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PREFACE

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1. BR 2806 UK Military Diving Manual is issued in Two Volumes and is sponsored by The Commander in Chief Fleet.

2. The purpose of Volume One is to promulgate the theory of diving, and administrative regulations governing the conduct of all Military Diving. MOD Civilian Diving and Health and Safety Diving Operations at Work Regulations are covered within Ministry of Defence Civilian Diving Manual (MDCDM). Guidance on relevant procedures and drills used in the conduct of diving will be found in Volume Two of BR 2806.

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Chapter 4	I of D
Chapter 5	Spare
Chapter 6	INM/I of D
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Chapter 8	)

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BR 2808(1)	Diver Underwater Tasks Manual
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ATP 10(D)BRIT SUPP2	Submarine Search and Rescue British Supplement 2
AGAI	Army General Administrative Instructions
JSP 327	Joint Service Manual of Movements
JSP 375 Vol 2	Health and Safety at Work Act 1974
FCD 3	The Maintenance of Operational Effectiveness in the Surface Flotillas
FLAGOs	Fleet Administrative and General Orders
FEOs	Fleet Engineering Orders

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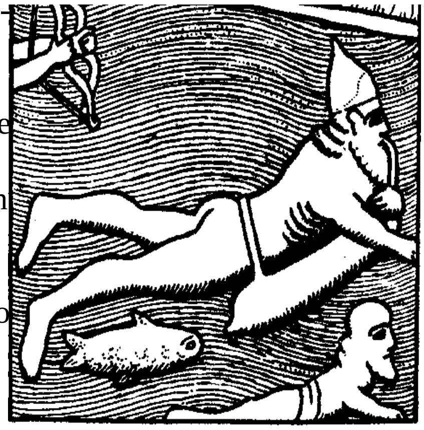
HISTORY OF DIVING

1. Archaeological excavations have revealed mother-of-pearl inlays dated as early as 4500 BC which must have been gathered by breath-hold divers. Although this is the earliest indication of mans first technique for underwater work. There have been many other examples of man's early attempts of underwater work both military and commercial. An Assyrian Frieze (900 BC) depicts an early underwater warrior. It was Aristotle in the fourth century BC who first made mention of a type of diving machine which sent containers of air down to the divers. Approximately 330 BC, Alexander the Great is reported to have used a primitive form of Diving Bell called the "Colimpha" to see for himself the wonders of the deep. Developments from Aristotle's time (384-322 BC) to the middle ages are difficult to identify although in 1240, Roger Bacon mentioned an "instrument whereby men can walk on the sea or river beds without danger to themselves".

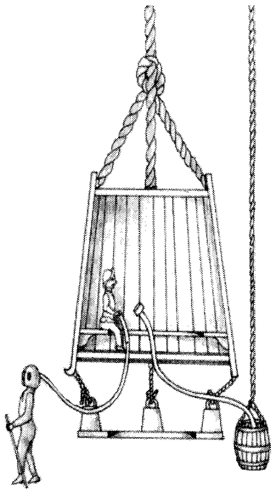


Assyrian Frieze (900 BC)

Lorena's One Man Diving Bell (1531)

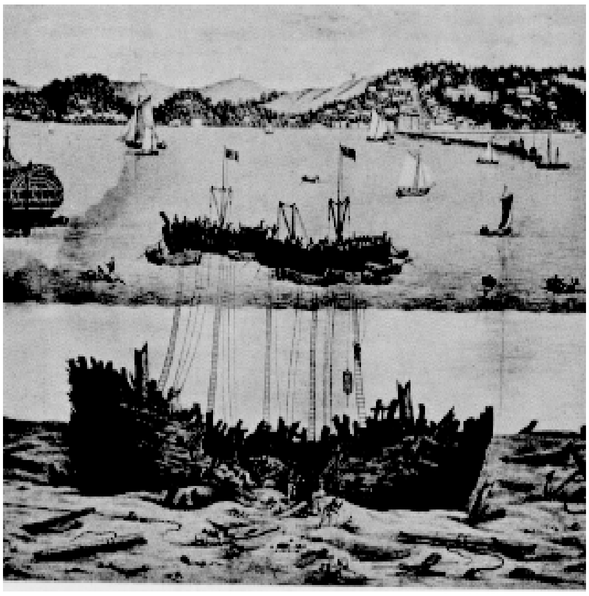
2. The first practical extension of mans ability to carry out more prolonged work underwater came with the advent of the diving bells in the 16th Century when in 1535, Guglielmo de Lorena developed what is accepted as the first real Diving Bell. Using this equipment, a Diver was able to work for approximately one hour in Lake Remi near Rome.

