. damp environments.

4.9. Compressed air systems

When compressed air systems are used during arc related welding activities (e.g. air arc gouging), the compressed air feed should be fitted with a suitable device that will remove moisture, oil and regulate pressure as appropriate. Excessive moisture or oil should not be allowed to enter the arc gouging hand piece.

4.10. Electrically hazardous environment

An environment is considered electrically hazardous whenever the welding operator has to work in physical contact with the work piece, particularly in a cramped (kneeling, sitting or lying) position. The hazard is compounded in wet, damp or hot locations where moisture or perspiration considerably reduces the electrical resistance of the human body and the insulating properties of clothing. Where there is a possibility of the welder being damp or having damp clothing, and there is a risk of contact with energised welding components, open circuit voltages of welding machines should not exceed 25 V. Refer to the table below.

Table 3 Critical Open Circuit Voltages from AS 1674.2

<table>
<tr><th>WORKING ENVIRONMENT CATEGORIES</th><th colspan="2">MAXIMUM PERMITTED OPEN CIRCUIT VOLTAGE (OCV)</th></tr>
<tr><td>Category A environment (AS 1674.2-2007 clauses 1.3.6.1, 2.2 (a) and 2.3.1) is where the risk of electric shock or electrocution is low due to controls to prevent the possibility of the welder being in contact with the workpiece in the event of being in contact with a live part of the welding circuit.</td><td colspan="2">d.c. 113 Volts peak, or
a.c. 113 Volts Peak or 80 Volts rms
observer not required</td></tr>
<tr><td rowspan="2">Category B environment (AS 1674.2-2007 clauses 1.3.6.2, 2.2 (b) and 2.3.2) is where there is a high probability of the welder being in contact with the workpiece. Freedom of movement may be restricted.</td><td>d.c. 113 Volts peak,
with an observer</td><td>d.c. 35 V peak,
observer not required</td></tr>
<tr><td>a.c. 68 V peak and 48 V rms,
with an observer</td><td>a.c. 35 V peak and 25 V rms,
observer not required</td></tr>
<tr><td>Category C environment (AS 1674.2-2007 clauses 1.3.6.3, 2.2 (c) and 2.3.3) is where there is a high probability of the welder being in contact with the workpiece and the risk of an electric shock or electrocution is greatly increased due to the presence of moisture e.g. from high humidity, high ambient temperature, perspiration or water.</td><td colspan="2">d.c.35 V peak,
always with an observer, or
a.c. 35 V peak and 25 V rms,
always with an observer</td></tr>
</table>

5. Grinding, cutting and abrasive discs

Work that incorporates grinding and abrasive cutting activities, whether driven by electricity or by fluid power (including compressed air), will generate elevated temperatures and sparks and should be regarded as hot work and the appropriate controls implemented. To minimise the potential for injury from grinding and abrasive discs, the following should apply:

- Grinding/cutting activities should be carried out in accordance with equipment and disc manufacturer's instructions. The disc should have a speed rating at least as high as the maximum spindle speed of the tool. Maximum rotation speed should not be exceeded. The discs have an expiry date that is stamped or printed on the disc, generally on the centre steel ring, and the disc should not be used past this date.

- The correct type of grinding/cutting discs should be used for the application. Abrasive cutting discs are often used incorrectly, e.g. for grinding operations, resulting in greater than intended stress and a possibility of disc failure. Correct use is required to ensure the disc is not overloaded or shock loaded as this can cause the disc to rupture.
- The hazard of a grinder kicking back or jamming should be addressed with precautionary measures. For example, jamming of the disc may lead to the disc shattering at high velocity with the potential of injury to the operator and others in the workplace. Jamming may also result in the grinder jerking out of the worker's hand.
- Discs should have no visible cracks, damage and should not have been wet.
- Grinding discs intended for larger spindle diameters should not be used with reducing bushes for smaller spindle grinders. This is a dangerous practice that can have serious consequences for the operator or any bystanders.
- Guarding should always be in place, correctly positioned, adjusted and checked on a regular basis. Handles should be fitted and used. Incorrectly fitted or missing guards, and operators not holding the grinding tool correctly with both hands are the cause of many injuries.
- Discs should be fitted correctly. Use of incorrect disc support washers also results in excessive stress on the disc and can lead to failure.
- There is high kinetic energy in a high-speed angle grinder. Due to the high incidence of serious injuries related to use of larger angle grinders (230 mm or nine inch), many companies in Australia have introduced strict controls on the use of angle grinders, particularly the larger types and they use alternate methods to cut the steelwork.
- A grinder should be sized according to the task and a larger grinder should not be used where a smaller grinder can do the task (this reduces the risk).
- Grinders should be fitted with control valves or switches that automatically return to the off position when released.

6. Specific areas

6.1. Overview

The risk of fire or electric shock may be significantly increased because of the nature of the environment. The risk of electric shock will increase significantly when the environment or PPE is damp, humid or wet. Therefore, additional precautions need to be taken when working in hazardous environments such as where there is a higher risk of fire or explosion, or where there is a high risk of electric shock.

Specific areas referred to in this TRG are:

- specialised work (clause 6.5)
- wet areas (clause 6.6)
- working outdoors (clause 6.7)
- hazardous areas (section 7)
- confined spaces (section 8)
- working in, on, or near enclosed spaces (section 9)
- working at heights (section 10)
- underground coal mines (section 11).

Electrode holders should be Type A (fully insulated) with no damage, and leads in good working order.

Also, care needs to be taken to ensure that the current only flows in the work return lead and not through structural members away from the point of work.

6.2. Task specific risk assessment

A task specific risk assessment should be conducted to identify any additional hazards and risks that may not have been identified in the initial hot work risk assessment (clause 2.4 Risk assessment). The task specific risk assessment should:

- consider all changing circumstances that may occur while hot work is being undertaken (e.g. specific site hazards on the day, environment, weather, ventilation, power failures)
- consider other hazards (e.g. working at heights, confined spaces, near fuel source)
- include emergency procedures (e.g. for fire or explosion, electric shock) relevant to the specific task.

6.3. Preparation of work sites

Prior to issuing a hot work permit (refer clause 2.13 Hot work permit system), the area should be inspected by a competent person. The inspection should cover the area within a 15 metre radius including above and below the work area. This radius may need to be greater when working at heights or when hazardous situations exist below the work area. Other work activities should not be undertaken within the areas that may be affected by the hot work activities e.g. sparks, slag, UV radiation and light radiation.

This inspection should include the following:

- All flammable materials are removed from the area.

Note: Particular attention should be paid to aerosol cans which are often used in hot work areas and are generally poorly controlled. Products used in aerosol cans include anti-spatter, paints, liquid penetrant and magnetic particle consumables. The propellant used in these cans often contain hydrocarbons which are flammable. Stray arcs, hot metal or spatter can cause incidents with aerosol cans. Consideration should be given to storing all aerosol cans in aerosol cages compliant with AS 4332 away from the work area.

- Ventilation is adequate to ensure the atmosphere does not contain flammable vapours or gases.
- Combustibles are identified and minimised by removal or wetting of the material if it cannot be removed from the area. This may include sweepings of floors and wetting them down, checking walls and horizontal surfaces for combustible dusts and lint. If outdoors, clear away combustible materials such as vegetation, sawdust, loose wood, and paper and wet down the area as appropriate.

Note: Care should be taken when applying water to an area where electricity is to be used as it greatly increases the risk of electric shock or electrocution.

- Wall and floor openings are covered where there is a risk of products of hot work falling through the openings and causing fire.
- Firefighting equipment is readily available (and suitable for use) at the work area. For underground mine and reclaim tunnel situations, firefighting equipment should be located on the upstream side of air flow of the work area.
- Isolation or protection of electrical equipment is carried out in the vicinity of the hot work.
- Communications and emergency preparedness are in place.
- Emergency egresses are available.

6.4. Disconnection of power by an output circuit safety switch

The welding power source output circuit safety switch should be in the off position:

- until the welding operator is ready to commence welding activities
- whenever electrodes are being changed
- whenever the operator is not welding
- if an observer is not present and is a required risk control identified in the risk assessment.

6.5. Specialised work

Specialised work activities should only be carried out by a welder who is competent and trained in the type of work being performed and provided with suitable procedures. Work examples that are considered to be specialised work (but not limited to), include:

- welding on pressure vessels
- welding on pressure equipment and pipelines
- any welding carried out on structures or where it is of the Structural Purpose type (SP) such as walkways, lift points, load bearing components (refer AS/NZS 1554.1) or where greater dynamic loading is present (e.g. cranes or heavy lifting equipment)
- hot work on or near petrol, fuel or bulk oil tanks where explosive vapours are likely to be present
- lancing (refer clause 3.5.2 and Appendix G)
- welding on roll over protection systems and falling object protection systems
- welding on vehicle stands.

6.6. Wet areas

The presence of water in the work area increases the risk of electric shock. Therefore, it is important that hot work activities in wet, damp or areas which are likely to be humid, should be avoided. Where this is not practicable, the welding activities should be carried out in accordance with the following, in order, and AS 1674.2 to reduce the risk of electric shock:

- Remove the work piece from the wet area to a dry location if possible.

- Ensure water is drained away from the work area and allow time for the area to dry.
- Additional insulating materials must be used (secondary insulation), e.g. insulating mats, duck board, etc to separate the welding operator from moisture in the work area.
- When electric arc welding, where there is a possibility that the welding operator may become wet due to moisture in the work area or perspiration carrying out the work, the welding environment should be classified as Category C[30] and managed accordingly.
- The welding operator needs to be kept dry to remain effectively insulated from all parts of the welding circuit, e.g. the use of covers to protect from rain, air conditioning in a hot confined space, or frequent changes of damp clothing (particularly gloves).
- Additional insulating materials should be used (secondary insulation), e.g. insulating mats, duck board, etc to separate the welder from the work area.

6.7. Working outdoors

6.7.1. Equipment

Welding power sources that comply with AS 60974.1 are marked with a degree of protection on their compliance plate. Welding power sources for use outdoors are rated with a degree of Ingress Protection (IP) to IP23 in accordance with AS 60529[31].

Equipment may require temporary shelter to provide protection from the elements.

When working with engine drive equipment, consideration should be given to having modern and reputable exhaust treatment devices fitted to reduce health and safety risks to workers and minimise the impact to the environment. It is also important to ensure the equipment is located away from the immediate work areas, to ensure exhaust fumes do not affect the hot work area itself or other work areas.

6.7.2. Environment

When working outdoors, the following should be considered:

- Vegetated areas should be cleared or otherwise protected from welding sparks or slag prior to commencement of any hot works.

[30] Refer AS 1674.2-2007 clauses 1.3.6.3, 2.2 (c) & 2.3.3
[31] AS 60529 IP 23 is a minimum for outdoor conditions (Refer AS 1674.2). A higher rating may be appropriate pending assessment of the environmental conditions

- A deliverable water source and/or fire extinguishers should be readily accessible and a competent firewatcher should be on duty[32].
- High wind conditions can increase the size of the fire hazard area.
- Shade should be provided over the hot work area, especially during the summer months, e.g. sunshades.
- Whether it is appropriate to carry out hot work on any **Total Fire Ban Days** including consideration of whether an exemption to a total fire ban for mining operations applies.

Note: A standard exemption to a total fire ban does not apply unless specifically referred to in the total fire ban order as made by the Minister or the Commissioner of the NSW Rural Fire Service[33].

- Adequate lighting should be provided in accordance with AS/NZS 1680.5.
- The proposed work area should be assessed against AS 1674.2-2007 Section 2 *Classification of Welding Environment* to determine the appropriate Category level. The relevant controls for that Category should then be implemented as a minimum.

7. Hazardous areas

7.1. General requirements

Note: For hazardous zones in underground coal mines, refer to clause 11.4 below.

In addition to the requirements in section 6, work carried out in hazardous areas should be in accordance with the following:

- Defined, prepared and controlled in accordance with AS/NZS 60079.10.1 and AS/NZS 3000.
- Hot work in Zones 0, 1, 2, 20 ,21 and 22, as defined in AS/NZS 60079.10.1 and AS/NZS 60079.10.2, must not be undertaken. Additional controls must be implemented that enables the hot work area to be reclassified as non-hazardous.
- The hot work equipment, including cables and leads, must be located within areas classified as non-hazardous prior to energising electrical equipment.
- There should be an assigned firewatcher/observer and hot work permit system implemented.

[32] Refer AS 1674.1 for the duties and responsibilities of a *firewatcher*
[33] *Schedule of standard exemptions to total fire bans, NSW Government Gazette No 16 of 9 February 2018 (pages 599-603)*

- Electrical equipment must be suitably rated.
- Proper ventilation must be provided.
- The welding work return lead must be connected to the equipment being welded to prevent welding currents returning via electrical earthing circuits.
- The minimum separation distances of flammable and combustible liquid storages from an ignition source should be maintained as prescribed in AS 1940.

