Resources Regulator
Department of Regional NSW

NSW GOVERNMENT

Consolidated report

Emergency planning – self-escape and refuge – Underground mines

March 2020 – February 2022

Published by the Department of Regional NSW

Title: Consolidated report – Emergency planning – self-escape and refuge – Underground mines

First published: January 2023

Department reference number: RDOC22/96391

More information

Amendment schedule		
Date	Version	Amendment
January 2023	1	First published

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Executive summary

A crucial part of the NSW Resources Regulator's *Incident Prevention Strategy* involves targeted assessment and planned inspection programs for mines and petroleum sites. This is a focus on assessing an operation's control of critical risks through evaluating the effectiveness of control measures in the mine's safety management system.

To this end, we developed a bowtie hazard management framework and standardised assessment checklist for each program plan. Under a program plan, the effectiveness of the safety management system at each mine site is assessed against a standard set of control supports and critical controls. From each of the bowties completed for the various principal hazards, emergency planning has continually been determined as a mitigating control.

This report summarises assessment findings from 29 underground mines (17 coal mines and 12 metalliferous mines) in relation to assessments for the hazard of emergency planning - self-escape and refuge during the period from March 2020 to February 2022.

Legislative requirements and published guidance relating to the hazard of emergency planning – self-escape and refuge are listed in Appendix A. Figures 1 - 4 present safety compliance findings for each de identified mine and critical control assessed for the material unwanted event of emergency planning – self-escape and refuge. Explanatory notes on the assessment system are also listed in Appendix B.

Key findings

Overall self-escape and refuge system requirements:

- Thirteen of the 29 mines assessed (45%) were found to be compliant with all self-escape and refuge requirements. This result consisted of:
  - Eight of 17 coal mines assessed (47%).
  - Five of 12 metal mines assessed (42%).
- Sixteen mines were found to have improvement opportunities in the following areas:
  - Provision of and training in the use of escape breathing apparatus.
  - Escapeway standards.
  - Refuge chamber standards.

Regarding the provision of and training in the use of escape breathing apparatus:

- Twenty of the 29 mines assessed (69%) were found to be compliant with escape breathing apparatus requirements. This result consisted of:
  - Twelve of 17 coal mines assessed (71%)
  - Eight of 12 metal mines assessed (67%)
- Nine mines including 5 coal mines and 4 metal mines were unable to demonstrate compliance with all elements of clause 100 of the Work Health and Safety (Mines and Petroleum Sites) Regulation 2014 including:
  - Not all workers were trained in the donning and changeover of each type of self-rescuer in use at the mine before starting work at one metal mine.
  - Not all workers were trained in donning and changeover of each type of self-rescuer in use at the mine in the previous 6 months at 4 coal mines and one metal mine.
  - Not all workers were trained in donning and changeover of each type of self-rescuer in use at the mine in a simulated work environment at 2 metal mines.
  - Not all workers were able to recall, and some workers overestimated self-rescuer rated duration at one coal mine.
- Workers provided with filter type self-rescuers and some types of self-contained self-rescuers were not provided with eye protection from the effects of smoke likely to be encountered in an event requiring the use of a self-rescuer. This issue was highlighted at a metal mine but equally applied where these self-rescuer types were used.
- One coal mines emergency plan operated under an assumption that motorised transport would always be available during an escape when calculating self-rescuer changeover station capacities and distances.

Regarding escapeway standards:

- Seventeen of the 28 mines assessed (61%) were found to be compliant with escapeway requirements. This result consisted of:
  - Eleven of 16 coal mines assessed (69%). One mine was not assessed.
  - Six of 12 metal mines assessed (50%).
- Improvement opportunities were identified at 11 mines including 5 coal mines and 6 metal mines. Improvement opportunities included:

  - At one coal mine and 2 metal mines the documenting of escapeway installation standards and commissioning checks and completing documented commissioning checks required improvement.
  - At 3 coal mines and 3 metal mines the maintenance of escapeways to ensure clear access including being clear of obstacles and rough floor with suitable height and width clearances for comfortable walking in potentially low visibility required improvement.
  - At one coal mine and 2 metal mines, ground support in escape roadways required improvement.
  - At one coal mine and one metal mine, refuge chambers, self-rescuer or breathing apparatus caches were not located at the site specified distance from the workplace. These sites had also not demonstrated by risk assessment or trial that these distances were within the rated duration of the belt worn self-rescuer when varying from site standard.
  - At one coal mine, the installation of escapeway lifeline tactile indicators to site standard required improvement.
  - At one coal mine and one metal mine, the process for maintaining up-to-date escapeway plans required improvement.
  - At one coal mine and 3 metal mines the placement of signage to the specified site standard required improvement.
- Other escapeway related findings included:
  - At one coal mine, communication systems were not in place to the specified site standard or otherwise not operating effectively.
  - At one coal mine, adequate water and rehydration facilities were not provided at refill or changeover stations.
  - At one metal mine, escape ladderway landing trapdoors were difficult to open from on top of the landing. This may have impeded access by rescuers.
  - At one metal mine, training in the use of fall arrest equipment associated with using escape ladderways was not being adequately maintained.

Regarding refuge chamber standards:

- Refuge chambers were not in use at underground coal mines due mainly to the risk of secondary explosion during a mine fire scenario involving the coal seam. Two underground coal mines used a pressurised changeover station where escaping workers can safely remove escape breathing apparatus for the purpose of self-rescuer changeover, hydration, or fatigue breaks. Changeover station style facilities at these mines were assessed using applicable refuge chamber assessment criteria.
- Ten of the 14 mines assessed (71%) were found to be compliant with refuge chamber requirements. This result consisted of:
  - Two of 2 coal mines assessed (100%)
  - Eight of 12 metal mines assessed (67%)
- Improvement opportunities were identified at 5 metal mines. Improvement opportunities included:
  - At 3 metal mines access to refuge chambers required improvement to walking conditions or to remove blockages.
  - At one metal mine providing refuge chamber operating instructions for equipment models contained within the refuge chamber required improvement.
  - At 2 metal mines the installation of communication systems to site standard and maintaining them in an effective operating condition required improvement.

  - At 4 metal mines, installing signs to site standard or maintaining legibility required improvement.
  - At one metal mine, the maintenance of installed atmospheric monitoring equipment inside and outside the refuge chamber required improvement.
  - At one metal mine, the compressed air supply to a refuge chamber did not meet the manufacturers recommended specification.

Regarding escape systems generally:

- At one coal mine and 2 metal mines, the trialling of escape systems under simulated low visibility conditions was yet to be completed.
- At 2 coal mines and one metal mine, the components of the escape system were yet to be included in the maintenance management system.

Recommendations

- When selecting self-rescuers, ensure the risk assessment addresses:
  - all potential scenarios capable of producing toxic, low oxygen, and smoke-filled atmospheres.
  - the capability of the selected self-rescuer to protect the wearer from identified potentially toxic, low oxygen and smoke-filled atmospheres noting that many materials used in mines produce toxic gases other than carbon monoxide when burning.
  - the eye irritation a person may experience when escaping through a smoke-filled environment and the impact that may have on their ability to travel the escapeway.
- Ensure underground workers can use the provided self-rescuers. Note Section 103 of the Work Health and Safety (Mines and Petroleum Sites) Regulation 2022 requires as a minimum:
  - training workers in a simulated work environment to don and changeover each of the self-rescuer types they may be required to use before starting work and every 6 months after that.
  - Coal mines must train workers to use oxygen-generating self-contained self-rescuers they may be required to use undertaking physical effort similar to an evacuation situation, before starting work and every 3 years after that.
- When designing escape and refuge systems ensure the supporting risk assessments address:
  - Escapeway characteristics such as the distance to be travelled, the grade of the roadway, the nature of the walking terrain and any obstacle that must be negotiated such as poor visibility, direction changes, low headroom, low clearances, overpasses, ladderways, and ventilation doors.
  - Physical attributes of workers that may impact their ability to use the escape systems including their ability to travel required distances within the rated duration of the selected breathing apparatus.
  - The length of time people may be required to occupy a refuge chamber and the conditions they are likely to have to endure inside the refuge chamber.
  - The ability to use communication systems when a self-rescuer mouthpiece is worn.

