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Resources Regulator

Mine Safety



GUIDE | SCREENS AND SCREEN MAINTENANCE

Managing screens and screen maintenance in extractive mining

A practical guide to the design, operation and maintenance of screens in extractive mining operations

Front cover: Photo courtesy of Boral

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Foreword

This document was initiated from the NSW Mine Safety Advisory Council's Safe Design Project. The content of this document was developed with the assistance of a working group that consisted of extractive workers, managers, original equipment manufacturers and the department. We also acknowledge the Institute of Quarrying Australia and Cement Concrete and Aggregates Australia for their help in developing this document.



Key terms

Term	Definition
MSD	Musculoskeletal disorder
PCBU	Person conducting a business or undertaking
Risk assessment	The overall process of risk analysis and evaluation
Risk management	Refer to the code of practice on <i>How to Manage Work Health and Safety Risks in the Workplace</i> and the Managing risks in mining guide
Should	The action or item is recommended but not mandatory
WHS	Work Health and Safety
Screens or screening	Involves determining the size and separates the material ahead of secondary and tertiary crushing circuits and/or in preparation for the stockpiling of final product. In essence, crushers produce the material and screens separate the material.

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1. Introduction

1.1 Purpose

This document provides guidance on the design, operation and maintenance of screens in extractive mining operations. In doing so, we aim to minimise the risk to the health and safety of workers and others.

1.2 Scope

This document examines the life cycle of screens, which includes design, retrofit and maintenance of screens in fixed plant extractive operations.

1.3 Who should use this document?

Use this document if you are:

- a person conducting a business or undertaking (PCBU), including the mine operator, **and** are responsible for the management or control of screens
- a health and safety representative (HSR) who needs to understand the hazards and risks associated with screens and screen maintenance
- designers, manufacturers, contractors and suppliers of screens, component parts or materials
- inspectors who advise mines on how to comply with legislation
- workers involved in a screen-related risk assessment
- workers involved in screen change outs and/or maintenance activities.

2. Importance of managing the risks

Screens are a critical element in producing aggregate materials. In most crushed stone operations, extracted rock is processed by a primary crusher and then passed through screens to produce either the final product or material for further crushing or other processing.

However, the use of screens and, in particular, their maintenance and repair, poses a number of health and safety risks. These include:

- musculoskeletal disorders (MSD) associated with hazardous manual tasks and hand-arm vibration (for more information, refer to the [Managing musculoskeletal disorders](#) guide)
- the need to work in confined spaces and the associated risks, including
 - loss of consciousness, impairment, injury or death due to the immediate effects of airborne contaminants
 - fire or explosion from the ignition of flammable contaminants
 - difficulty rescuing and treating an injured or unconscious person
- risk of fire when undertaking hot work
- working at heights
- exposure to dangerous dust and fumes
- electrocution or the ignition of fires from electrical work
- issues with workers, including increased
 - complaints from workers on being exposed to hazardous manual task risk factors while undertaking screen change outs
 - absenteeism of workers on planned screen change out days due to the nature of the work.

Musculoskeletal disorders (MSDs)

The term musculoskeletal disorders or MSDs do not refer to just one disorder. MSD is an umbrella-term for a variety of injuries and disorders including:

- sprains and strains of muscles, ligaments and tendons
 - for example, shoulder muscle strain leading to rotator cuff tear
- back injuries, including damage to the muscles, tendons, ligaments, spinal discs
 - for example, ruptured discs, nerves, sciatica, joints and bones
- joint injuries or degeneration, including injuries to the shoulder, elbow, wrist, hip, knee, ankle, hands and feet
- bone injuries, for example, fractures
- nerve injuries, for example, carpal tunnel syndrome of the wrist
- soft tissue hernias, for example, abdominal hernias
- muscular and vascular disorders as a result of hand-arm vibration (HAV).

Development of MSDs

There is no set timeframe for the development of a MSD. MSDs can happen suddenly or develop over time. They may:

- **occur suddenly** as a result of a single forceful action like pulling or moving an object, lifting a heavy object, actions causing overexertion or through a slip, trip or fall
- **develop over a longer period** as symptoms associated with minor tissue injuries (including nerve and vascular tissues) are ignored, eventually resulting in a more serious injury
 - injuries suffered by workers (for example, transport drivers, mechanics) doing repetitive work and/or work of a similar nature could also fall into this category
- **be a combination of both**, where tissue that is weakened by cumulative injury may become more vulnerable to an acute injury, even at much lower forces.

Many factors contribute to MSDs

For a manual task to be considered as hazardous there needs to be specific risk factors present. Based on research conducted in Australia and overseas, the key MSDs risk factors in a mining and petroleum environment are:

- awkward postures
- bending and twisting
- manual handling/load
- forceful exertions
- repetitive actions
- duration of task
- heavy lifting
- vibration of hand/arm and whole body (including jolting and jarring)
- poor access to equipment
- slips, trips and falls
- working long hours without the opportunity for rest and recovery
- exerting force in a static position for extended periods
- problems with the work environment, for example, working in hot or cold weather, rain and unpredictable conditions
- high job demands and time pressure
- fatigue
- lack of job rotation.

Workers' compensation claims for musculoskeletal disorders in mining are significantly higher than in any other sector. True injury rates may also be much higher than recorded in injury statistics. For example, a debilitating MSD injury may have occurred due to another event; however, the person's exposure to working within screens can contribute to this disorder through small injuries over time. This subsequently weakens the musculoskeletal system.

3. Managing the risk

Risk-management approach

Mine operators have a duty to manage risks associated with mining operations at the mine. This is achieved by, in so far as reasonably practicable **and** among other things:

- eliminating risks to health and safety **or**, if not reasonably practicable
- minimising risks by applying the hierarchy of control measures.

Eliminating or minimising hazards at the design stage is often more cost-effective. Research has demonstrated that design-stage actions result in higher-level controls being used to manage WHS risks.¹

Step 1

Gather information

It is important to consult with workers, particularly end users, about screens. It is also important to consult with original equipment manufacturers about screen design. When gathering information it is important for mine operators to adopt a holistic approach to managing their risks before the extractive site begins operating. Undertaking a holistic risk assessment with a group that includes workers (end users) and any regular contractors is beneficial.

The gathering information step is important as it enables articulation of how the screens will be used so that operators can design a safe and efficient system. Importantly the group should gather as much information as possible to assist in identifying the hazards, assessing the risks associated with them and considering potential controls emphasising control measures that can be built into the design of the site and plant selection.

