

JAMAICA FIRE BRIGADE TRAINING DEPARTMENT



BREATHING APPARATUS

Module

BREATHING APPARATUS

The firefighter is continuously called on to carry out his function of saving lives and protecting properties and he must do so under different conditions. Unquestionably, some of these conditions constitute a threat to life of the firefighter. These conditions include working in atmospheres that are both oxygen deficient and toxic. To survive under such conditions, firefighters must be given equipment that will provide adequate protection and a supply of air or oxygen sufficient to allow him to carry out his task without short term or long-term effects from exposure to these conditions.

The piece of equipment designed to allow a person working in an atmosphere where it is not possible to breathe freely without disastrous effect on his body is called a **Breathing Apparatus**. Some of the atmospheres which adversely affect breathing are: high temperature, oxygen deficient condition, toxic gases, fumes, smoke and other irritants and of course when working under water.

So briefly put, the Breathing Apparatus is a piece of equipment that enables the wearer to work in an atmosphere that would not otherwise support life. The importance of the Breathing Apparatus set cannot be over emphasized.

The Breathing Apparatus set can be categorized as operating on the OPEN or CLOSED CIRCUIT - Open Circuit set in which the exhaled air is discharged into the atmosphere and Closed Circuit set in which the exhaled air re-enters the set, is purified and recycled. Today most sets used internationally by fire departments are compressed air Breathing Apparatus because the introduction of ultra-light weight cylinders that have a larger capacity as increased the duration of the set. Also, compressed air breathing apparatus sets are easier to service and maintain than oxygen apparatus sets. Self-contained compressed air breathing apparatus is usually designed on the open circuit system.

Exhale air re-enters the set and is purified and recycled.

Exhaled air is discharged into the atmosphere

Breathing or Respiration is the spontaneous action carried out fifteen (15) to thirty (30) times per minute that provides the oxygen necessary for life. Breathing is divided into inhalation, exhalation and a short pause before the cycle starts again. On inhalation, 79.04% is nitrogen, 20.93% is oxygen, 0.03% is carbon dioxide. On exhalation, 79.04% is nitrogen, 16.96% is oxygen, 4.00% is carbon dioxide (CO₂). This clearly shows that about 4% oxygen has been used and replaced with carbon dioxide. Carbon dioxide is a respiratory stimulant and is produced by respiration in greater quantity than is supplied by the atmosphere. The muscles of the organs of the body require oxygen to function and the more work they do, the more oxygen they require. Thus, the work performed and the physical condition of the firefighter governs the rate of oxygen consumption with the average rate being about 40 liters per minute.

At fires, smoke of varying density with solid particles in suspension may cause inflammation of the lungs with the formation of sputum, thus affecting breathing. In addition to oxygen deficiency caused by carbon dioxide, carbon monoxide may also be present. Many gases may also be encountered, e.g. ammonia, hydrogen sulphide, sulphur oxide, fumes from paint and other industrial processes, petrol fumes, etc.

For satisfactory functioning of the body, air breathed must contain at least 20% oxygen and no poisonous gas or irritant. One of the most dangerous gases is carbon mono-oxide, due to the fact that this has a great affinity for red blood corpuscles with which it forms **Carboxyl Haemoglobin** resulting in the blood being unable to take oxygen from the lungs. Inhalation of pure carbon monoxide causes almost instantaneous unconsciousness.

COMPONENTS OF B.A. SET

The **main** items of which breathing apparatus sets consists are:

- i. A cylinder containing air under pressure
- ii. A system for reducing the pressure of the air from the cylinder and for supplying the wearer on demand according to his / her requirements.
- iii. A face mask.

Other parts of the B.A. set inclusive of above:

- i. Cylinder (same as i above)
- ii. Low pressure warning device
- iii. Back plate or carrying frame with waist and shoulder harness
- iv. Pressure reducer
- v. Lung demand Valve
- vi. Pressure gauge

vii. Face mask and head harness (same as iii above)

With a cylinder, the work capacity varies according to wearer's lung capacity and amount of work done. All B.A. sets are fitted with a low-pressure warning device designed to operate when the contents of the cylinder is within ten (10) minutes of complete expiration. The back plate or carrying harness allows the cylinder to be carried on the wearer's back, whereas the harness is used to secure the back plate and the cylinder to the wearer's body. The high-pressure air supplied from the cylinder can be reduced to a breathable pressure via the pressure reducer i.e. single stage reduction or two-stage reduction. The lung demand valve is designed to give the amount of air required and can be manually operated by pressing a diaphragm in the center of the regulator. The pressure is gauge connected via a high-pressure hose to the cylinder to show current cylinder pressure. All modern masks have: full vision visor, exhalation valve and demand valve port. Some are fitted with inner mask and are fitted over the nose and mouth to reduce the possibility of fogging up the inside of the visor.

The charged cylinder of existing compressed air sets represents two thirds of the total weight of the sets.

Cylinders are coloured for ease of identification. Oxygen cylinders are black and the valve down to the cylinder is white. The body of some air cylinders is grey while the valve down to the shoulder is black and white quarters.