    Coal mine operators note: Lifeline standards and associated tactile guides such as cones, balls, and plates vary between mines and companies. Mine operators should consult with other mines to work towards a common standard that would reduce confusion for people who work at several mines.

- Escape and refuge systems must be inspected and maintained to ensure they have been installed correctly and are available for use. Identified defects must be remedied as a matter of urgency.
- Workers must be trained in the use of all elements of the escape and refuge systems to ensure they can respond appropriately during an emergency.
- Escape and refuge systems should be tested under conditions that would be expected during an emergency to validate effectiveness of the system and to provide workers with a realistic training experience.
- Variation from the documented mine escape and refuge system standard must be validated through a change management process. Variation examples may include locating a refuge chamber, refill, or changeover station at a distance greater than specified in the mine standard or changing a refuge chamber, refill, or changeover station configuration or capacity.
- Assumptions made in emergency escape risk assessments must be supported by operating standards, procedures, and maintenance to ensure the assumptions are valid and will be in place when an emergency escape is required.

Mine operators are encouraged to review their site's risk assessments, principal control plans, and associated documents that manage the risks associated with emergency escape that are unique to their site. During the review process mine operators are encouraged to consider the above recommendations and the guidance published in Appendix A.

Findings by mine

Figures 1 - 2 present aggregate assessment findings by critical control, providing a summary view of the status of each mine's hazard management processes. Importantly, the system recognises the value of fully implemented and documented controls if both elements were assessed as present. More details explaining the assessment system are found at Appendix B.

FIGURE NUMBER	DESCRIPTION
1	Results for coal mines
2	Results for metalliferous mines

Figure 1: Assessment findings for the planned inspection program – emergency planning – self-escape and refuge – coal mines

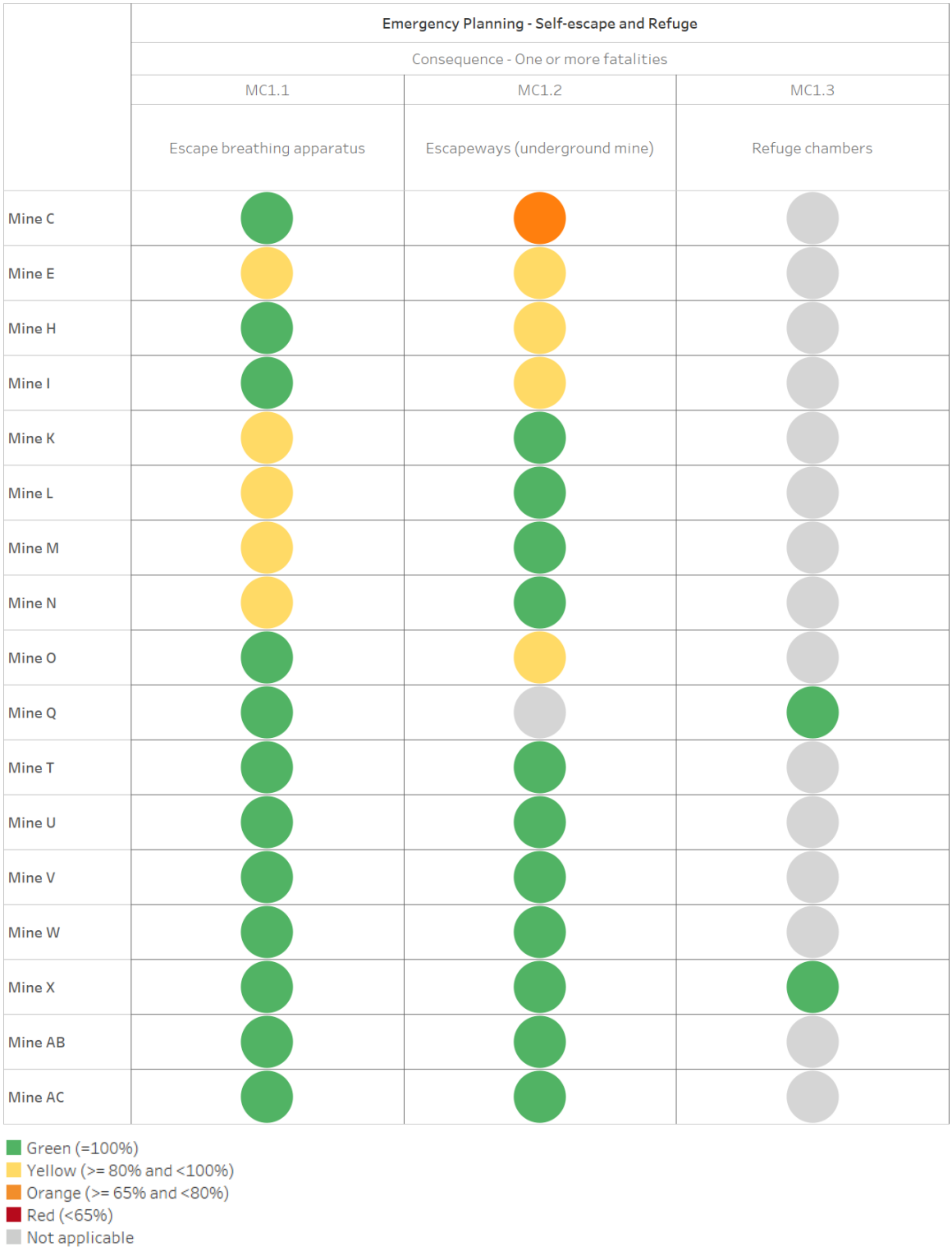
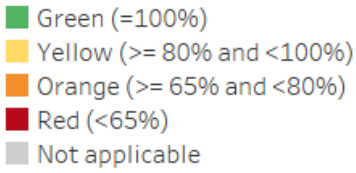


