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Mine Safety

MINING DESIGN GUIDELINE | MDG 3609

# Escape breathing apparatus for underground mining applications

Standards for design and ongoing monitoring



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*MDG 3609 Escape breathing apparatus for underground mine applications*

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Disclaimer: The information contained in this publication is based on knowledge and understanding at the time of writing (July 2015). However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up to date and to check currency of the information with the appropriate officer of the NSW Department of Industry, Skills and Regional Development or the user's independent advisor.

## Foreword

This document sets out standards for the design and ongoing performance of breathing apparatus to assist escape (including self-rescuers) for use in underground mines and includes procedures for the in-service testing of self-rescue breathing apparatus.

The performance criteria required for the design, ongoing performance and the maintenance of registration by in-service testing of breathing apparatus (including self-rescuers) have been identified by NSW and Qld industry working groups.

An important premise of performance testing is that any failure in a sample of about 1% of breathing apparatus units signals a problem that requires further investigation.

This document represents a culmination of overseas escape strategies, testing and evaluation of self-rescue chemical oxygen apparatus, compressed air and oxygen breathing apparatus, as well as our own experiences with such apparatus.

The constructive evaluation and input provided by manufacturers and suppliers is gratefully acknowledged.



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## Contents

1	Scope and general .....	1
1.1	Scope .....	1
1.2	Application .....	1
1.3	Referenced documents .....	1
1.4	Relationship with NSW Regulation.....	1
1.5	Relationship with AS/NZS 1716: 2012 .....	1
1.6	Abbreviations .....	1
1.7	Definitions.....	2
1.7.1	Body-worn.....	2
1.7.2	Cached .....	2
1.7.3	Certificate of compliance.....	2
1.7.4	Change over .....	2
1.7.5	Dust (in reference to filter self-rescuers) .....	2
1.7.6	Examination .....	2
1.7.7	Extended usage.....	2
1.7.8	In-service .....	2
1.7.9	Nominal duration.....	2
1.7.10	Operator .....	3
1.7.11	Rated duration .....	3
1.7.12	Recognised test authority.....	3
1.7.13	Must.....	3
1.7.14	Self-rescuer .....	3
1.7.15	Service life .....	3
1.7.16	Stored.....	3
1.7.17	Supplier .....	3
1.7.18	Test report .....	3
1.7.19	Regulatory authority.....	3
1.8	Tolerances for performance testing.....	4
1.9	Certificate of compliance.....	4
1.10	Monitoring programs .....	4
1.11	Records .....	5
1.12	Training units .....	5
2	Design requirements.....	6
2.1	Types of breathing apparatus.....	6
2.2	General requirements .....	6
2.2.1	Design and construction.....	6
2.2.2	Marking requirements .....	6

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2.2.3	Instructions for use of breathing apparatus .....	6
3	Additional design requirements for chemical and compressed oxygen apparatus .....	7
3.1	Chemical oxygen apparatus.....	7
3.2	Requirements for compressed oxygen apparatus .....	7
4	Additional design requirements for filter self-rescuers and compressed air apparatus.....	8
4.1	Carbon monoxide filter self-rescuers (FSRs).....	8
4.2	Requirements for compressed air apparatus.....	8
5	Examination and testing of new units before issue to operators .....	8
5.1	Supplier to submit samples .....	8
5.2	Test authority to examine and test samples .....	8
5.3	Procedure after results of examination and test are assessed .....	10
6	Examination and testing of self-rescue units in service .....	11
6.1	In-service testing procedure .....	11
6.2	Mine/owner to submit samples.....	11
6.3	Test authority to examine and test results .....	12
6.4	Procedure after results of examination and test are assessed .....	13
7	General maintenance requirements of apparatus in-service.....	15
7.1	Specific suggestions for maintenance of apparatus .....	15
8	Appendix A .....	16
9	Appendix B .....	17
10	Appendix C Wearer assessment of self-contained self-rescuers .....	18
11	Appendix D Informative references.....	21

## 1 Scope and general

### 1.1 Scope

This guideline sets out standards for design, ongoing performance and maintenance of breathing apparatus to assist escape (including self-rescuers) from the underground parts of a mining operation.

There are two broad areas that this document covers:

- the design standards in sections 2 to 4 for the design, testing and performance
- pre-release testing, ongoing monitoring of apparatus in service and general maintenance requirements in sections 5 to 7 .

Compliance with this standard does not negate the designer's work health and safety duties under section 22 of the *Work Health and Safety Act 2011*.

### 1.2 Application

This guideline is applicable to the design of all breathing apparatus to assist escape (including self-rescuers) intended to be design registered under clause 177(5) of the *Work Health and Safety (Mines) Regulation 2014* and Part 5.3 of the *Work Health and Safety Regulation 2011*.

**Note:** Applications for registration are to be made using the appropriate form found on the department's website.

### 1.3 Referenced documents

All references to the following standards in this guideline is a reference to such standard, as amended from time:

- MDG 1010:2011 *Minerals Industry Safety and Health Risk Management*.
- MDG 1014:1997 *Guide to Reviewing a Risk Assessment of Mine Equipment and Operations*.
- AS/NZS 1716:2012: *Respiratory protective devices*
- BS EN 13794:2002: *Respiratory protective devices. Self-contained closed-circuit breathing apparatus for escape. Requirements, testing, marking*

### 1.4 Relationship with NSW Regulation

Under clause 100 of the *Work Health and Safety (Mines) Regulation 2014*, "the mine operator of an underground mine (other than an opal mine) must ensure that a person who is to go underground is provided with an appropriate self-rescuer if there is a risk of an irrespirable atmosphere in the underground mine (including during an emergency)"

### 1.5 Relationship with AS/NZS 1716: 2012

In the event of any inconsistency with provisions of AS/NZS 1716:2012, this guideline prevails.

### 1.6 Abbreviations

AS	Australian Standard
AS/NZS	Australian/New Zealand Standard
BS EN	British Standard European Standard
BTPS	Body temperature and pressure saturated (37°C, ambient pressure and saturated)
EN	European Standard

MDG	Mining Design Guideline produced by the NSW Government and published on the NSW Department of Industry website.
NTP	Normal temperature and pressure i.e. 23°C and 101.3 kPa

## 1.7 Definitions

In this guideline the definitions given in AS/NZS 1716:2012 apply.