3. In 1691, the famous astronomer Sir Edmund Halley, introduced the forerunner of the modern Diving Bell. The Air in the Bell being replenished using barrels of fresh air passed down from the surface. Almost a century later, in 1788, Smeaton added a "force pump" to allow air to be pumped from the surface. Many notable feats of salvage were conducted using these primitive diving bells, some of which allowed a diver to work outside its confines using small flexible breathing pipes.



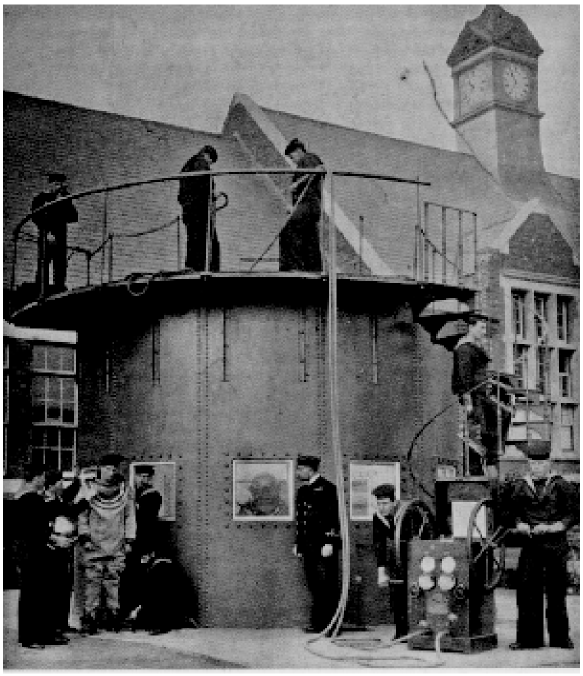
HALLEY's Early Diving Bell (1690)

4. The independence and working potential of the diver was dramatically improved when the Dean Brothers introduced the surface supplied diving helmet in 1832. In 1837 Augustus Siebe greatly improved upon the Dean's original design introduced the "closed" Diving Dress to supplement the helmet. This equipment widely known as the Standard Diving Dress has remained essentially unchanged and can still be found in use throughout the world. Until World War II it was the most widely used diving equipment. Advanced technology has allowed further development of this equipment with new Helmet designs and different Diving Dress materials but the basic principle of operation remains the same.



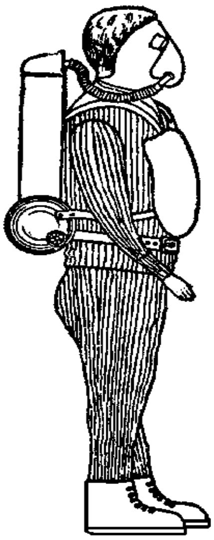
Colonel Pasley and the Royal Engineers on the Royal George