The operation of the B.A. set is of such that when the cylinder valve is opened, air at high pressure leaves the cylinder and enters the pressure reducing manifold where some of it is led via a reinforced high pressure hose to pressure gauge. The rest is taken to the demand valve (at a reduced pressure), which is attached to the facemask supplying the wearer on demand. Compressed air sets are lung governed – meaning, the demand valve opens on inhalation. More recently, sets valve open, which floods the face mask with air. On some sets (e.g. Drager Premier 90s Series) this mode is selected automatically with the first inhalation.

Dressing or donning with the apparatus is relatively simple and the method is common to all types when the arms have been placed through the shoulder straps. The body belt is tightened, all straps being adjustable. After opening the cylinder valve and checking the pressure gauge reading, the mask is put on and the head harness are adjusted.

Duration

The "Working Duration" varies considerably according to wearer's lung capacity and the amount of work done. Firefighting demands high rate of work and consumption of air may be as high as sixty (60) liters per minute or even more for

short periods, in which case the duration of the set would be less. It is assumed that the average rate of consumption is forty (40) liters per minute and the duration is found by dividing the full capacity of the set by the rate of consumption. This duration is further reduced by subtracting ten (10) minutes (safety margin). The resulting time is referred to as “**working duration**”. As an additional safety guard to ensure that the wearer does not exceed the working duration of his / her set, low-cylinder pressure warning devices are fitted to all sets to warn the wearer that a low amount of air is left, hence, the time is limited so he or she should proceed to the safe area.

Formula : $\frac{\text{GUAGE READING}}{\text{CAPACITY IN BARS}} \times \frac{\text{CAPACITY IN LITERS}}{\text{RATE OF CONSUMPTION}}$

$$\frac{120}{200} \times \frac{1800}{40} = \frac{3}{5} \times 45 = 27 \text{ Mins.}$$

Full Duration

Full duration is the time a breathing apparatus is expected to last from the moment it is started up until the cylinder is exhausted.

Working Duration

Working duration is the time a B.A. set is expected to last from the time it is started until the cylinder pressure is reached at which the low-pressure warning device starts to operate.

Safety Margin

Safety margin is the time from the moment the whistle starts to sound until the cylinder is fully exhausted.

In Short: WD = FD - SM

WORKING WITH BREATHING APPARATUS

It is important that every person who is required to wear breathing apparatus be adequately trained. It is not only a question of the wearer’s own safety but also that of his colleagues with whom he may be working at the time. B.A. wearers always work in pairs.

Breathing apparatus is worn at a fire or other incident only on the instructions of the officer-in-charge who in fact maybe a sub-officer. The officer should nominate a breathing apparatus control officer whose job is to collect the tallies from the wearer before they go in; having first made sure that the information required on the tallies including the cylinder pressure has been checked by the wearer when he dons his set and a record is made on the tallies.

Breathing apparatus must be donned and started up in fresh air and men standing by at a B.A. control should wait in fresh air until required. Once smoke or toxic fumes are present in the lungs and respiration passage, it takes sometime for them to be completely cleaned. Only in the most exceptional circumstances should a person who has already inhaled smoke, oxygen deficient or toxic fumes subsequently rig in B.A. set.

Inside the building it maybe found that visibility is extremely poor or non – existent due to lack of lighting or smoke fumes. Lamps are carried as a part of B.A. equipment but maybe little or no use in heavy smoke conditions. Firefighters should be in the minimum of pairs (which engenders confidence) and contact should be maintained by touch in strange surroundings.

N.B. Searching and working by touch is covered as apart of the practical training of this course.

Entrapped Procedures

In the event of a firefighter being trapped and unable to withdraw, to the extend the duration of the set he is wearing, he should relax in as comfortable a position as possible, breathe shallow and operate his distress signal warning device and wait for help.

Closing Down

When a B.A.wearer as completed his task and returns to normal atmosphere, the set should be closed down as follows : The head straps should be slackened , the face mask removed and then the cylinder valve closed.

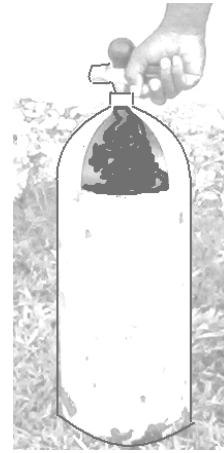
HANDLING OF CYLINDERS

All B.A. cylinders should be handled and carried correctly. Remember the air in the cylinder is stored at high pressure (up to 300 bars). Mishandling can cause the cylinder to fly like a MISSILE !! . Below are diagrams showing the correct and incorrect way of handling cylinders.

HANDLING CYLINDERS



CORRECT



WRONG

CARRYING CYLINDERS



N.B. - If the cylinder pressure is less than five sixth ($5/6$) of the maximum charging pressure of the set it should be replaced by a fully charged one.

VISUAL INSPECTION

Before using a breathing apparatus set, it should be inspected and checked for leaks and damages.

