

Guideline for the medical assessment of mines rescue personnel

Endorsed by meeting of nominated medical advisors on 18 July
2010

Queensland Mines Rescue Service

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Foreword

Discussion at the Nominated Medical Advisers' meeting in July 2008 revealed the need for a more detailed guideline for medical assessment of mines rescue personnel. An earlier Guideline developed by Dr Graham Rowles¹, was intended as an interim measure until such time as data became available on the physical nature of the mines rescue task.

A paper by Stewart, McDonald, Hunt and Parker² has provided physiological data acquired at a Queensland Mines Rescue Challenge, and reports that "*Cardiovascular and muscular endurance was average or below average compared with the general population*". The authors concluded that "*Relying on actual rescues or mining related work to provide adequate training is generally insufficient to maintain, let alone increase, physical fitness*" and went on to recommend that "*standards of required physical fitness be developed and mines rescue personnel undergo regular training (and assessment) in order to maintain these standards*".

The data presented in the above paper have provided an excellent basis for the development of a meaningful medical standard for local conditions.

The Western Australia Mines Occupational Safety and Health Advisory Board's *Guideline Fitness for Mine Rescue Personnel*^β is also acknowledged as a valuable source of information in developing this guideline.

1. Introduction

Mines rescue operations are physically and psychologically demanding and may require personnel to work under conditions that would not normally be considered tolerable.

Toxic atmospheres and poor ventilation encountered in rescue situations require personnel to wear self-contained breathing apparatus (SCBA) for many operations, which significantly increases the risk for heat stress, particularly as heat and humidity underground may already be high. The additional burden of heavy physical work such as shifting fallen material and retrieval of casualties, may add a high metabolic heat load to the equation.

In summary, conditions likely to be encountered include:

- Toxic, hot, humid and smoky atmospheres
- Rough broken terrain
- Work in awkward positions and a need to carry heavy unpredictable loads and people, whilst wearing cumbersome equipment
- Poor visibility, confined spaces and falling objects
- Conditions creating high psychological stress
- Possible long periods without food, drink and usual medication.

These conditions require personnel to have and to maintain a higher level of personal health and fitness than that required for normal mining operations.

2. Health assessment

The health assessment for mines rescue personnel needs to be more stringent than that for normal mining work and therefore the normal medical criteria for the coal mine workers' health scheme established under the Coal Mining Safety and Health Regulation 2017, are not sufficient on their own, either in the level or the frequency of the assessment.

The assessment for mines rescue personnel shall:

- Be carried out every two years for persons up to age 40 and every year thereafter.
- Be in two parts, Part A and Part B:
 - Part A will be the medical examination using the approved form for the coal mine workers' health scheme, but with the application of a set of more stringent criteria.
 - Part B is the assessment of VO₂ max by step test.
- Be conducted and signed off only by doctors who are experienced Appointed Medical Advisors (AMAs) under the Coal Mining Safety and Health Regulation (2017).

The following relative and absolute contraindications have been compiled from a number of sources:

- Medical Guidelines for Service (Black Coal), QMRS, 2003¹
- Fitness for Mine Rescue Personnel - Guideline, Department of Industry Resources, Government of Western Australia 1997³
- QFRS Medical Standards, Department of Emergency Services, Brisbane, 2007⁴.

2.1 Part A: Medical examination

The medical examination should follow the pro-forma of the "approved form" under the Coal Mine Workers' Health Scheme, but for mines rescue assessments it is necessary to apply more stringent criteria because of the very demanding nature of mines rescue operations and training.

Accordingly, there are a number of medical conditions that are absolute contra-indications for mines rescue personnel and some that are relative contra-indications, where the AMA may make a judgement based on the individual case.

Table 1: Absolute and relative contra-indications for mines rescue personnel

Absolute contra-indications	Relative contra-indications
<i>Cardiovascular - absolute</i>	<i>Cardiovascular - relative</i>
<ul style="list-style-type: none"> ● Known ischaemic heart disease ● Valvular heart disease ● Cardiomyopathies ● Resting blood pressure systolic 160 / diastolic 100 ● Heart block or pacemaker ● Implanted defibrillator 	<ul style="list-style-type: none"> ● Surgically corrected ischaemic heart disease with normal work capacity ● After myocardial infarction - taking into account amount of necrosis, efficacy of revascularisation, functional capacity and predisposition to VT or other arrhythmia and "normal" post MI exercise stress test ● Body mass index >32 ● Evidence of severe raised cholesterol >5.5 in conjunction with other risk factors including smoking, or with a +ve family history of heart disease ● Excessive smoker >20/day for >10 years ● Arrhythmias with cardiologist's letter "fit for strenuous exercise" ● More than 3 risk factors or a score >14 on the Framingham heart-risk scale
<i>Respiratory - absolute</i>	<i>Respiratory - relative</i>
<ul style="list-style-type: none"> ● Active respiratory disease or dyspnoea sufficient to prevent the individual from carrying out the physical demands of the job ● COAD ● Bronchiectasis ● Recurrent pneumothorax or recent pneumothorax (within previous 6 weeks) ● Pulmonary tuberculosis 	<ul style="list-style-type: none"> ● FEV₁ or FVC less than 70% of predicted value. ● FEV₁/FVC ratio <75% ● Asthma - need careful assessment regarding sensitivity to dust, smoke and additional burden of SCBA and breathing cold dry air with positive histamine test
<i>Gastrointestinal - absolute</i>	<i>Gastrointestinal - relative</i>
<ul style="list-style-type: none"> ● Inguinal hernia ● Active GI or hepatobiliary disorder 	<ul style="list-style-type: none"> ● Abdominal hernias other than inguinal ● Peptic ulcer on treatment ● Ulcerative colitis ● Active diverticular disease ● History of pancreatitis ● Hepatitis ● Enlarged liver or spleen, unless cleared as safe for heavy lifting

