

Work Health and Safety Variation of Codes of Practice Notice (No. 3) 2011

The Tunnelling Code of Practice 2007 has been varied under section 274 of the *Work Health and Safety Act 2011* by the *Work Health and Safety Variation of Codes of Practice Notice (No. 3) 2011*:

This notice commences:

- (i) on 31 March 2012 in relation to all variations except those in section 2.2.7.8; and
- (ii) on 1 July 2012 in relation to those variations in section 2.2.7.8.

Signature: _____
Minister for Education and Industrial Relations

Date: _____

Tunnelling Code of Practice 2007

The code of practice entitled the 'Tunnelling Code of Practice 2007' has been amended by:

Contents

Regenerate as necessary.

2.2.1 Site investigation

Fourth paragraph, insert new dot point 'rock cutting and dust production'

2.2.7.3 Communication systems

After end of text insert:

'The WHS Regulation requires that a PCBU must manage risks to the health and safety of a worker associated with remote or isolated work. In minimising risks to the health and safety of workers associated with remote or isolated work, a PCBU must provide a system of work that includes effective communication with the worker.'

There needs to be an effective method of warning all persons underground that the tunnel is to be evacuated and which can be activated quickly in the event of an emergency call. Emergency warning systems need to be tested, using emergency evacuation drills.'

2.2.7.4 Amenities

First paragraph after boxed text, insert at end of sentence '(for example a RESPA type system)'

2.2.7.5 Personal protective equipment (PPE)

Section titled 'Respiratory protective equipment', omit all text and insert:

'Where people could be exposed to harmful atmospheric contaminants, such as siliceous dust, diesel particulate matter and welding fumes, respiratory protective equipment that complies with *AS/NZS 1716 – Respiratory protective devices* (providing it is within the performance capability of the PPE) should be provided. Such equipment should be selected and used in accordance with *AS/NZS 1715 Selection, use and maintenance of respiratory protective equipment*. Persons using respiratory protective equipment must be provided information, instruction and training of use of the equipment (for example for the equipment to be effective a person needs to be clean shaven).'

Section titled 'Self-rescuers', omit all text and insert:

'Where people could be exposed to harmful atmospheric contaminants beyond the capacity of the ventilation system or respiratory protective equipment, self-rescuers should be provided to each worker, and be available for use by the worker, in an emergency to give the user sufficient oxygen to walk to the surface, or a designated sealable respirable air equipped refuge. The size of the self-rescuer (e.g. minutes) needs to relate to the maximum distance the worker may have to walk (via either their primary or secondary means of exit) to a safe place of refuge or the surface.'

2.2.7.8 Emergency Response

Omit title and all text and insert:

‘2.2.7.8 Preparation, maintenance and implementation of emergency plan

A person conducting a business or undertaking at a workplace must ensure that an emergency plan is prepared for the workplace that provides for the following:

- (a) emergency procedures, including:
 - (i) an effective response to an emergency; and
 - (ii) evacuation procedures; and
 - (iii) notifying emergency service organisations at the earliest opportunity; and
 - (iv) medical treatment and assistance; and
 - (v) effective communication between the person authorised by the person conducting the business or undertaking to coordinate the emergency response and all persons at the workplace;
- (b) testing of the emergency procedures, including the frequency of testing;
- (c) information, training and instruction to relevant workers in relation to implementing the emergency procedures;
- (d) first aid and rescue procedures to be followed in the event of an emergency in the tunnel or other confined space.

The first aid, escape and rescue procedures applicable for an emergency in the tunnel or a confined space must be initiated as soon as practicable in an emergency.

A person conducting a business or undertaking at a workplace must maintain the emergency plan for the workplace so that it remains effective.

The person conducting the business or undertaking must consider all relevant matters including:

- (a) the nature of the work being carried out at the workplace; and
- (b) the nature of the hazards at the workplace; and
- (c) the size and location of the workplace; and
- (d) the number and composition of the workers and other persons at the workplace.

A person conducting a business or undertaking at a workplace must implement the emergency plan for the workplace in the event of an emergency.

The preparation of an emergency plan for a workplace shared by a number of PCBU's (e.g. contractors, subcontractors, suppliers, emergency service organisation) must be prepared in consultation and cooperation with all PCBU's who share the workplace. The person with management or control of the workplace (e.g. the principal contractor) should co-ordinate the consultation.

If the workplace presents a significant hazard in an emergency or the emergency plan includes a potential role for an emergency service organisation such as Queensland Fire and Rescue Services then the PCBU

must consult, cooperate and coordinate with the emergency service organisation in the preparation, maintenance and implementation of the emergency plan. The PCBU should provide a copy of the emergency plan for the workplace to the emergency service organisation prior to work commencing or after any review to ensure the duty to consult, cooperate and coordinate has been fulfilled.

If the emergency service organisation gives the person a written recommendation about the content or effectiveness of the emergency plan, the person must revise the plan in accordance with the recommendation or in another agreed way.

If the emergency plan does not include any role for an emergency service organisation then the risk assessment completed for work conducted in the tunnel should document why there is no role for an emergency service organisation.

Workers and their health and safety representatives must be consulted when reviewing, and if necessary revising, the emergency plan by the person responsible for preparing it.