7.2. Types of hazardous areas

Hazardous areas may be found in (but not limited to) locations, such as:

- explosives storage areas
- battery charging and/or storage areas
- near a refuelling station, fuel spillage or any exposed combustible material
- near any fuels, oil, bulk storage tanks, pipelines and their surrounds
- near any drum or opening which has contained or is suspected to have contained chemicals
- conveyor belts and/or associated structures where coal or other combustible materials are handled. For example:
  - conveyor transfer chutes
  - coal reclaim tunnels
  - coal and refuse storage bins
- inside any confined space
- an area in which an explosive gas atmosphere is present or likely to occur, as per AS/NZS 60079.10.1
- an area in which an explosive dust atmosphere is present or likely to occur, as per AS/NZS 60079.10.2
- a hazardous zone in an underground coal mine.

Note: Refer to clause 11.4 Hazardous zones underground coal mines.

7.3. Firewatchers

A firewatcher should be working with the hot work operator at all times. The firewatcher should:

- be alert for fire outbreak or other hazards
- stop work if conditions change to a hazardous environment
- not leave the job until replaced or until a designated time period (defined in the hot work permit) after the hot work is completed
- be trained in the emergency response plan
- be trained in first aid
- remain in communication with the person conducting the hot work
- where a welding power source output circuit safety switch is required, be prepared to operate the safety switch when:
  - required in an emergency
  - changing electrodes
  - welding operations have ceased.

Note: A firewatcher and an observer could be the one person. It is noted that AS 2865 uses the term “stand-by person” to cover the roles which may be fulfilled by the firewatcher or the observer and may be the same person.

8. Confined spaces

8.1. Introduction

Risks associated with working in a confined space are increased when undertaking hot work activities within the confined space. The WHS Regulation details specific controls relating to work in a confined space (WHS Regulation Part 4.3).

The mine workings of an underground mine and any shafts are not considered confined spaces. However, these environments have unique hazards that need to be addressed to control the risk associated with hot work.

For information about managing risks to health safety associated with undertaking hot work in confined spaces, refer to:

- NSW Code of Practice Confined Spaces
- NSW Code of Practice Welding Processes (August 2019) - clause 3.9
- Weld Australia-TN-07 chapter 20 'Welding and cutting in confined spaces'.

8.2. Identifying a confined space

For guidance on identifying a confined space, refer to:

- NSW Code of Practice Confined Spaces (August 2019) clause 1.1
- AS 2865-2009, clause 1.5.5.

8.3. Recommendations from standards[34] and TN 07

When hot work is carried out in a confined space the following should be considered:

- The atmosphere is purged of flammable liquids and vapours by establishing effective ventilation.
- Gas cylinders and welding machines are left outside the confined space if possible.
- A safety switch is fitted to the welding electrode lead and positioned where an observer can easily operate.
- If electric welding is stopped for any period of time, welding handpieces and electrode holders should be removed from the confined space. If not practical to remove, then the leads should be disconnected from the welding machine. . The welding machine should also be disconnected from the power source.
- The emergency plan should include means for the hot work operator to be removed in the event of an emergency and/or injury.
- To prevent accidental gas leakage, cylinder valves should be closed whenever the torch is not to be used for a sustained period. Where practicable the torch and hoses should be removed from the confined space.

[34] Refer to AS 2865 clause 3 and AS 2865 Appendix A for detailed guidance on implementation of confined space management.

8.4. Atmospheric hazards and engulfment hazards of confined spaces

For information on atmospheric hazards and engulfment hazards of confined spaces, refer to AS 2865-2009 clause 3.1.2.

Note: Using a cutting process such as oxy acetylene can rapidly increase the oxygen content of the atmosphere.

8.5. Task-related hazards

For information about task-related hazards and other occupational hazards in confined spaces, refer to AS 2865-2009 clause 3.1.3.

Many confined spaces are also electrically hazardous environments. In these circumstances, the requirements of clause 4.10 should apply. If confined spaces are hot and humid, the requirements of Weld Australia's TN 07-2020 chapter 23 should also apply.

8.6. Supervision, permits and precautions

Where hot work is required in a confined space, a responsible person should supervise the preparations for work and issue suitable permits. A risk assessment must be undertaken to identify all hazards, assess the risks and put controls in place prior to issuing a permit.

The atmosphere and any materials present in a confined space should be tested and examined in respect of toxicity and flammability prior to the commencement of works.[35].

8.7. Atmospheric testing and monitoring

For information about atmospheric testing and monitoring, refer to AS 2865-2009 clause 3.4.24.

Atmospheric testing should include testing by calibrated and well maintained instruments for:

- oxygen concentration
- concentration of flammable airborne contaminants
- concentration of airborne contaminants.

[35] Where required, the cleaning and safe working procedures given in Weld Australia's TN 07-20 Chapter 21 *Welding or Cutting In or On Containers* should be carried out i.e. where the contents or previous contents are known or suspected to be flammable, explosive or toxic.

8.7.1. Gas monitors

Gas monitors used for the purpose of atmospheric monitoring within a confined space should be maintained and used in accordance with the manufacturer's instructions and warnings.[36]

8.7.2. Challenge/bump testing

Gas monitors should be challenge tested[37] on a routine basis using premixed calibration gases to ensure their accuracy and sensitivity across the range of use. Detectors can become contaminated ("poisoned") leading to potential errors in readings.

8.8. Electric shock

Because of the cramped conditions and probability of the welder sweating, the risk of electric shock is greatly increased in confined spaces, and deaths have occurred in these conditions in Australia.[38] In addition to the normal safe operating procedures outlined in Weld Australia's TN 07-2020 chapter 14, the following measures should be taken:

- **Power sources** are to be left outside the confined working space and should be d.c.
- Power supply **hazard reducing devices** that eliminate or restrict the no-load voltages to a value as low as practicable should be used.
- **Electrical connection** to the welding power source, electrodes, work and equipment should be thoroughly checked, fully insulated and protected from edges that will cut or damage leads.
- **Means for cutting off power** to the welding handpiece should be installed and readily accessible.
- **Insulating mats** or layers of a suitable material to insulate the welder from the work surface should be provided (refer Weld Australia's TN 07-2020 Figure 20.1).
- **Electrical lighting** in the confined space should be as low a voltage as practical - typically extra low voltage (12Vdc or battery powered).

[36] Refer to AS/NZS 60079.0 and AS/NZS 60079.11.
[37] Challenge testing requires the instrument to correctly determine the concentration of a premixed "calibration gas" at appropriate concentration close to the value being measured.
[38] Weld Australia recommends that all electric welding in confined spaces be managed in accordance with the requirements of AS 1674.2 Category C environments.

- **Hand tools** and other electrical equipment (e.g. grinders) should be battery powered if possible. Where not practicable to be battery powered, other energy sources should be considered. Where the only practicable option is the use of 240 V hand tools, then additional protective measures should be used including 10 mA RCDs and screened cables.
- **High frequency** (HF) (high voltage pilot arc) is often used to facilitate arc starting, e.g. to eliminate scratch or lift-arc starting in GTAW (TIG welding). In the event of high frequency system failure, the output voltage is not to exceed the levels shown in Weld Australia's TN 07-2020 Table 4.2.

Note: It is recommended that HF not be used in confined spaces because ordinary insulation is ineffective against high frequency.

8.9. Flame cutting, welding or preheating

Where gases are required for cutting, welding or preheating, precautions are required to ensure a build-up of toxic or flammable gases cannot occur. The following precautions should be observed:

- **Gas cylinders** should be kept away from the working area and preferably outside the confined space.
- **Blowpipes** should be lit outside to minimise gas and heat build-up inside the confined space.
- **Torches and pressure hosing** connected to the supply should not be left inside the working area when not in use. Very slow leaks of oxygen or fuel gas can allow an explosive atmosphere to build up rapidly.
- **Gas cutting** may result in a build-up of oxygen level due to only a small portion of the oxygen being used in the cutting operation. Ventilation is required to ensure that the oxygen levels do not increase.
- **Preheating** using a gas flame that is not supported by oxygen, such as a naturally aspirated LPG flame, will rapidly deplete the oxygen level in a small confined space. Ventilation is required to ensure that the oxygen levels do not decrease. Alternative pre-heating equipment should be considered. These should be positioned externally to the confined space where practical.
- **Flame cutting, welding or preheating activities** generate heat which can increase the ambient air temperature. Forced ventilation may be required to cool the area. Additional cooling aids may include personal cooling protective equipment.

- **Build-up of asphyxiant gases** will accompany any gas cutting or heating activity carried out in a confined space. Ventilation is required to ensure that the asphyxiant gas levels do not increase.

8.10. The operator

Working under confined space conditions increases the fatigue experienced by the operator and can therefore reduce their concentration level. This situation is more serious in hot conditions that can arise from either preheating or build-up of heat during welding. Additional care should be given to the selection of working clothing and protective clothing[39].

The following control measures should be considered:

- Personal air cooling vests or clothing.
- Filtered respirator air to aid in operator cooling.
- Flame resistant protective clothing e.g. wool.
- Clothing should not be soiled with readily combustible materials such as oil or grease.
- Gauntlet gloves should be in good condition, without metal rivets, flame-resistant and kept dry.
- Footwear should be robust, watertight and of the non-nailed type. Steel toecaps are recommended, but metal should not be exposed.
- Protection from UV radiation including reflection, stray arcs and arc flashes from other welding operations.
- Rest periods. This may be achieved by using several operators in turn.

9. Enclosed and sealed spaces

9.1. Introduction

For the purposes of this clause, an ‘enclosed space’ has been differentiated against a ‘sealed space’.

An enclosed space is one where a person may enter the space for the purposes of carrying out an activity such as hot work. An enclosed space may also be a confined space at the same time (see section

[39] Refer Weld Australia TN 07-20 Chapter 19 *Protective Equipment for Welding and Allied Processes*

8 Confined spaces). This may include any piping, vats, tanks, bins, crushers, kilns, drums, vessels and containers.

A sealed space is not accessible to a person by virtue of its size and is not vented to atmosphere.

Where enclosed spaces are known or suspected to have contained flammable or toxic substances, the provisions of Weld Australia’s TN 07-2020 clause 21.3 should be carried out prior to performing hot work. The requirements of AS 1674.1 should also be followed.

9.2. Hazards

Hot work in, on or near enclosed or sealed spaces may present additional hazards not commonly encountered in other hot work operations. For example, hazards could arise from the flammability, toxicity or explosive characteristics of contained liquids, gases or solids or from their release. Welding of components under internal pressure also poses hazards to the operator and those in the vicinity.

A number of serious incidents have resulted from hot work being carried out on sealed spaces that created a fire or explosion. Examples of hazards which led to incidents relating to sealed spaces include:

- counterweight box on a dragline – hydrogen gas produced over time due to trapped moisture
- excavator boom – hydrogen gas and carbon monoxide gas produced within a box section by incomplete combustion of LPG during preheating[40]
- counterweight box on an excavator – hydrogen gas produced over time due to trapped moisture[41]
- fuel tanks[42]
- sealed box section on a highway bridge – hydrogen gas produced over time due to trapped moisture
- hot work on a piping system containing flammable fumes connected to a vessel containing a flammable liquid[43]

[40] Refer www.resourcesregulator.nsw.gov.au/__data/assets/pdf_file/0005/67469/Safety-Alert-03-08-Pre-Heating-on-Confined-Space-Prior-to-Welding.pdf
[41] Refer www.resourcesregulator.nsw.gov.au/__data/assets/pdf_file/0005/541877/SA-15-01-Fire-ignites-from-worker-drilling-into-sealed-void.pdf
[42] Refer www.resourcesregulator.nsw.gov.au/__data/assets/pdf_file/0007/66985/Safety-Alert-00-05-Fatality-from-hot-work-on-a-diesel-fuel-tank.pdf
[43] Refer www.news.com.au/national/top-winemaker-killed-in-blast/news-story/6263c45c1df51c12b8b0e3f70ada4329

- oxy-fuel gas cutting a box section containing grease where a combination of heated lubricants inside the space and elevated oxygen levels due to oxy-cutting resulted in an explosion.

In these serious incidents, the fuel has been:

- hydrocarbons such as lubricating or hydraulic fluids that have seeped into the space due to cracking
- hydrogen evolved by bacterial action on moist and/or rusty steel ballast within a sealed space
- hydrogen and carbon monoxide gas produced from incomplete combustion of a preheating flame
- sudden release of pressure generated from the change of state from water to steam forcibly ejecting a 50 kg pin[44].