Figure 2: Assessment findings for the planned inspection program – emergency planning – self-escape and refuge – metalliferous mines

	Emergency Planning - Self-escape and Refuge		
	Consequence - One or more fatalities		
	MC1.1	MC1.2	MC1.3
	Escape breathing apparatus	Escapeways (underground mine)	Refuge chambers
Mine A			
Mine B			
Mine D			
Mine F			
Mine G			
Mine J			
Mine P			
Mine R			
Mine S			
Mine Y			
Mine Z			
Mine AA			



Notices issued

Of the 29 sites assessed under the inspection program, 19 separate mine operators were given notices about the hazard of emergency planning – self-escape and refuge, while some were given notices about other matters. For the purposes of this report, contraventions related to other matters were removed from the analysis. The notices issued for emergency planning – self-escape and refuge were examined in detail and Table 1 below lists the notices issued by type and details.

Table 1: Notices issued for the planned inspection program – emergency planning – self-escape and refuge – underground mines

NOTICE TYPE	TOTAL ISSUED	NUMBER OF MINES
s.195 prohibition notice	-	-
s.191 improvement notice	23	13
s.23 notice of concerns	14	14
Total	**37**	**19**

Of the combined 37 notices issued, there were some common themes that were apparent throughout the program plan. Table 2 summarises the common contravention themes that were encountered. These themes can be related to the critical controls outlined earlier and identify some trends which were of concern.

Table 2: Notices issued - prevalence of categories of concern

IDENTIFIED CONCERN CATEGORY
Escapeway hazards were identified such as narrow clearances, fenced roadways, materials stored in walkways, accumulated waste, trip hazards, fallen strata material, poorly supported backs, roof, and sides.
Distances from workplace to refuge chamber, self-rescuer or breathing apparatus cache or between refill or changeover station was not to site standard, or not demonstrated to be possible to traverse within the rated duration of the provided self-rescuer.
Escape systems were not trialled under simulated low visibility conditions.
Elements of the escape system were not included in the inspection and maintenance scheme.
Lifeline tactile indicators were absent or not to standard.
Communication systems were not operating effectively or not in place at the locations nominated in the site standard.
Escape way and refuge chamber signs were illegible or not installed to site standard.
Escape plans were not up to date.
Water and hydration facilities were not provided at coal mine refill or changeover stations.
Instructions and procedures were provided for different models of escape equipment than those that were in use.
Assumptions were made that transport would be available when calculating escape timeframes compared with self-rescuer rated duration.
Escape breathing apparatus locations were not sign posted.
Workers were not trained in the donning and change-over of each type of self-rescuers before starting work at the mine.
Workers were not trained in the donning and change-over of each type of self-rescuer in a simulated work environment.