All rescue-related safety measures have to be brought together and described in detail in the emergency plan. Fundamentally, the rescue measures regarding tunnel construction projects are divided into self-rescue measures and rescue measures taken from outside the tunnel. The importance of self-rescue rises with the length and the difficulty of the access which the emergency services have to pass before reaching the place of the incident. Time and energy for performing necessary self-rescue measures are determined by the expected maximum time period between the occurrence of the event and the arrival of the emergency services at the place of the incident. The maximum allowed number of persons within the tunnel has to be taken into account when determining safety facilities and rescue capacity.

The emergency procedures in the emergency plan must clearly explain how to respond in various types of emergency, including how to evacuate people from the workplace in a controlled manner. The procedures must be written clearly and simple to understand.

The triggers for evacuation of the tunnel need to be carefully set out, and should include:

- confirmed or suspected underground fire irrespective of size;
- compromised primary ventilation system (fans and/or intakes, ventilation controls) which impacts on the integrity or readiness of the emergency plan;
- failure of fire fighting systems (e.g. loss of water supply if the tunnels partly rely on sprinkler systems);
- compromised primary ventilation intake air (an example could be a surface fire or chemical spill which could affect the fresh air intakes). For this reason, great care should be taken in allowing combustible or toxic

material (diesel fuel storage, heavy vegetation, ammonia refrigeration plants, etc) near fresh air intakes;

- seriously compromised emergency system equipment (communication equipment, breathable air systems, emergency lighting, recall of self-rescuers, etc).

Types of emergencies considered should include:

- treatment and evacuation of a seriously injured person
- fire underground (e.g. fire on a tunnel-boring machine (TBM) or a truck)
- sudden flooding (e.g. inrush from an underground water feature)
- underground explosion (e.g. methane ignition or other airborne gases, vapours and dusts)
- hazardous atmosphere (e.g. harmful concentrations of any airborne contaminants or an atmosphere that does not have a safe oxygen level)
- tunnel collapse, resulting in people being trapped
- power failure, and
- above ground emergency that compromises tunnel safety (e.g. fire or chemical spill).

The PCBU should ensure that, in the event of an emergency at a project, arrangements have been made for:

- allocation of roles and responsibilities for specific actions in an emergency to persons with appropriate skills — for example, appointment of area wardens
- clear lines of communication between the person authorised to co-ordinate the emergency response and all persons at the workplace
- the activation of alarms and alerting staff and other people at the workplace
- the safety of all the people who may be at the workplace in an emergency, including visitors
- workers or other persons who will require special assistance to evacuate
- specific procedures for critical functions such as a power shut-off
- identification of safe places
- potential traffic restrictions
- distribution and display of a site plan that illustrates the location of fire protection equipment, emergency exits and assembly points
- the distribution of emergency phone numbers, including out-of-hours contact numbers
- access for emergency services (such as ambulances) and their ability to get close to work area
- the safe and rapid evacuation of people from the workplace
- appropriate medical treatment of injured people
- regular evacuation practice drills (at least every six months or as soon as practicable after the plan has been amended)
- the use and maintenance of equipment required to deal with specific types of emergencies (for example, spill kits, fire extinguishers, early warning systems such as fixed gas monitors or smoke detectors and automatic response systems such as sprinklers), and
- regular review of procedures and training.

The following emergency response control measures should be implemented:

- providing a system to identify who is underground (e.g. a tag board)
- developing site emergency procedures appropriate for the level of risk, including establishing an emergency assembly area and a plan for contacting, and subsequently interacting with emergency services
- providing emergency response equipment and training in how to use it
- providing control measures to reduce the severity of the emergency (e.g. self-closing bulkheads to control water inrush)
- providing fire suppression on vehicles, and
- providing self-rescuers, breathing apparatus and sealable, self-contained atmosphere refuges as well as instruction and practice in how to use the equipment.

Risk assessments determine if special emergency provisions, such as emergency rescue cages and means to extract people from difficult locations (e.g. from the base of a shaft or heading of a tunnel), are needed.

Traffic management rules should be implemented to ensure vehicles and mobile plant park in a way that prevents potential runaway and enables clear access at all times.

Emergency procedures must be tested in accordance with the emergency plan in which they are contained.

Evacuation procedures should be displayed in a prominent place, for example, on a noticeboard. Workers must be instructed and trained in the procedures.

Further guidance on emergency plans and procedures is available in *AS 3745 – 2010 Planning for Emergencies in Facilities.*

2.2.7.9 Fire and Explosion

Omit all text and insert:

‘The PCBU and principal contractor have a duty to control risks associated with fire and explosion.

Fire in an underground workplace is of particular concern, as the rapid consumption of oxygen and the production of noxious fumes and gases makes the severity of this risk extreme. In addition to the production of noxious fumes and gases a fire will reduce, and in some cases eliminate, visibility and there is a significant risk that the fire will block at least one means of exit from the tunnel forcing workers to seek an alternate exit or safe refuge.

While there are combustible materials present in a tunnel the risk of fire is always present, every tunnel construction project must be prepared for such an event. The principal contractor and all PCBU’s must ensure that all working areas, installations and equipment used, in a tunnel construction project, are managed in such a way that the initiation or support of a fire or combustion is eliminated or minimised as far as is reasonably practicable.

An emergency preparedness plan should be in place and understood by all personnel working in the tunnel and adequate appliances for the suppression of fire should be provided.

Diesel powered equipment is associated with a significant risk of fires. Many of these fires result from hydraulic or fuel hose failures, allowing oil or fuel to spray on to hot parts, sparking from abraded direct-current (DC) power leads damaging fuel lines, hot surfaces such as exhausts and turbochargers and binding brakes causing grease fires in wheel hubs and igniting tyres.. Other potential ignition sources include naked flames, hot work (e.g. welding, cutting and grinding), electrical equipment and sources of static electricity, near flammable substances, dusts or waste materials.

