

MACHINERY DESIGN AND INJURIES IN U/G MINING

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What is Ergonomics?

The word 'ergonomics' is derived from an Ancient Greek word meaning 'rules or study of work'

It is also referred to as 'human factors (in design)'



What is Ergonomics?

The appropriate design for people – the design of systems, processes, equipment and environments so that tasks and activities required of them are within their limitations but also make the best use of their capabilities.

The focus of the design is on the person or a group of people.



What is Ergonomics?

It is a rigorous, user-centred approach to research and design

It is also a philosophy and a way of thinking

Ergonomics in Mining

- Ergonomics is an essential component in OHS Risk Management
- Often overlooked or not recognised as ergonomics
- Need basic knowledge of ergonomics for adequate risk control

Ergonomics in Mining

- Impression that ergonomics is limited in its range and application – physical design
- Ergonomics seems straightforward but its application may not be obvious or easy

Ergonomics in mining

Difficulties in applying ergonomics arise from:

- the differences between people
- how these can be accommodated
- knowing when enough has been done

Principles of ergonomics

This presentation highlights operating principles of ergonomics rather than solutions to particular problems

Principles of ergonomics

Using broad principles enables people to know:

- Where the cut-off point is between completing tasks and maintaining a safe and healthy work environment
- When to make a fuss
- What further technical information may be required

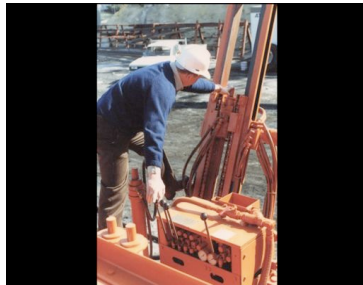
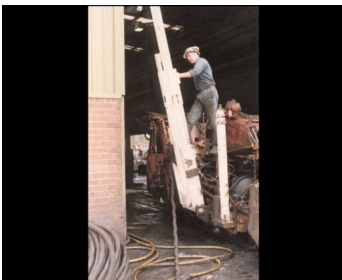
Issues in ergonomics

1. No one mine is the same as any other mine
2. No one work area is the same as any other work area
3. Most solutions comprise of lots of small changes over time
4. Ergonomics solutions (controls) have a regional and local context

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The bad old days

- High roof, lack of consultation and NO ergonomics!



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The bad old days

- Un-driveable machines, poor visibility – NO ergonomics!



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The bad old days

- This is the way it has always been – NO ergonomics!
- Displays and controls – primitive, inadequate or non-existent
- Seating was being improved



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The bad old days

- Back breakers – NO ergonomics!
- Transport vehicles were designed for orangatangas
- No suspension
- Seating was primitive



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The bad old days

- LHDs – the work horses of mining, never break down, never wear out – but NO ergonomics!



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The bad old days – but getting better

- Transport vehicles are improving
- Seating
- Headroom
- Suspension



Elements of ergonomics

There are 4 main areas of ergonomics:

People – capabilities and limitations

Task design – what people do and how they do it

Workplace design – the design of tools, equipment, furniture and the work environment

Work organisation – how work is organised and managed

The person

Designing work for people is less of an afterthought than it once was

We need to consider the least fit, able and healthy and their particular needs.

This is very important with an aging workforce

Job/task design

What the employee is required to do and what they actually do

- job content
- work demands
- restrictions and time requirements such as deadlines
- individual's control over workload including decision latitude
- working with other employees
- responsibilities of the job

Karasek model

Low demand High control	High demand High control
Low demand Low control	High demand Low control

High demands + High control =

Learning motivation to develop new behaviours

High demands + Low control =

Risk of psychological strain and physical illness

Work environment

- buildings
- work areas and spaces
- storage
- lighting
- noise
- vibration
- thermal environment

These components can change subtly and need to be regularly monitored and evaluated

Equipment design

Hardware of the workplace – the part of ergonomics that everybody recognises

- electronic and mobile equipment
- fixed equipment
- protective clothing
- furniture
- tools