IDENTIFIED CONCERN CATEGORY
People working underground were overdue for their 6 monthly self-rescuer donning and change-over refresher training.
Operators were unable to demonstrate compliance with 6 monthly self-rescuer refresher training.
Eye protection from smoke or other irritants was not supplied as part of some belt worn self-rescuers.
Workers were unable to recall or overestimated the rated duration of their self-rescuers.

Further information

For more information on safety assessment programs, the findings outlined in this report, or other mine safety information, please contact the NSW Resources Regulator:

CONTACT TYPE	CONTACT DETAILS
Email	cau@regional.nsw.gov.au
Incident reporting	To report an incident or injury call 1300 814 609 or log in to the Regulator Portal
Website	www.resourcesregulator.nsw.gov.au
Address	NSW Resources Regulator 516 High Street Maitland NSW 2320

Appendix A. Legislative requirements and published guidance relating to the principal hazard emergency planning – self-escape and refuge

The following is a list of certain legislative requirements for the management of emergency planning – self-escape and refuge risks referred to in this report, as provided by the Work Health and Safety (Mines and Petroleum Sites) Regulation 2022 and Work Health and Safety Regulation 2017.

Work Health and Safety Regulation 2017:

- Clause 43 - Duty to prepare, maintain and implement emergency plan

  (1) 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 —

  (ii) evacuation procedures,

Work Health and Safety (Mines and Petroleum Sites) Regulation 2022:

- Section 99 - Emergency exits
- Section 100 - Safe escape and refuge
- Section 101 - Signage for emergency refuge
- Section 102 - Signage for caches, refill stations and change-over stations
- Section 103 - Self-rescuers
- Schedule 7 - Matters to be included in emergency plan

  Section 5 - Procedures

  (1) Procedures for the safe evacuation of, and accounting for, all persons at the mine or petroleum site.

Appendix B. Assessment system explained

The NSW Resources Regulator uses a bowtie framework to proactively assess how mine sites manage their principal hazards. Bowties are a widely used risk management tool that integrates preventative and mitigating controls onto threat lines that relate to a material unwanted event.

As part of program planning, controls were categorised by the NSW Resources Regulator's mine safety inspectorate in accordance with the ICMM handbook. Only controls deemed critical[1] are assessed under a planned inspection program. For a control to be assessed as effective, each of its control supports must be in place and operational.

Assessment findings results calculation

During the program, each control support assessed at each mine was rated and the findings recorded. Points were awarded depending on whether there was evidence that the control support had been documented and / or implemented. Importantly, the system recognises the value of fully implemented and documented controls by allocating four points if both these elements were present.

For finding outcomes, points were awarded for each control support identified within a critical control. An overall assessment result for the critical control was then calculated as a proportion of the maximum possible points for that critical control. For example, if a critical control comprises ten control supports and five were assessed as fully implemented ('documented and implemented') and five were found to be 'not documented and not implemented' then the overall assessment result for that critical control would be 50%.

Table 1: Finding outcome and points

FINDING OUTCOME	POINTS
Documented and implemented	4
Implemented but not documented	2
Documented but not implemented	1
Not documented and not implemented	0

Critical control calculations also took into account instances where control supports were not applicable to the mine being assessed or when control supports were not able to be assessed during a site visit.

The overall assessment result for each critical control has been assigned a colour based on the assessment bands presented in the table below. The colour band results are then used to identify industry focus areas requiring improvement.

Table 2: Assessment results and colour code

CRITERIA	COLOUR
An assessment result of 100% of possible points	Green
An assessment result of ≥ 80% but < 100% of possible points	Yellow
An assessment result of ≥ 65% but < 80% of possible points	Orange
An assessment result of < 65% of possible points	Red

[1] Critical Control Management Implementation Guide, International Council on Mining and Metals (ICMM), 2015.