Diesel Equipment Fire Precautions

All diesel equipment operating within the tunnel should be inspected for fire risk by a competent person. Consideration should be given to modifications and systems to minimise the incidence and severity of fires associated with diesel equipment, including:-

- fitting loaders, trucks, turbocharged vehicles and other vehicles larger than 125kW with a fixed Aqueous Film Forming Foam (AFFF) or Film-Forming Fluoroprotein (FFFP) system or another equivalent fire suppression solution;
- the installation of brake drag/brake temperature indicators;
- the suitable fusing and insulation of high current electrical systems;
- a fail safe engine shut down system;
- the installation of engine fire walls, in particular in loaders;
- the relocation of electrical wiring and hydraulic hosing from the engine compartment;
- the shielding of hot parts from possible oil or fuel spray;
- the provision of fire fighting equipment in accordance with Australian Standard AS 2444 "Portable Fire Extinguishers- Selection and Location"; and
- the integration of the activation of the AFFF system with the engine management system.

Hot Work Procedure

Where a blow torch, welding, cutting or other hot work equipment is used underground in a location where a fire may endanger a tunnel entrance or exit or where the fumes from the fire may jeopardise the safety of persons in the tunnel, implementation of standard written procedures for the safe use of such equipment is essential. In critical or identified fire risk areas a "work permit" system is warranted.

Electrical Equipment

Procedures and suitable fire fighting facilities should be in place and notices placed close to electrical installations to ensure correct procedures are followed in case of fire. Fire fighting equipment is best located on the ventilation intake side of the hazard.

Training For Underground Fire Emergency

Effective training is probably the most crucial factor determining the success of personnel protection strategies. Training should include:-

- basic recognition of fire hazards and fire prevention;
- response to various types of fires (eg. selection and use of extinguishers);
- use of communication systems and emergency message techniques;
- when and how to use self rescuers, and their limitations;
- orderly evacuation procedures and use of escape routes;
- use of refuge chambers and fresh air bases;
- survival techniques when trapped or lost underground; and
- occupational first aid.

In addition PCBU's should ensure the following control measures when implementing fire prevention procedures:

- eliminating activities that could generate flammable or explosive atmospheres, or control the generation by providing adequate ventilation
- removing unnecessary flammable substances, dusts or waste regularly
- providing an appropriate number and type of fire extinguishers strategically located around the site (including flammable goods storage areas)
- highlighting fire extinguishers, fire hoses and hydrants so they are easily identifiable and easily accessed
- providing flammable goods storage areas, identified with appropriate warning signs
- providing automated fire protection where possible – this may depend on the type and size of plant used, particular nature of the tunnel, difficulty of egress underground work areas and also the potential for fire
- developing site emergency procedures appropriate for the level of fire risk, including establishing an emergency assembly area, and
- providing self-rescuers, breathing apparatus and sealable, self-contained atmosphere refuges as well as instruction and practice in how to use the equipment.'

2.2.7.10 Record keeping

Third dot point, omit all text and insert 'workplace environment reports (occupational hygiene, e.g. dust, diesel particulate matter (DPM), noise, carbon monoxide, heat and ventilation)'

2.2.7.12 Access

Omit title and all text and insert:

'2.2.7.12 Entry, Exit and Escape Routes

When conducting a risk assessment about safe entry and exit to, from and within the workplace, the following must be considered:

- the layout and condition of the premises, including the presence of any confined spaces
- the physical working environment, including the potential for people slipping, tripping or falling
- how to avoid objects or structures falling on people, and
- how to control the risks to visitors coming onto the worksite.

An assessment of should also take into account:

- the number of people using particular entry and exit points
- any tools and equipment that may need to be carried to or from the worksite
- lighting, ramps, walkways, stairways, scaffolding and ladders.

Examples of hazards include:

- wet or oily floors or surfaces
- untidy work areas
- cluttered passageways
- steep or slippery steps
- exposure to plant
- poorly-lit work areas
- trenches, steel reinforcing or bars prior to concrete pours and vertical benches at blast sites.

Control measures that could be introduced include:

- installing overhead and fall protection
- storing materials and plant
- keeping work areas and passageways clear and free of obstructions
- removing rubbish, including construction waste and excavated material
- providing handrails
- implementing traffic management controls, including collision avoidance guidelines on the surface and underground
- erecting safety fences and warning signs, and
- providing non-slip surfaces on passageways and work platforms on plant and machinery.

ESCAPE ROUTES

An alternative escape route for tunnel workers must be available. Examples of escape routes include connected parallel tunnels, return airways or exhaust shafts. In a fire emergency such airways can be expected to have limited visibility and may have an irrespirable atmosphere. Some of these could be chimneys in the event of a fire. Exhaust shafts should never be the second egress.

Integrity of Escape Routes to Surface

Escape routes that cannot be maintained in fresh air with certainty during an emergency should be evaluated to determine if they should or should not be used in the event of fire.

The initial problem confronting an underground worker in the event of a fire is securing an immediate supply of breathable air. This is normally addressed by supplying everyone working underground with an oxygen-generating self-contained self-rescuer (SCSR). These devices come in various designs, and allow a person to travel from an endangered position to the surface or a safe haven.