In all cases there was no expectation that there was anything flammable on the other side of the metal where the hot work was being carried out.

Oxy-fuel gas cutting where the oxygen cutting jet is directed into the sealed space will generally result in an increase in the oxygen concentration due to only a small portion of the oxygen being used in the cutting operation.

9.3. Purging

9.3.1. Gas freeing

Gas freeing refers to the purging of flammable, explosive or noxious gas from an intended workplace in an enclosed space, sealed and confined space. Unless a building has been designed and certified for such work, all "gas freeing" is to be performed outdoors, remote from all sources of ignition (in the case of combustibles) or sufficiently isolated to protect personnel in the immediate vicinity. The following points should be considered:

- Gas freeing areas should be clearly identified.

[44] Refer NSW Resources Regulator IIR19-09 *Causal investigation initiated after worker injured by pin ejected under pressure* available at https://www.resourcesregulator.nsw.gov.au/compliance-and-enforcement/investigation-reports

- The vent from the enclosed space should be positioned where vapours will not drift indoors, towards sources of ignition (in the case of combustibles) or endanger personnel in the case of toxic or asphyxiating gases.
- Many vapours are heavier than air and will accumulate in low areas.
- Safe distances need to be established from sources of ignition in the case of combustibles and air contamination requirements in the case of toxic gases etc.
- Where water or steam is used, the work area should be contained to control any environmental hazards.
- The gas-free status of an atmosphere must be checked by instruments that are used by experienced and qualified personnel to ensure safe entry.

9.3.2. Inertisation

Purging with inert gas is used primarily for sealed spaces.

Purging requires that flammable gases and vapours are rendered safe within the sealed space by diluting them sufficiently with a non-flammable (inert) gas[45]. The aim is to reduce the oxygen concentration to well below the minimum oxygen level necessary to support combustion, known as the limiting oxygen concentration (LOC)[46] or minimum oxygen concentration (MOC). When the oxygen concentration is well below the LOC, flammable gas or fuel vapour can be safely generated by hot work in the sealed space because the possibility of internal explosion has been controlled. This is often referred to as ‘inertisation’ or ‘inerting’.

Carbon dioxide added as dry ice or in gas form and nitrogen are the most commonly used inert gases.

Pure oxygen or oxygen mixtures are dangerous and must not be used for this purpose.

9.3.3. Other considerations

Fire precautions should be adhered to[47] even if the relevant precautions noted in Weld Australia’s TN 07-20 clause 21.3 have been carried out.

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[45] Lower explosive limit (LEL) and lower flammable limit (LFL) for any flammable species depends on the oxygen concentration

[46] Limiting oxygen concentration, (LOC), also known as the minimum oxygen concentration, (MOC), is defined as the limiting concentration of oxygen below which combustion of a particular flammable species is not possible, independent of the concentration of fuel. It is expressed in units of volume per cent of oxygen. The LOC varies with pressure and temperature. It is also dependent on the type of inert (non-flammable) gas.

[47] Refer Weld Australia TN 07-20 Chapter 16 *Fire and Explosion Protection*

Interruptions to work that involve a reasonable elapsed time require a re-assessment of the conditions to ensure that it is safe to recommence work.

9.4. Shafts

When working in a shaft, rise, lift or pit, equipment should be located above the cutting point so that sparks, slag and molten material cannot fall on the equipment including hoses, cylinders, cables, leads and other welding equipment.

Molten metal, slag and sparks should be prevented from falling down a shaft[48] [49].

A firewatcher should be located at the bottom of the shaft in a safe position.

10. Working at heights

10.1. Introduction

Many hot work operations involved in site or maintenance activities are undertaken at heights where falls can have serious consequences. Additionally, falling objects can cause severe injury to personnel below. Attention should be paid to the special considerations that apply in Part 4.4 of the WHS Regulation that sets out the requirements relating to managing risks to health and safety associated with falls, as many accidents occur in these situations.

Note: Refer to the NSW code of practice: *Managing the risk of falls at workplaces* for practical guidance on how to manage health and safety risks arising from falls.

10.2. Electric shock

Electric shock can result in the hot work operator falling from a height or causing other objects to fall. Consideration should be given to the relevant controls and precautions identified in Weld Australia's TN 07-20 Chapter 14 *Electric Shock*.

[48] In 1980, three miners died in a fire while in the mine shaft's person-riding cage. The Coroner believed hot metal, slag or sparks falling down the shaft ignited flammable material below the cage, such as old concrete delivery pipes (refer: www.resourcesregulator.nsw.gov.au/safety-and-health/events/learning-from-disasters/learning-from-disasters-timeline/cobar-1980

[49] Two persons received fatal injuries whilst oxy cutting in a mine shaft in NSW where spilt diesel fuel contained in the water rings caught alight.

10.3. Fire and burns to personnel

Controls should be in place to ensure that molten metal from cutting, lancing, or gouging operations will not cause a fire or injury to other workers below. Examples of hot work carried out at heights may include coal handling plants, concentrator mills, transfer chutes, top of bins and any platform level which does not have a solid floor and areas below are accessible by other workers.

Examples of controls may include protective shields, fire blankets, nets and screens or for areas below barricading and access control.

10.4. Elevating work platforms

When conducting hot work from an elevating work platform (EWP) or a suspended work box, it is important to ensure that the basket is maintained at the same potential as the work piece to prevent currents flowing through suspension or pivot points. Consideration should be given to installing equipotential bond conductors between the workpiece and other conductive structures in the vicinity of any welding work, including the basket.

Equipotential bonding cables should have at least the same capacity as the welding leads and be clearly marked to distinguish them from the welding leads. Reference should be made to the manufacturer of the EWP or work box for guidance on the use and connection of equipotential bond conductors to prevent damage or cause unintended operation of the EWP or crane.

Hot work consumables such as worn cutting or grinding discs and especially hot electrode stubs should be captured and placed in a separate receptacle and removed from the EWP on completion of the task.

11. Underground coal mines

11.1. General requirements

The requirements listed in this section 11 apply to all hot work carried out in underground coal mines. The requirements in the earlier sections of this TRG also apply.

11.1.1. Compliance with legislation

Hot work within a hazardous zone is identified as a high risk activity (refer to Schedule 3 clause 11 of the WHS (MPS) Regulation) and subject to the provisions of clause 33 of the WHS (MPS) Regulation ‘Notification of high risk activities’.

For hot work activities outside the hazardous zone, refer to Schedule 4 clause 3(1)(a) of the WHS (MPS) Regulation and provisions in the MECP and EECP in Schedule 2 and provisions in clause 26 of the WHS (MPS) Regulation.

Matters also need to be addressed in the PHMP for fire or explosion (WHS (MPS) Regulation Schedule 1 Clause 6 (1)(b) and (2)).

Note: Refer to clause 1.3 for information about the legislative requirements for managing hot work, including at an underground coal mine.

11.1.2. Locations for hot work underground

The use of hot work equipment in underground coal mines should be considered in relation to the following locations:

- Underground workshops (refer clause 11.2)
- Non-hazardous zones underground (refer clause 11.3)
- Hazardous zones underground (refer clause 11.4)

Hot work in these locations represents an increase in potential hazards which must be managed in accordance with WHS (MPS) Regulation Part 2, Division 1 Subdivision 1 “Control of risk”.

It is preferable for all hot work underground to be carried out in designated underground workshops. When hot work is carried out in an underground workshop, controls should already be in place and engineered before hot work activities commence.

11.1.3. Initial risk assessment

An initial risk assessment must be conducted to assess the risk associated with the task of using hot work equipment including hot work equipment for locations underground. In addition to the general requirements (refer clause 2.4), this risk assessment should include, but not necessarily be limited to, consideration of the:

- frequency and nature of inspections (before, during and after)
- competencies of site personnel relating to reading, recording and the interpretation of real-time monitoring
- minimum gas and ventilation standards to be applied
- site preparation and housekeeping standards (before, during and after)
- actions to be included in the emergency response plan
- firefighting provisions to be provided
- communication requirements

- equipment and standards
- transport and storage requirements
- earthing of the electrical welding equipment
- means of separating the hot work from combustible material including coal
- means of rendering safe any enclosed items which may contain flammable/combustible gas e.g. methane
- proximity to a goaf area which may contain combustible gas
- area in which the hot work is to take place has been examined and roof and ribs have been deemed structurally safe by a person competent to do so.

Senior mining and engineering personnel along with site safety and health representatives (management and employees representative SSHR) should participate in this risk assessment process along with those who undertake the hot work activities. The risk assessment must be conducted by a person who is competent to conduct the particular risk assessment having regard to the nature of the hazard (refer clause 9(2) WHS (MPS) Regulation).

11.1.4. Task specific risk assessment

A task-specific risk assessment should be conducted on each occasion where hot work is being carried out in:

- a workshop or splicing station, if they were not covered by the initial risk assessment
- a workshop or splicing station, where hazards are present other than those covered in the initial risk assessment
- other non-hazardous zones
- a hazardous zone.

Senior mining and engineering personnel along with site safety and health representatives should participate in this risk assessment process along with those who undertake the hot work activities.

11.1.5. Appointment of hot work operators

All people carrying out hot work in underground coal mines should be authorised, in writing, as per the site's safety management system.

The person carrying out the hot work should be provided with a copy of this authorisation. The authorisation should consider:

- types of work permitted by the person being authorised
- the duration of the authorisation
- locations of the permitted work area
- any other management controls.

All people carrying out hot work activities should be given appropriate training in the outcomes of any risk assessment and the mine's HWMS.

11.1.5.1. Contractors

Contractors are to be competent and authorised to carry out hot work activities. Training should extend to the additional hazards associated with the underground coal mining environment.

11.1.6. Inspections recording

All inspections records should be kept as part of the mine's inspection system and HWMS.

Note: Refer to clause 11.3.4 Inspections non-hazardous zones and clause 11.4.4 Inspections hazardous zone

11.1.7. Transport of equipment to the work site

All hot work equipment should be transported to site in accordance with the following:

- Transported directly between the surface of the mine or underground workshop and the location where hot work is to take place.
- Cylinders secured in an upright position (if practical) so they cannot move about and do not protrude outside the vehicle or conveyance.
- Before transporting, close all shut-off valves and check for leakage on cylinders.
- Disconnect all ancillary equipment such as regulators, gauges etc.
- Unload all cylinders as soon as possible.

- Inspect equipment prior to use.
- Comply with the mine's portable electrical apparatus management plan.

11.1.8. Ventilation and gas

Ventilation and gas controls should include the following:

- The provisions of ventilation arrangements including plans, rules and guidance for the site are considered.
- A positive airflow of intake air is directed and maintained over the hot work site at all times.
- If the percentage of flammable gas anywhere within 20 metres of the hot work area exceeds 0.25% (refer WHS Regulation clause 51(2)(c) and WHS (MPS) Regulation clause 71(c)) then:
    - work must not commence
    - work must be stopped until such time as the percentage of flammable gas is reduced to below 0.25%
    - special attention is to be paid to examination and history of flammable gas at roof level, crevices and floor breaks, and within equipment such as roof support leg pockets.

  Note: These can be issuing gas that gets mixed with ventilation. However if hot slag, dross or hot sparks occur in the vicinity of a gas blower such as a floor break it may ignite the gas and initiate an explosion.
- Real-time (continuous) methane and carbon monoxide gas monitoring should be operational in an underground workshop. This continuous gas monitoring should be transmitted to a central control room location. It should also monitor the return air from the workshop.
- Adequate local ventilation must be provided in order to prevent the accumulation of any gases.
- Provision needs to be made for the inadvertent loss of ventilation due to main fan stoppage or other events causing a loss of adequate ventilation.

Note: If hot work involving gas cutting on substantially sized steel sections is in progress, it may be necessary to cool the steel sections to avoid ignition of methane.

11.1.9. Flammable materials

The hot work site should be thoroughly cleaned down to remove all dirt, grease, oil, loose coal etc. prior to starting hot work. Special precautions should be taken when access is not possible to the back of the work item, or material being worked on e.g. sealed space, void, roof support canopy, pan line deck plate.

There should be no flammable materials such as spilt oil, grease, diesel fuel, chemicals, paper, cardboard and coal dust or rags within a 15 m radius of the hot work activity.

Where practicable, the machinery, floor or material immediately beneath the area of the hot work operations should be protected by sheet metal covered with wet sand or fireproof blankets to prevent sparks and hot dross being scattered unless the floor is concrete or other non-flammable material.

There should be no flammable material in any voids behind or around the hot work operations.