Step 2

Identify and assess risk associated with tasks

As with any hazard, the hazards associated with screens must be identified and a risk assessment must be undertaken. The risk assessment should explore the likely hazards that take place during a screen change. As part of the risk assessment a number of different tools will need to be used to ensure hazards are properly assessed and appropriately controlled.

The risk assessment should also examine the hazards that may vary according to the site's life cycle. Stages of this life cycle include:

- **development** risks, when setting up activities for mining, for example, portable plant
- **operating** risks, when building screens or maintaining them
- **suspension/closure** risks, when making the mine safe for any person to access it as planned and required.

¹ Lingard, H, Sunders, L, Pirzadeh, P, Blismas, N, Kleiner, N & Wakefield, R 2015, 'The relationship between pre-construction decision-making and the effectiveness of risk control: Testing the time-safety influence curve', *Engineering, Construction and Architectural Management*, 22(1), pp 108-124.

Bow tie risk assessment

The bow tie risk assessment is a risk management tool. It illustrates the relationship between causes and hazards, the catalyst for an event, how the event could lead to negative consequences, and how controls could be used to prevent any negative consequences from occurring (Kirsh, 2012).

A series of sample bow tie risk assessments on screens and screen maintenance is included on the following pages. Their aim is to provide an overarching guide to the current risk and controls for screen activities. These risk assessments will assist you in identifying hazards and developing site-specific risk assessments for your operation.

MSD risk assessments

Due to the nature of screen change outs, a specific hazardous manual task risk assessment should also be undertaken. Tools are available to assist in the risk assessment of hazardous manual tasks. However, some of these risk assessment tools are reasonably complex. Quite often it is necessary to engage the skills and experience of a health or medical professional such as an ergonomist, physiotherapist, occupational therapist or WHS nurse to assist in the risk assessment process.

Relevant MSD risk assessments include:

- Ovaka working posture analysis system
- Rapid upper limb assessment (RULA)
- Rapid entire body assessment (REBA)
- NIOSH lifting equation guidelines
- Borg rating of perceived exertion
- PErforM tool.

For more detailed information on these tools, please refer to section 2.4 of the [Participatory ergonomics: train the work teams facilitator's guide](#).

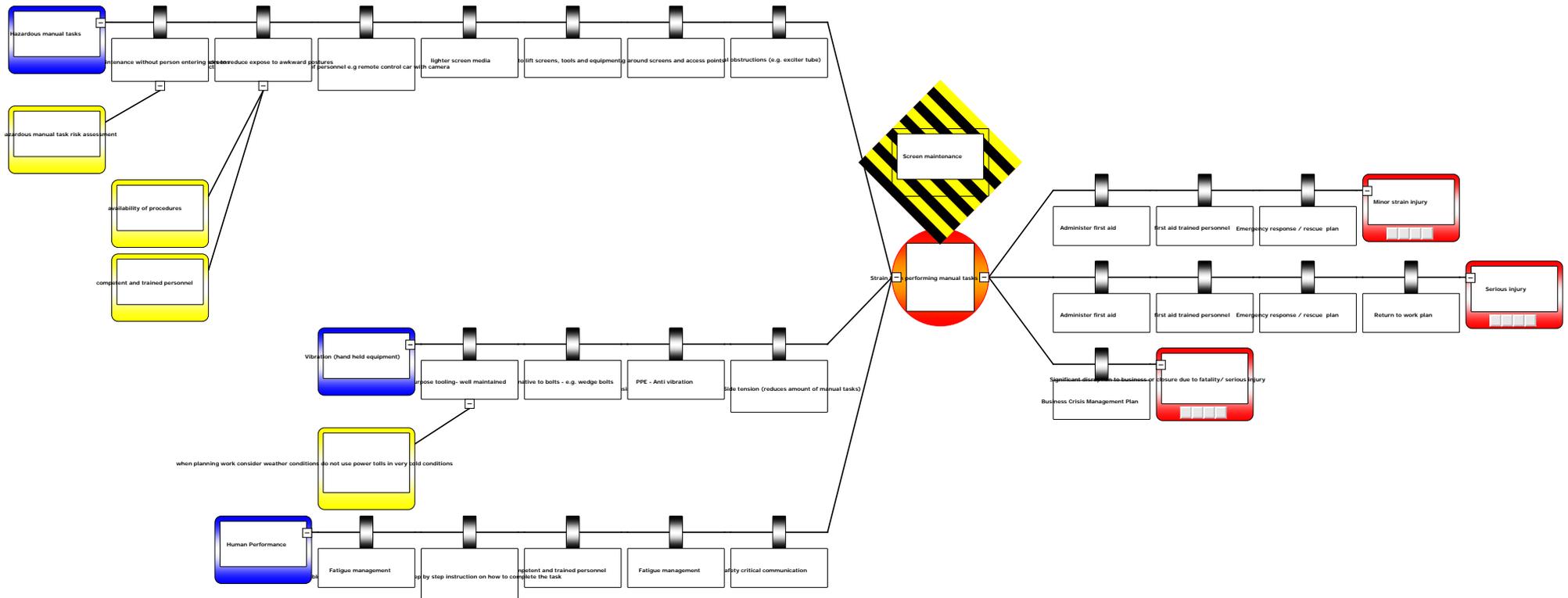
Participatory ergonomics approach

A participatory ergonomics approach to risk assessment allows a focus group to tackle a hazardous manual task using a systematic approach with a view to identifying solutions to the problem.