It is recommended that the maximum distance separating a worker from the surface or a safe haven (e.g. a refuge chamber) be based on how far a person, in a reasonable state of physical fitness, can travel at a moderate walking pace, using 50% of the nominal duration of the SCSR. If it is assumed that workers are equipped with SCSRs of nominal 30-minute (minimum) duration, at a rate of 30 litres per minute, then no-one should be expected to travel further than 750 m to reach safety.

This distance should be regarded as an absolute maximum because:

- the duration of the SCSR can be adversely affected by the wearer's state of agitation
- physical difficulties may be encountered while travelling
- smoke from a fire underground may be so thick that crawling is the only feasible means of movement.

The alternative to using the escape routes to surface is to use refuge chambers, fresh air bases or a combination of these. Workers should be notified through induction and regular retraining on where to report in a fire emergency. Refuge chambers should be sited near active workplaces, taking into account the needs of people working there and potential hazards they face.

Vehicles within the tunnel introduce a significant risk to the health and safety of workers. Vehicles increase the risk of fire, risk of death or injury resulting from coming into contact with vehicular traffic or moving plant, and risk compromising the integrity of an escape route by blocking or hindering access.

The principal contractor should establish a permit system for vehicles entering the tunnel to ensure:

- Vehicles have been modified to minimise fire risk;
- The number of vehicles in the tunnel at any time is minimised;
- The number and location of vehicles in the tunnel is known;
- Workers have been provided with information, instruction and training for driving the vehicle within the tunnel and where to park the vehicle to ensure escape routes and access to services or emergency equipment are not blocked or compromised.

Escape Route Signs

Escape route signs and notices posted in the tunnel, should be properly maintained and marked in accordance with the Regulations and Australian Standard AS 1319. They should also be conspicuous and located at a low elevation in order to be visible in smoke. In areas that are difficult to traverse in low visibility, the strategic placement of lighting, ropes or chains to guide employees to safe egress is of benefit.

Unfamiliar Escape Routes

Escape routes from the workplace may include travelling in parts of the tunnel not normally travelled by some employees. All floor openings should be fenced and the escape route well marked.

Rescue Team Access

All escape routes and ladderways giving access in a tunnel should be of sufficient dimensions to permit stretchers and rescue team members using breathing apparatus to pass without undue hindrance.

Entrapped Procedure

All persons who are required to work or visit a tunnel need to be instructed in entrapped procedures, or be accompanied by a person with the knowledge of entrapped procedures. An incidence of fire or explosions in the tunnel can expose a person or persons to an irrespirable atmosphere, where escape to the surface, a fresh air base or refuge chamber is not possible.

There are several courses of action to be included in the training, depending on the resources available. These can be summarised as follows:-

- compressed air available;
- compressed air not available;
- using an oxygen self rescuer; and
- using more than one self rescuer.

Decisions to be made by the entrapped person need to be conservative in order to avoid unwarranted risk, and having decided upon an action, the person needs to remain calm and relaxed, but alert. It may be necessary to respond to changes in the circumstances whilst awaiting rescue.

Underground Refuge Chambers

The primary function of a tunnel refuge chamber is to provide a safe haven for people working in the immediate area in the event of the atmosphere becoming irrespirable.

The location of refuge chambers in the tunnel should be based on strategic rather than convenience factors. Tunnelling activity, ventilation and proximity to working places should be evaluated in the tunnel planning process when determining the siting of refuge chambers. The duty holder should be aware of the time limitations and active duration of the self rescuers used at the tunnel, and this information should be taken into consideration when locating refuge chambers. In many instances a refuge chamber will replace an alternative exits that could become contaminated in a fire situation.

The chamber size should recognise that other personnel such as supervisors, surveyors, geologists and service technicians may also need to use the facility. The number of such people in the workings from time to time can require:

- provision for a refuge capacity more than double that determined from the size of the locally operating crew alone; or
- implementation of a system to limit the number of personnel in the area.

Sufficient refuge chambers should provide for all persons at risk and should be capable of supporting life for 36 hours of entrapment without external power or services. The communication system with the refuge chambers must be designed so that communication cannot be disrupted during an emergency.

The induction process and emergency procedure should specify if workers are to proceed to refuge chambers or escape routes from the tunnel in the event of fire. All emergency related information signs should be in accordance with Australian Standard AS 1319.

2.2.7.13 Site security

After end of text insert:

‘2.2.7.14 Identification and Location of Persons in the Tunnel

A method is required to determine quickly and accurately the names and working locations of all persons in the tunnel. This is commonly achieved by use of a tag board that is checked by all supervisors at the start and end of every shift, and by the use of daily time sheets.

The integrity of such systems should be maintained at all times. The presence of an additional tag, or the absence of one is critical in determining search and rescue criteria for tunnel rescue team briefing, and can cause unnecessary delays where time is precious. During an emergency people may be exiting the tunnel via alternate routes, the system must be sufficiently robust to ensure that these persons exiting the tunnel are accounted for and the rescue team are not searching for a person who has already exited the tunnel.

Identification and Possible Location of Unaccounted Persons

A system is required that is able to determine quickly if and how many persons are trapped in the tunnel and their approximate locations, preferably prior to the tunnel rescue team reporting for instructions. Persons located in refuge chambers or fresh air bases should be instructed to remain there and to contact base only if their safety conditions change or other persons arrive.

