23. Ergonomics

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23.1 Purpose

Ergonomic surveys are conducted to identify ergonomics-related risk factors in a workplace. The surveys include elementary hazard identification, risk assessment and identification of areas where specialist ergonomics advice is required.

This Chapter provides the reader with basic tools in the form of checklists to identify ergonomics-related risk factors in a workplace. In the present context an ergonomics programme is regarded as a systematic approach to anticipating, identifying, analysing and controlling ergonomics-related hazards. The hazard identification process provides the data needed to identify, control, and prevent work-related injuries and illnesses.

23.2 Background

Ergonomics is the science and practice of designing systems to fit people so that the tasks required of the human users are not only within their limitations, but also to ensure that best use is made of their functional capabilities. Unhealthy, unsafe or inefficient situations at work could often be avoided by taking into account the physiological and psychological capabilities and limitations of humans.

Ergonomics is a multi-disciplinary science as specialists from various areas, e.g., engineering, physiology, medicine, psychology, industrial design and occupational hygiene contribute to the body of knowledge. Ergonomics should therefore not be viewed in isolation when applied in the work environment and it is essential to draw on all available skills and experience from the above-mentioned disciplines in a multi-disciplinary team.

Ergonomics differs from other fields by its inter-disciplinary approach and applied nature. As a consequence, the ergonomics approach results in the adaptation of the work environment or workplace to fit people, rather than the other way round.

A large number of factors play a role in ergonomics such as working postures (sitting, standing, stooping), body movements (pushing, pulling, lifting), the physical nature of the task (energy expenditure), environmental factors (thermal stress, noise, vibration, illumination, air quality), information gained through displays (visually or through other senses), the relation between displays and controls, as well as general work organisation. These factors largely determine the health, safety, comfort and efficiency of task performance in the workplace.

The ultimate goal of ergonomics is to improve and maintain the well-being of an individual worker. At the same time the well-being of the organisation, reflected by increased productivity, will also be improved and maintained. The application of sound ergonomic principles in a workplace will minimise design-induced human error, and also eliminate significant occupational health and safety risks, especially those related to the musculo-skeletal system.

The identification of ergonomics-related hazards in a workplace should ideally be part of a mine's ergonomics programme, which in turn should form an integral part of the overall occupational health and safety programme. Most mines have, as a result of the requirements of Section 11 of the MHSA, established risk management elements such as hazard identification, risk quantification, training, audit and feedback within a specific management system but have not yet adequately addressed ergonomics.

23.3 Legislation

"Ergonomics" is not a new concept in the South African mining industry. The MHSA makes specific reference to ergonomics. Section 21(1)(c) of the Act states that: any person who designs,

manufactures, erects or installs any article for use at a mine must ensure, as far as reasonably practicable, that ergonomic principles are considered and implemented during the design, manufacture, erection or installation. Mine management must ensure that original equipment manufacturers (OEMs) comply with this requirement.

23.4 Methodology

23.4.1 Principles

In practice it is essential that the design of workstations and optimal working conditions take the following into consideration:

- The physical sizes of people and the implications for the "fit" of an individual at a workplace and within a facility.
- The cardiovascular system and its limitations on physically-demanding work, as measured by work physiology.
- The major musculo-skeletal system and its limitations on manual materials handling.
- The minor musculo-skeletal systems and their limitations on fine work, manipulation and dexterity.
- Environmental factors such as lighting, noise and thermal comfort, and their impact on worker performance.
- Cognitive capabilities of people and their impact on the processing of information and "human error".

23.4.2 Identification of Ergonomics-Related Hazards

Ergonomics surveys should ideally be conducted on a regular basis to identify any significant changes in a workplace. Effective and regular analysis of the potential hazards in a mine will allow for a greater degree of control of the risks identified. The selection of a particular task or workplace for further or more detailed investigation should always be done by considering the priority areas of the mine and in consultation with the relevant personnel in a given work area. Some factors which may indicate the need for intervention include an increase in incidence of musculo-skeletal injury, greater prevalence of absenteeism or significant reductions in worker productivity.