11.1.10. Fire fighting facilities

The following firefighting and fire prevention facilities in the designated hot work area should be provided as a minimum:

- two fire extinguishers[50] of a suitable type and capacity, such as 80BE-rated dry chemical
- suitable firefighting water supply with a fire hydrant located on the intake side within 25 m of the hot work area
- a fire depot located beside the fire hydrant with sufficient hose to reach all extremities of the area where hot work activities are being undertaken
- a suitable hose, minimum 25 mm and pressurised in readiness for use
- adequate supplies of stone dust (five by 20 kg bags minimum)
- fire blankets.

11.1.11. Emergency egress

There must be a second means of egress provided.

11.1.12. Lighting

Adequate lighting is to be provided in order to allow hot work activities to be carried out safely.

[50] AS 1850 *Portable fire extinguishers – Classification, rating and performance testing*

11.2. Underground workshops

11.2.1. General

All underground workshops should be constructed, operated and maintained in accordance with risk control measures determined by site personnel from risk assessments. The following measures are to aid in that process.

Hot work activities should not be carried out:

- in the vicinity of battery charging facilities
- in an area used for refuelling.

11.2.2. Materials of construction

Workshop floor, roof and walls are to be constructed from a suitable fit-for-purpose non-flammable material. It is preferable to have concrete floors and sprayed roof and walls.

11.2.3. Storage of equipment

All hot work equipment should be stored and maintained in accordance with the following:

- In a designated area set aside and marked for the storage of hot work apparatus.
- The storage area should be a secure lockable area with limited access. Consideration should be given that the lockable area consists of a fireproof cabinet if practical.
- Access to the storage area should be limited to appointed people only.
- A register should be kept of the equipment stored. This register should record all quantities and movements of the equipment.
- Fuel and oxygen cylinders are to be segregated and stored separately.

11.2.4. Garages

Hot work should not be conducted in the same part of a workshop as that is used for refuelling or the storage of flammable materials such as oils and greases.

Where refuelling facilities (underground garage) are provided near a workshop, then the risk assessment should address the following additional hazards, as a minimum, but not be limited to:

- hot work and refuelling should not be carried out simultaneously

- effectiveness of segregation between any fuel and the hot work ignition source. This segregation should be based on:
    - the quantity and type of fuel source
    - ventilation
    - the environment e.g. type of flooring, roof, walls
    - other potential fuel sources such as oils and greases.
- floor grades to prevent fuel spillage running towards the area where hot work is being conducted
- mechanisms to positively prevent any vehicle entering the workshop space when hot work activities are being carried out.

11.3. Non-hazardous zones

11.3.1. General

The environment is likely to present greater risk when hot work is carried out in non-hazardous zones if undertaken outside dedicated workshops.

The provisions in clause 11.3 are additional to the general requirements of clause 11.1 above.

All cutting and welding equipment is to be transported directly to the surface or to an underground workshop after completion of cutting and welding activities, for safe storage. There should not be storage facilities for cutting and welding equipment in the non-hazardous zone outside an underground workshop.

Note: Refer to clause 1.3. *Legislative requirements for managing hot work*, Schedule 4 *Prohibited items and substances* clause 3(1)(a) *Ignition sources* of the WHS (MPS) Regulation and provisions in the MECP and EECP in clause 26 and in Schedule 2 of the WHS (MPS) Regulation for requirements relating to hot work activities outside a hazardous zone.

11.3.2. Task specific risk assessment

In addition to the initial risk assessment, a task specific risk assessment must be conducted on each occasion where hot work is being carried out in a non-hazardous zone.

This risk assessment should also include the following:

- A site inspection on each specific occasion to assess and address site-specific hazards.

- Be applied to a specific location that has clearly defined boundaries.
- The inspections are to be performed before, during and after hot work activities.
- The removal and/or protection of flammable materials including coal dust from accidental ignition.
- Stone-dusting standards.
- Strata-control requirements.
- The potential for sudden fluctuations in ventilation quantity and/or gas emission and controls designed to protect against such events e.g. barometric pressure.
- Ground or floor conditions for the presence of water.

11.3.3. Site preparation

The area should be thoroughly stone-dusted for at least a radius of 20 metres from the hot work site or be composed of non-combustible material.

Firefighting facilities, as stated above, should be provided.

Ground or floor conditions should be free from water.

11.3.4. Inspections non-hazardous zones

11.3.4.1. Before, during and after completion of hot work

A mining supervisor must see that these conditions have been carried out before welding or cutting is commenced.

Inspections carried out as detailed in clause 11.4.4. should be considered.

There should be no flame lit to ignite the equipment and no arc struck with an electric welding apparatus except by or in the presence of a mining supervisor.

A mining supervisor should:

- inspect the site regularly at appropriate intervals (maximum of one hour) while the equipment is in operation
- check the area is thoroughly stone-dusted and firefighting facilities are available
- remain at the site or in close proximity to the site while cutting, welding or heating operations are in progress

- remain at the site for a period determined in the risk assessment (this should be at least one hour) after the completion of cutting and welding activities and inspect for fire, smouldering material or dangerous methane concentrations.

11.4. Hazardous zones underground coal mines

11.4.1. General

Hot work in a 'hazardous zone' is associated with a high level of risk and is not considered acceptable unless there is no reasonably practicable alternative.

Where a mine has determined that the hot work is essential, the WHS (MPS) Regulation requires notification of the hot work as a high-risk activity (HRA) in accordance with clauses 33 and Schedule 3 clause 11.

Note: Additional specific requirements for hot work are identified in clause 79 and Schedule 1 under fire or explosion, and Schedule 2 under the mechanical and electrical engineering control plans of the WHS (MPS) Regulation.

11.4.2. HRA notification procedure

The notification of "hot work" within the hazardous zone must be in accordance with clause 33 of the WHS (MPS) Regulation. The following is a list of preparatory actions which should be undertaken before notification is given, but is not an exhaustive list as items may change as a result of site-specific requirements and arrangements.

Note: It should be noted that incomplete or inadequate notifications may result in delays to the commencement of the hot work activities.

Preparation should include the following:

- A list of all alternative options to hot work in the hazardous zone which have been considered. Examples may include:
  - repair of equipment by other means
  - relocating the equipment to a non-hazardous zone such that the component can be welded on
  - dismantling and moving the components to the surface
  - changing ventilation such that the area is no longer a hazardous zone.

- The mine should demonstrate by risk assessment techniques that the hot work risk controls are as low as reasonably practicable.
- A copy of the task specific risk assessment which:
  - identifies the hazards. For example consideration should include possible gas (methane) incursion into the hot work activity area from sources such as windblast, unstable strata, atmospheric pressure changes, ventilation system interruptions, localised emission of gas from the strata, failure of methane drainage system, failure of main, booster and/or auxiliary fans, failure of stoppings.
  - establishes controls to eliminate or minimise the risk to an acceptable level.
- A plan of the area showing relevant information, equipment, power supply, ventilation and areas of potential gas.
- Work procedure (SWP, JSA, etc.) for the specific task.
- Clearly identify the authorised person (for example: Manager, Deputy Manager or Undermanager) that should be present on the hot work site at all times when hot work activities are being carried out.
- State the date and time, and which hot work activities are to be carried out.
- Determine details of inspections before, during and after hot work activities are carried out. Refer clause 11.3.4 as a minimum.
- Determine details of all electrical equipment.
- Document maintenance and inspection records for hot work equipment to ensure the equipment is safe to use.

11.4.3. Notification waiting period

The waiting period for the high-risk activity of conducting hot work in a hazardous zone is as per Schedule 3 of the WHS (MPS) Regulation.

NSW Resources Regulator

11.4.4. Inspections hazardous zone

11.4.4.1. Before the commencement of hot work in the hazardous zone

Hot work in the hazardous zone is a high-risk activity notifiable under legislation (refer clause 1.3 Legislative requirements for managing hot work). This clause should be considered when undertaking hot work in an underground coal mine.

For hot work in any area underground, a competent person (e.g. mining supervisor) is to carry out and record the following inspections before any hot work activities are commenced:

- A thorough examination of the area within a radius of 20 metres of the hot work site for the presence of:
  - adequate ventilation and positive air flow over the hot work site
  - flammable gas (e.g. less than 0.25% CH_4)
  - combustible materials – these are to be identified, removed or made safe so as not to present a hazard
  - strata conditions and floor conditions (e.g. water)
  - firefighting facilities which are operational and meet the criteria necessary for the task
  - adequate stone dust supplies (bags).
- An examination of the hot work equipment to ensure it is fit-for-purpose and safe for use. Arc welding equipment should be suitable and safe for use in a Category C environment (see AS 1674.2).
- An examination of the area within a radius of 15 m of the hot work site for confirmation that:
  - the walls, floor and roof are covered with a non-flammable material (heavily stone-dusted)
  - grease, coal dust and all movable flammable material are not in the vicinity of the area.
- The operator to be protected with appropriate PPE and have spare dry PPE available to change into if necessary.

11.4.4.2. During and after completion of hot work

A mining supervisor should inspect the hot work location:

- continuously while the equipment is in use
- continuously for at least two hours after completion of the hot work to ensure that the place is free from any fire or smouldering material and the site is in a safe condition. This may include wetting the area with water.

Inspections of the workplace by the observer/firewatcher during and after hot work is performed may vary depending on the risk and hazard identified. Accordingly, these will differ depending on the location where hot work is taking place (refer clause 11.1.2. 'Locations for hot work underground').

Considerations for inspecting the physical site should include the following:

- PPE is still functioning and not damp.
- Ventilation has not reduced.
- Dispersion of fumes as a result of the hot work is safely carried out.
- Monitoring of methane shows it is within acceptable levels (less than 0.25%).
- All dross and spent electrodes are progressively collected, cooled and contained in a metal container.
- Scrap metal is put aside, cooled and monitored.
- Lighting is adequate in the working area and on the work piece.

NSW Resources Regulator

Appendix A Abbreviations, definitions and standards

Abbreviations

a.c.	alternating current
AS	Australian Standard
AS/NZS	Australian/New Zealand Standard
AS/NZS IEC	Australian/New Zealand International Electro-technical Commission Standard
AS/NZS ISO	Australian/New Zealand International Organization for Standardization Standard
d.c.	direct current
EECP	electrical engineering control plan
FCAW	Flux cored arc welding – may be gas shielded with CO2 – FCAW(C) – or mixed gas – FCAW(M) – or self-shielded – FCAW(N)
GMAW (MIG/MAG)	Gas metal arc welding also known as MIG – Metal Inert Gas – and MAG – Metal Active Gas – welding
GTAW (TIG)	Gas tungsten arc welding also known as TIG – Tungsten Inert Gas – welding
HRD	Hazard-reducing device. A device designed to reduce the hazard of electric shocks from a welding circuit
HWMS	hot work management system
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
JSA	job safety analysis
LFL	lower flammable limit
LOC	limiting oxygen concentration
LPG	liquefied petroleum gas
MDG	mining design guideline
MECP	mechanical engineering control plan
MMAW	manual metal arc welding

MOC	minimum oxygen concentration
OCV	open circuit voltage also known as no-load voltage
PAPR	powered air purifying respirator
PHMP	principal hazard management plan
PPE	personal protective equipment
RCD	residual current device – also known as earth leakage protection
rms	root mean square
SAE	Society of Automotive Engineers (USA)
SDS	safety data sheet
SWP	standard work procedure
TN 07	Weld Australia Technical Note 7 – Health and Safety in Welding
TN 22	Weld Australia Technical Note 22 – Welding Electrical Safety
TRG	Technical reference guide
VRD	voltage reducing device – a type of hazard-reducing device (either internally or externally fitted to a welding power source) that is designed to automatically reduce the open-circuit voltage to a safer level
WHS Act	*Work Health and Safety Act 2011*
WHS Regulation	Work Health and Safety Regulation 2017
WHS (MPS) Act	*Work Health and Safety (Mines and Petroleum Sites) Act 2013*
WHS (MPS) Regulation	Work Health and Safety (Mines and Petroleum Sites) Regulation 2014

Definitions

For the purpose of this document the definitions below apply:

Backfire	Momentary retrogression of the flame into the mixed gas passages of the blowpipe, accompanied by a loud popping noise, and with or without flame extinction.
Backflow	The flow of gas from one of the inlet gas passages of the blowpipe at higher pressure into the other gas passage at lower pressure, including possibly the hose.