All Persons Evacuating the Tunnel to Report

An established routine is required where persons evacuating the tunnel are checked against the list of persons known to be in the tunnel. This may require a person to be posted at each of the surface openings (muster points) of emergency escape routes to ensure they are unlocked and unobstructed, and to arrange orderly transfer to the emergency headquarters for debriefing. Any person leaving the tunnel during an emergency should be required to personally sign out. This will ensure that everyone can be accounted for within the duration of the emergency.

Information, Instruction and Training

Prior to any person being issued a tag or other permit to enter the tunnel they must be provided with information, instruction and training to the extent necessary to protect them from risks to their health and safety arising from work carried out in the tunnel.

The duty holder must ensure that information, training and instruction provided to a worker is suitable and adequate having regard to:

- the nature of the work carried out by the worker; and
- the nature of the risks associated with the work at the time the information, training or instruction is provided; and
- the control measures implemented.’

4. Managing risks during tunnelling

Omit all text and insert:

‘A person conducting a business or undertaking must ensure, so far as is reasonably practicable, the health and safety of—
(a) workers engaged, or caused to be engaged by the person; and
(b) workers whose activities in carrying out work are influenced or directed by the person;
while the workers are at work in the business or undertaking.

A person conducting a business or undertaking must ensure, so far as is reasonably practicable, that the health and safety of other persons is not put at risk from work carried out as part of the conduct of the business or undertaking.

Control measures to prevent people being injured during all stages of the tunnel construction and fit-out must be provided and maintained as part of a safe system of work.

A person conducting a business or undertaking must manage risks to health and safety associated with tunnel construction including risks associated with entering, exiting, working in, on or in the vicinity of the tunnel. The PCBU should ensure that a risk assessment, recorded in writing, is conducted by a competent person prior to the work commencing.

The risk assessment must be reviewed and as necessary revised by a competent person to reflect any review and revision of control measures implemented so as to maintain, so far as is reasonably practicable, a work environment that is without risks to health or safety.

A duty holder, in managing risks to health and safety, must identify reasonably foreseeable hazards that could give rise to risks to health and safety.

A duty holder, in managing risks to health and safety, must—

- eliminate risks to health and safety so far as is reasonably practicable; and
- if it is not reasonably practicable to eliminate risks to health and safety—minimise those risks so far as is reasonably practicable.

If it is not reasonably practicable for a duty holder to eliminate risks to health and safety then they must minimise risks, so far as is reasonably practicable, by doing one or more of the following—

- substituting (wholly or partly) the hazard giving rise to the risk with something that gives rise to a lesser risk;
- isolating the hazard from any person exposed to it;
- implementing engineering controls.

If a risk then remains, the duty holder must minimise the remaining risk, so far as is reasonably practicable, by implementing administrative controls and then by ensuring the provision and use of suitable personal protective equipment.

A combination of controls may be used to minimise a risk, so far as is practicable, if a single control is not sufficient for the purpose.

A duty holder who implements a control measure to eliminate or minimise risks to health and safety must ensure that the control measure is, and is maintained so that it remains, effective, including by ensuring that the control measure is and remains—

- fit for purpose; and
- suitable for the nature and duration of the work; and
- installed, set up and used correctly.

A duty holder must review and, as necessary, revise control measures implemented so as to maintain, so far as is reasonably practicable, a work environment that is without risks to health or safety.

A duty holder must review a control measure if —

- the control measure does not control the risk it was implemented to control so far as is reasonably practicable (for example the results of monitoring show that the control measure does not control the risk or a notifiable incident occurs because of the risk);
- before a change at the workplace that is likely to give rise to a new or different risk to health or safety that the measure may not effectively control (for example a change to the workplace itself or any aspect of the work environment or a change to a system of work, a process or a procedure);
- a new relevant hazard or risk is identified;
- the results of consultation by the duty holder under the Act or this regulation indicate that a review is necessary;
- a health and safety representative requests the review in accordance with the regulation.'

4.1 Risk controls in common tunnelling methods and activities

First dot point, omit 'bursts' and insert 'or gas outbursts'.

After last dot point insert:

- crystalline silica
- blasting fumes
- flammable gases and vapours
- combustion gases including diesel particulate matter
- production of vapours during the use of rock bolting bonding agents

Title of table 1, omit 'Common' and insert 'Hazards and risks associated with common'

4.1.1 Excavation methods

Omit last two dot points and insert:

- other hazards, either natural or man-made, such as:
 - heavy loadings, above or adjacent to the tunnel (e.g. roadways, railway lines, buildings)

- rivers or planned or existing spoil stockpiles
- chemical contamination (e.g. from past dumping or natural deposits)
- the presence of methane, or other hazardous , leaking tanks or pipes gases and vapours (e.g. where coal seams are present or vegetation has decayed in the soil or hydrocarbon contamination from historical fuel leaks exist), and
- dynamic loads or ground vibration near an excavation, including:
 - traffic (highway or rail)
 - excavation equipment
 - explosives.
- dust production and dust control measures.
- airborne contaminants

After end of text insert:

‘Note: when unexpected hazards are encountered (such as the presence of an unidentified coal seam) then the excavation methods, safety management plan, monitoring and control measures need to be reviewed, and if necessary revised, prior to work being allowed to continue. If you are tunnelling through coal you will need flameproof equipment.’

4.3 Air quality and ventilation systems

First paragraph, omit all text and insert:

‘A duty holder must ensure, so far as is reasonably practicable, that ventilation enables workers to carry out work without risk to health and safety and that workers carrying out work in extremes of heat or cold are able to carry out work without risk to health and safety.’