In addition the following definitions apply:

### 1.7.1 Body-worn

Body-worn refers to a unit that has at any time been issued to be worn by a person. Units which are stored on a vehicle are equivalent to body-worn units.

Breathing apparatus to assist escape including self-rescuers is described as escape breathing apparatus in this guideline and covers the following types of apparatus

- Chemical oxygen self-contained self-rescuers (chemical oxygen apparatus);
- Carbon monoxide filter self-rescuers also called Filter self-rescuers
- Compressed air self-contained breathing apparatus (compressed air apparatus); and
- Compressed oxygen self-contained breathing apparatus (compressed oxygen apparatus).

### 1.7.2 Cached

Refers to a escape breathing apparatus that has been stored underground in a cache which is a stationary and vibration-free location.

### 1.7.3 Certificate of compliance

Certificate issued by a recognised test authority verifying that the examined escape breathing apparatus of a particular model, made in a particular calendar year, complies with the relevant registration requirements.

### 1.7.4 Change over

Change over means the process of donning a fresh rescuer and removing a spent rescuer while in an irrespirable atmosphere.

### 1.7.5 Dust (in reference to filter self-rescuers)

Dust (in reference to filter self-rescuers) is residue in a filter self-rescuer casing due to breakdown of its chemical components.

### 1.7.6 Examination

Examination refers to an inspection to determine the condition of the breathing apparatus. This may involve visual inspection and/or testing to verify the performance of equipment.

### 1.7.7 Extended usage

Extended usage refers to the time between the rated duration and exhaustion of the chemical or collapse of the breathing bag when the breathing apparatus is subjected to a breathing simulator test at a breathing rate of 35 litres per minute.

### 1.7.8 In-service

In-service refers to a unit that has been issued for use underground and has not been removed from service, and includes units that are body-worn or cached. Units which are stored on mobile equipment are equivalent to body-worn units.

### 1.7.9 Nominal duration

The duration in minutes nominated by the manufacturer for the apparatus to provide protection to the wearer.

### 1.7.10 Operator

A mine, rescue station, contractor or other organisation that uses escape breathing apparatus.

### 1.7.11 Rated duration

Rated duration means the duration in minutes that the breathing apparatus complies with the assessment criteria when subjected to testing on a breathing simulator at the prescribed breathing rate and CO<sub>2</sub> delivery rate.

The rated duration cannot be greater than the nominal duration.

### 1.7.12 Recognised test authority

A recognised test authority is either:

- a) the Department of Trade and Investment, Regional Infrastructure and Services, Mine Safety Technology Centre, Thornton NSW; or
- b) a facility acceptable to the Chief Inspector having regard to test equipment, equipment calibration, quality processes, work methods, past test experience and independent technical verification.

### 1.7.13 Must

Mandatory for compliance with this document.

### 1.7.14 Self-rescuer

Self-rescuer is a type of breathing apparatus that is normally worn on a person's belt and used to assist their escape in an emergency. They can also be stored in a cache.

### 1.7.15 Service life

Service life means the number of years from the date of manufacture after which a unit must be discarded. Manufacturers may state a different service life for a unit depending on its storage and handling (e.g. cached or body worn).

### 1.7.16 Stored

Stored refers to a unit that is held in stationary storage, has never been in service, and is not cached.

### 1.7.17 Supplier

Supplier means an Australian manufacturer, or an Australian representative of a manufacturer, of breathing apparatus, that supplies this apparatus directly to users. Or a mining organisation that imports escape breathing apparatus directly from a manufacturer.

### 1.7.18 Test report

A test is a report provided by a recognised test authority giving results of examination and testing as specified in this MDG.

### 1.7.19 Regulatory authority

For the purposes of this document the regulatory authority for NSW is the person appointed as Chief Inspector, under the *Work Health and Safety (Mines) Act 2013*.



## 1.8 Tolerances for performance testing

Except for temperature limits, values that are not stated as maxima or minima must be subjected to a tolerance of  $\pm 5\%$ .

Unless otherwise specified, temperature limits in this guideline must be subject to a tolerance of  $\pm 1^\circ\text{C}$ . Fast response 0.05mm diameter thermocouples must be used for these measurements.

Unless otherwise specified, the ambient temperature for testing must be  $23 \pm 3^\circ\text{C}$ .

Gas concentrations for performance limits are expressed by volume at NTP on a dry basis. Gas volumes are measured at BTPS unless otherwise specified.

## 1.9 Certificate of compliance

When issued, a certificate of compliance must indicate:

- A clearly visible identification of the self-rescuers, represented by the sample(s) tested; and
- the date of expiry of the certificate in accordance with the appropriate examination schedule below.
- A certificate of compliance must not be issued unless the equipment complies in all respects with the requirements for registration, unless otherwise allowed in this guideline.

Where several units of a particular make and model made in a particular calendar year, are tested at various times during the course of a year, the units will have several test reports. However, only one certificate of compliance needs be issued in relation to these units.

## 1.10 Monitoring programs

There are various levels of monitoring. Some may be carried out at the mine site by trained site personnel, while others may be carried out at the mine site or elsewhere by a technician authorised by the supplier.

There are three options with respect to the submission of samples:

- a) By a single user or mine
- b) By a user or group of users

A user or group of users may elect to submit a sample representing their combined number of rescuers. If this is done, the user or group of users must notify the relevant regulatory authority in writing of the arrangement that is to be put in place, nominating the body (for example, a mine or mining company or other organisation) that will accept responsibility for operating the monitoring scheme.

- c) By the supplier or other provider

The supplier or other provider may be engaged to arrange for samples of apparatus in service at work sites to be given to a recognised test authority. In this scheme, the supplier plays a key role in maintaining records of the breathing apparatus in service, monitoring its condition, arranging for periodic resampling and testing and providing to the operator a copy of each certificate of compliance relevant to the breathing apparatus in use by that operator.