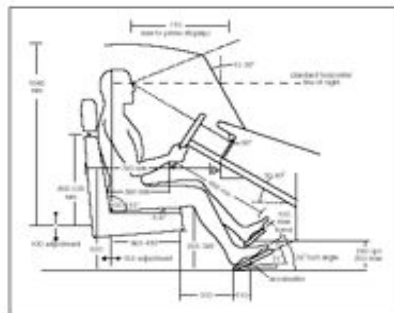
Design with users in mind

Cab dimensions

Cab dimensions for free steered vehicles

MDG1

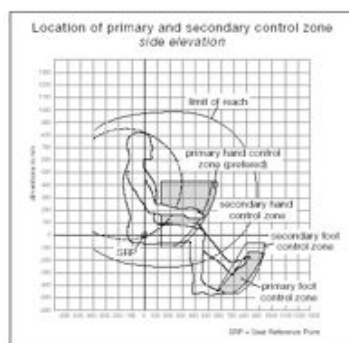
SAE



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The seated operator

- MDG 1
- SAE guides
- Practical Ergonomics
- Bad Vibrations



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Work organisation

The broader context of the business and its work and how this affects individuals

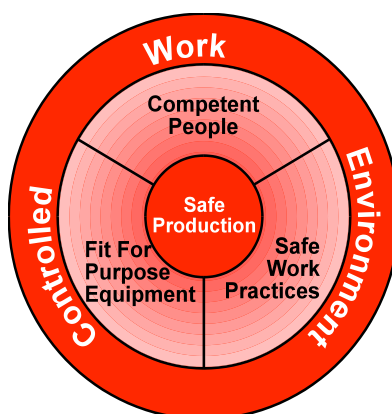
- patterns of work
- peaks and troughs in workload
- shiftwork
- consultation with the workforce
- inefficiencies or organisational difficulties
- rest and work breaks

Work organisation

- teamwork
- how the work is organised and why
- workplace culture
- broader economic and social influences

Work organisation is often the source of many problems related to ergonomics and is the hardest to change

Nertney Wheel



Main contributors to injury in underground mining in NSW

- Poor access
- Poor machinery design – cab, seat, visibility
- Poor tool design
- Poor floor conditions/slippery work surfaces/ uneven platforms
- Work above the head
- Handling heavy weights
- Poor illumination
- Vibration

Sources of injury in underground mining in NSW

- Unplanned movement of machinery
- Failure to isolate electricity
- Inadequate procedures/design for Fluid Power Systems

Common types of injury in underground mining in NSW

- slips, trips and falls (STF)
- sprains and strains (S&S)
- crushing, bruising
- amputation
- cuts and abrasions
- fluid injection
- [fatality]

About the operator/maintainer

- Who will be operating/using the equipment? Are they adequately trained?
- Where will they be working? Conditions?
- What will they be doing? SWP? Variations?
- Who will service/maintain equipment? Where?

Access to the vehicle/machine for the operator

- Steps, stairs ladders, walkways & access platforms. Are they safe to use under all foreseeable conditions?
- Are there handrails and handholds where necessary?
- Are doorways wide and high enough?

Safe and efficient operation

- Can the operator see and hear?
- Can s/he understand and act appropriately when given information?
- Can s/he manipulate controls easily and without confusion?
- Can s/he work in reasonable comfort without unnecessary or excessive physical and/or mental stress or fatigue?

Environmental conditions

- Is there protection from noise, dust and other risks to health?
- Can doors and windows in cabs be closed and are seals adequate to prevent the ingress of unwanted, distracting or dangerous noise, dust, fumes or other environmental contaminants?

Environmental conditions

- Is the operator able to work in reasonable comfort (seating, work platforms etc)?
- Can enclosed cabs be kept at a reasonable temperature for sedentary work (20 – 25° C)?

Environmental conditions

- Can the operator communicate easily and without misunderstanding with people outside the cab?
- Is whole-body vibration reduced to an acceptable level?

Manual Handling – Access to supplies and equipment

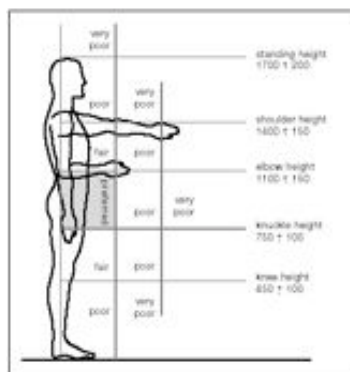


Manual Handling – Access to supplies, equipment, displays and controls

- Designated storage areas for supplies and equipment
- Adequate, safe access
- Enable operators to:
 - ✓ keep loads close to the body
 - ✓ lift and carry at waist height
 - ✓ handle above knees and below shoulders