23.4.3 Factors Influencing Data Acquisition

One of the major challenges facing an occupational hygienist or ergonomist is the complexity of human responses. No two workers will respond to a given situation in exactly the same way and various data acquisition techniques are available to address this issue. The ergonomics experience of an assessor will dictate the level of sophistication of the data acquisition and analysis techniques used for the specific type of work being done. Ergonomics data are useful for health surveillance, assessment of workstation design and selection of tools or equipment, product design, quality aspects, participative aspects and education, training and information. Due to the inherent complexities it is recommended that simple methods be used (at least initially) to identify potential hazards. It is further recommended that basic checklists be used whenever a work process is changed, when new tasks are introduced, and periodically thereafter (especially after new cases of musculo-skeletal disorders are reported) to detect whether trends exist across jobs that use similar equipment, tools or processes.

23.4.4 Limitations

An effective ergonomics hazard identification and risk assessment process should facilitate the classification of possible high risk jobs in a mining environment. In instances when the risks associated with a job are considered to be extreme when compared with recognised standards, it is strongly recommended that an experienced professional ergonomist be consulted. Certain jobs may require extensive re-design and this should be done in consultation with the inter-disciplinary team members.

23.4.5 Procedures

When conducting an ergonomics risk assessment the following general steps listed below should be followed [1].

- Identify potential hazards in the workplace
- Estimate the risk for each hazard
- Evaluate the risk
- Prepare risk control action plans

The control of workplace hazards requires regular assessment of working conditions on a mine. Occupational surveillance systems include data collection relating to the specific or general working area, analysis of the data, and some action or response to ensure that surveillance activities are translated into preventive action.

Once areas of priority have been identified it is possible to follow a BASIC ERGONOMICS SURVEY along the lines suggested by the US Air Force (USAF) School of Aerospace Medicine Ergonomics Program, 2004, as given below [2].

Step 1: Prepare for a workplace ergonomics risk assessment

At the outset it is helpful to review the data available, which identify a shop or workplace as a potential ergonomics problem area. It is also useful to become familiar with the processes and job activities that are performed in each work area.

Step 2: Conduct a workplace/ work area visit

The evaluation needs to be arranged with relevant personnel working in that specific workplace. Various checklists may be used to evaluate the current work demands but should be used cautiously when making generalisations about the working environment.

Step 3: Complete an ergonomics assessment checklist

In conducting an assessment of a workplace it is important to ensure that task or job requirements are clearly detailed. The information needed to complete most work-related checklists can usually be collected by observation and by talking to the workers or their supervisor. Worker involvement is critical in problem identification and problem-solving processes. Most checklists enable the recording of any comments or suggestions that a worker may have on how to improve the jobs/ processes. Worker suggestions can be helpful later when controls for identified hazards are being evaluated and selected.

Step 4: Assess hazards

Potential workplace hazards will become apparent during the completion of a risk assessment. There are very few workplaces where there are no hazards, so quantification of exposure is important unless the situation is so blatantly hazardous as to warrant immediate cessation of activities. A useful guideline is to assess the frequency of exposure and to make general notes relating to the type of work done for the majority of the working shift.

Step 5: Hazard control selection (corrective actions)

Once workplace hazards are identified and evaluated using a checklist, the next logical step is to identify appropriate corrective actions (controls) for the hazards that pose the greatest risk of work-related musculo-skeletal disorders (WMSDs). Generally, corrective actions should be identified for any task hazard that receives a task rating of "medium" or "high." The goal is to eliminate or reduce the magnitude of the risk to the point where the task in question would be rated as "low" risk on follow-up evaluation.

Step 6: Summarise recommendations

Once a list of potential corrective actions has been developed, a final report that summarises the recommendations (with justifications) is mandatory. The intent of this recommendation report is for management to use it for planning and implementing "Corrective Actions". Since this report is a summary, only the most critical information from the Checklist Scoring Summary and the Corrective Actions List should be provided.