In this option, as above, the user or group of users must notify the relevant regulatory authority in writing of the arrangement that is to be put in place, nominating the supplier or other provider who will be providing samples.

## 1.11 Records

Comprehensive records for each breathing apparatus must be maintained by the operator and the supplier, including, but not limited to the following:

*Records to be maintained by the operator:*

- Inventory of all apparatus
- Reference numbers – manufacturer's number, number allocated by the operator, transponder number (where relevant)
- Brand and model of escape apparatus
- Date of manufacture
- Date of procurement
- Supplier
- Inspection history – manufacturer's recommended tests and tests by a recognised test authority
- Service and maintenance history including refurbishment records
- History of use (employee or contractor, cached, stored, double-shift use etc.)
- Escape apparatus removed from service, and the reason for removal
- Date of removal from service
- Escape apparatus not located during routine maintenance inspections
- Escape apparatus used in any emergency
- A compliance certificate covering all units in service

*Records to be maintained by the supplier:*

- Name of operator
- Reference numbers – manufacturer's reference, transponder number (where relevant), any other appropriate identification
- Traceability (quality records)
- Date of manufacture
- Date of delivery
- History of any service and maintenance carried out by the supplier, including refurbishment records
- Identification of escape apparatus removed from service for testing, and the date of removal
- Details of the current quality assurance system used by the manufacturer
- Details of compliance of the breathing apparatus with registration requirements.

## 1.12 Training units

Training units:

- must be clearly marked and coloured, in such a way that they cannot inadvertently be mistaken as functional escape devices
- may simulate breathing resistance, temperature increase, donning and changeover, and weight.
- should be resistant to cleaning and disinfectant fluids.

Units that have exceeded their service life should not be used for training purposes.

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## 2 Design requirements

### 2.1 Types of breathing apparatus

Breathing apparatus must be classified in accordance with the following types:

- Chemical oxygen self-contained self-rescuers (chemical oxygen apparatus)
- Carbon monoxide filter self-rescuers
- Compressed air self-contained breathing apparatus (compressed air apparatus)
- Compressed oxygen self-contained breathing apparatus (compressed oxygen apparatus)

Where the classification of the apparatus is not clear the relevant regulatory authority should be consulted concerning the appropriate registration requirements.

### 2.2 General requirements

#### 2.2.1 Design and construction

The design and construction must:

- permit the breathing apparatus to be worn without undue discomfort and in such a manner that it is practicable for the wearer to escape and not unduly impede the wearer when walking or in a crouching position, crawling or manoeuvring in confined areas
- prevent leakage from the circuit to atmosphere except through a relief valve or exhalation valve on compressed air apparatus
- allow parts of the breathing apparatus to be effectively sealed from atmospheric air during storage
- ensure that the use of aluminium is limited to those applications that may be justified on the grounds of safety and health
- where a change-over is required, be designed for easy removal when changing from one unit to another. For example, have neck straps with quick release clips.

#### 2.2.2 Marking requirements

The following information must be clearly marked on each self-rescue:

- the manufacturer and supplier, which must be identified by name, trade mark or other means of identification
- rated duration
- serial number
- month and year of manufacture
- a pictogram on the carrying container showing the donning procedure

#### 2.2.3 Instructions for use of breathing apparatus

On delivery, instructions for use accompany every apparatus. Instructions must be written in simple plain English.

The instructions contain all information necessary for trained and qualified people with respect to:

- application limitation
- maximum surface temperature during use
- checks before use
- donning and fitting
- change over instructions
- use

- maintenance (preferably separately printed instructions)
- inspection intervals
- storage
- shelf-life
- service life (may be different for body worn or cached units)
- disposal after use

The instructions must be clear. If helpful, illustrations, part numbers, marking (and similar) can be added. The instructions for use should be complemented by an easy-to-understand pictogram on the carrying container showing the donning procedure.

Warning must be given against possible problems likely to be encountered, for example:

- integrity of the apparatus during carriage or transport
- during donning
- use of the apparatus in an explosive atmosphere
- danger of ignition if chemicals come into contact with combustible substances or water
- any other information the supplier may wish to provide to ensure that the apparatus is appropriate for use in underground coal mines.

### **3 Additional design requirements for chemical and compressed oxygen apparatus**

#### **3.1 Chemical oxygen apparatus**

Chemical oxygen apparatus must comply with AS/NZS 1716:2012, as amended below:

- Units must not exceed 55°C inhalation temperature at any time
- The water leakage test in Appendix H6.3 of AS/NZS 1716:2012 is replaced with the leakage test Clause 7.5.1 of BS EN 13794:2002
- Clause 11.3.4 carbon monoxide leakage test is not required
- Clause 11.3.6 the high volume test is not required
- Clause 11.1 (c) must be the same as that specified by the manufacturer for storage conditions.

A minimum of 12 sets of the apparatus must be submitted to the testing authority for pre-registration testing.

#### **3.2 Requirements for compressed oxygen apparatus**

Compressed oxygen apparatus must comply with AS/NZS 1716:2012, as amended below:

- Units must not exceed 50°C inhalation temperature at any time
- The performance requirements for the unit must comply with clauses 11.3.1 to 11.3.3, 11.3.5 and 11.3.7 to 11.3.13 of AS/NZS 1716:2012
- The water leakage test in Appendix H6.3 is replaced with the leakage test in clause 7.5.2 of BS EN 13794:2002
- A leak tightness test of the casing must be conducted in accordance with clause 7.5.1 of BS EN 13794:2002
- Units with non-refillable gas cylinders are not required to comply with clauses 10.14 and 10.15 pressure gauge or cylinder colour coding per AS 4484-2004: *Gas cylinders for industrial, scientific, medical and refrigerant use – Labelling and colour coding*
- Appendix J Simulated Work Tests J4.6 must be used instead of J4.4. (Note: The tests described in J4.4 relate to rescue units.)

A minimum of 12 sets of the apparatus must be submitted to the testing authority for pre-registration testing.

## **4 Additional design requirements for filter self-rescuers and compressed air apparatus**

### **4.1 Carbon monoxide filter self-rescuers (FSRs)**

Filter self-rescuers must comply with AS/NZS 1716:2012, as amended below:

- Exhalation resistance must not exceed 300 Pa.