5. The first recorded military interest in diving came in 1838 when Colonel Pasley, Royal Engineers, of the School of Military Engineering at Chatham undertook to demolish the wreck of a collier blocking the fairway of the Thames at Tilbury. After unsuccessful attempts to position the charges using the diving bell from the Naval Dockyard Pasley trained a number of his soldiers in the use of Mr Kemp's diving equipment, having first tested the concept himself and thus become the first Service diver on 28 April that year. Within a short period charges had been successfully laid by divers of the Royal Sappers and Miners and the wreck demolished. Encouraged by this success he turned his attention the following year to the wreck of the Royal George at Spithead and over 5 subsequent years conducted salvage operations and demolished both this and a number of other wrecks in the area. During this period he evaluated a number of different types of diving equipment and in his final technical report commended the use of Siebe's diving dress for 'public service'. Having persuaded the Navy of the advantages of this equipment over the unwieldy Dockyard diving bell he subsequently detached Lcpl Jones to HMS EXCELLENT to train a party of 13 Petty Officers and Seamen in its use.



Early RN Diver Training at HMS EXCELLENT

6. Since then the Royal Navy and Army have operated and trained its own divers making a significant contribution to diving throughout the world. Immense progress has been made in the intervening years, with early trials and experiments conducted in close co-operation with such great men as Sir Robert Davis and Professor John Haldane. The United Kingdom held the world deep-diving record for a number of years and lead the way in the development of many deep diving techniques.



Fluess's Early Rebreather (1878)

7. The first really practicable self-contained breathing apparatus was designed in 1878 by Henry Fluess, an English merchant seaman. The equipment consisted of a watertight rubber face mask connected by breathing tubes with a copper tank containing oxygen compressed to 450 pounds per square inch gauge and a breathing bag. Inhaling pure oxygen, the diver would exhale into the breathing bag, where his breath was drawn through ropes yarn soaked in a solution of caustic potash to remove the Carbon Dioxide. Fluess's diving set was used successfully in work in flooded collieries in 1880 and by Alexander Lambert in his famous exploit in saving the flooded Severn Tunnel in 1882.

8. The first Open-Circuit apparatus was developed as early as 1866 by Frenchmen, Benoist Rouquayrol and Auguste Denayrouze. This was a demand regulator system which was described by Jules Verne in his Classic book "Twenty Thousand Leagues Under the Sea". This book, written in 1869, four years after the Rouquayrol-Denayrouze gear had been developed, described the apparatus and its use in a conversation between Captain Nemo and Professor Aronnax. In 1933, the development of the Open Circuit Diving Equipment was again picked up by a French Naval Officer, Commander LePrieur. He used a tank of compressed air, but did not include a demand-regulator in his design. The diver was forced to spend most of the time manually controlling his air supply by manipulating a valve. This coupled with a short endurance severely limited the practical use of the equipment and it wasn't until two other Frenchmen, Captain Jacques-Yves Cousteau and Mr Emile Gagnan combined an improved demand regulator and high-pressure air tanks that the first truly successful Open-Circuit Self Contained Diving Apparatus was available. The "Aqua Lung" was successfully demonstrated in 1943 and popularised underwater exploration and exploitation.

Rouquayrol-Denayrouze Early Open Circuit Set (1866)

P Party Diver Clearing a Harbour during WW2

9. During the Second World War the need arose for a diver with self-contained streamlined equipment to deal with the threat of the influence mine and the underwater sabotage charge. From this requirement there evolved many of the Closed and Semi-Closed Diving equipment's used in the Services today including the acoustically quiet, magnetically clean, Clearance Divers Breathing Apparatus.

10. Deep diving employing breathing mixtures of oxygen and helium is a comparatively recent innovation and it has been proved that man can live and work at great depths for long periods. The type of diving where men are kept under pressure in a purpose built habitat for long periods is known as Saturation Diving. Useful work can be undertaken by making excursions to the seabed in a Submersible Compression Chamber, sometimes referred to as a Bell. The Royal Navy entered the field of saturation diving in 1968. Experimental, working dives and equipment trials continued until 1990 when it was decided that this type of diving would no longer be undertaken.

11. Diving, marine technology and medical research still continues with the aim to provide safe and efficient equipment and improve on the conduct of diving tasks.