A duty holder must 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. Where a non-standard work roster is employed (i.e. a roster that is not 5 x 8 hour shifts each 7 calendar days) then the exposure standard must be adjusted to suit the hours of work. The exposure levels can be found in Safework Australia’s *Workplace Exposure Standards for Airborne Contaminants* or at safeworkaustralia.gov.au’

Third paragraph, insert new dot point ‘blasting activities’.

After end of seventh paragraph insert:

‘The consequences of poor ventilation include:

- heat exhaustion where temperatures are excessive;
- exposure to fumes, substances or mixtures, which can lead to unconsciousness, longer-term health problems and disease and even death;
- exposure to excessive levels of diesel particulates, which can lead to health issues such as lung damage; and
- fatigue and impaired judgment.

A duty holder involved in tunnelling work must ensure that ventilating air is provided in sufficient volume, velocity and quantity to:

- remove any atmospheric contaminants; and

- maintain a healthy atmosphere in workplaces.

Ventilation design should ensure there are no dead spots, low air speed areas, flow reversals, dust concentration or recirculation. To address the adverse effects of poor ventilation an air velocity of not less than 0.5 metres per second (m/s) of uncontaminated air should be provided in all tunnel sections averaged across the full open section.’

Final paragraph, omit dot point ‘self-contained breathing apparatus (self-rescuer) supplied to anyone working in an area where the atmosphere is not safely maintained’ and insert ‘adequate re-entry times after blasting, and adequate re-entry testing procedures’.

4.3.1 Monitoring air quality

Omit all text and insert:

‘A person conducting a business or undertaking at a workplace must ensure that air monitoring is carried out to determine the airborne concentration of a substance or mixture at the workplace to which an exposure standard applies if—

- (a) the person is not certain on reasonable grounds whether or not the airborne concentration of the substance or mixture at the workplace exceeds the relevant exposure standard; or
- (b) monitoring is necessary to determine whether there is a risk to health.

A person conducting a business or undertaking at a workplace must manage risks to health and safety associated with a hazardous atmosphere at the workplace. An atmosphere is a *hazardous atmosphere* if—

- (a) the atmosphere does not have a minimum oxygen content in air of 19.5% by volume under normal atmospheric pressure and a maximum oxygen content of air of 23.5% by volume under normal atmospheric pressure; or
- (b) the concentration of oxygen in the atmosphere increases the fire risk; or
- (c) the concentration of flammable gas, vapour, mist, or fumes exceeds 5% of the lower explosive limit for the gas, vapour, mist or fumes; or
- (d) a hazardous chemical in the form of a combustible dust is present in a quantity and form that would result in a hazardous area.

A person conducting a business or undertaking at a workplace should also manage risks to health and safety associated with all other toxic gases or aerosols.

The risk assessment process must be used to:

- determine the engineering controls, work practices and on-site atmospheric or biological monitoring required, and
- determine the monitoring program for airborne contaminants, such as dust and fumes, including taking air samples and ensuring the relevant exposure standard is not exceeded or that people are not exposed to a hazardous atmosphere.

Daily tests should be carried out before work starts, with continued monitoring throughout the work period. The work should be examined by competent persons using appropriate detection and measuring equipment.

The monitoring should include air testing for:

- flammable fumes or gases
- oxygen deficiency (e.g. presence of asphyxiant gases)
- temperature and humidity, and
- airborne contaminants (e.g. toxic gases, fumes or respirable dusts).

The principal contractor should ensure that:

- (a) air monitoring is undertaken in accordance with a suitable procedure, and
- (b) the results of the air monitoring are recorded, and
- (c) any worker or other person who may be or may have been exposed to an atmospheric contaminant that has been monitored is provided with the results of the monitoring, and
- (d) the air monitoring records are readily accessible to any worker or person.

The PCBU must ensure that exposure to an airborne concentration of a contaminant classified as a hazardous chemical is not at a level greater than the exposure standard. Current exposure standards can be found in Safework Australia's *Workplace Exposure Standards for Airborne Contaminants* or the Hazardous Chemicals Information System (HSIS) at safeworkaustralia.gov.au. Where a non-standard work roster is employed then the exposure standard must be adjusted to suit the hours of work.'

4.3.2 Hazardous contaminants

First paragraph, omit 'Refer to Part 23 of the regulation for more detailed information about atmospheric contaminants' and insert 'Due to the nature of working in a tunnel, contaminants generated in one area of the tunnel will transfer readily to other areas. Protection against airborne hazards should encompass all appropriate workers, not just the ones creating the hazard'

Second paragraph, insert at end of first dot point ' , diesel particulate material'

Third paragraph, insert at end of text 'Additional biological risk could be introduced via the ventilation system and should be controlled.'

Fourth paragraph, second dot point, after words 'internal combustion engines' insert ' , welding or shotcreting'

Table 2, omit and insert:

Activity	Contaminant	Harmful component
Hot work	Welding/cutting fumes	Metal oxides, oxides of nitrogen, ozone, fluorides.
Operation of internal combustion engines	Exhaust fumes	Carbon monoxide, carbon dioxide, diesel and other particulates, oxides of nitrogen, fuel vapours, aldehydes and hydrogen

		sulphide. Oxygen depletion can occur.
Tunnelling	Rock dust	Chrystalline Silica and other mineral dusts, including coal dust.
Shotcreting, rock bolting, concreting, grouting	Cement dust/accelerator	Cement dust, ammonia and chemical accelerating compounds.
Battery charging	Vapours	Flammable gas, acid fumes.
Shot firing	Blasting fumes	Chrystalline Silica dust, ammonia, oxides of nitrogen, carbon monoxide, sulphur dioxide, carbon dioxide.