23.4.6 Evaluation and Interpretation of Results

A key purpose of ergonomics is to enable a work system to function better by improving the interactions between workers and machines [3]. Following a basic ergonomics survey it is essential to evaluate the results collected in a workplace. The risk assessment should have assisted in the identification of any current or potential hazards to the workers. In evaluating the results it is important to consider the following aspects of any manual task [4].

- Force
- Posture
- Repetition
- Duration

As mentioned previously, certain jobs may require a high level of specialist input by an occupational hygienist, occupational medical practitioner or ergonomist, especially where the work-related problems are not simple to interpret or where corrective steps may require significant workplace changes.

23.4.7 Summary of Procedures

Ideally, actions to prevent ergonomics-related hazards should proceed before injuries and/ or symptoms develop. Sound ergonomics principles should be applied proactively rather than reactively in a workplace.

The first step in a hazard survey is to establish whether functional job descriptions are available. A functional job description typically identifies essential functions, or fundamental job duties, and the physical and mental abilities needed to perform these functions. If functional job descriptions are available, they may provide useful information for identifying potentially stressful jobs or jobs requiring unique skills or special endurance.

The next step in the identification of ergonomic risk factors in a workplace is a walk-through survey. Investigators observe job activities to detect obvious risk factors, interview workers and supervisors to obtain job information not apparent from observation, and use checklists to score job features against a listing of risk factors.

Hazard surveys should be conducted whenever a job, task or process is changed substantially, when new jobs are introduced, and periodically (especially after new cases of musculo-skeletal disorders are reported) to detect whether trends exist across jobs that use similar equipment, tools or processes.

23.4.8 Checklists

Examples of checklists that may be used for ergonomic hazard identification are provided in the Appendix. These include:

- a general ergonomics checklist (for use in cases when there are instances of heavy manual materials handling, high physical job demands, poor environmental conditions and lack of general workplace organisation);
- a checklist for evaluating vehicle cab design;
- a computer/ office ergonomics checklist [5] and
- a manual tasks risk assessment tool using codes 1 to 5 to score the risk factors [6].

23.5 Reports

The ergonomics survey report must include relevant workplace information that identifies priority areas and practicable recommendations for improvement (see also Chapter 2 Report Writing).

23.5.1 Ergonomics Report Guidelines

The report should include, where relevant, a selection of the sub-sections listed below.

- Checklist findings and selection of priority/ action areas
- These findings should be based on the general ergonomics checklist in the following format:
  - Manual materials handling: list of the major risks associated with manual work
  - Physical energy demands: list of the major risks associated with energy outputs required from workers
  - Other musculo-skeletal demands: list of the major risks associated with working procedures (e.g., repetitive motions or poor working posture)
  - Environmental conditions: list of the major risks associated with environmental conditions (e.g., heat, cold, lighting or noise)
  - General workplace: list of major risks associated with the workplace including obstructions and working heights
- Short description of the current “worst case” or priority sites
- Practical recommendations for improvement

23.5.2 Guidelines for an Ergonomics Action Plan

An ergonomics report should also include an “action plan” that will allow progress to be monitored in priority areas. The plan provides a simple summary of the control options to ensure that progress is monitored.

When completing an action plan after an ergonomics survey the following is a useful framework based on HSE (UK) guidelines [7].

- Summarise and prioritise the control options
  - Examine the completed general ergonomics checklist and the comments to prioritise action. Identify the categories with the highest number of ‘Yes’ ticks and then set up a priority listing. For example, manual materials handling may have 5 out of 5 ‘Yes’ ticks and therefore requires immediate action in that area.
  - In areas where injury reporting is high or recent cases of injury have been recorded as well as risk factors established in the survey, view this combination as a HIGH PRIORITY for implementing control measures.
- Develop a short-, medium- and long-term strategy to implement controls with proposed completion dates.
- Propose a date for re-evaluation in the action plan table to ensure that implementation dates are monitored in a particular work area.