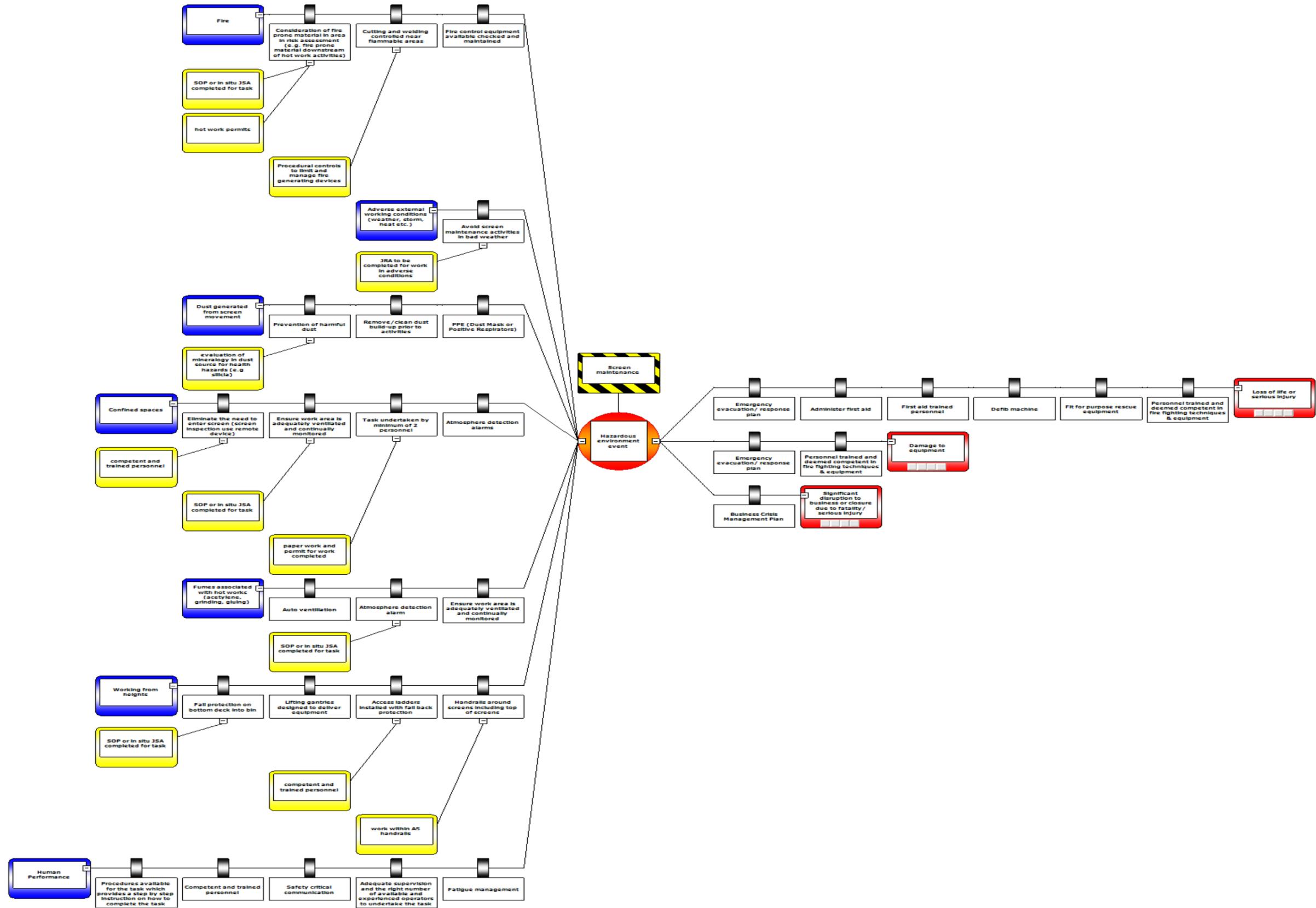
The availability of relevant information and expertise is essential to the effectiveness of the participatory process. The approach provides a forum for constructive consultation, something that can be difficult to achieve in other processes. Fundamentally the participatory ergonomics approach needs to be realistic and provide achievable solutions. If effectively executed, McPhee (2005) states it will:

- provide a sense of ownership of ideas and responsibility for identifying the most appropriate solution
- provide a framework for workers to use to solve problems
- present the worker the theory and application of ergonomics
- promote effective workplace communication.

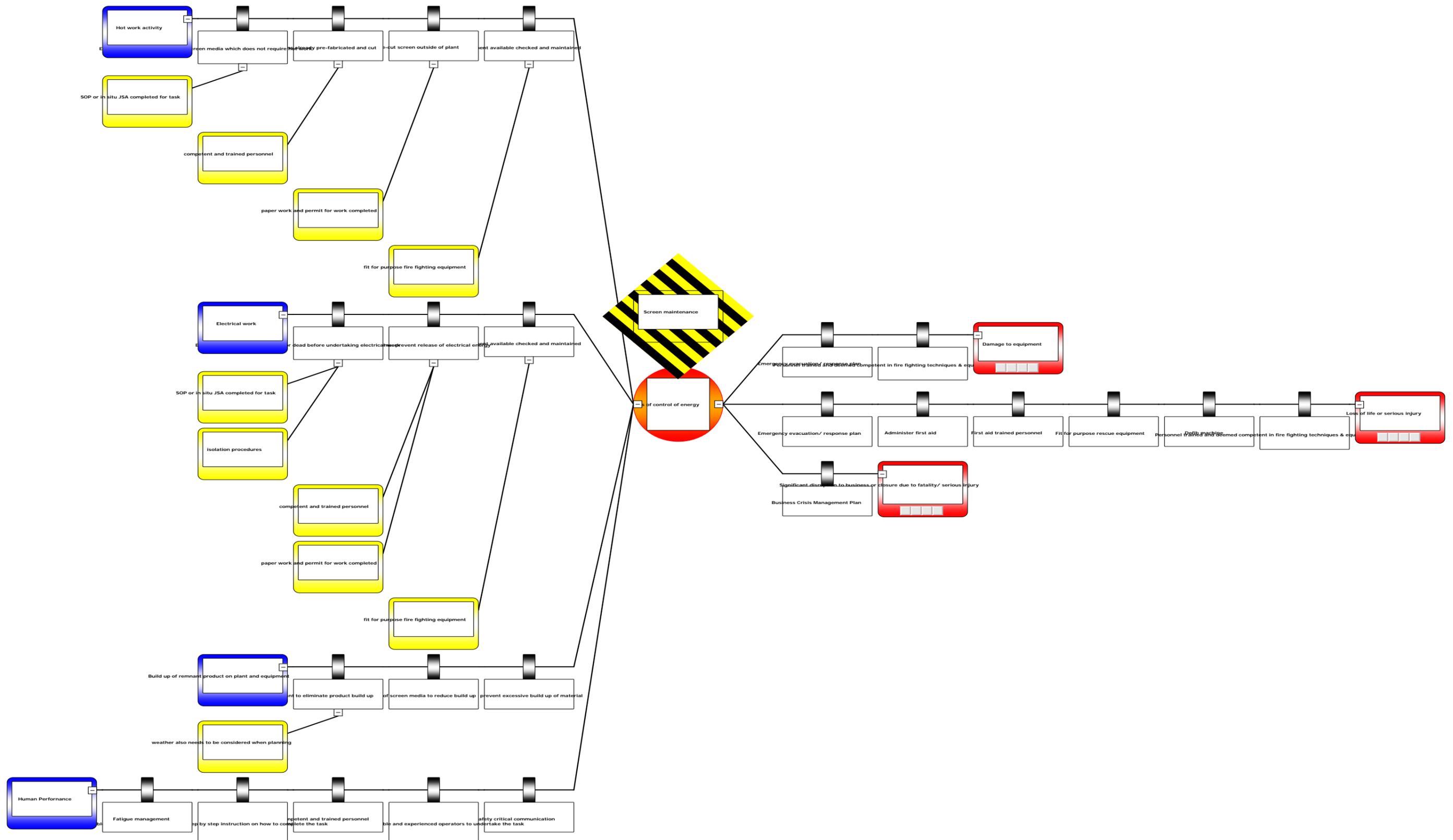
Bow tie risk assessment 1: Strain from performing manual task



Bow tie risk assessment 2: Hazardous environment event



Bow tie risk assessment 3: Loss of control of energy



Step 3

Control the risk

A person conducting a business or undertaking has the primary duty to ensure, so far as is reasonably practicable, workers and other people are not exposed to health and safety risks arising from the business or undertaking.