12. Professional diving in various categories is carried out by the Royal Navy, the Royal Marines and the Army, as well as in industry. In addition, diving is an authorised adventurous training activity and facilities exist in all the Services for people to enjoy the wonders of the underwater environment.

Port Clearance Diver - Charioteer

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SECTION 1 - PHYSICS OF DIVING

0101. Introduction

a. The effects of diving on the human body are caused by the operation of certain physical laws, in particular the physical properties possessed by liquids and gases.

b. Under water, the human body operates in a completely different environment, in which it is exposed to much greater pressures than it experiences at the surface. It is necessary, therefore, to consider carefully the meanings of the terms **force, pressure** and **density** as applied to liquids and gases.

0102. Mass, Force, Weight, Pressure and Density

a. **Introduction.** The following paragraphs introduce the concepts of mass, force, weight, pressure and density. The diver needs to be aware of the physical properties of the fluids and gases which surround him and which he breathes.

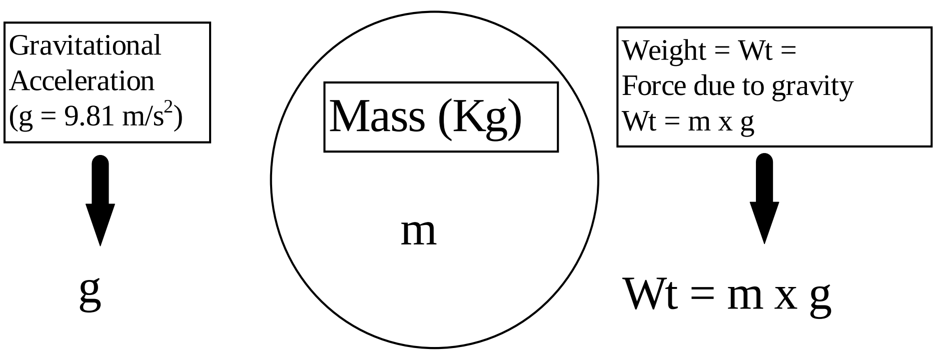
b. **Mass.** This is a basic property of matter, and measures the quantity of matter that a body, whether solid, liquid or a gas, contains. The standard of mass is a cylinder of platinum iridium of a special size (39mm diameter, 39mm high) kept at the International Bureau of Weights and Measures and called a Kilogram.

c. **Force.** A force will move or try to move an object. If the object is already moving the application of force will increase or decrease the objects velocity (speed). Force cannot be seen, only the effects can be noticed. Force can be defined as the product of a mass (kilograms) multiplied by its acceleration (m/s^2). As this definition was propounded by Sir Isaac Newton it is fitting that the unit of force is the Newton, and is defined as that Force which accelerates a mass of 1 Kg by 1m per second per second. To move a body from rest, or if it is moving, to change its velocity a force must be applied which will overcome all the other forces resisting motion (ie: gravitational and frictional forces).

Force	=	Mass x Acceleration (and is measured in Newton's (N))
[Note 1 Kn	=	*1000 N]*

d. **Weight.** This is a measure of the force exerted on a body (mass) in a gravitational field and is equal to:

Weight	=	Mass (of body) x	gravitational acceleration
(Newton's)		(Kg)	($g = 9.81\ m/s^2$)



Weight is expressed in Newton's. In normal circumstances the gravitational effect of the earth can be considered to be constant and equal to 9.81 m/s^2 but for all practical purposes gravitational acceleration (g) can be approximated to 10 m/s^2. It should be noted, that if the gravitation acceleration is changed (eg by going to the moon) the apparent weight of a given mass will also change.

e. **Pressure.** This is defined as being the force applied to a unit area (1 square m) of surface. Thus:

$$\text{PRESSURE} = \frac{\text{FORCE}}{\text{AREA}} \quad \text{(measured in Bars or } N/m^2\text{)}$$