Competent person WHS Regulation cl 5 Definitions.	A person who has acquired through training, qualification or experience the knowledge and skills to carry out the task.
Confined space WHS Regulation cl 5 Definitions.	An enclosed or partially enclosed space that: a. is not designed or intended primarily to be occupied by a person, and b. is, or is designed or intended to be, at normal atmospheric pressure while any person is in the space, and c. is or is likely to be a risk to health and safety from: i. an atmosphere that does not have a safe oxygen level, or ii. contaminants, including airborne gases, vapours and dusts, that may cause injury from fire or explosion, or iii. harmful concentrations of any airborne contaminants, or iv. engulfment, but does not include a mine shaft or the workings of a mine. **Note:** The mine workings of an underground mine and any shafts are not considered confined spaces. However, these environments have unique hazards that need to be addressed to control the risk of hot work.
Electric shock	The physiological reaction or injury caused by electric current passing through the human body.
Electrocution	Death caused by electric shock.
Firewatcher	A person assigned to continuously monitor a hot work task to observe and ensure that no condition arises, or action is taken, that will lead to a hazardous situation in the hot-work area. **Note:** Often a firewatcher/observer are the same person dependent on competencies available.
Flashback	Retrogression of the flame into the upstream gas passages of the blowpipe, possibly including the hose, and with risk of subsequent explosion.
Flashback arrestor	A safety device incorporating as a minimum, a flame arrestor and additionally any other safety devices. See AS 4603.
Flammable gases WHS Regulation cl 5 Definitions.	Flammable gas has the same meaning as it has in the Globally Harmonised System of Classification (GHS) and Labelling of Chemicals, Third revised edition, published by the United Nations as modified under Schedule 6. Also refer to ‘A Manual on Mines Rescue, Safety and Gas Detection’ J Strang & P MacKenzie-Wood, ISBN 0 9588861 0 5.

Fuel source	Any substance or material that will sustain or propagate a fire or may cause an explosion.
Hazard reducing device	A device designed to reduce the hazard of electric shocks from a welding circuit.
Hazardous area WHS Regulation cl 5 Definitions.	An area in which— a. an explosive gas is present in the atmosphere in a quantity that requires special precautions to be taken for the construction, installation and use of plant, or b. a combustible dust is present, or could reasonably be expected to be present, in the atmosphere in a quantity that requires special precautions to be taken for the construction, installation and use of plant.
Hazardous zone (underground coal mines) Refer WHS(MPS) Regulation cl 3 Definitions.	Hazardous zone, at an underground coal mine, means each of the following: a. any part at the mine in which the concentration of methane in the general body of the air is 1.25% by volume or greater, b. a return airway, c. any part of an intake airway that is on the return side of such points that are within 100 metres outbye of: i. the most inbye completed line of cut-throughs, or ii. any longwall or shortwall face, but only to the extent that the intake airway is on the intake side of that face (but not if the longwall face is an installation face at which the development of the face, and mining for development coal, have been completed and at which longwall mining has yet to commence).
Hot work Refer WHS(MPS) Regulation cl 3 Definitions.	Welding, soldering, heating, cutting, grinding or vulcanising where a surface temperature of more than 150 degrees Celsius is likely to be generated. For this TRG, the definition does not include vulcanizing. It also does not include the cutting or drilling of strata. **Note:** This includes the use of mechanical, electrical or flame cutting and welding equipment. Examples are grinding, electric arc welding, arc brazing and arc cutting, plasma arc welding and cutting, oxygen-fuel gas welding, brazing, cutting or heating and other heat-producing or spark-producing operations.
Hot work equipment	Hot work equipment includes any blowlamp (blowpipe), flame-torch, grinding and cutting disc, sander, hand held grinders, electric welding equipment, oxy-acetylene or gas welding apparatus or similar heating and cutting devices and hand held equipment such as dye grinders, pencil grinders and other like equipment etc.

	considered to be hot work equipment if likely to generate sparks or temperatures greater than 150°C.
Intermittent backfire	Means a rapid succession of backfires with the flame re-igniting at the nozzle. This may be accompanied by a noise resembling machinegun fire.
May	Indicates an optional course of action that this guide is indicating the duty holder should consider. However, an alternative method of achieving a safe system of work may be chosen.
Mining supervisor Refer WHS(MPS) Regulation cl 3 Definitions.	An individual nominated to exercise any of the following statutory functions at the mine—mining engineering manager, undermanager, underground mine supervisor, deputy, quarry manager, open cut examiner.
Must	Indicates that legal requirements exist and must be complied with.
Observer	A person whose sole responsibility is to monitor the hot work operator's activity, and who is capable of responding appropriately in an emergency.
Output circuit safety switch	A device located between the welding machine and the electrode holder to enable the welder or an assistant to cut off the current supply to a welding handpiece.
Open circuit voltage or no load voltage	The voltage between the output terminals of a welding machine with no current flowing in the welding circuit.
Initial risk assessment	A risk assessment to identify the generic hazards, risks and controls associated with hot work on a mine or petroleum site. **Note:** An initial risk assessment may not adequately cover all risks for a specific task.
Reclaim tunnels	A tunnel in or under a stockpile used for removing product from the stockpile.
Should	Indicates a recommended course of action. **Note:** Deviations from recommendations should be provided with a respective management control, shown to provide the same level of safety outcome.
Splicing or vulcanising station	A place used for the repairs, joints or maintenance of conveyor belts. This may be on a routine basis or a one-off occurrence.
Stand-by person (confined space) Definition from AS 2865:2009: Confined Spaces.	A competent person assigned to remain on the outside of, and in close proximity to, the confined space and capable of being in continuous communication with and, if practical, observing those inside. In addition, where necessary, the competent person may operate and monitor equipment for the safety of personnel in the confined space and initiate emergency response.
Sustained backfire	Backfire resulting in a continuing internal flame in or near the blowpipe mixer passages, with resulting hissing or squealing sound.

Task specific risk assessment	A risk assessment which covers specific hazards and risks that lie outside the scope of the initial risk assessment, e.g. welding on hydraulic tanks, hazardous areas, wet areas, confined spaces, non-hazardous zones in underground coal mines and hazardous zones in underground coal mines.
Underground workshop	A garage or dedicated work area located in the underground parts of a mine intended for the purpose of undertaking repair and maintenance activities. **Note:** Workshops are often designated areas for the purpose of conducting hot work activities.
Voltage reducing device (VRD)	A type of hazard-reducing device (fitted either internally or externally to a welding power source) that is designed to automatically reduce the open-circuit voltage to a safer level when welding is not taking place[51].
Hot work management system (HWMS)	A systematic approach for the undertaking of hot work activities. The extent of the system will depend on the hazards at the mine or petroleum site.
Welder	A person who performs welding (including tack welding) or cutting operations. **Note:** The term 'welder' is often used incorrectly to refer to a welding power source.
Welding power source (also known as a welding machine)	A device that supplies welding current and output characteristics that are suitable for arc welding or allied processes.
Welding circuit (also known as output circuit)	An electrical circuit that includes the conductive material through which a welding current is intended to flow.

[51] Refer Weld Australia TN 07 and Weld Australia TN 22 for more information on VRDs

NSW Resources Regulator

Standards

The following list of documents are relevant for hot work activities. This list is provided for information only and it is not a full and comprehensive list of all documents that may be applicable.

Note: All Standards referred to in this guide relate to the current revision of the Standard, as amended from time-to-time.

AS/NZS 1269.3	AS/NZS 1269.3 Occupational noise management – Hearing protector program
AS/NZS 1270	AS/NZS 1270 Acoustics – Hearing protectors
AS/NZS 1335	AS/NZS 1335 Hose and hose assemblies for welding, cutting and allied processes
AS/NZS 1336	AS/NZS 1336 Eye and face protection – Guidelines
AS 1337.0	AS 1337.0 Personal protective equipment Eye and face protection – Vocabulary
AS/NZS 1337.1	AS/NZS 1337.1 Personal eye protection – Eye and face protectors for occupational applications
AS/NZS 1337.2	AS/NZS 1337.2 Personal eye protection – Mesh eye and face protectors for occupational applications
AS/NZS 1337.4	AS/NZS 1337.4 Eye and face protection – Filters and eye protectors against laser radiation (laser eye-protectors)
AS/NZS 1337.5	AS/NZS 1337.5 Eye and face protection – Eye protectors for adjustment work on lasers and laser systems (laser adjustment eye-protectors)
AS/NZS 1337.6	AS/NZS 1337.6 Personal eye protection – Prescription eye protectors against low and medium impact
AS/NZS 1338.1	AS/NZS 1338.1 Filters for eye protectors – Filters for protection against radiation generated in welding and allied operations
AS/NZS 1338.2	AS/NZS 1338.2 Filters for eye protectors – Filters for protection against ultraviolet radiation
AS/NZS 1338.3	AS/NZS 1338.3 Filters for eye protectors – Filters for protection against infra-red radiation
AS 1345	AS 1345 Identification of the contents of pipes, conduits and ducts

AS/NZS 1554.1	Structural steel welding – Part 1: Welding of steel structures
AS/NZS 1576.1	AS/NZS 1576.1 Scaffolding – General requirements
AS/NZS 1596	AS/NZS 1596 The storage and handling of LP Gas
AS 1674.1	AS 1674.1 Safety in welding and allied processes – Fire precautions
AS 1674.2	AS 1674.2 Safety in welding and allied processes – Electrical
AS/NZS 1680.2.4	AS/NZS 1680.2.4Interior and workplace lighting – Industrial tasks and processes
AS/NZS 1680.5	AS/NZS 1680.5 Interior and workplace lighting – Outdoor workplace lighting
AS/NZS 1715	AS/NZS 1715 Selection, use and maintenance of respiratory protective equipment
AS/NZS 1716	AS/NZS 1716 Respiratory protective devices
AS/NZS 1801	AS/NZS 1801: Occupational protective helmets
AS/NZS 1850	AS/NZS 1850 Portable fire extinguishers – Classification, rating and performance testing
AS 1851	AS 1851 Routine service of fire protection systems and equipment
AS/NZS 1869	AS/NZS 1869 Hose and hose assemblies for liquefied petroleum gases (LP Gas), natural gas and town gas
AS/NZS 1891.4	AS/NZS 1891.4 Industrial fall-arrest systems and devices – Selection, use and maintenance
AS/NZS 1892.5	AS/NZS 1892.5 Portable ladders – Selection, safe use and care
AS 1940	AS 1940 The storage and handling of flammable and combustible liquids
AS/NZS 1995	AS/NZS 1995 Welding cables
AS 2030.1	AS 2030.1 Gas cylinders - General requirements
AS 2030.2	AS 2030.2The verification, filling, inspection, testing and maintenance of cylinders for the storage and transport of compressed gases – Cylinders for dissolved acetylene
AS 2030.4	AS 2030.4 The verification, filling, inspection, testing and maintenance of cylinders for the storage and transport of compressed gases – Welded cylinders – Insulated

AS 2030.5	AS 2030.5 Gas cylinders – Filling, inspection and testing of refillable cylinders
AS/NZS 2161.1	AS/NZS 2161.1 Occupational protective gloves – Selection, use and maintenance
AS/NZS 2161.2	AS/NZS 2161.2 Occupational protective gloves – General requirements
AS/NZS 2161.3	AS/NZS 2161.3 Occupational protective gloves – Protection against mechanical risks
AS/NZS 2161.4	AS/NZS 2161.4 Occupational protective gloves – Protection against thermal risks (heat and fire)
AS/NZS 2210.1	AS/NZS 2210.1 Safety, protective and occupational footwear – Guide to selection, care and use
AS 2210.3	AS 2210.3: Personal protective equipment: safety footwear (ISO 20345, MOD)
AS/NZS 2210.4	AS/NZS 2210.4 Occupational protective footwear – Specification for protective footwear (ISO 20346:2004, MOD)
AS/NZS 2210.5	AS/NZS 2210.5 Personal protective equipment: Occupational footwear (ISO 20347, MOD)
AS 2374.1.2	AS 2374.1.2 Power transformers – Minimum Energy Performance Standard (MEPS) requirements for distribution transformers
AS 2444	AS 2444 Portable fire extinguishers and fire blankets – Selection and location
AS 2550.1	AS 2550.1 Cranes, Hoists and Winches – Safe Use – General Requirements
AS 2865	AS 2865 Confined spaces
AS/NZS 3000	AS/NZS 3000 Electrical Installations (known as the Australian/New Zealand Wiring Rules)
AS/NZS 3010	AS/NZS 3010 Electrical installations - Generating Sets
AS/NZS 3100	AS/NZS 3100 Approval and test specification – General requirements for electrical equipment
AS/NZS 3123	AS/NZS 3123 Approval and test specification – Plugs, socket-outlets and couplers for general industrial application
AS/NZS 3190	AS/NZS 3190 Approval and test specification – Residual current devices (current-operated earth-leakage devices)