23.5.2.1 Practical Example of an Action Plan

Summary of Findings

A worker is required to lift heavy objects from floor level and place them overhead for the entire working shift. The load exceeds 25 kg and the task is repetitive in nature. During the task the worker bends to lift the load and there is also excessive twisting of the spine. The working environment is hot and noisy with only basic PPE provided. Housekeeping is acceptable and the floor is even and clear.

To address the above findings an action plan summary is provided in Table 23.1.

Table 23.1 Action Plan Summary: Workstation 1, Area X (Date of survey: 31 March)

Controls to be Implemented	Responsible Person to Implement Controls	Target Implementation Date	Date of Reevaluation
1. Manual Materials Handling. Priority: High			
• Minimise repetitive manual handling • Investigate a hoist	Person A	31 May	31 July
2. Physical Energy Demands. Priority High (load exceeds 25 kg)			
• Investigate reduced load • Job rotation to reduce operator loading	Person A	31 May	31 July
3. Other Musculo-skeletal Demands. Priority High (posture is poor)			
• Minimise repetitive motions	Person B	31 May	31 July
4. Environment. Priority: Moderate			
• Evaluate noise PPE • Ensure that fresh water is available	Person B	30 June	31 July
5. General Workplace. Priority: No			
• Housekeeping and work area acceptable	N/A	N/A	31 July

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Chapter 23 Appendix

Checklists

1. General

When completing any checklist the procedures outlined below should be observed:

- Place a tick in the 'Yes' box where you observe examples of risk factors and a tick in the 'No' box when you do not. A 'Yes' answer may require further investigation.
- Write down a short note (in the comments column) of what the worker is doing in relation to that risk factor, including:
  - Body part(s) affected
  - How long the task is being done (times per minute, hour or day)
  - What aspects of the task are presenting the risk
  - Type of work equipment being used
- Write down any possible control measures that can be taken to minimise the risk of injury.

GENERAL ERGONOMICS CHECKLIST

AREA:	
Number of Workers:	

1. Manual Material Handling	Yes	No	Comments
• Is there lifting of loads, tools or equipment?			
• Is there lowering of loads, tools or equipment?			
• Is there overhead reaching for loads, tools or equipment?			
• Is there bending at the waist to handle loads, tools or equipment?			
• Is there twisting at the waist to handle loads, tools or equipment?			

2. Physical Energy Demands	Yes	No	Comments
• Do tools and equipment used weigh more than 25 kg?			
• Is reaching more than 55 cm?			
• Is bending, stooping, or squatting a primary task activity?			
• Is lifting or lowering loads a primary task activity?			
• Is walking or carrying loads a primary task activity?			
• Is stair or ladder climbing with loads a primary task activity?			
• Is pushing or pulling of loads a primary task activity?			
• Is reaching overhead a primary task activity?			
• Is operating equipment or tools above shoulder height a primary task activity?			

GENERAL ERGONOMICS CHECKLIST
(Continued)

3. Other Musculo-skeletal Demands	Yes	No	Comments
• Do manual tasks require frequent, repetitive motions?			
• Does work posture require frequent bending of neck, shoulder, elbow, wrist or finger joints?			
• Does the worker kneel (on one or both knees)?			
• Is the worker unable to change body position often?			
• Does the work involve forceful, quick, or sudden motions?			
• Does the work involve whole-hand grasping with straight elbows?			
• Does job posture involve sustained muscle contraction of any limb for periods of more than 30 minutes?			
• Does the worker stand continuously for periods of more than 30 minutes?			

4. Environment	Yes	No	Comments
• Is the temperature too hot or too cold?			
• Is there dust?			
• Is the workplace poorly lit?			
• Is it a noisy environment?			
• Is the worker working with vibrating hand tools or equipment?			
• Is the worker working with hazardous chemicals?			
• Is the worker subjected to whole body vibration?			