The correct SI unit of pressure is the Pascal which is defined as 1 Newton per Square Metres, however, this unit is very small, and in diving the Bar is used which is 10^5 Pascals. For practical purposes 1 Bar approximates to 1 atmosphere, 14.5 lb/in^2, 100 KN/m^2 or the additional pressure experienced at a depth of 10m.

f. **Density.** This is defined as being the mass of a unit volume of a substance. It is a measure of the degree of 'packing' of the molecules of which the substance is composed; therefore, the greater the degree of packing the higher the density. Thus:

$$\text{DENSITY} = \frac{\text{MASS}}{\text{VOLUME}} \quad \text{(Unit = } Kg/m^3\text{)}$$

0103. Liquids and Gases

a. **Liquids.** A liquid has a definite volume and weight, and will take the shape of its container. To the diver the most significant liquid is water. For all practical purposes water can be considered as being incompressible, and, in the context of this manual, the changes in volume or density caused by temperature changes can be disregarded. Therefore:

Density (fresh water) = 1000 Kg/m^3

Seawater varies in density in the different oceans of the world, depending on the amount of dissolved matter (mainly salt) in it. For example, in some parts of the Baltic the water is almost fresh, while in the Red Sea the salt content is very high and so, therefore, is the density. For all practical purposes, and for the purposes of this manual, the average density can be used:

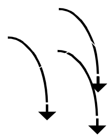
Density (sea water) = 1030 Kg/m^3

b. **Gases.** All gases have some weight and occupy space but have no definite volume or shape. Compared with liquids they are very light and are compressible. **Atmospheric air**, the air we normally breathe, is a natural mixture of approximately 21 per cent oxygen and 79 per cent nitrogen, with a trace of carbon dioxide and other rare gases. It also contains water vapour in an amount depending upon the weather conditions. Since gases are compressible, the density of a gas varies according to the pressure applied. Thus, the density of the gas a diver breathes varies according to the depth at which he is working.

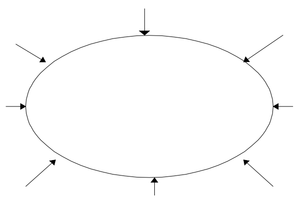
0104. Water Pressure

a. The pressure with which the diver is most directly concerned is the pressure of the surrounding water at his diving depth (ambient pressure). Pressure in liquids conforms to certain basic laws, which are as follows:

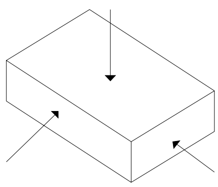
(1) The pressure on an object in liquid is produced by the weight of the liquid above the object.



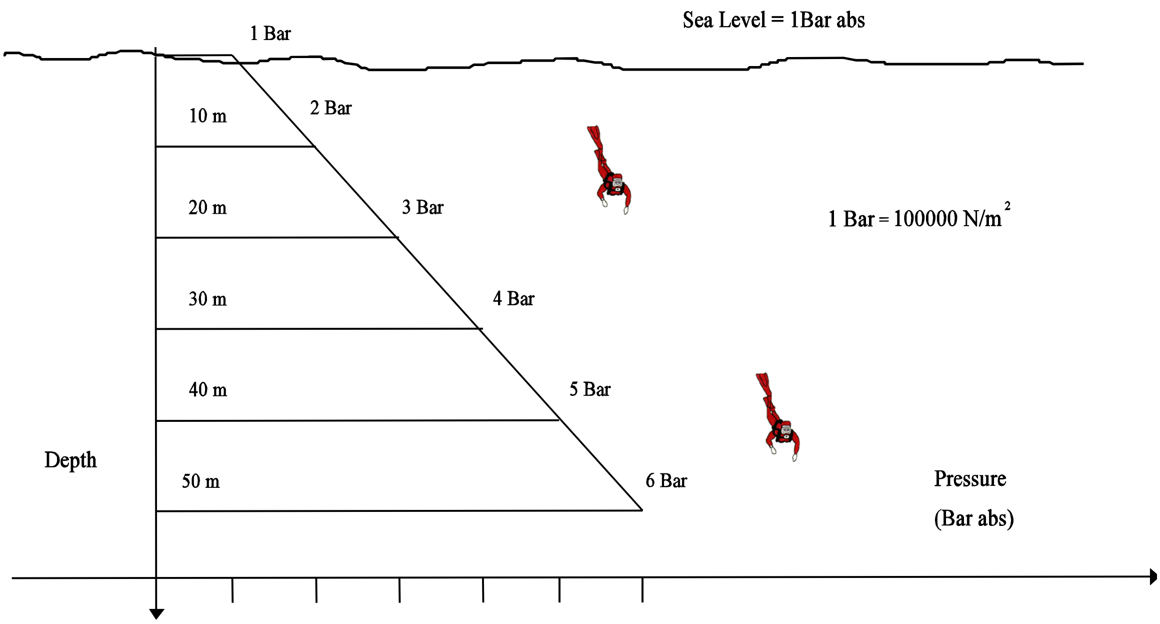
(2) The pressure produced acts on the object from all directions.