AS/NZS 3191	AS/NZS 3191 Electric flexible cords
AS 3853.1	AS 3853.1 Health and safety in welding and allied processes - Sampling of airborne particles and gases in the operator's breathing zone - Sampling of airborne particles
AS 3853.2	AS 3853.2 Health and safety in welding and allied processes - Sampling of airborne particles and gases in the operator's breathing zone, Part 2: Sampling of gases
AS/NZS 3957	AS/NZS 3957 Light-transmitting screens and curtains for welding operations
AS 4214	AS 4214 Gaseous fire-extinguishing systems
AS 4267	AS 4267 Pressure regulators for use with industrial compressed gas cylinders
AS 4289	AS 4289 Oxygen and acetylene gas reticulation systems
AS 4332	AS 4332The storage and handling of gases in cylinders
AS/NZS 4502	AS/NZS 4502 Methods for evaluating clothing for protection against heat and fire
AS/NZS 4576	AS/NZS 4576 Guidelines for scaffolding
AS 4603	AS 4603 Flashback arresters – Safety devices for use with fuel gases and oxygen or compressed air
AS/NZS ISO 4801	AS/NZS 45001 Occupational health and safety management systems – Requirements with guidance for use
AS/NZS 4804	AS/NZS 4804 Occupational health and safety management systems – General guidelines on principles, systems and supporting techniques
AS 4839	AS 4839 The safe use of portable and mobile oxy-fuel gas systems for welding, cutting, heating and allied processes
ISO 10882-1	ISO 10882-1 Health and safety in welding and allied processes - Sampling of airborne particles and gases in the operators breathing zone - Part 1: Sampling of airborne particles
ISO 10882-2	ISO 10882-2 Health and safety in welding and allied processes -- Sampling of airborne particles and gases in the operators breathing zone -- Part 2: Sampling of gases'
ISO 11611	ISO 11611: Protective clothing for use in welding and allied processes

AS ISO 31000	AS ISO 31000 Risk management –Guidelines
AS/NZS 60079.10.1	AS/NZS 60079.10.1: Explosive atmospheres – Classification of areas – Explosive gas atmospheres (IEC 60079-10-1, Ed.1.0(2008) MOD)
AS/NZS 60079.10.2	AS/NZS 60079.10.2 Explosive atmospheres – Classification of areas – Explosive dust atmospheres
AS/NZS IEC 60300.1	AS/NZS IEC 60300.1: Dependability management – Part 1: Guidance for management and application
AS/NZS 60320.1	AS/NZS 60320.1 Appliance couplers for household and similar general purposes - General requirements (IEC 60320-1, MOD)
AS/NZS 60479.1	AS/NZS 60479.1 Effects of current on human beings and livestock – General aspects
IEC 60479-1	IEC 60479-1 Effects of current on human beings and livestock. General aspects
AS 60529	AS 60529 Degrees of protection provided by enclosures (IP Code)
AS 60974.1	AS 60974.1Arc welding equipment Part 1: Welding power sources – (IEC 60974-1, MOD)
IEC 60974-2	IEC 60974-2 Arc welding equipment: Liquid cooling systems
IEC 60974-5	IEC 60974-5 Arc welding equipment: Wire feeders
AS 60974.6	AS 60974.6: Arc welding equipment: Limited duty portable arc welding and allied process power sources (IEC 60974-6, MOD)
IEC 60974-7	IEC 60974-7 Arc welding equipment: Torches
IEC 60974.11	IEC 60974.11: Arc welding equipment: Electrode holders
IEC 60974-12	IEC 60974-12: Arc welding equipment: Coupling devices for welding cables
AS/NZS 61558.1	AS/NZS 61558.1: Safety of Power Transformers, reactors, Power Supply units and combinations thereof– General requirements and tests (IEC 61558-1, MOD)

NSW codes of practice

NSW Resources Regulator

- Emergency planning for mines
- Electrical engineering control plan
- Mechanical engineering control plan
- Safety management systems in mines

SafeWork NSW

- Welding processes
- Confined spaces
- Managing the risk of falls at workplaces

Other standards and documents

- Weld Australia Technical Note TN 07 – Health and Safety in Welding
- Weld Australia TN 22 – Welding Electrical Safety
- WTIA TN 05 – Flame Cutting of Steels (now published by Weld Australia)
- Weld Australia Technical Guidance Note TGN-SW01 - Fume Minimisation Guidelines: Welding, Cutting, Brazing and Soldering
- Weld Australia Technical Guidance Note TGN-SW07- Health & Safety in welding—Guides & forms
- NSW Resources Regulator Safety Bulletin (SB18- 17) Welding processes declared a carcinogen, dated November 2018
- Breath Freely Australia – Breath Freely in welding - https://www.breathefreelyaustralia.org.au/welding/

Appendix B Assessment for hot work management system

Note: The following checklist is to be used as guidance material for review of a HWMS. It is not intended to be a comprehensive list.

- ❑ Does a HWMS exist?

Is the HWMS:

- ❑ An easily understood document?
- ❑ Accessible to all employees and contractors?
- ❑ Actively maintained and up to date?
- ❑ Definite in the locations that the HWMS applies to?

Risk Assessment

- ❑ Has a risk assessment been carried out (view the documents)?
- ❑ Is the risk assessment team appropriately selected?
- ❑ Has the risk assessment been carried out in accordance with a recognised standard?
- ❑ Is this standard stated?
- ❑ Has an assessment to this standard been carried out?
- ❑ Does the risk assessment include:
  - ❑ Identification of risks to people?
  - ❑ Identification of risks to plant?
- ❑ Have all hazards associated with hot work been identified for each location where hot work is to take place?
- ❑ Have controls been put in place to adequately address the hazards stated?

Does the Initial Risk Assessment consider dedicated hot work areas on site such as:

- ❑ Surface general and workshops?
- ❑ Surface specific areas?
- ❑ Ambient temperature and humidity?
- ❑ Product processing plant?

- ❑ Confined spaces?
- ❑ Diesel Tanks etc.?
- ❑ Underground workshops?
- ❑ Underground garages?
- ❑ Splicing and vulcanizing stations?
- ❑ Non-hazardous zones (coal)?
- ❑ Hazardous zones (coal)?

Consultation

- ❑ Is there evidence that consultation has taken place?

Instruction, Training and Competencies

- ❑ Have competencies been defined for people carrying out hot work activities? Include observers/firewatchers and operators.
- ❑ Is there an authorisation process in place for these people?
- ❑ Do these competencies cover particular types of work?
- ❑ Does training include safe operation, inspection, and maintenance of the equipment?
- ❑ Have competencies been defined for supervisors of the work?

Audit, Monitor and Review

- ❑ Is there a process to audit hot work activities against the site's HWMS?
- ❑ Is there a process to audit the HWMS?
- ❑ Is a frequency stated for these audits?
- ❑ Is there a system for monitoring and recording defects and hazards identified?
- ❑ Is the HWMS revised after audit or reviews taken place?

Responsibilities and Accountabilities

- ❑ Is there a document owner as the person responsible for ensuring the document is kept up to date?
- ❑ Are accountabilities and responsibilities defined for all personnel associated with the hot work activities?

Documentation

- ❑ Are the relevant documents kept in accordance with the records management procedures set out in the mine or petroleum site's Safety Management System?

Maintenance and Inspection

- ❑ Is there a system to examine, inspect and test all hot work equipment to ensure it is safe to use?
- ❑ Does this system cover mechanical and electrical safety inspections?

Emergency Preparedness

- ❑ Does the HWMS consider emergency response?

General

- ❑ Is hot work activity being carried out in accordance with AS 1674.1 and AS 1674.2?
- ❑ Does the HWMS identify appropriate PPE to be worn?
- ❑ Is there a safe area identified for hot work activities?
- ❑ Have fire controls been addressed?
- ❑ Have ventilation requirements been addressed?

Specific Areas

- ❑ Does the HWMS include additional requirements for specific areas?
- ❑ Controls for electronically hazardous environments?
- ❑ Does this include:
  - ❑ Hot work permits?
  - ❑ Task specific risk assessments?
  - ❑ Site preparation?
  - ❑ Emergency response?
  - ❑ Particular requirements for types of areas, e.g. wet areas, hazardous areas and confined spaces?

Appendix C Assessment for HWMS for hot work underground in coal mines

Note: The following checklist is to be used as guidance material for review of a HWMS. It is not intended to be a comprehensive list. In addition to the above assessment for HWMS (see Appendix B), the following assessment can be used when hot work is being undertaken underground in a coal mine.

- ❑ Does the HWMS meet the general requirements of this Technical Reference Guide?
- ❑ Has notification been given to the NSW Resources Regulator for the high risk activity of conducting hot work in a hazardous zone?

Risk Assessment

- ❑ Is there an initial risk assessment to identify the hazards associated with each location that hot work activities will be carried out at underground?
- ❑ Has an assessment of alternative methods been conducted?

Does risk assessment include hot work in the following locations:

- ❑ Splicing station?
- ❑ U/G workshop?
- ❑ Non-hazardous zone?
- ❑ Hazardous zone?
- ❑ Hot work in emergency situations?

- ❑ Does this risk assessment identify the controls that are required to reduce the risk to an acceptable level?
- ❑ Does this risk assessment address items listed in clauses 11.1.3 and 11.1.4 of this TRG?
- ❑ Is there a process to identify when a task specific risk assessment is required in a workshop and splicing station?
- ❑ Is there a system for the appointment of hot work operators?
- ❑ Is there a system to record all inspections?
- ❑ Is there a system to transport equipment to the work site?
- ❑ Is there a ventilation and gas management procedure?
- ❑ Is there a system for the preparation of the site?
- ❑ Is there a system of fire-fighting facilities and procedures?
- ❑ Is there a system for inspections, before, during and after hot work?
- ❑ Is there an emergency response plan?

Hazardous Zones

- ❑ Is there a system to undertake hot work in a hazardous zone:
    - ❑ Have alternatives to hot work been considered?
    - ❑ Have all hazards be identified?
    - ❑ Is there a process to notify the Resources Regulator?

Appendix D Gas cutting, heating and welding equipment maintenance inspection schedule

Note: The following schedule is from Weld Australia's TN-07 and is based on Table 1 from AS 4839 -2001.

EQUIPMENT	MAINTENANCE		
	Weekly (if in constant use) or before every use (to be performed by the operator)	As nominated (to be carried out by technically competent person)	Refurbishment or replacement intervals (Equipment condition determines whether refurbishment or replacement is required)
☐Regulators (including their integral protective devices)	According to the manufacturer's instructions including – visual examination to determine suitability for service (e.g. gas, pressure rating, damage); condition of threads and sealing surfaces; and oil or grease contamination. Leak-test all joints at working pressure.	Six monthly: Functional tests to ensure the correct operation of internal components.	Manufacturer or supplier recommendation, but not exceeding five years.[52]

[52] Regulator elastomers and seals will wear and deteriorate in service and deteriorate out of service. Items stored for one year or over without use should receive inspection as per the annual maintenance inspection.

EQUIPMENT	MAINTENANCE		
	Weekly (if in constant use) or before every use (to be performed by the operator)	As nominated (to be carried out by technically competent person)	Refurbishment or replacement intervals (Equipment condition determines whether refurbishment or replacement is required)
☐ Flashback arrestors and other external devices (including non-return valves)	Visual examination to determine suitability for service (e.g. gas, pressure rating, damage); condition of threads and sealing surfaces; and oil or grease contamination. Leak-test all joints at working pressure.	Yearly as detailed in: AS 4603 or following a flashback: Proper functioning of the non-return valves and flashback arresters. For pressure-activated valves, check there is no flow in the normal direction with the valve tripped.	Manufacturer or supplier recommendations but not exceeding five years. Industry standard is to replace all flashback arrestors annually.
☐ Hose assemblies	Visual examination to determine suitability for service (e.g. gas, pressure rating, damage); condition of cover; and threads and sealing surfaces of the end fittings. Leak-test all joints at working pressure.	Six monthly: Check for absence of cuts and excessive wear by bending the hose in a tight radius, to ensure reinforcement is not visible.	Determined by the hose assembly condition.
☐ Blowpipes, mixers and attachments	Visual examination for damage of the threads and sealing surfaces of the hose connections and the attachment connections. Leak-test all joints at working pressure.	Six monthly: Test control valve function. Blank the attachment connection and leak-test for internal malfunction.	Manufacturer or supplier recommendation, but not exceeding five years.