### **4.2 Requirements for compressed air apparatus**

Compressed air apparatus must comply with AS/NZS 1716:2012.

## **5 Examination and testing of new units before issue to operators**

This section applies to:

- self-contained chemical oxygen apparatus
- carbon monoxide filter self-rescuers
- compressed oxygen apparatus

This section does not apply to compressed air apparatus.

### **5.1 Supplier to submit samples**

A supplier must not issue registered chemical oxygen apparatus or carbon monoxide filter self-rescuers or compressed oxygen apparatus to the mining industry until a certificate of compliance for the approved/certified rated duration, relevant to those units, has been obtained from a recognised test authority.

If a supplier intends to sell units of a particular model made in a particular year, and does not already have a certificate of compliance for these units, the supplier must submit at least 1% to a test authority for examination and testing. The test authority must issue a test report and may issue a certificate of compliance to the supplier.

Once the supplier has a certificate of compliance for that model, made in that year, the supplier may continue to supply to the mining industry units of that model, made in that year, provided that the number of units tested does not fall below 1% of the units supplied to the mining industry. The supplier may need to submit further units for test to maintain this ratio.

Provided the results of further samples continue to be satisfactory, the same certificate of compliance continues to cover further supplies of that model made in that year. Where possible, samples should be representative of the period of manufacture.

### **5.2 Test authority to examine and test samples**

The test authority should subject the samples to a visual examination, any compliance tests as specified by the manufacturer, and any other checks which the test authority considers necessary. Example forms are in Appendix A. (for chemical oxygen apparatus and compressed oxygen apparatus) or Appendix B (for carbon monoxide filter self-rescuers).

If these examinations are satisfactory, the test authority should conduct relevant tests using the test method and breathing rate shown in Table 3.1.

Table 3.1: Testing procedures for each self-rescuer type.

Rescuer type	Certificate of compliance required for units before release?	Breathing rate for laboratory test at BTPS	Laboratory test procedure (before release and re-testing)
Chemical Oxygen	Yes	35L/min	AS/NZS 1716, Appendix R4a)
Carbon Monoxide filter	Yes	35L/min	AS/NZS 1716, Appendix E 5.1
Compressed air	No	(none required)	(none required)
Compressed Oxygen	Yes	35L/min	AS/NZS 1716, Appendix R4a)

The test authority should assess the test results against the criteria for new apparatus for the rated duration, as given in Table 3.2 to Table 3.4.

Table 3.2: Performance criteria for new chemical oxygen apparatus.

Parameters	Units	Rated duration ≤ 30 minutes	Rated duration > 30 minutes
Inhaled CO <sub>2</sub> during rated duration	%	≤3.0	≤3.0
Average CO <sub>2</sub> during rated duration	%	≤1.5	≤1.5
Inhalation/exhalation resistance	kPa	≤1.0	≤0.75
Sum of inhalation and exhalation resistances	kPa	≤1.6	≤1.3
Inhalation temperature *	°C	≤55	≤55

\* Because the inhaled gas is dry, higher temperatures are allowed than for types of apparatus which supply humid inhaled gas.

Table 3.3: Performance criteria for new carbon monoxide filter self-rescuers.

Parameters	Units	Rated duration ≤ 60 minutes	Rated duration > 60 minutes
Inhaled CO during rated duration	ppm	≤400	≤400
Average CO during rated duration	ppm	≤200	≤130‡
Inhalation resistance	Pa	≤900	≤900
Exhalation resistance	Pa	≤300	≤300
* Inhalation temperature	°C	≤90	≤90

\* This limit is applied when the apparatus is tested with 1.5% carbon monoxide. The test is conducted only on new apparatus. Because the inhaled gas is dry, higher temperatures are allowed than for types of apparatus that supply humid inhaled gas.

‡ These values relate to a 90-minute duration. They would need to be modified for longer or shorter durations, so as not to exceed a total of 400mL of carbon monoxide for new apparatus, and not more than 600mL for in-service units.

Table 3.4: Performance criteria for new compressed oxygen apparatus.

Parameters	Units	Duration ≤30 minutes	Duration >30 minutes
Inhaled CO <sub>2</sub> during rated duration	%	≤1.5	≤1.5
Average CO <sub>2</sub> during rated duration	%	-	-
Inhalation/exhalation resistance	kPa	≤0.5	≤0.5
Total of resistances	kPa	-	-
Inhalation temperature *	°C	≤50	≤50

\* Note: because the inhaled gas is humid, lower temperature limits apply to this type of apparatus than to those types which supply dry inhaled gas.