<i>Renal absolute</i>	<i>Renal - relative</i>
<ul style="list-style-type: none"> ● Renal failure acute or chronic with GFR <60 ● Multiple renal stones 	<ul style="list-style-type: none"> ● Renal failure acute or chronic with GFR 60 and above
<i>Neurological - absolute</i>	<i>Neurological - relative</i>
<ul style="list-style-type: none"> ● Fainting, loss of consciousness ● Cerebro-vascular event (stroke, cerebral artery occlusion or cerebral haemorrhage) or subarachnoid haemorrhage - with neurological deficit ● Proven transient ischaemic attacks ● Disorder of coordination or muscle control ● Peripheral neuropathies ● Parkinson's disease ● Vestibular disorders ● Visual migraine ● Multiple sclerosis 	<ul style="list-style-type: none"> ● Any history of epilepsy or seizure (commercial driver standards to be applied) ● Frequent and severe headaches, migraines ● History of severe head injury ● Cerebro-vascular event the cause of which has been corrected (e.g. subarachnoid haemorrhage from cerebral aneurysm corrected by neurosurgery) - with minimal residual neurological deficit
<i>Hearing and vestibular - absolute</i>	<i>Hearing - relative</i>
<ul style="list-style-type: none"> ● Audiometric loss >40dB in the better ear unaided - averaged over the speech frequencies (500,1000, 2000 and 3000 Hz) ● Vestibular disorders with recurrent vertigo 	<ul style="list-style-type: none"> ● Current middle ear disease ● Perforated tympanic membrane ● Suppurating ear disease
<i>Vision - absolute</i>	<i>Vision - relative</i>
<ul style="list-style-type: none"> ● Loss of vision in one eye (under 6 months) ● Tunnel vision ● Diplopia ● Aphakia (monocular or binocular) ● Glaucoma ● Progressive cataract 	<ul style="list-style-type: none"> ● Monocular vision for > 6 months ● Contact lenses ● Nystagmus ● Failure of Ishihara > 6 plates ● Distant vision worse than 6/12 best eye unaided.(and 6/18 in the worst eye) ● Near vision worse than N10 unaided ● Reduced peripheral vision
<i>Haematological - absolute</i>	
<ul style="list-style-type: none"> ● Active leukaemia or lymphoma ● Severe anaemia Hb<10 ● Polycythaemia 	
<i>Endocrine - absolute</i>	<i>Endocrine - relative</i>
<ul style="list-style-type: none"> ● Insulin dependent diabetes ● Cushing's syndrome 	<ul style="list-style-type: none"> ● NIDDM needing regular medication ● Systemic steroid therapy ● Pituitary disease ● Thyroid disease
<i>Musculoskeletal - absolute</i>	<i>Musculoskeletal - relative</i>
<ul style="list-style-type: none"> ● Any condition limiting full range of movement, strength or co-ordination in one or more of the four limbs or back ● History of back disability with >3 months off work in one episode 	<ul style="list-style-type: none"> ● Acute or chronic spinal pain ● Minor strength deficiencies

<i>Behavioural - absolute</i>	<i>Behavioural - relative</i>
<ul style="list-style-type: none"> ● Agoraphobia, claustrophobia or pyromania ● History of panic attacks ● Alcohol or drug dependence ● Severe anxiety state ● Depressive or other psychosis 	<ul style="list-style-type: none"> ● Schizophrenia or any condition requiring regular medication for stability (condition to be frequently reviewed)
<i>Other - absolute</i>	
<ul style="list-style-type: none"> ● Facial characteristics preventing a good seal with the SCBA face piece. ● Facial hair or severe dermatological condition sufficient to prevent a facial seal when wearing a respirator ● Any widespread skin disease that may impair sweating ● Pregnancy 	
<i>Heat exposure - absolute</i>	<i>Heat exposure - relative</i>
	<ul style="list-style-type: none"> ● Medication with drugs that predispose to heat stress <ul style="list-style-type: none"> – Drugs that inhibit sweating by inhibiting cholinergic action <ul style="list-style-type: none"> ▪ antihistamines ▪ beta blockers ▪ anticholinergic drugs (atropine, scopolamine) – Drugs that increase heat load by stimulating metabolism <ul style="list-style-type: none"> ▪ thyroid replacement preparations ▪ amphetamines – Miscellaneous <ul style="list-style-type: none"> ▪ tricyclic antidepressants ▪ monoamine oxidase inhibitors ▪ diuretics

2.2 Part B: Physical fitness assessment

The main physical fitness criterion involves assessment of VO₂ max by the assessing doctor. A separate assessment of practical physical ability may also be required and will be conducted by Queensland Mines Rescue Service personnel if required.