Appendix E Recommended oxy-fuel gas daily inspection and pre-start check list

Note: The following is for guidance only and should be reviewed by a suitably qualified and competent person before use. (Source: Weld Australia TGN-SW07)

ITEM	DESCRIPTION OF INSPECTIONS TO BE CARRIED OUT
Gas Cylinders	Check cylinders are secured against falling over and in an upright position before making any connections. Check cylinder labelling. Check there is no mechanical damage.
Cylinder Valve	Inspect the valve for damage. If the valve appears to be damaged DO NOT OPEN. You may not be able to close it again. Do not crack cylinder valve – uncontrolled discharge of gas can be hazardous. Remove dust protection cap manually. Clean seat with a clean dry cloth prior to fitting gauges. USE NO OIL!
Regulators	Check type, rating and condition. When fitting regulators to cylinders ensure they are not contaminated with oil or grease. Face the front of the gauges and ensure the rears of the gauges are directed away from others when opening the cylinder valve. Use only oxygen compatible-o–rings and thread tape.
Flashback Arrestors	FBAs should be fitted at both the regulator and blowpipe ends of hoses and be suitable for the gas flow requirements. Check current inspection tag or sticker.
Hoses	Check correct type hoses are fitted. Oxygen – BLUE. Acetylene – RED. LPG – ORANGE. Check hoses for damage particularly at junctions to fittings where mechanical fatigue damage occurs. Maximum length of standard hoses is 15 metres. Use larger diameter hoses for increased length or high draw rate attachments e.g. heating torches. Refer to and follow recommendations of equipment manufacturers.
Blowpipe	Ensure the blowpipe is in good condition, the body is true, valves open and close fully, threads and seats are in good condition. Use only oxygen compatible-o–rings and thread tape.
Tip	Check the tip condition, seats are in good condition, face is flat and clean, holes are open and free of contamination, tip is the right size and type for the job in hand. Set regulator pressures to suit tip and plate thickness. Ensure the required flow rate of acetylene tips is within the safe draw rate of the acetylene cylinder/s (1/7th/hr).
Purging and Pressurising	• Ensure blowpipe valves are closed and regulator pressure adjusting knobs are wound all the way out (anti-clockwise). • Slowly open cylinder valves (one full turn only on fuel gas). • Wind regulator adjusting knobs in until required line pressure is indicated. • Individually open the blowpipe valves and allow gas to run through the line, readjust pressure to achieve correct pressure when gas is flowing, then close the blowpipe valve before opening the other one.
Pressure Test	• With the system purged and pressurised and blowpipe valves closed, close the cylinder valves. • Observe the regulator valves for one minute. Note any anti-clockwise movement of the cylinder pressure or regulated pressure gauges. • Open the cylinder valves. Note any clockwise movement of the cylinder pressure or regulated pressure gauges. • A change in the cylinder pressure gauge or regulated pressure gauge indicates a leak. • Find and eliminate all leaks. Use a soapy water technique to find leaks.
Lighting up	• Use approved lighting flint (not matches or cigarette lighter). • Light fuel gas with medium flow. If the flame is burning off the tip, reduce the fuel gas flow until the flame is coming off the tip. • Open oxy feed blowpipe valve to achieve the required flame.
Shutting down	• Shut down fuel feed blowpipe valve. • Shut down oxy feed blowpipe valve. • Close cylinder valves and depressurise the hoses and blowpipe.

ITEM	DESCRIPTION OF INSPECTIONS TO BE CARRIED OUT
	• Wind regulator adjusting knobs all the way out (anti-clockwise).
Storage	• Store in approved storage areas only. • Keep different gas types separated and empty and full cylinders segregated. • Be aware of mandatory requirements for storing gas cylinders.
Transport	• Transport in secure upright position. • Be aware of mandatory requirements for transporting gas cylinders.
Inspection Tag	Check that a current inspection tag, traceable to your equipment maintenance register, is attached to the equipment.

Notes

- If on completion of this pre-start checklist you are unsure of the safety of any part of this equipment - DO NOT USE. Isolate the equipment and notify your supervisor immediately, in order that remedial action can be taken.
- Fumes are generated by hot work. Take adequate precautions to limit exposure to fumes from welding consumables or surface coatings and contaminants.
- Oils, greases and other organic compounds may become highly flammable or explosive in the presence of pressurised oxygen. Ensure all fittings are clean and dry before assembly. Ensure there is no opportunity for contamination of parts.
- Ensure that you have all necessary Personal Protective Equipment in place, in good order and dry, before turning on the oxy-fuel gas equipment.

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Appendix F Electric welding equipment inspection schedules

Electric welding equipment should be inspected and maintained regularly, so as to keep the welding equipment in a safe working condition. There are three levels of inspections recommended:

- Daily/pre-use inspection checks
- Monthly inspection checks
- Overhaul inspection checks

The daily/pre-use inspection is a basic visual type of external inspection, and the inspection criteria advances through to overhaul where the equipment undergoes a comprehensive external and internal inspection.

Daily/pre-use inspection checks

The purpose of a daily/pre-use inspection is for the user of the equipment to identify, by a thorough visual inspection of the equipment, any physical damage or deficiencies to the welding equipment.

Welding equipment should be visually inspected each day prior to use. Daily checks should involve a complete visual inspection of the equipment by the person using the equipment.

This inspection includes the body of the welding machine, electrical cables to the primary and electrical leads to the secondary circuits, instruments, indicator lamps and controls, hand pieces, return work lead clamps, plugs and connectors.

Guidance on the checks to be carried out is shown below in ‘Recommended welding machine daily inspection and pre-start check list’. The person carrying out the checks should fill in a record of inspection.

Recommended welding machine daily inspection and pre-start check list

Note: The following is for guidance only and should be reviewed by a suitably qualified and competent person before use. This table is based on the version in in Weld Australia's TGN-SW07 and has been modified.

Recommended Power Source Daily Inspection and Pre-Start Check List	
ITEM	DESCRIPTION OF INSPECTIONS TO BE CARRIED OUT
Safety	Disconnect and isolate the power supply to the welding machine prior to performing these pre-start checks.
Plug & primary cable supply to the welding machine	Check the power supply cable and plug is for the rated current for the welding machine, and for any damage to plug. Special attention should be given to any cuts, burns, abrasions, and fraying or other damage to the cable insulation, which may expose live wires. Ensure the mains supply cable is located away from welding leads and connections. Ensure the cable is securely anchored onto welding machine and plug.
Power source	Inspect the welding machine for obvious damage to the cabinet, power switches, indicator lights or controls.
Welding lead connections	Ensure that welding lead connections to the welding machine are in good condition; contact surfaces are clean and are properly tightened. If terminal posts are used ensure only brass washers and the correct insulated type brass nut is used. Any unused terminal posts shall have an insulated brass nut in place. Ensure that all connections are fully insulated and leads are firmly anchored to fittings. • For A.C. welding machines check that electrode and work return leads are correctly connected to the welding machine. • For D.C. welding machines check polarity and ensure electrode and work leads are correctly connected for the procedure in use and that any other D.C. welding machines in the vicinity are connected with the same polarity.
Welding leads (Electrode and work return leads)	Examine all leads for damage such as cuts or abrasions, burns, damaged insulation or frayed wires or any other damage that may expose live wires. Electrode and work return leads should be of similar length. Electrode and work return leads should be of the same current carrying capacity and rated for the maximum current rating and duty cycle of the welding activity. Building steelwork shall not be used as a work return path.
Welding lead extension connections	Check that both the male and female connections are fully insulated with clean contact surfaces and all fittings are tightened properly with no conductors exposed.
Electrode holder	Check that the electrode holder is in good condition and is fully insulated with no cracked or damaged parts. • Cracked or damaged electrode holders must be taken out of service immediately. The electrode holder must be rated for the maximum current rating and duty cycle of the welding activity.
Work return clamp	Check that the work return clamp or connection is securely connected to the work return lead (no loose or broken strands of copper) and spring tension is good and the clamp is connected to the work piece close to the welding activity.
Engine drive welding machines	Check that all exhaust fume emissions are dispersed away from the work area and any other personnel working in the immediate vicinity. Do not use in an enclosed area or building.
Voltage reduction device (VRD)	If a voltage reduction device (VRD) is used ensure that the indicator lights or voltmeter are functioning and indicating low voltage (Safe → green) and high or welding voltage (Unsafe → green flashing or red) condition as the welding machine is operated in a normal welding cycle. *Note: This check is done with power on.*
Electrical inspection tag	Check that a current electrical inspection tag, traceable to your equipment maintenance register, is attached to the welding machine.
Notes • If on completion of this pre-start checklist you are unsure of the safety of any part of this equipment - DO NOT USE. Isolate the equipment and notify your supervisor immediately so that remedial action can be taken. • Residual current devices (RCD's) do not usually require daily or pre-start testing, however they should be tested by pressing the "Test" button in accordance with the manufacturer's recommendations (the RCD is working correctly if the power goes off). • Fumes are generated by hot work. Take adequate precautions to limit exposure to fumes from welding consumables or surface coatings and contaminants. • Ensure that you have all necessary Personal Protective Equipment in place, in good order and dry, before turning on the welding power source.	

Welding machine detailed inspection

The welding machine detailed inspection is a more detailed inspection, that in addition to the daily/pre-use checks also includes electrical tests and checks on VRD performance. An authorised person should carry out these inspections and tests.

Specific information on the electrical design requirements for welding power sources is contained in AS 60974.1, AS/NZS 1995, and AS 60974.6.

Information relating to the inspection and testing of welding power sources is contained in AS 1674.2.

Recommended detailed inspections

Carry out all the inspection checks as per the recommended daily/pre-use inspection checklist (above) and carry out the following checks:

Note: Refer to Table 5.1.2 in AS 1674.2 for minimum insulation resistance values

- Insulation resistance levels of mains power conductors and control circuits to earth and exposed conductive parts.
- Insulation resistance levels of welding circuit conductors and control circuits to earth and exposed conductive parts.
- Insulation resistance between the primary to secondary windings.
- Earth continuity on mains power supply cable to the frame of the welder.
- For machines fitted with a VRD the operation of the VRD should be verified by placing load resistors across the output circuit. Results of the test should verify the VRD switches between the low-voltage state and the open circuit voltage of the welding power source at resistance levels and within maximum timeframes in accordance with the manufacturer’s data sheet. Response time should be verified for switching from full OCV to low-voltage state.
- Indicator lamps should be checked to verify they correctly indicate status of the electrical circuit in accordance with the manufacturer’s data sheet.

Major service/inspection

Welding equipment should be given a major service at least annually. More frequent inspections are recommended in harsh environments where mechanical damage, corrosion or accumulation of potentially hazardous materials could lead to an electrical hazard. Servicing of welding power sources should be carried out by a competent service organisation or a competent electrician with knowledge of welding power sources who is familiar with the electrical components of welding sources.

Compliance of the welding equipment with the requirements of relevant Australian Standards should be verified, along with OEM requirements/specifications.

The purpose of these major inspections/service is to carry out a thorough assessment of the overall condition of the equipment and ensure electrical safety and functionality. This should include:

- A thorough visual inspection of the internal components and removal of accumulated dust and debris from within the casing of the welding machine.
- Inspection of all internal wiring including terminations, anchoring of cables, earth bonding, shielding and insulating covers, protection of wiring harnesses from abrasion and damage.
- The condition of switches, sockets, external cabling, instruments and indicator lamps.
- The condition of insulation.
- Insulation tests between windings.
- The condition of all connections, screw threads and fixings.
- Testing of VRD/HRD devices.
- No load voltage tests.
- Rated load voltage test.
- Temperature checks to verify the operation of overheating protective devices.
- Checks on the current rating of supply flexible cord(s).
- Tests for degree of ingress protection.
- Injection testing of electrical protection systems.
- Leakage current test.
- Earth leakage/RCD performance tests (including 0 and 180 degree phase testing).
- Portable Appliance Testing of the machine (supply cable/plug).
- An updated electrical major service inspection tag attached to the welding machine.
- Any associated equipment (such as an engine or a compressor) should be inspected and maintained in accordance with OEM recommendations.

Appendix G Thermal Lancing – additional information

Note: The information in this Appendix is provided to assist in undertaking a risk management approach when preparing to conduct thermal lancing. The information below is not an exhaustive list and is intended as guidance only.

Overview

A thermal lance, thermic lance, oxygen lance, or burning bar is a tool that heats and melts steel in the presence of pressurized oxygen to create very high temperatures for cutting, reaching over 3,000°C. It consists of a long steel tube (see Figure 1 below) packed with alloy steel rods, sometimes mixed with aluminium rods to increase the heat output. One end of the tube is placed in a holder and oxygen is fed through the tube.

The far end of the tube is pre-heated and lit by an oxyacetylene torch. An intense stream of burning steel is produced at the working end and can be used to cut rapidly through thick materials, including steel and concrete. The tube is consumed by the process within a few minutes. Due to the physical length of the thermal lance, the operator is able to make the cut without having to be directly next to or over the operation. The most common lance sizes are 6mm, 10mm and 12mm. They are also available up to 75mm in diameter.

A thermal lance kit typically consists of an oxygen cylinder, regulator, flashback arrestor, supply hoses, on/off valve with a latch to lock in position, shield and consumable steel pipe.