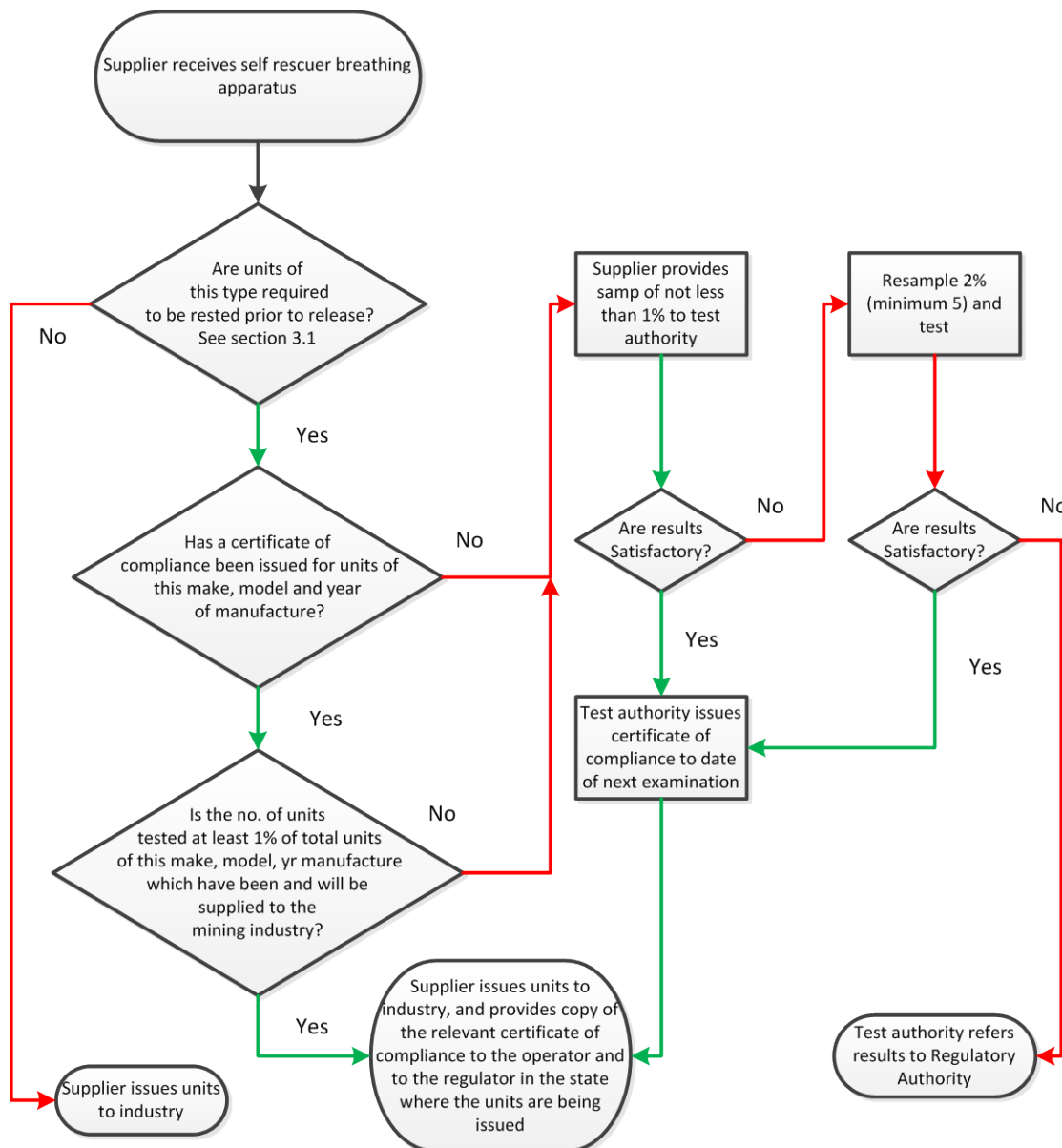
Before issuing a certificate of compliance the test authority should compare the performance of the tested units with the test data on which the registration was based. If the apparatus complies with the requirements, but there is a deterioration of more than 15% in any of the criteria from the type testing, the test authority may discuss the results with the supplier and may require further investigations before issuing the certificate.

### 5.3 Procedure after results of examination and test are assessed

The test authority should issue a test report to the supplier. If all apparatus in a sample of not less than 1% satisfy the examinations, tests, and assessments described in section 4 and a certificate of compliance has not previously been issued in relation to units of that model made in the particular calendar year, the test authority should issue to the supplier a certificate of compliance covering the period to the next required examination.

Section 4 details the resampling schedules for the various types of apparatus. The supplier should provide a copy of the compliance certificate to each operator receiving apparatus of that model made in the relevant calendar year, and to the regulatory authority in the state where the units are to be supplied.

Figure 5.1: Flowchart of the process for units before issue to operators.



If any of the test results do not comply with the relevant criteria, further sampling may be required. This may take the form of a further 2% sample, with a minimum of five units. If all of the units tested in the resampling pass, the test authority may issue a certificate of compliance. In the event of a failure in the further sample, the test authority must inform the supplier and refer the results to the regulatory authority to direct appropriate action. If any examination by a test authority reveals defects which may point to a widespread problem, the test authority must inform the regulatory authority.

## **6 Examination and testing of self-rescue units in service**

### **6.1 In-service testing procedure**

This requirement applies to:

- self-contained chemical apparatus
- carbon monoxide filter self-rescuers
- compressed oxygen apparatus

This section does not apply to compressed air apparatus.

### **6.2 Mine/owner to submit samples**

The mine or owner of the breathing apparatus, (or, where an alternative scheme provided for in section 1.8 is in place, the responsible body), must arrange for samples of units in service to be submitted to a recognised test authority for prescribed testing.

The retesting schedule for CO filter self-rescuers is given in Table 4.1.

The retesting schedule for chemical oxygen and compressed oxygen apparatus is given in Table 4.2. Chemical oxygen apparatus should be removed from service at the end of the manufacturer's recommended service life, which may be less than 10 years for some models.

The numbers of units to be submitted for various types of rescuers are given in Table 4.3.

Resampling of each model is based on the calendar year of manufacture, across approved/certified units in service, and must be carried out in advance of the expiry date of the certificate of compliance relevant to those units.

Where possible, samples must be selected such that:

- over time, a wide range of locations are included
- at each location, samples are weighted towards those uses that are most likely to cause degradation of the apparatus
- dates of manufacture are spread across the calendar year of manufacture.

The relevant information specified in 1.9.1 and 1.9.2 is to be submitted with each unit submitted to the recognised test authority. The test authority reserves the right to query and/or reject unrepresentative samples.



Table 6.1: Retesting schedule for in-service co filter rescue units.

Age of unit (years)	Test schedule
1	No test
2	No test
3	No test
4	Test required
5	Test required
6	Test required
7	Test required
8	Remove in month of manufacture

Table 6.2: Retesting schedule for in-service chemical oxygen and compressed oxygen apparatus.

Age of unit (years since manufacture)	Test schedule
1	No test
2	Test required
3	No test
4	Test required
5	No test
6	Test required
7	Test required
8	Test required
9	Test required
10	Remove in month of manufacture

Table 6.3: Number of units to be submitted for in-service testing.