This duty includes eliminating exposure to risks associated with screens, so far as is reasonably practicable. This could include, for example, using alternative screens. If it is not reasonably practicable to do so, then risks must be minimised, so far as is reasonably practicable, by applying the hierarchy of control.

Controls should eliminate risks rather than relying on people to do the right thing. The hierarchy of control is a well-recognised model in risk management. It must be applied by all persons conducting a business or undertaking at a mine or petroleum site to manage risks to health and safety.

Controlling the risk directly—by designing out the hazard (high order control)—is generally more effective than lower order controls relying on physical barriers (for example, personal protective equipment), or administrative control measures (relying on appropriate and/or compliant worker behaviour).

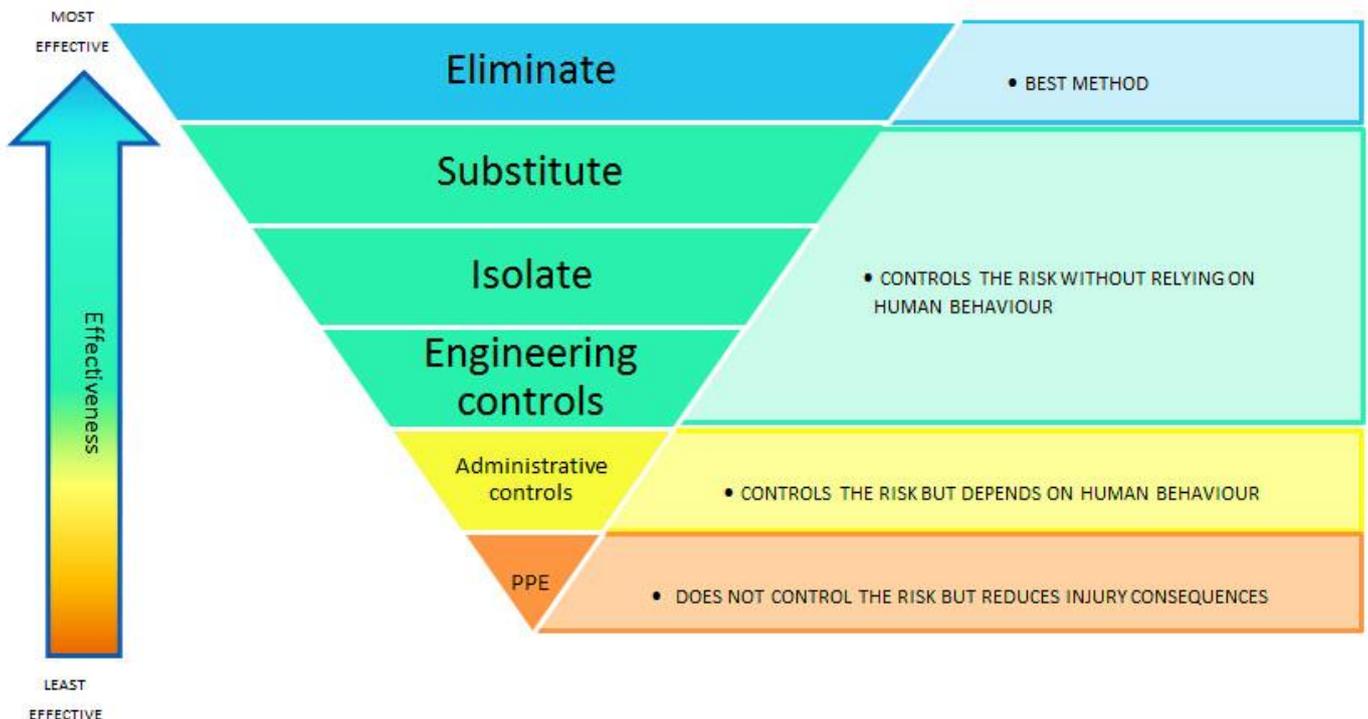


Figure 1: Hierarchy of control

Implementation principles

There are several principles that can help when selecting and implementing risk controls under the hierarchy of control model. You should:

- trial solutions before making them permanent
- review controls after an initial testing period as they may need modification
- develop work procedures to ensure that the controls are understood and responsibilities are clear
- communicate the reasons for the change to workers and others
- train workers to use the controls
- supervise the reliable implementation of controls.

Better design

Better design is crucial to reducing adverse outcomes. For further information on better design, [Safe Work Australia](#) have produced a [Principles of good work design handbook](#), which contains information about the 10 principles and how they can be successfully applied to any workplace, business or industry.

Design controls

Design controls refer to a control strategy that involves redesigning the screen layout, workplace or the task or tool to reduce risk. Design controls include substitution and engineering controls. An easy way to begin the process of introducing these control strategies could be to ask whether:

- you need a screen, and what alternatives can provide the same outcome?
- workers need to enter a screen, and how can workers undertake work without entering the screen?

Application to screen risks

Examples of risk control measures for screens are list below. They are organised by the type of control measure under the hierarchy of control. Please note, substitution, isolation and engineering controls are considered as one level in the hierarchy as they can be equally effective in controlling the risk.

Type	Example
Substitution	<ul style="list-style-type: none"> • providing lighter screen media • providing gantries or lifting equipment • upgrading screens to include rollaway chutes for easier access
Isolation	<ul style="list-style-type: none"> • changing and inspecting screens remotely
Engineering controls	<ul style="list-style-type: none"> • redesigning and upgrading the screen plant to allow more height between decks (preferably 500 mm as a minimum) • designing and constructing media so that it can be replaced through an automated process such as spooling technique or a cassette deck • designing tension and fixture locations so that they are easily accessible and do not require entry into the screen compartment
Administrative controls	<ul style="list-style-type: none"> • reliance on procedure to manage the risk of manual handling • worker participation in manual handling training • risk assessment for screen change outs <p>Note: administrative controls are far less effective than substitution,</p>

isolation and engineering controls. Administrative controls rely on the behaviour or actions of the worker or supervisors to control the risk. Administrative controls are best used as part of a comprehensive control strategy, to complement design control or for short-term risk management.