5. General Workplace	Yes	No	Comments
• Are the walkways uneven?			
• Is the floor surface free of obstacles and flat?			
• Is the workplace at a gradient?			
• Is the ceiling height less than 2.5 m?			
• Is there inadequate clearance to or accessibility for performing the task?			
• Is housekeeping poor?			

CHECKLIST FOR EVALUATING THE CAB DESIGN OF A CONSTRUCTION OR MINING VEHICLE

	Area for Consideration	Yes	No	N/A
1	Is the seat height adjustable?			
2	Can the seat be adjusted horizontally?			
3	Is the seat set at the proper height?			
4	Does the seat have a back support?			
5	Does the seat have a lumbar support?			
6	Are there armrests available?			
7	Are the armrests adjustable?			
8	Are the armrests set at the proper height?			
9	Do you feel any vibration from the equipment through the seat?			
10	Do you feel any vibration from the equipment through the floor?			
11	Do you feel any vibration from the equipment through the controls?			
12	Is the seat firmly mounted to the floor of the cab?			
13	Can the seat be tilted backward?			
14	Can the seat swivel?			
15	Is the location of the controls or levers adjustable?			
16	Can you easily reach the levers or controls?			
17	Can you easily operate the levers or controls?			
18	Can you easily reach the pedals?			
19	Can you easily operate the pedals?			
20	Is the cab area large enough (e.g., uncramped area) for you?			
21	Do you have sufficient upward visibility?			
22	Is your view of the operation obstructed (e.g., by cab guards, pipes/ hoses, etc.)?			
23	Do you feel the cab is noisy?			
24	Can you control the temperature of the cab?			
25	Does the equipment have steps?			
26	Does the equipment have handrails?			
27	Can you easily open/ close the cab doors?			
28	Does the equipment have proper means for entering the cab?			
29	Does the equipment have proper means for exiting the cab?			
30	Do you have a good general view of the ground?			
31	Are the cab windows free from distracting reflections?			

NIOSH COMPUTER AND OFFICE EVALUATION CHECKLIST

Desk/ Workstation		Yes	No
1	Do you have enough room on your work surface for all your computer accessories?		
2	Is your desk surface deep enough to provide at least 45 cm between your eyes and the computer screen?		
3	Are your most frequently accessed items (e.g., phone, manuals) easy to reach?		
4	If your desk has a fixed height, is the keyboard tray adjustable?		
5	Have you removed all under-desk obstructions?		
6	Do you have a document holder to hold paper for prolonged computer inputting?		
7	Do your arms rest on, or contact any sharp or square edges on your work surfaces?		
8	If a large percentage of your time involves using a phone do you use a phone headset?		
9	Is your source light out of your line of sight?		

Chair		Yes	No
1	Is your chair height adjustable?		
2	Is your chair back adjustable up and down?		
3	Is your chair back contoured to support the lower back?		
4	Is your backrest large enough to support your entire back, but not interfere with the use of your arms?		
5	Is your lumbar support a minimum of 30 cm wide?		
6	Is there room (5 - 10 cm) between the front edge of the seat pan and the back of your knees?		
7	If your feet do not rest flat on the floor when your chair is properly adjusted, do you use a footrest?		
8	Is the top of your footrest covered with a non-skid material to reduce slippage?		
9	Do your chair arms interfere with you getting close to your work?		
10	Do your chair arms allow you to sit with your shoulders relaxed and not elevated?		
11	Does your chair have removable armrests?		
12	Is the distance between your armrests adjustable?		
13	Are your knees bent forming approximately a 90 degree or greater angle?		
14	Does the chair have a stable base supported by five legs with castors?		