Number of rescuers in-service of a given year of manufacture	Carbon Monoxide filter self-rescuers	Chemical Oxygen and compressed Oxygen apparatus
1-10	1	1
11-20	2	2
21-200	3	2
201-300	3	at least 1%
301+	at least 1%	at least 1%

### 6.3 Test authority to examine and test results

The test authority should subject the samples to a visual examination, any compliance tests as specified by the manufacturer, and any other checks that the test authority considers necessary. Example forms are in Appendix A (for chemical oxygen apparatus or compressed oxygen apparatus) or Appendix B (for carbon monoxide filter self-rescuers).

If these examinations are satisfactory, the test authority is to conduct relevant tests using the test method and breathing rate shown in Table 3.1. The test authority should assess the test results against the criteria for in-service apparatus for the approved/certified rated duration. Performance criteria are shown in Table 4.4, Table 4.5, and Table 4.6 for chemical oxygen, carbon monoxide filter, and compressed oxygen apparatus respectively.

**Table 4.4: Performance criteria for in-service chemical oxygen apparatus.**

Parameters	Units	Rated duration ≤ 30 minutes	Rated duration > 30 minutes
Inhaled CO <sub>2</sub> during rated duration	%	≤3.0	≤3.0
Average CO <sub>2</sub> during rated duration	%	≤2.0	≤2.0
Inhalation/exhalation resistance	kPa	≤1.5	≤1.2
Sum of inhalation and exhalation resistances	kPa	≤2.4	≤2.0
Inhalation temperature	°C	≤55	≤55
Average inhalation temperature during rated duration	°C	≤55	-

**Table 4.5: Performance criteria for in-service CO filter self-rescuers.**

Parameters	Units	Rated duration ≤ 60 minutes	Rated duration > 60 minutes
Inhaled CO during rated duration	ppm	≤400	≤400
Average CO during rated duration	ppm	≤290	≤200‡
Inhalation resistance	Pa	≤900	≤900
Exhalation resistance	Pa	≤300	≤300
* Inhalation temperature	°C	90	90
Dust	g	<2	<2

\* Because the inhaled gas is dry, higher temperatures are allowed than for types of apparatus which supply humid inhaled gas.

‡ These values relate to a 90-minute duration. They would need to be modified for longer or shorter durations, so as not to exceed a total of 400mL of carbon monoxide for new apparatus, and not more than 600mL for in-service units.

**Table 4.6: Performance criteria for in-service compressed oxygen apparatus.**

Parameters	Units	Duration ≤30 minutes	Duration >30 minutes
Inhaled CO <sub>2</sub> during rated duration	%	≤3.0	≤3.0
Average CO <sub>2</sub> during rated duration	%	≤2.0	≤2.0
Inhalation/exhalation resistance	kPa	≤1.5	≤1.2
Total of resistances	kPa	≤2.4	≤2.0
Inhalation temperature *	°C	≤50	≤50

\* Note: because the inhaled gas is humid, lower temperature limits apply to this type of apparatus than to those types which supply dry inhaled gas.

## 6.4 Procedure after results of examination and test are assessed

The test authority should issue a test report to the supplier.

If all apparatus in a sample of not less than 1% satisfy the examinations, tests, and assessments described in 4.3., the test authority should issue to the supplier a certificate of compliance covering the period to the next required examination.

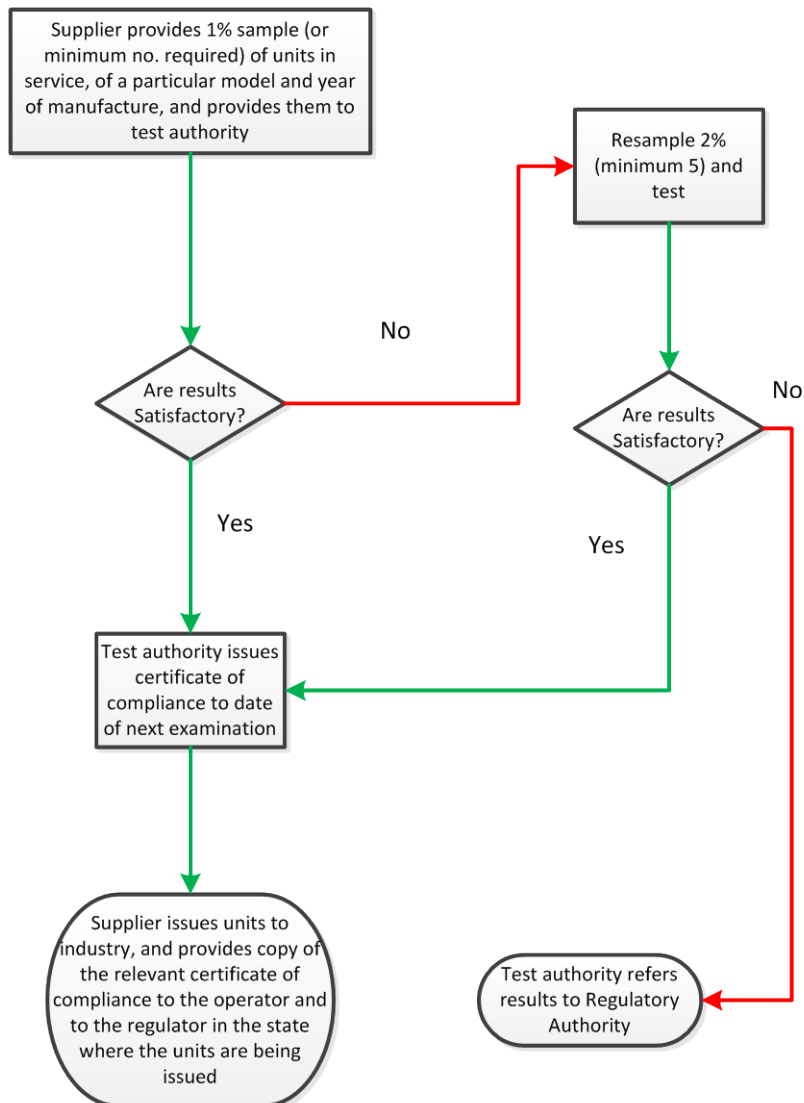
The extended service granted to a unit must not exceed the service life agreed by the manufacturer. However, on the basis of service history, a manufacturer may agree to support an apparatus beyond its initially recommended service life.