Personal protective equipment

- wearing a safety harness

Note: personal protective equipment (PPE) is a less effective control as it relies on the worker to manage the risk by wearing and fitting their PPE correctly. PPE equipment is the least effective in minimising risk as it reduces the consequences of an incident, not the hazard itself. Examples of PPE include ear muffs, face masks, hard hats and gloves.

Screen hazards and recommended controls

You should consider hazards at the design stage, when new or expanded operations are set up. However, in existing operations with legacy screens and/or screen houses, it may be reasonably practicable for a mine operator to implement controls through a step-change approach. Planning to eliminate screen hazards may involve retrofitting and the reduction of associated hazards.

Some recommended controls that should be considered in the mining operations management of screens are set out below. But it is important to remember that all decisions on the selection of controls must consider the particular circumstances in which the control is to be used. Decisions on controls must be made in consultation with relevant workers.

Key controls in relation to screens and screen maintenance include:

- screen design, including consideration of screen media, general access and height between decks, among other factors
- providing screen storage, appropriate lifting equipment and appropriate tools
- the availability of skilled and competent workers to maintain screens.

Systems for maintenance, inspection and testing of the screening plant are diverse. Mine operators and workers should consider the environmental conditions when undertaking screen change outs. For example, undertaking screen change outs in extreme heat and or very cold and snowy conditions can exacerbate the risks.

The PCBU/mine operator should fully understand the risks associated with the ongoing maintenance of screens. This should be clearly documented within the risk assessment process. The following is an example of risks that should be considered by the mine. Please note that this is just an example and the list may vary from extractive operation to extractive operation.



Figure 2: Top view of a screen deck with walkways

Screen design

Height between decks

On average the current distance between decks is approximately 270 mm, which is the width of a hard hat. However, screen supply companies have indicated that screens can be supplied with a distance of 500 mm. Companies operating overseas also supply screens with a distance of about 750 mm.

At the current distance of 270 mm, there is only an opportunity for small or slim workers to undertake the screen change outs, exposing them to awkward postures for an extended period of time. An **increase** in screen distance between decks:

- allows easier access
- reduces exposure to hazardous manual task risk factors
- decreases the time taken to complete the maintenance activity, thereby decreasing down time and increasing production.



Figure 3: View inside a screen deck that has utilised wire cloth

Screen media

Screen media is a replaceable surface that can be made up of one or more removable panel sections on a single deck. There are a vast number of screen media configurations based on material types, aperture sizes and styles, fixing systems and surface features. Screen media includes steel options of wire and plate, perforated and flame-cut plate, polymers (polyurethane and rubber), and hybrid media.

Lighter screening media is the preferred type of media; however, the process should be undertaken through a step-change or trial approach when moving from wire to rubber screen media. For example, hanging out a small section of the wire cloth for modular screening will allow workers to trial the different media. It provides an opportunity for the quarry to test the abrasiveness of material against the different screen media and illuminate what new challenges workers might encounter when changing out the new screen media.

Most manufacturers have a resource that can assist quarries to work out the calculations for the different screening media options, costs and performance requirements.



Figures 4 & 5: View inside screen deck (L) and example of rubber modular screen media (R)

Walkways

Walkways should be provided to allow easy access to screens, particularly if they are situated at an unsafe distance above the ground. As a minimum, walkways should meet AS 1657-2013 *Fixed platforms, walkways, stairways and ladders - Design, construction and installation*; however, this standard is a minimum standard and all effort should be made to allow easy access for workers of all shapes and sizes. In addition, walkways should be wide enough so workers are able to manoeuvre tools, screens and any other equipment required for the maintenance of screens.

Walkways are a vital component of safe work design. You must consider the following principles when designing walkways:

- all walkways should include a handrail and be fitted to allow easy access to all areas of the screen decks, including the top decks
- as the walkways are utilised as a work area during maintenance activities, all walkways should have a load rating to include workers, tools, screens and other equipment
- as the majority of maintenance activities are completed at the back of the screen, the walkway needs to be large enough to accommodate workers, tools and old and new screens.



Figure 6: Top of screen deck with modular screen media and walkways

Access (up and onto screen)

Mine operators should consider how workers can access the screens, especially the top deck. Workers should have reasonable access to screens via walkways. If access is difficult the risk of falls needs to be managed and included as part of any procedures. All people accessing the screens should be trained and certified in working at heights.

Handrails should also be in place to prevent falls from the top deck. In sites where handrails are not available, all workers must wear a regularly inspected and maintained harness. Where access to the top deck is required additional protection may be necessary at the access point.

This will prevent a person from being exposed to a fall from height over the surrounding lower handrail.

These are lower order controls and if you are planning on building new screens, the design process must include at least a consideration of how to eliminate the risk of poor access to screens and working at heights.

Safe Work Australia's [Managing the risk of falls at workplaces code of practice](#) provides more information on how you can manage the risk of falls.

Screen storage and appropriate lifting equipment

Screen storage and moving screens

Housekeeping is vital when managing the risks associated with screen and moving of screens. When designing storage for screens, you should consider:

- how workers access the screens
- whether the screen media need to be protected from the weather
- if screens are moved with a lifting device, how workers secure the screens to the lifting device.

Hazards associated with screen storage include:

- toppling of multiple screens (as the screens may have a total weight of 150kg or more)
- obstruction of access
- contact with ends of screen, with the potential to cause a laceration.

Screens should be stored in a designated area with specific restraining devices to prevent screens from toppling.



Figure 7: Example of good screen storage

Moving screens and provision of lifting equipment

As outlined in the walkway section, how screens are stored during a screen change out must be considered by the mine operator. This is because the way screens are stored limits the working space around the screens. Walkways may also not be rated to take the extra load.

Mine operators must consider how the screen media is manoeuvred around and up to the screen plant, particularly the top deck. Screens should be lifted to the screen area by mechanical means wherever reasonably practicable. Walking up stairs or up ladders with screens and tools increases the risk of injury; individuals are unable to maintain three points of contact and have limited visual awareness due to the size of the screen cloths.