(3) The pressure will act at right angles to any surface of the object



(4) Water pressure increases at a constant rate because water is incompressible and its density remains the same at any depth.



b. If, for the moment, the effect of atmospheric pressure on the surface of the water is disregarded then the pressure exerted by the water at a given depth is due to the direct weight of the water above that depth. The density of seawater is:

Density (sea water) = 1030 Kg/m^3

and, as water is virtually incompressible, this density remains constant irrespective of depth or pressure variations. The pressure exerted is, therefore, directly proportional to the depth, ie the pressure exerted at 20m is twice that exerted at 10m and so on.

c. **Calculation of Pressure at any Depth in Seawater.** Consider Fig 1-1. It represents a plate lying on the bottom at a depth of 10m. The pressure on the plate is produced by the weight of water above it.

Wt of water above the plate = vol of water above plate **x** density of seawater **x** g

= (10m x 1m x 1m) x (1030 Kg/m^3) x (10 m/s^2)

= 103000 N

and Pressure = $\frac{\text{Wt of water above the plate}}{\text{Area of Plate}}$

= $\frac{103000 \text{ N}}{1\text{m x } 1\text{m}}$

= 103000 N/m^2

= **103 KN/m^2**

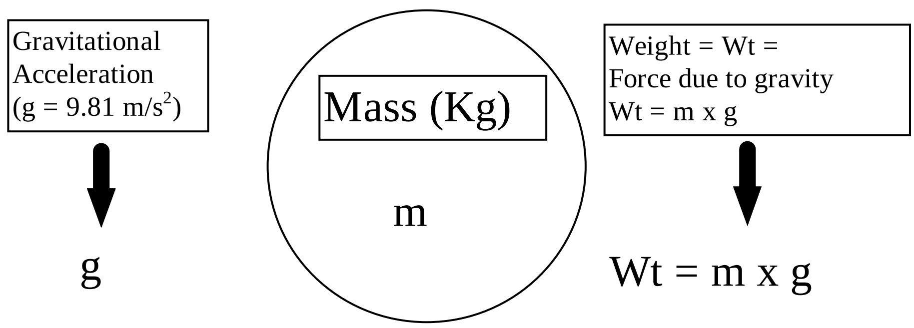


Fig 1-1. Water Pressure

With this in mind it is safe to say that for every metre the diver descends the pressure of water will increase by:

(1) Sea Water

$$\text{Pressure} = \frac{\text{Wt (sw)}}{\text{Area}}$$

$$= \frac{\text{mass x g}}{\text{Area}}$$

$$= \frac{\text{Vol x Density x g}}{\text{Area}}$$

$$= \frac{1m^3 \text{ x } 1030 \text{ kg/m}^3 \text{ x } 10m/s^2}{1m^2}$$

$$= \mathbf{10300\ N/m^2}$$

(2) Fresh water

$$= \frac{1m^3 \text{ x } 1000 \text{ kg/m}^3 \text{ x } 10m/s^2}{1m^2}$$

$$= \mathbf{10000\ N/m^2}$$

Therefore to calculate the pressure at any depth:

Pressure (N/ m^2) = Depth (m) x Density (Kg/m^3) x grav accel (g)

Notes:

1. In this case, gravitational acceleration is assumed constant at Approx 10m/s^2 (Normally 9.81m/s^2)

2. 1000 N = 1 KN

0105. Atmospheric Pressure

a. The atmosphere exerts a pressure on the earth's surface in the same way as water exerts pressure, ie it is produced by the weight of air above the earth. However, unlike water, the atmosphere, being gaseous, is compressible; therefore, its density varies with height, the greatest density being at the earth's surface, ie sea level. This means that maximum atmospheric pressure is experienced at sea level. At heights above sea level, the pressure will be less, depending on height.

b. **Calculation of Atmospheric Pressure.** Although atmospheric pressure at sea level varies from day to day (as can be seen on an ordinary barometer) it can be shown that, under average conditions, the atmosphere will support a column of seawater 10m in height (Fig 1-2).

Thus:

(1) Atmospheric pressure = pressure due to 10m of seawater

= $10 \times 10300\ N/m^2$

= $103000\ N/m^2$

(2) Thus, atmospheric pressure

= $103000\ N/m^2$

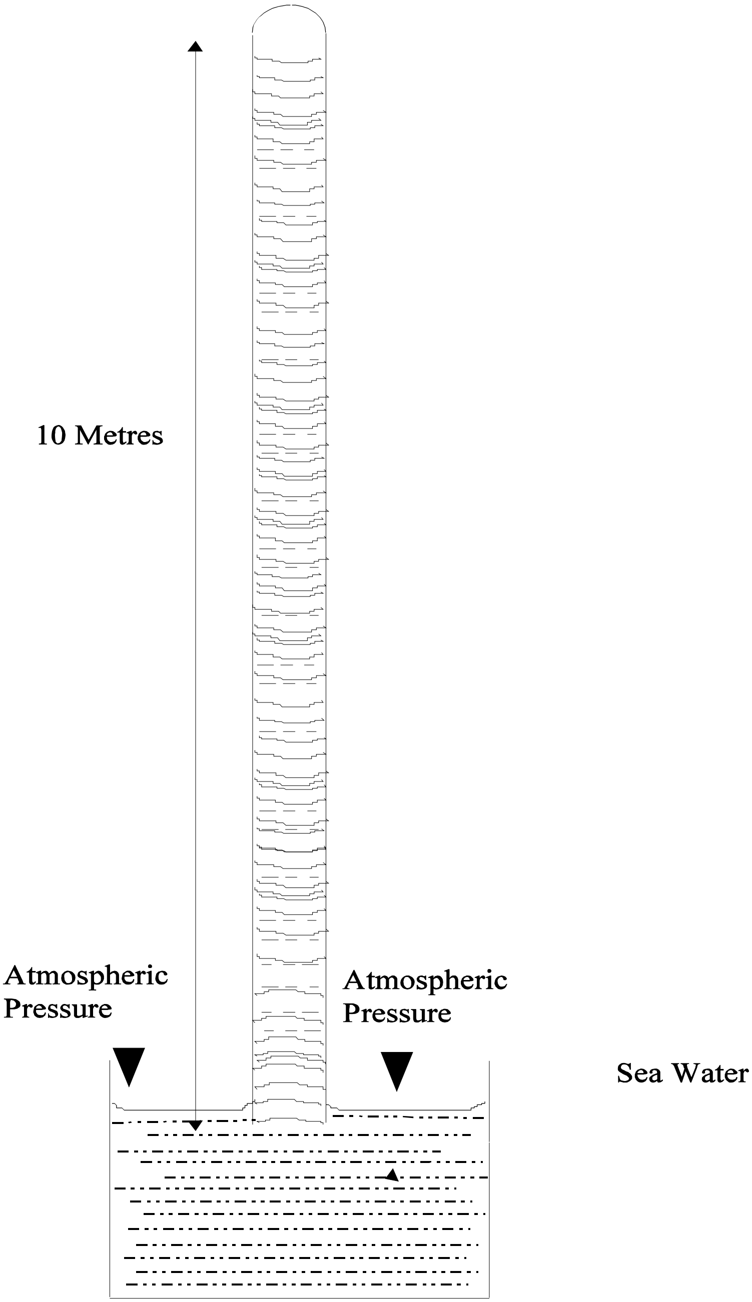


Fig 1-2. Atmospheric Pressure

c. **Water Gauge Pressure.** Gas pressures can be measured in terms of the height of liquid they will support rather than in the units mentioned previously. This can be useful where the pressures to be measured are low and need to be known accurately. Usually the liquid used is water and the arrangement is as shown in Fig 1-3 below. The pressure measured will be expressed, if this device is used, in millimetres water gauge (mm wg).

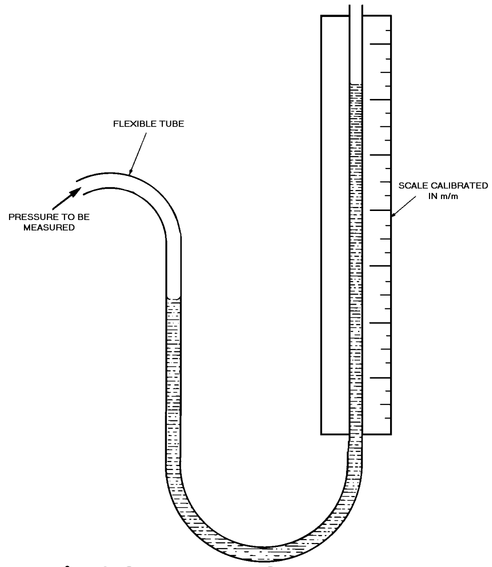