Height ranges for lifting

- Codes of Practice for Manual Handling in each state and territory
- Practical Ergonomics
- Numerous papers and textbooks



Manual Handling – Ergonomics design principles

- Minimise height restrictions where possible (all operators can stand up)
- Minimise reach distances especially for bolting and handling

Manual Handling – Ergonomics design principles

- Minimise the need for bending especially bending and twisting
- Improve access for routine maintenance and checks

Manual Handling – Ergonomics design principles

- Minimise manual handling of supplies particularly multiple handling
- Reduce the amount of work carried out above the shoulders or below the knees



Slips, trips and falls – Access to machinery

- Steps and handholds
- Walkways
- Work platforms
- Doorways



Access to machinery – Ergonomics design principles

- Free and uncluttered walkways that are wide enough to be able to walk forward



- Minimise or eliminate changes in levels of walking surfaces

Access to machinery – Ergonomics design principles

- Cover (or otherwise eliminate) all holes or depressions where a foot could get stuck or which may pose a trip or a fall hazard
- Slip-resistant surfaces on all platforms, walkways and steps

Access to machinery – Ergonomics design principles

- Well-designed steps, footholds and ladders for access to the miners (size, shape, location, surface, handrails)
- Minimum of 200mm deep, 500mm off the ground and two boot widths wide

Access to machinery – Ergonomics design principles

- Handholds – vertical rather than horizontal, rounded with no sharp edges and large enough for the biggest hands wearing gloves
- Handrails need to be within reach of the smallest person

Access to machinery – Ergonomics design principles

- Impact damping surfaces may be desirable on work platforms
- Bolting platform on miner can accommodate two people without posing a hazard to either

Crushes, amputations, cuts,
abrasions

- Eliminate pinch points and the risk of crushing of hands, feet, body with any parts that move
- Minimise or eliminate sharp edges and protruding obstructions

Safety – Ergonomics design
principles

- Optimise location for operators near the miner while flitting or breaking off
- Change location of equipment that requires the operator to turn his back to the face or ribs before bolting is completed

Ergonomics design principles

Consider:

shortest person – reach and using stairs

tallest person – standing height

biggest person – access, spaces, work
areas

biggest foot – steps, walkways

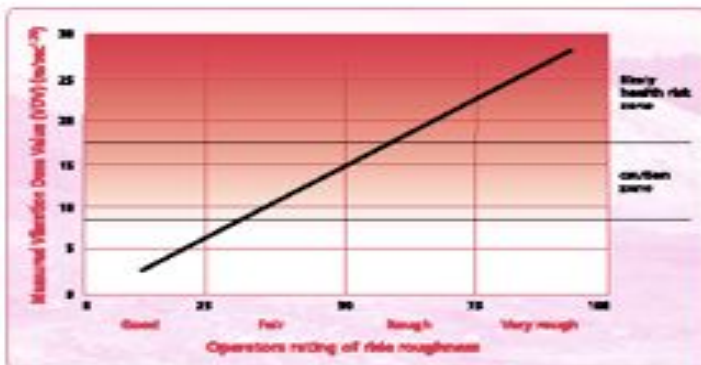
smallest foot or hand – holes

weakest person – strength and stamina
especially in awkward work situations

Vibration

- Generally unrecognised source of serious injury
- Needs systematic approach to solve the problem
- Solutions – combination of approaches: such as road maintenance, cab and seat design and maintenance, machine design and driver skills and awareness

Drivers' rating vs measured Vibration Dose Value (VDV)



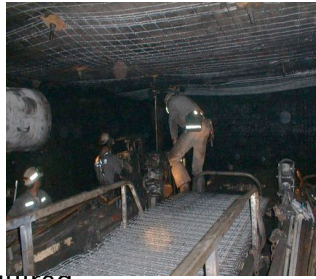
Changing conditions

- Changing technology – e.g. mesh
- Improvements in design – rib barriers and extendable bolting platforms
- Change in conditions e.g. ribs and roof, water, geological issues



Visibility

- Always a problem
- Glare/dazzle
- Often inadequate on vehicles – particular problem with rough rides
- Considerable adaptation required



Maintenance

- Is there easy access to machine parts or areas requiring attention?
- Does maintenance require undue force, awkward postures or dangerous practices?