When moving screens using gantries, the lifting device and fixture points should be fit for purpose and rated to carry the weight of the screen and tools that are to be moved. The use of homemade lifting devices such as old ropes and chains is not appropriate.



Figure 8: Moving heavy wire cloth screen media

Tools for attaching or repairing screens

The tools for the job need to be carefully selected after consultation with the workers involved. Depending on the work environment power tools may not be able to be used due to the increased risk of electric shock when exposed to water. In that instance, air/battery hand tools should be considered. However, the hazardous manual tasks associated with the use of hand tools must be assessed first. If power tools are used, a site-specific risk assessment should be undertaken before use.



Figure 9: Example of tools that may be used in screen change outs

Hot work

Hot work should not be undertaken in a confined area of the screen decks. Screens should be pre-cut before entering the screen. Mine operators should consider purchasing different screen media that provides the same wear requirements but does not need any hot work to fix the screens.



Figure 10: Wire screen media should be pre-cut outside of screen decks

Skilled and competent workers

Efficient production always relies on having people who know how to do their job safely and efficiently. As noted in previous sections in this guide, workers may require training, instruction and supervision on:

- working at heights
- how to follow safe procedures for accessing screens
- how to follow safe and efficient procedures for changing screens, such as pre-cutting screen media before entering the screen
- correct use of appropriate tools for the environment.

Skilled workers are a valuable resource for finding solutions to problems. Any signs of reluctance to do particular work or signs of absenteeism should be seen as an indicator of a problem. PCBUs should engage workers to find out what the problem is and the workers' proposed suggestions for fixing it.

Systems for maintenance, inspection and testing

These systems may include:

- visual inspections by competent people, using aids such as checklists
- equipment that can assess and evaluate the condition of the screen, or allow workers to do so without entering the screen.

For more information on the remote inspection of screens, please refer to the case study in Appendix B.

Step 4

Monitoring, review and audit

Monitoring

Once the controls for screens and screen maintenance have been implemented, duty holders must ensure they remain effective and are maintained. The controls must be, and must remain:

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

To achieve this, maintenance, inspection and testing should be undertaken with reference to two important questions:

- have adequate resources and staff been made available to undertake the necessary maintenance, inspection and testing of these controls in your organisation?
- do senior managers and directors fully understand the consequences of failing to provide these resources?

There are a number of key points to consider when developing a system to support maintenance, inspection and testing. These include:

- allocation of roles and responsibilities for managing these activities
- a system for identifying plant and equipment
- a system for assuring competence and supervision for personnel who undertake these activities
- providing appropriate instruction, communication and procedures for maintenance, inspection and testing.

For more information on monitoring controls, please refer to the [UK Health and Safety Executive](#).

Review

It is important to continually monitor risks and check control measures to ensure they remain effective. Control measures must be reviewed when an incident occurs, or when any changes may raise a new or different risk associated with screens and screen maintenance.

In undertaking the review, workers and their site health and safety representatives should be consulted. Mine operators or their delegates should consider these questions:

- are the control measures working effectively in both their design and operation?
- how effective is the risk assessment process?
 - are all hazards being identified?
- are workers actively involved in the risk management process?
 - are they openly raising health and safety concerns and reporting problems promptly?
- what has been the impact, if any, of new work methods or changes in equipment?
- are safety procedures being followed?
- has the instruction and training provided to workers been successful?
- if new legislation, information or technology becomes available, does it indicate current controls may no longer be as effective?

Audit

An audit determines whether controls for screen and screen maintenance are in place. It covers several key metrics including whether:

- workers understand their responsibilities
- training has been carried out
- equipment is available, including monitoring equipment
- inspections have been executed
- appropriate responses to any triggers have occurred
- required reports have been completed.

The audit will provide information regarding how well the controls are being maintained and should aim to identify if they are effective. An audit plan should include the:

- frequency of the audits
- scope of the audit
- audit methodology

- competency of the auditor
- responsibility for ensuring the audit is conducted and that the report is acted on
- reporting protocol for the audit
- performance standards, which should include that the
 - audit confirms 100% compliance with legislation **and**
 - controls in place are effective.

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Appendix A: Screen media selection

Please note, this section on screen media selection is an extract from Pit and Quarry magazine. The full article can be [downloaded from their website](#).

Screen media originated with the steel options of wire and plate. Now, the choices include wire, perforated and flame-cut plate, polymers (polyurethane and rubber), and hybrid media. See below for an overview of each of these options.

Wire cloth is the best option for an operation with frequent media change outs as a result of varying product specifications. The most common wire cloth options are high-carbon, oil-tempered and stainless steel wire, each with its own application benefits. Stainless steel, for example, is beneficial for corrosion prevention and is effective as an anti-blinding solution.

Perforated and flame-cut plate screens are a good alternative for secondary screening and are available in various steel types and hardness. Plate screens are ideal on top- and middle-deck applications for impact and abrasion resistance. Steel plates have seen recent improvements in quality with options available all the way up to the 400- to 500-Brinell range (a measurement of the hardness of the steel plate), providing for longer wear life and durability.

Polyurethane is available in different durometers and more frequently applied in wet applications where water is added or the feed is in slurry form. Urethane is also the best choice for dewatering screens.

Polyurethane does have its place in dry applications as well, with the development and improvement of material compounds and chemical formulations. Open-cast thermoset polyurethanes have superior wear-life performance over injection-moulded urethanes, primarily due to the slow-curing manufacturing process, which creates stronger molecular bonds in the material. Polyurethane panels are often found in a modular configuration for ease of installation and replacement. However, there are large cable-tensioned polymer screens that are better suited for aggressive, high-impact applications.

Rubber media is ideal in dry, high-impact applications and can often be offered in place of plate screens, depending on the nature of the feed. Modular rubber systems combine the benefits of modular screen panels with the durability of rubber impact screens in a high, open-area design. Rubber screen media may also be recommended in a wet-screening application such as where a plant is processing only natural sand and gravel. As well, self-cleaning rubber screens are used in fine, sticky or near-size material applications to prevent blinding from fines build-up, and to gain greater sizing accuracy.

Rubber generally offers the longest wear life of any screen media in the most difficult and aggressive scalping applications. Rubber panels are effective in reducing noise levels by up to 9 decibels when compared with steel media, which is about a 50% reduction as recorded by the human ear.

Hybrid screens come in several different types that maximize open area and wear life. Urethane-encapsulated wire offers the advantage of urethane screen media (wear life and noise reduction) without the need to convert to a modular deck and without great sacrifice to open area. Another common hybrid screen combines wire held in place with rubber or urethane strips for greater wear life and an optimal flexing action during screening to prevent plugging or blinding.