The face mask should be checked as follows;

- a. head harness for deterioration

- b. visor for cracks
- c. check valve connection port for the presence of oils or grease
- d. the presence of neck straps
- e. orinazal mask

The cylinder should be checked as follows;

- a. abrasion on the cylinder body
- b. rubber buffer in place
- c. colour of cylinder
- d. sticker containing amount in bars, charging pressure, hydrostatic test and nominal duration
- e. blank cap at connecting port

The back plate should be checked to ensure that:

- a. reinforcement pressure hose is not damaged.
- b. straps on carrying harness are in good condition.
- c. gauge is not damaged.
- d. demand valve and reducer are not damaged.
- e. warning device is in place.
- f. rubber washer is in connecting port.

HIGH PRESSURE TEST

After inspecting the set and found intact and in working condition:

- a. don cylinder.
- b. make connections ensuring they are finger tight.
- c. ensure that demand valve is in positive pressure mode.
- d. open cylinder valve slowly but fully.
- f. listen for audible leaks and observe pressure gauge for rise in needle.
- g. close cylinder valve and observe needle, if needle falls below ten (10) bars in a minute there is a leak.
- h. check to ensure that low pressure warning device sounds when the supply is released from the cylinder.

LOW PRESSURE TEST

The aim of this test is to ensure a seal is formed.

- a. the set should be fully assembled with the exception of the facemask.

- b. don the set and connect the facemask with visor facing you.
- c. observe that the demand regulator in positive pressure mode, open cylinder valve fully but slowly.
- d. with straps adjusted, place mask on face then tightened to fit.
- e. closed valve then breathe set down until air is fully exhausted.
- f. mask should now fall to the face and form a seal.
- g. open cylinder valve slowly but fully, then release straps and remove facemask.

USE OF THE GUIDE LINES

The purpose of a guideline is to provide a means whereby the first team or crew to enter and search a smoke filled risk can retrace their steps and for subsequent teams to proceed to the scene of operation and return without difficulty. The term '*guide line*' means a special line, which maybe used either as a main guideline, for initial search, and to indicate a route between B.A. control and scene of operation or alternately as a branch guideline, when it is necessary to traverse to search deeply off a main guideline. The method of use of the line for either purpose is the same.

The running end should be fitted with a snap hook sufficiently large to hook on the guideline and the other end should terminate in a loop 6 inches (152mm) in length. To identify by touch 'way out' two tabs 6 inches (152mm) apart are fitted at 8ft (2.44m) intervals along the length of the line. One tab is to have two separate knots and an overall length of 2 inches (51mm) and the other is to be unknotted and be 5 inches (127mm) long. The knotted tab is to be on the 'way out' on the side of the plain tab i.e. near to the end of the line fitted with the snap hook. Only one main guideline is to be laid along a route from B.A. Control Officer. Main guidelines are to be designated alphabetically by the letters 'A' and 'B'.

PROCEDURES FOR THE USE OF GUIDE AND PERSONAL LINE

- a) A guideline team should consist of a minimum of two men.
- b) The guideline is to be carried by a team leader. The last man of team is to make the line fast at a suitable point at a convenient height from the ground. Tie off points need to be close together but at sufficient intervals to keep the line off the ground.

- c) The line is to be made fast on the side of search and crossing over one side to the other is to be avoided as far as possible.
- d) When it is known or suspected that penetration will be deep, another member of the team should carry an additional guideline.
- e) When a guide is being laid members of teams other than the leader should attach themselves to the line by means of the hook of their personal line so arranged to use the short 4ft (1.22m) length of line. Alternatively the members may attach themselves to the main in front of the guideline.
- f) After a guide has being laid all members of the team proceeding along the route are to attach themselves to the line by means of their personal short line. Alternatively the leader will attach himself to the guide line and the remaining members may attach themselves to the man in front.
- g) When attached individually to the guideline by means of their short personal line, team/crew should maintain contact as far as possible by physical touch.
- h) To search or otherwise move away from guidelines then personal lines should be used. Where the distance is greater than can be covered with a personal line a branch guideline should be used.

THE DISTRESS SIGNAL

A further safeguard of the B.A. set is provided with a device which is manually operated once the wearer of that set has become distressed for any reason. These devices will give off an audible warning and are so designed that once separated, they cannot be switched off without the use of a special key. In order for the unit to be switched off, the wearer must return to the B.A. control point.

NB:

“Once a distress signal warning is heard, rendering assistance must take precedence over the work at hand. FIREFIGHTERS MUST ALWAYS WORK IN PAIRS.

CONTROL BOARD

This is kept in place at the cold zone at an operation. It consists of a clock to the top left hand corner of the board. To the top right hand corner of the board is the diagram showing duration of the B.A. set in minutes.

The remainder of the set is labeled with:

- the time of whistle
- the location of the team
- remarks

The board also consists of slots for the containment of the tally. The tally has a hole on it in which the key for the distress signal unit is kept. Written on the tally is the name, compress air in the cylinder, pressure and time. To the back of the tally is the dosimeter reading having in and out.