The extension that the certificate of compliance grants to the service of the apparatus will be that which is specified Table 4.1 and Table 4.2. However, the test authority may issue a certificate of compliance with a lesser extension, if it determines that the apparatus is deteriorating at such a rate that it may exceed the prescribed limits before the next scheduled resampling.

The supplier must provide a copy of the certificate to each operator holding apparatus of that model made in the relevant calendar year, and to the regulatory authority in the state where the units are being held.

If any of the test results do not comply with the relevant criteria, further sampling may be required. This may take the form of a further 2% sample, with a minimum of five units, of which two units must be from the same operator as the previously failed unit(s). If all of the units tested in the resampling pass, the test authority may issue a certificate of compliance. In the event of a failure in the further sample, the test authority should inform the supplier and refer the results to the regulatory authority to direct appropriate action. If any examination by a test authority reveals defects that may point to a widespread problem, the test authority should inform the regulatory authority.

Figure 6.1: Flowchart of the process for self-rescuers in service.



## 7 General maintenance requirements of apparatus in-service

The operator, in consultation with the supplier and an appropriate representative of the employees, should draw up a risk-based scheme for regular maintenance and checks on the apparatus. This should take account of the manner in which the apparatus is used and stored. The risk assessment should be conducted in accordance with MDG 1010, and any review should be conducted in accordance with MDG 1014, or other formal risk assessment and review criteria. The scheme should be documented for inclusion in the underground emergency system for the mine.

The scheme should implement the supplier's recommendations for maintaining the apparatus, and must define the frequency, responsibility, location and details of the required maintenance and checks, and clear criteria for deciding whether a particular apparatus is to be accepted, examined further, or rejected.

Damaged units must be repaired only by the manufacturer or authorised agent. The manufacturer or authorised agent must certify the integrity of any repaired apparatus before being returned to service.

### 7.1 Specific suggestions for maintenance of apparatus

In drawing up a scheme for regular checks on breathing apparatus, the operator should consider the following:

- Apparatus that is body-worn, handled frequently, or subjected to rough usage, should be checked visually, possibly on a daily basis by the user. The checks should verify that:
  - the apparatus is free of external damage
  - the seal is intact and has not been tampered with
  - the case does not have a significant dent (according to manufacturer's recommendations)
  - the apparatus has no visible puncture, and
  - the moisture indicator (where fitted) has not changed colour.
- It may be desirable to have the regular checks repeated at less frequent intervals by a single nominated person, to ensure that consistent standards are being maintained, and that progressive deterioration is detected.
- All units should be maintained in a clean condition, as ingrained dirt may affect seals and disguise damage.
- Carbon monoxide filter self-rescuers must be accurately weighed in a clean condition on a monthly basis. Any apparatus that shows an increase in weight of 12 grams or more above the weight indicated on the unit must be immediately withdrawn from service. (This may indicate that the unit has absorbed moisture.)
- Cylinders used for compressed gases, and refilling devices, must comply with statutory requirements and any relevant Australian Standard (such as for periodic pressure testing, internal examination).
- Cylinder pressures must be checked frequently to ensure that they are fully charged (minimum pressure 90% or other value defined by the escape strategy).
- Cylinders with rubber protective boots may suffer corrosion under the boot. Checks should be made where appropriate.
- All cylinder refilling devices must be subjected to the checks and tests detailed in the manufacturer's maintenance schedule, to ensure that they are free of visible external damage and meet the manufacturer's test requirements.
- Any required protection on aluminium and light alloys must be intact.
- Detergents and cleaning agents should not be used unless recommended by the supplier.

## 8 Appendix A

### Worksheet for the examination of chemical oxygen and compressed oxygen self-rescuers.

Testing organisation:

Make and model :	Date of test :
Unit serial no. :	Supplier :
Date manufactured :	From mine :
Weight of rescuer :	Exhalation CO <sub>2</sub> :
Rated duration :	Dead space :
Lab. Reg. no. :	

#### 1. LEAK TEST ON COMPLETE UNIT (SEALED)

Leak test			Start =	Finish =
			Change in pressure =	(Pa)
Leak test (water bath)			Change in weight =	.....(g)

#### 2. VISUAL INSPECTION OF COMPLETE UNIT (Prior to Breathing Simulator Test)

INSPECTION			COMMENTS
Tampering seal OK	YES	NO	
Clamping device OK	YES	NO	
Casing lid OK	YES	NO	
Belt loops OK	YES	NO	
Casing OK	YES	NO	
Casing seal OK	YES	NO	
Indicator window OK	YES	NO	
Indicator showing dry OK	YES	NO	

#### 3. VISUAL INSPECTION OF INNER UNIT (Before breathing simulator test)

INSPECTION			COMMENTS
Mouthpiece OK	YES	NO	
Breathing tube OK	YES	NO	
Nose clip OK	YES	NO	
Breathing bag OK	YES	NO	
Pressure relief valve OK	YES	NO	
Head strap OK	YES	NO	
Neck strap OK	YES	NO	
Waist strap OK	YES	NO	
Starter mechanism OK	YES	NO	
Mouthpiece plug in place OK	YES	NO	

COMMENTS:

\_\_\_\_\_

\_\_\_\_\_

TESTED BY \_\_\_\_\_ DATE \_\_\_\_\_

## 9 Appendix B

Worksheet for the examination of carbon monoxide filter self-rescuers.