Some examples of thermal lance setups are provided in the figures below:

Figure 1 Consumable steel tubes

Figure 2 Thermic lance basics

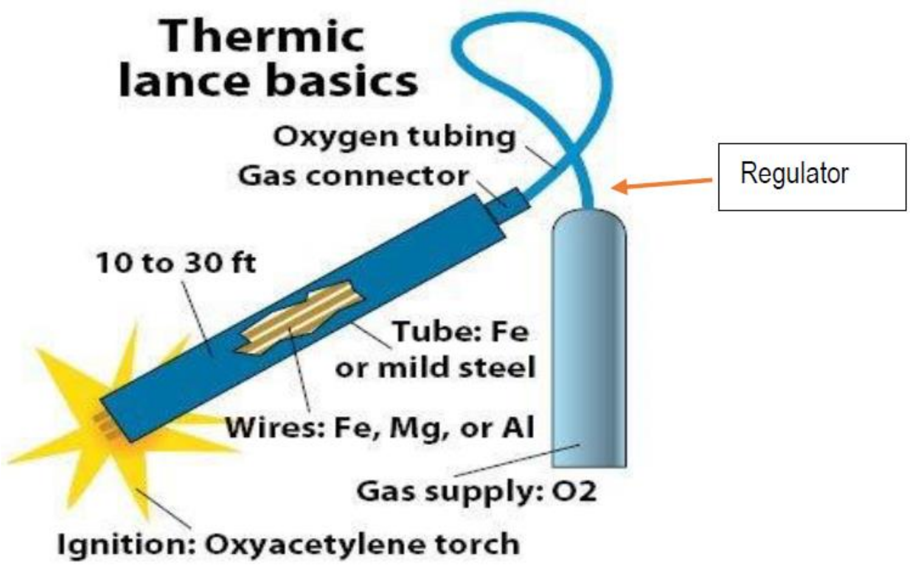


Figure 3 Schematic view of oxygen lance cutting

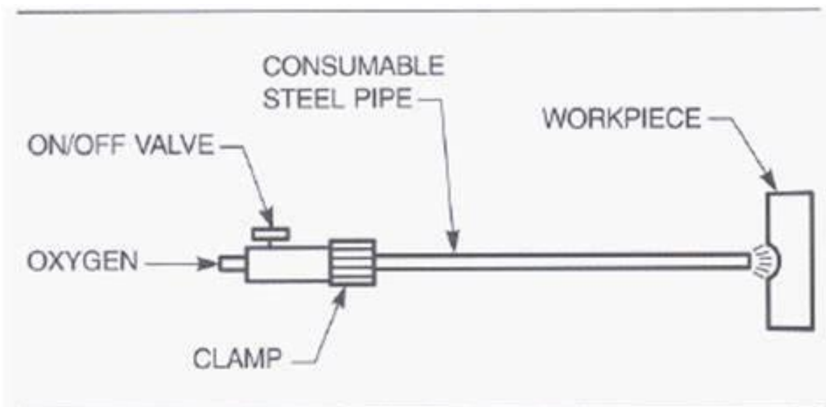


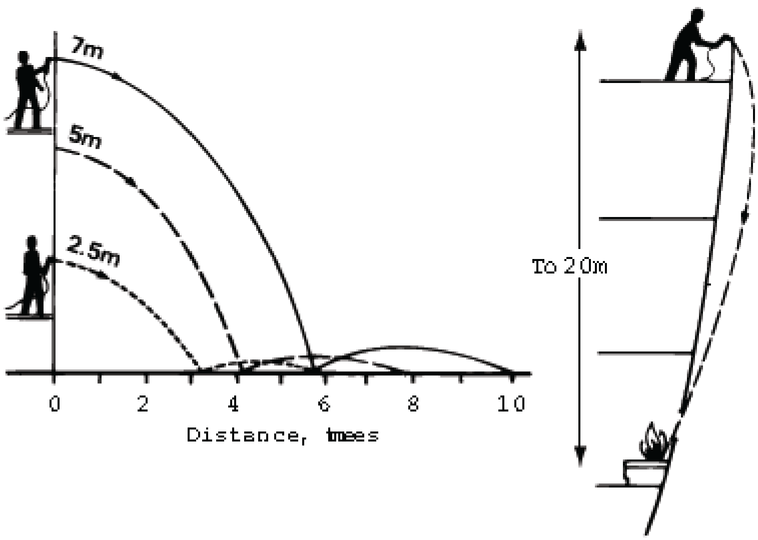
Figure 4 Example of a thermal lancing setup

Hazards

The following is a list of hazards associated with thermal lancing. It is not an exhaustive list and is intended as guidance only:

- failure to isolate other energies including item falling when cut
- extreme heat (up to 4000ºC and liquid slag of iron oxides and other materials, which sprays, splashes and dribbles out over large areas, just like an enormous firework sparkler)
- burns and heat radiation during lancing and steam burns when cooling components
- fire and explosion
- concrete/floor damage of work area due to slag dropping and pooling
- unstable ground conditions
- unwanted/uncontrolled vehicle and people interaction
- tools and equipment not fit-for-purpose
- people not competent or untrained for the task
- unplanned movement of machine
- toxic fumes
- inadequate ventilation
- firewatcher not competent in understanding process and actions
- sealed voids behind components that cannot be vented to atmosphere
- inadequate PPE
- damage to other material surfaces to include molten metal
- generation of sparks and particles at high temperature. Such particles can travel long distances while retaining sufficient heat to cause combustion as illustrated by Figure 5 below. Even if fires do not commence immediately, smouldering of combustible matter leading to fire at a later time may result.

Figure 5 Ground clearances when lancing at height



Pre-use inspection of thermal lancing equipment

The following is not an exhaustive check-list and is intended as guidance only:

- Ensure oxygen cylinders are secured.
- Ensure the oxygen cylinder is fitted with a dedicated and appropriately rated flow regulator.
- Inspect hand piece and on/off valve to ensure it is fitted with a latch to open/close the valve to prevent unintended oxygen release.
- Inspect hoses for oxygen leaks.
- Ensure all connections are securely tightened and are not leaking.
- Inspect lance torch and check locking assemblies for lance rod diameter are installed.
- Check oxygen delivery lines are rated and sized for the required flow.
- Check lance rods are the correct size for the task and the handles being used.
- Ensure splash protection shield is in place.

Personal protective equipment

The following PPE should form part of every thermal lancing task:

- goggles or shields with appropriate light filters
- thick fire-retardant mittens/gloves
- suitable respirators (P2 minimum, PAPR)
- a fire-retardant full head and face mask/hood
- suitably weighted steel makers suit and apron
- fire retardant boots and boot protector/linings
- adequate hearing protection.

Protection material

Material used to protect slag from the lancing process from hitting unwanted components such as flooring, and structures and components such as aluminium engine sumps is called 'protection material'. Common protection material can be compressed fibre, sand or 10-20mm steel plate.

Fire watcher

A nominated fire watcher with skill and knowledge of the lancing process should be present at all times while thermal lancing is being conducted.

A fire watcher should:

- monitor for any fires or other hazards
- take immediate action to combat any outbreak of fire that may occur
- immediately stop the work and withdraw the hot work permit if a hazardous condition is observed
- monitor for any slag distribution
- monitor the gas and equipment
- monitor for other people entering the area

- monitor other parts of the plant for damage during the lancing process
- ensure appropriate firefighting equipment is in close proximity to the work area
- inspect adjoining areas or compartments and determine if heat transfer is possible
- monitor changes in wind direction
- wear the appropriate PPE required for the task
- not allow hot work to proceed outside the area specified on the hot-work permit
- not leave the job unless properly relieved by an authorised person
- not be involved in other activities of the job such as being a trades assistant
- remain in the hot work area until at least 30 minutes after hot work activities have ceased and no fire conditions are identified after this time.

Setting up the job

Note: The temperature generated in the thermal lancing process is greater than the melting point of any known substance – with diamond having the highest at 3,547°C. Stringent controls and maintenance of these controls is critical.

The following precautions should form part of setting up the task of thermal lancing:

- Remove any flammable material and equipment within a radius of 15 metres or cover with a suitably rated fire blanket.
- Set up protection of surrounding equipment and components to prevent damage by the lance or slag dripping. Consider damage to flooring and protect where required. This can be achieved by having sand baskets to capture the slag material. See 'protection material' section above. Ensure suitable fire-fighting equipment is located within reach.
- Locate and protect gas and oxygen cylinders from sparks.
- Operators should work upwind of the lancing location if possible or use extraction fans or good ventilation. This should be done in conjunction with forced ventilation helmets or other appropriate PPE.
- Place barriers to prevent personnel from crossing the path of the flames. No other people should be working within 2.5 metres of any person carrying out thermal lancing.

Note: The process of thermal lancing creates iron oxide fumes, ozone and aluminium fumes and dust which are a hazard to the health of the workers carrying out this task and also to bystanders such as firewatchers.

- Clean the lancing area thoroughly prior to commencing using a steam cleaning or non-flammable/non-combustible solvent.
- Remove all grease seals and cages. Polymeric seals and bushes may decompose into noxious fumes when exposed to high temperatures.

Note: The presence of oil or grease can cause ignition to occur and the rapid oxidation that results can cause fire to rage at a very high temperature and with a ferocity that may be hard to control.

- Particular attention should be paid when lancing pins[53] or any component where it is possible a sealed void may be present behind it. A thorough understanding of the area is required to ensure this hazard is adequately managed.

Note: Steam can expand 1700:1 times the liquid volume during quenching and/or rapid oxidation of hydrocarbons pressurising the area behind the components causing them to eject violently if the void is not vented to atmosphere.

- Use of isolation procedures – this could also mean the removal or deflation of tyres, removing pressure in accumulators and also protection of hydraulic hoses and lines and protection of fuel systems. Also consider overheating of seals on hydraulic cylinders or other such similar components for protection. Another consideration would be the protection of any windscreens or other plastic or fibreglass material.
- Use of protective fire blankets, 10-20mm steel plate, sand or compressed cement to protect other parts of the plant from damage during the lancing process. This should include protection of flooring.
- Workers should position themselves out of the line of fire of any potential release of energy.
- Provision should be made for supporting/restraining the member/component or other supported components when the cut is made.

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[53] Refer to www.resourcesregulator.nsw.gov.au/safety-and-health/incidents/investigation-reports for the following resources relating to a lancing incident where a worker was injured by a pin ejected under pressure:

- Investigation Information Release - Causal investigation initiated after worker injured by pin ejection under pressure (IIR19-09, August 2019)
- Causal Investigation Report - Pin Ejection Incident, Ravensworth Open Cut Mine
- Learning from investigations video resource: Worker injured by pin ejecting under pressure.

Appendix H Health effects of welding fume

The fume given off by welding and hot cutting processes is a varying mixture of airborne gases and very fine particles that can cause a range of acute and chronic respiratory ill health effects if inhaled.

Acute respiratory health effects include irritation of the throat and larger airways in the lungs, irritant-induced asthma, metal fume fever and acute pneumonia. Irritation and dryness of the throat, coughing and tightness in the chest is often caused by the ozone in tungsten inert gas (TIG) welding of stainless steel and aluminium, while high exposures to nitrogen oxides during a.c. welding can also cause irritation. Exposure to high concentrations of inhaled irritants can also cause asthma. Flu-like symptoms of metal fume fever are caused by short-term exposure to high fume concentrations from welding galvanised metals or mild steel. Metal fume fever is a temporary effect, with the onset usually starting after welding begins and continues for some time after exposure has ceased. Exposure to welding fume can also increase the risk of developing lung infections and pneumonia.

More serious, chronic health effects develop more gradually after exposure to welding fume over longer time periods. Prolonged and repeated exposure to welding fume is associated with lung cancer, chronic obstructive pulmonary disease (COPD), welders lung and occupational asthma.

Welding of stainless steel fume is considered more harmful than mild steel fume as it contains chromium oxide (CrO_3) and nickel oxide, which are both asthmagens (cause asthma) and carcinogens - although there is a higher risk of lung cancer for all welders. Exposure to welding fume also causes neuro physiological and psychological effects due to inhalation of manganese fume; while the inhalation of ozone and nitrous oxides can also cause respiratory irritation, bronchitis and possibly pulmonary oedema.

Welders are known to be particularly susceptible to lung infections that can, in some cases, lead to pneumonia. Other health hazards include asphyxiation through using inert gases that reduce the amount of oxygen in enclosed spaces. Exposure to tobacco smoke acts with welding fume to cause more damage to the lungs than would be the case with exposure to welding fume or smoking alone.

***Sources**: AIOH Breathe Freely Australia – Controlling Exposure to Prevent Occupational Lung Disease in Welding; HSE COSHH Essentials for Welding, Hot work and Allied Processes – HSG173*