Maintenance

- Are there suitable tools readily available when maintaining and servicing of equipment?
- Are the demands of maintenance tasks within the capabilities of maintenance personnel?

The ergonomics approach

Consider the miner as a mobile work platform and storage facility as well as a cutting and bolting machine (continuous miners)

A second class ride is not better than a first class walk (transport vehicles)

What has been accepted for years is not necessarily acceptable (shuttle cars)



The ergonomics approach

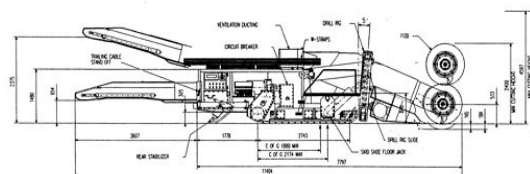
1. Consultation
2. Observation
3. Objective data (stats, audits, reports etc)

These are critical to finding and implementing effective ergonomics solutions



Ergonomics design reviews

- Use plans, schematics, mock ups etc to get it right
- Continuous process of review and improvements



Ergonomics design reviews

- Ensure that all significant stakeholders are involved in planning, purchasing and commissioning of equipment



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Mock-ups of roof bolting control panels – Kestrel

Barry's crew



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Mock-ups of roof bolting control panels – Kestrel

Smithy's crew



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Risk Assessments in ergonomics

Participative risk assessments are always the starting point for identifying and assessing ergonomics problems and developing ongoing solutions

Risk assessments in ergonomics

The same rules apply to ergonomics risk assessments as to other risk assessments in mining

MDG 1010 and MDG 1014
Practical Ergonomics

Risk assessments

- Participation
- Ownership
- All issues are captured
- Documented starting point from which progress can be measured
- Framework for change
- Dissemination of information
- Training tool



Ergonomics risk assessments

Limited if there is a poor understanding of ergonomics

RA needs people knowledgeable in ergonomics and can then be a training tool



Ergonomics risk assessments

Different methods can be used to 'quantify' risk

WRAC and its variations – consistent with organisation's systems and approaches
Easy to learn and use

Fines Nomogram (tie line) is more useful (includes exposure) but can be more time consuming and the numbers don't quite fit with WRAC

Ergonomics risk assessment

The Workplace Risk Assessment and Control (WRAC) method of Risk Ranking

PROBABILITY

A	Common
B	Has Happened
C	Could Happen
D	Not Likely
E	Practically Impossible

PROBABILITY

	A	B	C	D	E
1	1	2	4	7	11
2	3	5	8	12	16
3	6	9	13	17	20
4	10	14	18	21	23
5	15	19	22	24	25

CONSEQUENCES

	Description	People	Equipment	Public Reputation (?)
1	Catastrophic	Fatality	Major > \$500K	
2	Major	Serious Injury	\$250K - \$500K	
3	Moderate	Lost Time Injury	\$50K - \$250K	
4	Minor	Minor Injury	\$5K - \$50K	
5	Insignificant	Medical Treatment	Minor <\$5K	

Barriers and controls

Barriers and Controls



Training & Competencies

For the:

- person
- task
- organisation

Type:

- awareness raising
- knowledge
- skills



Training and competency

- Are operators aware of all features on the vehicle/machine, how to use them optimally and why it is important that they do?
- Is there suitable competency training available for operators and maintenance personnel?

Important references for vehicle/ machinery/equipment design

NSW Guidelines (Mine Safety Operations, NSW
Department of Primary Industries)

- MDG 1 – Free steered vehicles (Being revised)
- MDG 29 – Management of diesel engine system pollutants in underground environments (Draft)
- MDG 35 – Bolting and drilling equipment in mines (Draft)
- MDG 41 – Fluid power system safety at mines (Draft)

Important references for vehicle/ machinery/equipment design

- Australian Standard – AS 4024.1–
2006 Safety of machinery
- Australian Safety and Compensation
Council – Guidance on the
principles of safe design for work –
2006

Important references for vehicle/ machinery/equipment design

NSW WorkCover – Safe Design Seminar
Workshop discussion papers 2005
Improving Design Safety

- Regulatory options
- Non-regulatory options
- The role of consultation

Important references for vehicle/ machinery/equipment design

- National Occupational Health and Safety Commission (NOHSC 2004 now ASCC) – The role of design issues in work-related injuries in Australia 1997-2002.