### 1. Filter self-rescuer details

Mine..... \_\_\_\_\_  
 Manufacturer..... \_\_\_\_\_  
 Model..... \_\_\_\_\_  
 Serial number..... \_\_\_\_\_  
 Date manufactured/reconditioned..... \_\_\_\_\_  
 Registered weight..... \_\_\_\_\_

### 2. Visual examination of external casing

External casing in good condition Y/N \_\_\_\_\_  
 Seal on opening lever is correct and in place Y/N \_\_\_\_\_  
 Locking assembly is fitted and in place Y/N \_\_\_\_\_

### 3. Weight

Measured weight of filter self-rescuer \_\_\_\_\_

### 4. Opening efficiency

The opening seal breaks easily Y/N \_\_\_\_\_  
 The locking assembly releases easily Y/N \_\_\_\_\_  
 The top cover is removed easily Y/N \_\_\_\_\_  
 The 'O' ring seal is present Y/N \_\_\_\_\_  
 The rescuer is easily removed from casing Y/N \_\_\_\_\_

### 5. Contamination

Weight of dust contamination \_\_\_\_\_

### 6. Examination of rubber components

Mouthpiece is present and intact Y/N \_\_\_\_\_  
 Mouthpiece rubber is pliable not perished Y/N \_\_\_\_\_  
 Mouthpiece withstands tugging and flexing Y/N \_\_\_\_\_  
 Chinrest withstands slight flexing Y/N \_\_\_\_\_  
 The rubber is soft (not hard) Y/N \_\_\_\_\_  
 The rubber is strong (not weak) Y/N \_\_\_\_\_

### 7. Examination of headstraps

Headstraps are not perished Y/N \_\_\_\_\_  
 Headstraps are firmly attached Y/N \_\_\_\_\_

### 8. Examination of nose clip

Spring functions correctly Y/N \_\_\_\_\_  
 The rubber is soft (not hard) Y/N \_\_\_\_\_  
 The rubber is strong (not weak) Y/N \_\_\_\_\_

INTERNAL SERIAL NUMBER..... \_\_\_\_\_

Set aside for breathing simulator test by \_\_\_\_\_

Signed \_\_\_\_\_ Date \_\_\_\_\_

## 10 Appendix C Wearer assessment of self-contained self-rescuers

The apparatus should be subjected to the simulated escape test and subjectively assessed according to the following questionnaire, none of the wearers should experience any undue discomfort caused by the operational imperfections.

APPARATUS TYPE: .....

SERIAL NUMBER: .....

LOCATION OF TEST: .....

DATE OF TEST: .....

NAME OF WEARER: . .....

AMBIENT CONDITIONS: .....

DURATION OF APPARATUS:.....

Reason test stopped: .....

### WEARER'S ASSESSMENT

1. Describe the quality of the written and illustrated instructions supplied with the apparatus?

- Clear and concise
- Some difficulty understanding them
- Very difficult to understand

Comment:

.....

.....

2. Explain the ease of donning the apparatus?

- Simple
- Difficult
- Very difficult

Comment:

.....

.....

3. Determine the feeling of the apparatus while wearing it on your belt?

- Comfortable
- Uncomfortable
- Very uncomfortable

Comment:

.....

.....

4. Describe the comfort level of the apparatus harness after donning?

- Comfortable
- Uncomfortable
- Very uncomfortable

Comment:

.....

.....

5. Describe the ease of changeover from one apparatus to another during use?

- Good
- Fair
- Difficult

Comment:

.....  
.....

6. Describe the temperature of the inhaled atmosphere from the apparatus?

- Comfortable
- Tolerable
- Very hot

Comment:

.....  
.....

7. What is the resistance to breathing while wearing the apparatus?

- Comfortable
- Tolerable
- Hard

Comment:

.....  
.....

8. Describe the taste of the inhaled atmosphere from the apparatus?

- Pleasant
- Tolerable
- Unpleasant

Comment:

.....  
.....

9. What is the comfort level of the nose clip?

- Effective
- Not effective

Comment:

.....  
.....



10. What is the effect of the surface temperature of the apparatus?

- Warm
- Tolerable
- Very hot

Comment:

.....  
.....

11. What is the effectiveness of the goggles (where supplied)?

- Effective
- Tolerable
- Ineffective

Comment:

.....  
.....

**OVERALL ASSESSMENT OF THE APPARATUS**

.....  
.....  
.....  
.....

SIGNATURE OF WEARER:.....

DATE: .....

## 11 Appendix D Informative references

The preparation of this document has used the following standards as references:

- AS/NZS 1716: 2012 Respiratory protective devices
- BS EN 401:1993 Respiratory protective devices for self-rescue Chemical Oxygen (KO<sub>2</sub>) escape apparatus
- SABS draft document body worn escape type breathing apparatus

### Sources of criteria used in this document.

#### Chemical oxygen self-rescuers

##### ***New apparatus:***

- MDG 3006 *Code for Chemical Oxygen (KO<sub>2</sub>) Self Contained Self Rescuers*, which was based on:
- BS EN 401: 1993 *Respiratory Protective Devices for Self-Rescue – Self-Contained Closed Circuit Breathing Apparatus – Chemical Oxygen (KO<sub>2</sub>) Escape Apparatus – Requirements, Testing, Marking*
- South African Standard - SABS private specification on SCSR , 839 (CKM) 1989

##### ***In-service apparatus:***

#### Carbon dioxide limits were derived using the following information:

- South African service limits - CSIR Mining Technology: Report No: ES&H - 98 - 0337
- Personal communication re MSHA and NIOSH criteria.
- Discussions with Mr John Pennefather
- (Scientific Officer, RAN Submarine and Underwater Medicine Unit)
- Discussions with experts associated with the manufacture and supply of escape breathing apparatus, concerning physiology stressor limits.
- Report by Dr Ian Lambert for Dartbrook Colliery, concerning health considerations in carbon dioxide exposures.
- Published literature (various) concerning exposure to carbon dioxide.

#### Breathing resistance limits (inhalation and exhalation)

These were derived from discussions with the suppliers and information from the US, to establish a maximum of 1.5kPa. This allowed a 50% increase in the limit for in-service apparatus up to 30 minutes duration. The same increase was allowed for other resistance limits.

#### Carbon monoxide filter self-rescuers

##### ***Apparatus with duration up to 60 minutes:***

For units with durations up to 60 minutes, the limits for both new and in-service apparatus are those which have been applied by the department since these units were introduced into the mining industry. The average CO value replaces the previous measure of 'CO slip', a concept which was not well understood. The replacement values are equivalent.

##### ***Apparatus with duration greater than 60 minutes***

To account for new apparatus and provide equivalent protection for the wearer, the maximum and average CO concentrations are lowered for longer duration apparatus to ensure that the total quantity of CO passing to the wearer does not increase.