Monitor		Yes	No
1	Is the viewing distance to your computer monitor somewhere between 45 - 75 cm?		
2	Is the top of your computer screen at or just below eye level?		
3	If you wear bifocals or trifocals, can you see the computer monitor without having to tilt your head back to read the screen or other items in your work area?		
4	Is your computer monitor free of glare or reflections?		
5	Is the monitor screen clean?		
6	Is the character size easy to read?		
7	Do you have blinds on the windows near your computer?		
8	Do you use a glare screen to reduce glare on your monitor?		

Keyboard		Yes	No
1	With your chair adjusted properly is your work surface at approximately elbow level?		
2	Are your shoulders relaxed and not elevated when you work at your work surface?		
3	Is the height of your keyboard low enough so your arms are relaxed at your side?		
4	When you address your work surface to type or write is there approximately a 90 degree angle between your forearms and upper arms and are your elbows close to your body?		
5	When you address your work surface to type are your wrists in line with your forearms and not bent upwards, downwards, or side-to-side?		
6	Do you have a wrist rest to support your wrists in a straight and neutral position?		

Mouse, Trackball, or Other Input Device		Yes	No
1	Is your mouse, trackball, or other input device (i.e., touch-pad, etc.) located directly in your immediate reach zone?		
2	Is your mouse or trackball positioned next to your keyboard?		
3	Is your mouse or trackball placed together with your keyboard on an adjustable work surface or tray?		
4	Is your mouse work surface stable?		
5	Is the mouse or trackball at the same level as your keyboard?		

Work Habits		Yes	No
1	Do you take short and frequent breaks every 20 - 30 minutes?		
2	Do you frequently change body positions while working?		
3	Do you provide your eyes with vision breaks every half hour?		
4	Are you free from experiencing any pain or discomfort while working?		

Manual Tasks Risk Assessment Tool (ManTRA) V 2.0 Scoring Matrix

Body Region	Task Codes									Cumulative Risk
	Total Time	Duration	Cycle Time	Repetition Risk	Force	Speed	Exertion Risk	Awkwardness	Vibration	
Lower Limbs										
Back										
Neck/ Shoulder										
Arm/ Wrist/ Hand										

Codes				
1	2	3	4	5
Total Time (Total time which would be spent performing the task on a typical day)				
0 - 2 h/day	2 - 4 h/day	4 - 6 h/day	6 - 8 h/day	> 8 h/day
Duration of Continuous Performance (Time for which repetitions of the task are performed without a break)				
< 10 min	10 - 30 min	30 - 60 min	1 - 2 h	> 2 h
Cycle Time (Duration of task which is performed more than once without interruption)				
> 5 min	1 - 5 min	30 s - 1 min	10 - 30 s	< 10 s
Force (A maximum force score corresponds to the maximum force possible)				
Minimal force		Moderate force		Maximum force
Speed (The least risk arises when a task involves slow to moderately paced movement**s)**				
Slow movements	Moderately paced	Little or no movement - static posture	Fast and smooth movements	Fast, jerky movements
Awkwardness (Typically postures which involve significant deviations from the mid range of movement)				
All postures close to neutral	Moderate deviations from neutral in one direction only	Moderate deviations in more than one direction	Near end range of motion posture in one direction	Near end range of motion in more than one direction
Vibration (**Whole body:** lower limbs, back, and neck regions. **Peripheral:** shoulder/ arm and wrist/ hand regions)				
None	Minimal	Moderate	Large amplitude	Severe Amplitude

Scoring Keys for Repetition and Exertion

Codes:	1	2	3	4	5
Scoring key for Repetition					
Cycle Time	**Duration**				
1	1	1	2	3	4
2	1	2	3	4	4
3	2	3	4	4	5
4	2	3	4	5	5
5	3	4	5	5	5
Scoring key for Exertion					
Speed	**Force**				
1	1	1	2	3	4
2	1	2	3	4	4
3	2	3	4	4	5
4	2	3	4	5	5
5	3	4	5	5	5

Action may be indicated if, for any region, the Exertion risk factor is 5, the sum of exertion and awkwardness is 8 or greater, or the cumulative risk is 15 or greater.