Typically, premium rubber compounds are used in hybrid screens, as they are most effective in high-volume applications; and they are particularly ideal in hot and humid environments.

Appendix B: A screen life cycle

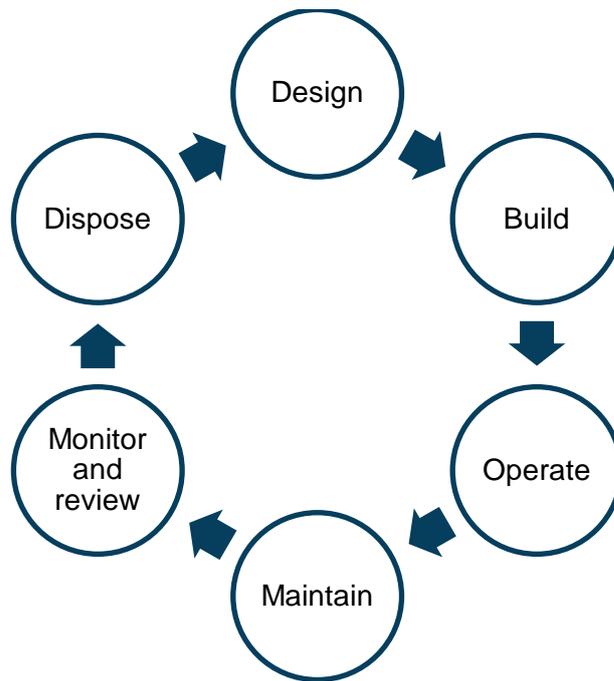


Figure AB1: screen life cycle

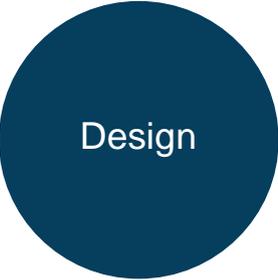
The following are considerations for an extractive operation to manage the risks associated with screen change outs. Each site may need to consider other factors according to their circumstances.

Ask

Design screens and equipment for maintainability, which involves reducing complexity and improving accessibility. You should ask:

- What is the screen intended to do?
- Who needs to use it? What are their requirements?
- What loads does it need to carry?
- What does the finished product need to be?
- What is the life span of this screening plant: life of mine, panel life or short-term?
- What will this screen be used for in the long-term?

Involve all relevant maintenance personnel in plant and equipment design, job design, task analysis and writing procedures.



Design

Key considerations:

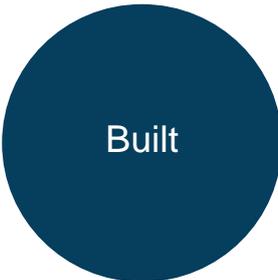
- walkways
- general access
- ladders and handrails
- reducing the necessity to work on top of screen
- screen storage
- chute design
- height between decks
- screen media
- gantries and lifting equipment
- screen handling
- maintenance including screen lift in and out.

Requirements:

- Are any specialised equipment, tools, consumables, skills or processes needed?
- How can the plant or structures be built or installed safely?

Key considerations:

- whether this a new screen or a retrofit of an old screen
- installations required for build: lighting, communications, signage, etc.



Built

- whether the screen has been built and installed as per the design
 - what checks are in place to make sure this happens (contract, deliverables, final sign off).
-



Operate

Check:

- Will the equipment, loads and other requirements be met?
 - Have safe procedures and risk assessments been established for maintenance tasks?
-



Maintain

Ask:

- What is required to maintain the screen to an appropriate standard, given the use and type of screen?
 - Are there special tools, equipment, supplies and other materials required to maintain the screen?
 - What training and communication is necessary?
 - What inspection regime is in place to determine whether the screen is being maintained, or meets the appropriate standard? For example, an inspection program.
-



Monitor
& review

Review:

- analyse the effectiveness of controls
 - determine if there have been any changes and if these have been documented
 - ascertain whether there is regular inspection and maintenance regime on the screens
 - determine whether workers actively involved in the review and risk management process, and whether they are openly raising health and safety concerns and reporting problems promptly.
-



Dispose

Key considerations

- risk assessment must consider potential clean-up issues
 - disposal plans must be incorporated at the design phase
-

- plant should be dismantled in accordance with the designers' and manufactures' instructions
 - workers should be given the opportunity to give feedback about the positives and negative of the old plant, which can be fed into the design phase for new plant.
-

Appendix C: Case study (Boral)

Seaham Quarry's autonomous inspection units

Please note this appendix was prepared by David Looschelder, Student Engineer at the NSW Resources Regulator.

Over the past two years, Boral's Seaham Quarry has developed autonomous inspection units to improve the efficient execution of preventative maintenance. This allows screen maintenance to be conducted without the associated human risk, by removing workers from the hazardous environment and thereby eliminating the risk of injury.

Boral has found that the unit is able to identify a range of issues with screens. These include:

- missing bolts
- wear on screen media
- worn centre and side rails
- material build up
- pegging.

(Boral, 2015)

The current version of the unit is made up of a remote control (RC) vehicle with a camera unit and flashlights attached to the front, as shown in Figures AC1 and AC2. It is operated remotely through the use of a hand-held control, which consists of half a steering wheel for navigation and buttons for other controls. The camera attached to the unit is synced to an iPad to provide a live feed of the inspection.

The use of an RC vehicle improves flexibility as the user is able to direct it to any point on the screen and focus on certain areas of interest. Operators can undertake a complete inspection for any issues that may be present while the worker operates the unit remotely without needing to access the screen.

Current work is being done on introducing a 360 degree pivot control system on the camera. This will further improve the flexibility of the camera, allowing for an increased level of reliability on the findings of the unit.



Figure AC1: RC vehicle



Figure AC2: Attached camera and flashlights

In addition to eliminating the exposure to the hazardous manual task as well as the confined space, the autonomous inspection unit is able to record the inspection as well as take photos. This allows for high-quality record keeping that can be referred to post-inspection. An example of the images that can be taken by the unit is given in Figure AC3.