Final two paragraphs, omit and insert:

‘The regulation requires PCBUs to make sure that no one is exposed to an airborne concentration of atmospheric contaminants above the exposure standards. The exposure levels can be found in Safework Australia’s *Workplace Exposure Standards for Airborne Contaminants* or at safeworkaustralia.gov.au

An approximate guide to the effects and consequences of some common airborne contaminants at various concentrations is provided in Table 3. The applicable exposure standards can be found in the ‘Hazardous chemicals Information System’ (HSIS) at safeworkaustralia.gov.au.’

Table 3, omit and insert:

Common contaminants	Range of typical effects at increasing levels of exposure above acceptable limits
Carbon dioxide	Increased depth of breathing within 15 mins of exposure.
	Feeling of inability to breathe, headache, dizziness, sweating and disorientation.
	Nausea, strangling sensation, stupor and loss of consciousness within 15 mins. Many deaths reported from exposure above 20 per cent.
Carbon monoxide	Headache within a few minutes. Possibility of collapse in half hour, coma in 1 hour and possible death in 1.5 hours.
Hydrogen sulphide	Initial eye irritation, then loss of sense of smell.
	Rapid breathing, respiratory arrest, collapse, death.
	Immediate collapse and respiratory paralysis, death.
Nitrogen dioxide	Considered dangerous for short-term exposure. Moderately irritating to eyes and nose.
	Fatal within 30 mins. Death is due to fluid build up in lungs (pulmonary oedema) leading to asphyxia.
Sulphur dioxide	Irritation of the eyes, nose and throat, choking and coughing within 5 to 15 minutes.
	Immediately dangerous.
	A 10 minute exposure has been fatal at high concentration.

Chrystalline Silica dust	Cumulative exposure leads to lung damage/disease (silicosis and chrystalline silica is a carcinogen).
	Can occur after 15 to 20 years of moderate to low exposure, or after a few months of very high exposure.
	Death can occur from respiratory failure.
Non contaminants	
Oxygen depletion	
Oxygen	Normal atmosphere.
	Rate of respiration increased.
	Fatigue on exertion, disturbed respiration.
	Nausea, inability to move freely, collapse.
	Respiration stops, heart stops within a few minutes.

4.3.2.1 Dusts and silica

Omit all text and insert:

‘Dust in tunnel construction needs to be controlled. Airborne respirable dust particles (as defined in AS 2985 - Workplace atmospheres - Method for sampling and gravimetric determination of respirable dust) are too fine to be filtered by the nasal cavity and can be inhaled, or respired, deep into the lungs. Long-term exposure to respirable dusts can lead to diseases ranging from bronchitis to various cancers. Even if the dust is not at harmful levels or sizes, it can increase the risk of physical injury or harm because of the reduced visibility and irritation to the eyes and throat.

Non-hazardous nuisance dust can be generated about the site or underground by dry roadways, bare soil or rock, vegetation removal, traffic and the wind.

Respirable crystalline silica is the most common hazardous dust particle found in tunnelling. The risk assessment of the tunnel construction should consider the presence of silica and the likely generation of dust containing silica.

Crystalline silica (quartz) is a common mineral present in sandstone, clay, granite and many other rocks as well as in the overburden and spoil. Exposure to respirable crystalline silica is known to cause silicosis, a respiratory lung disease that can be fatal.

Mineral dust can be generated and released into the atmosphere during the tunnelling operation when:

- rock or concrete is broken, drilled, cut or blasted, or wherever ground is disturbed
- rock cutting with road headers or tunnel boring machines (TBMs)
- loading broken rock at the face
- transporting spoil on conveyor belts
- working at spoil transfer points
- installing or removing ventilation ducts
- concreting and shotcreting, spraying and handling bagged ingredients
- moving traffic, and
- muck piles dry out.

All possible sources of the generation of dust in a tunnel should be identified and control measures selected to eliminate or minimise the generation of the dust at the source.

Control measures for harmful airborne substances include:

- designing, using and maintaining an exhaust ventilation system
- maintaining extraction at, or close to, the point of generation (e.g. use of brattice curtains or half-curtains to reduce dust roll-back)
- using extractors or dust collection devices in-line, near the face
- increasing the extraction rate (ventilation capacity) when and where required
- wet spraying, to suppress dust at the point of generation (e.g. at drop points on conveyors)
- adding surfactant (detergent) to dust suppression water
- using tools fitted with dust extraction or water attachments
- wet drilling
- installing water applicators onto the machinery, rather than using hand-held applicators
- wetting muck piles, spoil conveyors and roadways
- spraying water over spoil heaps after blasting and while loading
- limiting exposure times to dust
- providing PPE (e.g. respirators rated for concentration and duration of exposure)
- enclosed cabins with windows closed at all times
- wet cleaning of cabins and crib rooms regularly
- fitting air filtering systems to the air conditioning units of front end loaders, excavators and other machinery
- keeping personnel vehicles dust sealed and pressurised, and
- assessing and controlling the risk of cross contamination between worksites, work processes or workers' clothing.