2.2.1 VO₂ max: Overview

VO₂ max is a reliable measure of physical fitness that measures the capacity of the body to transport and utilise oxygen during exercise. It is expressed in millilitres of oxygen per kilogram of bodyweight per minute (ml/kg/min).

The value for VO₂ max increases with increasing fitness, so that endurance athletes, such as cyclists and cross country skiers, have the highest reported values, usually above 75ml/kg/min.

Normative values for the general population (non-athletes) are given in table 2.

Scores will increase with training but decrease with age.

Table 2: Normative values for VO₂ max for non-athletes (in ml/kg/min)⁵

Age	Male	Female
10-19	47-56	38-46
20-29	43-52	33-42
30-39	39-48	30-38
40-49	36-44	26-35
50-59	34-41	24-33
60-69	31-38	22-30
70-79	28-35	20-27

2.2.2 Estimation of VO₂ max

Accurate measurement of VO₂ max is generally performed on a treadmill or bicycle ergometer but since it is a maximum effort test, it carries an element of risk. It also requires complex equipment not readily available to most doctors in practice.

Less risky "sub-maximal" procedures have been developed for estimating the VO₂ max which can also be undertaken using simple equipment. These utilize a simple step test which assesses fitness based on the post-exercise heart rate.

A number of step tests have been developed including the Harvard Step Test, the YMCA Step Test (used by Coal Services in NSW) and the Queen's College Step Test. Most have been validated against the maximum effort tests, but only the Queen's College test uses a different formula for men and women. Therefore the Queen's College Step Test, which requires only a step (41.3 cm), a metronome and a calculator, has been selected. A heart rate monitor is a recommended addition.

2.2.3 Queens's College Step Test (also called the McArdle step test⁶)

Method

The candidate steps up and down on the step at a rate of 22 steps per minute (female) or 24 steps per minute (male) for three minutes. At the end of the three minutes the candidate stops stepping and within 5 seconds, the heart rate is taken for 15 seconds.

Scoring

VO₂ max is calculated using the following equations:

- Men: VO₂ max (ml/kg/min) = 111.33 - (0.42 x heart rate [bpm])
- Women: VO₂ max (ml/kg/min) = 65.81 - (0.1847 x heart rate [bpm])

Validation

The test has been validated in several studies where there was good correlation between laboratory measured VO₂ max and estimated VO₂ max using the Queen's College Step Test.^{7, 8}

Although it has been suggested that shorter people are at a disadvantage, and conversely taller people an advantage, with standardised step tests, a study comparing the standardised step with variable step heights based on stature, showed no significant difference.⁹

Table 3: Normative data for VO₂ max¹⁰

Males (values in ml/kg/min)

Age	Very poor	Poor	Fair	Good	Excellent	Superior
13-19	< 35.0	35.0-38.3	38.4-45.1	45.2-50.9	51.0-55.9	> 55.9
20-29	< 33.0	33.0-36.4	36.5-42.4	42.5-46.4	46.5-52.4	> 52.4
30-39	< 31.5	31.5-35.4	35.5-40.9	41.0-44.9	45.0-49.4	> 49.4
40-49	< 30.2	30.2-33.5	33.6-38.9	39.0-43.7	43.8-48.0	> 48.0
50-59	< 26.1	26.1-30.9	31.0-35.7	35.8-40.9	41.0-45.3	> 45.3
60+	< 20.5	20.5-26.0	26.1-32.2	32.3-36.4	36.5-44.2	> 44.2

Females (values in ml/kg/min)

Age	Very poor	Poor	Fair	Good	Excellent	Superior
13-19	< 25	25.0-30.9	31.0-34.9	35.0-38.9	39.0-41.9	> 41.9
20-29	< 23.6	23.6-28.9	29.0-32.9	33.0-36.9	37.0-41.0	> 41.0
30-39	< 22.8	22.8-26.9	27.0-31.4	31.5-35.6	35.7-40.0	> 40.0
40-49	< 21.0	21.0-24.4	24.5- 28.9	29.0-32.8	32.9-36.9	> 36.9
50-59	< 20.2	20.2-22.7	22.8-26.9	27.0-31.4	31.5-35.7	> 35.7
60+	< 17.5	17.5-20.1	20.2-24.4	24.5-30.2	30.3-31.4	> 31.4

In the published study of QMRS personnel by Stewart, McDonald, Hunt and Parker² the VO₂ max for 79 personnel was 42 with a standard deviation of 8.3, which assuming most were males, means that many may fall within just the "fair" column or worse, in table 3.

The QMRS has adopted the standard set for Western Australian mines; that is, candidates for the Queensland Mines Rescue Service must achieve a VO₂ max for males of 40 ml/kg/minute and for females 35 ml/kg/min³.

For further information contact Health Surveillance Unit 07 3181 5420.

3. References

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