Through the use of the unit the inspection time required can be halved once the operator is trained and familiarised with the system. This brings the associated benefit of enabling the screen to be operating for a longer period of time and hence increase its productivity

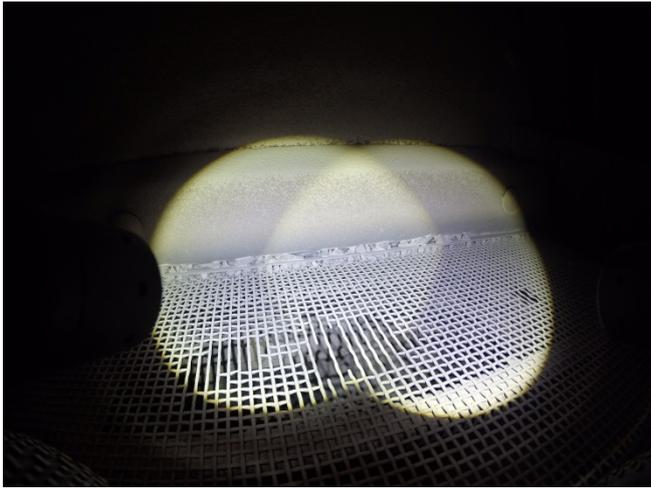


Figure AC3: Image captured from the autonomous inspection unit during inspection

The process of undertaking an inspection using the unit involves two main steps. The first step is to isolate the screen to ensure no electricity is flowing. The second step requires a single operator to control the unit and undertake the inspection. Requiring only one worker to complete the inspection is one of the unit's major benefits, meaning the process is very cost-effective.

The unit is currently being trialled across the country, with a roll-out at one Boral operation in every state except for Western Australia. This application has been targeted at 'high risk' quarries to ensure that it is able to meet higher demand operations. 'High risk' quarries include those whose higher silica content and volume require a higher frequency of inspections. Once the autonomous inspection unit has been proven a success, it is expected they will be introduced in other Boral operations around Australia.

Reference: Boral Limited 2015, *Autonomous Inspection Unit* [webpage], Boral Limited, Sydney, available at boral.com.au/article/ccaa-environment-health-and-safety-awards-2015.asp, [accessed: 10 December 2015].

Appendix D: Case study (quartz gravel plant)

Site: A quarry in regional NSW.

Process: Dry processing quartz gravel plant.

Problem: The primary screen (16x6) used is for scalping. It typically used traditional wire mesh screens or wire ripple screens for producing a 20 mm scalp product. However, the screens were typically changed out every four to six weeks due to the high abrasion of the quartzite material.

Solution: Installation of polyurethane, fully-welded screens. These new screens have seen the site increase the wear life of the screening media. Note Figure AD1, which shows the screen after 26 weeks in operation.



Figure AD1: Screen after 26 weeks in operation

Benefits: there were several benefits for the new screens. They include:

- extended wear life of screen media
- reduction in maintenance and downtime for screen change outs
- increased productivity
- reduction in WHS issues that related to screen changes
- reduced operational noise generated by screening processes.

Operational information

Type	Details
Source material	Quartzite gravel
Process	Dry
Plant throughput	180TPH
Screen	16x6, three deck, 20 degrees
Tufflex deck	Bottom deck
Feed material	Minus 40 mm
Previous screen	Poly ripple 20 apt x 5.0 diameter, high tensile
New screen	10.0 square aperture x 4.0 diameter fully welded
Site cost benefits	<ul style="list-style-type: none"> • Cost savings: expected to be \$10,000 in savings pa. • Labour savings: 7 changes at 2 hr each and \$40/hr is \$560 pa. • Productivity improvements: extra aggregate 15% at 180 TPH. • The new screen allowed smaller aperture • Screens to be utilised without blinding, producing 15% more aggregate for the same screening time and throughput.

Appendix E: Checklist for screens

Instructions

Use the checklist to identify the controls implemented in the extractive site. Please type 'x' in the box to identify the control's level in the hierarchy of controls. You must only type in the 'x' for **one** of the following: elimination, substitution, engineering controls, administration and training, or personal protective equipment (PPE).

Audit type	Control	Elimination	Substitution	Engineering controls	Admin and training	PPE	Improvement
	Briefly describe the control implemented by the mine to manage the risk.	Type an 'x' in only one of these.					Provide suggestions for improvement. PPE and administrative controls are the least effective controls.
Risk assessment <ul style="list-style-type: none"> • Has a risk assessment been completed for the safety critical task? • Worker involvement in development? • In general where do most of the controls for the risk assessment fall? 							
Hazardous manual task risk assessment <ul style="list-style-type: none"> • Has the site undertaken a site-specific hazardous manual task risk assessment for screens and screen change outs? 							

<ul style="list-style-type: none"> In general where do most of the controls of the risk assessment fall? 							
<p>Height between decks Consider:</p> <ul style="list-style-type: none"> Confined areas. Screen inspections (how is this undertaken?) How do workers access screens for screen change out? Are workers required to work within the screens? 							
<p>Screen Media Consider:</p> <ul style="list-style-type: none"> What type of screen media is being utilised by the mine? Does the site outline why a specific screen media is used within the mine? Does the mine have a plan to introduce lighter screen media? 							
<p>Walkways Consider</p> <ul style="list-style-type: none"> Do they meet AS1657? Provision of easy access for workers? Wide enough to allowing carrying tools and equipment? Provision of hand rail? Are walkways load rated? 							
<p>Availability of gantries and appropriate lifting equipment</p>							

<p>Consider:</p> <ul style="list-style-type: none"> • Whether screen media is lifted to change out by mechanical means? • Are gantries fixture points attached to the screens and are lifting devices appropriate and rated to move the weight of the screen? • Are screens secured to the lifting device? And is this rated? 							
<p>Screen storage Consider</p> <ul style="list-style-type: none"> • Is this stored in a designated area? • Are there restraining devices? • Does screen media need to be protected from the weather? 							
<p>Tools Consider:</p> <ul style="list-style-type: none"> • Are the tools fit-for-purpose, including regarding vibration? • Has a site-specific risk assessment been completed prior to work being undertaken? • Are power tools expected to be used near water? • What air or battery tools are being used? 							
<p>Working at heights (including accessing screens for screen change outs) Consider:</p> <ul style="list-style-type: none"> • Is there a risk from falling from heights when undertaking 							

<p>screen work?</p> <ul style="list-style-type: none"> • Has a relevant working at height permit been completed? • Are workers trained and competent to undertake work at heights? • Has maintenance inspection and testing been undertaken with regard to working at heights equipment? • Is there a handrail present? 							
<p>Hot work Consider:</p> <ul style="list-style-type: none"> • Has hot work been undertaken within the screen deck? Hot work must not be undertaken there. • Are screens pre-cut? 							
<p>Other: to be filled in as necessary.</p>							
<p>Other: to be filled in as necessary.</p>							