Examine how workers' clothes are cleaned at the end of each shift. Roadheader operators in particular will have dust-saturated clothing. Unless it can be demonstrated that dust on clothing in this system is not a mechanism for the spread of silica around the work site, or off-site, or contributing to individual doses, contaminated clothing should be washed daily in an approved manner. Cleaning of people and plant should never be undertaken using compressed air blow-down.

4.3.2.2 Use of respiratory protection to control dust exposures

Where higher order controls fail to control hazardous chemical, particularly respirable dust, exposures, and resort is made to the low order control of PPE, the PCBU should ensure any respirators supplied are capable of preventing people inhaling hazardous dust or other airborne contaminants at the concentration and duration of the exposure. Guidance on the selection, use and maintenance of respirators can be found in *AS/NZS 1715 Selection, use and maintenance of respiratory protective equipment*.

Workers exposed to crystalline silica dust in excess of the exposure standard will require health monitoring (see 4.5.2.1 – Health monitoring for hazardous chemicals).’

4.3.2.3 Diesel emissions

First two paragraphs, omit and insert:

‘Internal combustion engines, other than diesel, are not to be used underground. The exhaust emissions from diesel engines can be a major source of contamination and oxygen depletion to a tunnel atmosphere. This should be considered in the plant selection, and in the design, operation and monitoring of the ventilation system.

Where diesel engines are used, the tunnel ventilation should be monitored by testing the tunnel air for the products and effects of diesel engines, such as:

- oxygen deficiency and presence of asphyxiant gases such as carbon monoxide, and
- airborne contaminants, such as toxic gases and fumes.

A duty holder should achieve the underground work industry best practice exposure standard of $0.1\text{mg}/\text{m}^3$ for submicron diesel particulate matter measured as Elemental Carbon to minimise the irritant effects of exposure.’

4.3.3 Managing heat stress

Second paragraph, final dot point, omit ‘clothing’ and insert ‘PPE and clothing’

4.4.3 Plant suitability and assessment

Second paragraph, second last dot point, omit ‘excavated face’ and insert ‘excavated face, or ability to eliminate or minimise dust’

4.5.1 Noise

Second last paragraph, insert before text:

‘If a worker is frequently required to use personal protective equipment to protect the worker from the risk of hearing loss associated with noise that exceeds the exposure standard for noise, the duty holder who provides the personal protective equipment as a control measure must provide audiometric testing for the worker—

- within 3 months of the worker commencing the work; and
- in any event, at least every 2 years.

audiometric testing means the testing and measurement of the hearing threshold levels of each ear of a person by means of pure tone air conduction threshold tests.’

4.5.2 Hazardous substances

After last paragraph insert:

‘4.5.2.1 Health monitoring for hazardous chemicals

In tunnelling environments, hazardous chemicals for which health monitoring may be required by regulation is limited mostly to crystalline silica. The requirements for health monitoring are provided in Schedule 14 of the Work Health and Safety Regulation 2011.

Generally, chest x-rays are not required until 10 years after the first exposure, assuming that the worker has not had prior exposure to silica in other jobs. However, the need for health monitoring is determined by the level of risk resulting from the exposure to respirable crystalline silica. Health monitoring would be indicated if air monitoring results show workers have been and are being consistently exposed to elevated levels of respirable crystalline silica. Health monitoring is undertaken by a registered medical practitioner with experience in health monitoring.'

4.5.3 Visibility and lighting

Last paragraph, omit text and insert:

'If there is any credible circumstance in which the lighting, and in particular the emergency lighting, may fail then the duty holder should ensure that every person entering the tunnel is issued with a cap lamp. Where cap lamps are provided:

- one cap lamp charged and maintained for each underground person;
- adequate lamps to allow each lamp to be fully charged and provide at least 12 hours light each shift;
- spare cap lamps for other people who may be underground on any given day;
- cap lights do not increase igniting risks;
- cap lights can produce sufficient light to guide the user in the event of a underground fire.'

4.5.4 Compressed air

Second paragraph, insert new dot point 'breakdown products of oils in compressed breathing air including carbon monoxide'

4.5.6 Welding (and oxy-cutting)

Final paragraph, insert new dot point 'preventing the ignition of substances that could cause a fire'

Appendix B – Dictionary of defined terms

Meaning of self rescuers, omit all text and insert:

'**Self rescuers** is a respirator generally designed to be belt-mounted and put on immediately to provide a breath-activated oxygen supply according to demand. Self-rescuers provide a certain duration (minutes) of breathable air under specific work rate conditions. They also need regular inspections and have a maximum storage life limit.'

Appendix C – Ventilation methods and equipment

Fourth paragraph, second dot point, insert at end of first sub dot point '(particularly in blind or dead-end headings)'

Fifth paragraph, first dot point, after word 'evase' insert 'if they are exhausting fans'

Eighth paragraph, insert at start of final dot point 'handheld electronic gas monitors or'

Twelfth paragraph, omit all text and insert:

‘This system does have some disadvantages that have to be considered including:

- the rigid ducting is harder to repair or replace than flexible ducting
- installation rates are slower for rigid ducting
- costs are higher for rigid ducting, it is harder to store and takes up more room
- more leaks are possible due to the greater number of joints and the need to align and sleeve each joint
- a forcing system or overlap is still required at the face, generally to allow flexibility and to reduce the number of set-ups to install rigid ducting that is ideally done from some distance behind the face
- it is heavier than flexible ducting and can contribute to manual task risks and crush risks
- the "capture zone" in front of the duct inlet is small, and
- the dust, fumes or gases from activity behind the face is drawn to the face first before being exhausted to the surface.’