Fig 1-3. Water Gauge Pressure

0106. Absolute and Gauge Pressures

a. **Gauge Pressure.** A pressure gauge is normally graduated to read ZERO when the gauge is at atmospheric pressure. This is because a pressure gauge normally records only 'difference of pressure'; ie the difference between that of the high-pressure source and atmospheric pressure. This is invariably known as GAUGE pressure and, if such a gauge was taken underwater, would show only the pressure exerted by the water. Similarly, if a gauge on a bottle reads 120 Bar, then the pressure being measured is actually 120 Bar above atmospheric pressure, ie 121 Bar.

b. **Absolute Pressure.** Before a diver leaves the surface, he is already under a pressure of:

1 Bar or 103000 N/m^2

For every metre he descends, the pressure on him will increase by 0.1 Bar. Thus, the total pressure on the diver at any depth will be the pressure of the water at that depth plus atmospheric pressure, 1 Bar. This total pressure is known as absolute pressure and the relationship is, therefore, as follows:

ABSOLUTE PRESSURE = GAUGE PRESSURE +ATMOSPHERIC PRESSURE

To obtain the absolute pressure, it is necessary to add the atmospheric pressure to the gauge pressure, using the same units, eg:

Absolute pressure (Bar abs) = gauge pressure (Bar) + 1 Bar

Since pressure is directly proportional to depth, it is often convenient, in diving calculations, to work in depth rather than pressure. For this purpose, atmospheric pressure is regarded as being equivalent to a depth of 10m. Hence:

ABSOLUTE DEPTH (m) = GAUGE DEPTH (m) + 10m

0107-0109. Spare.

SECTION 2 - ARCHIMEDES' PRINCIPLE AND BUOYANCY

0110. Displaced Liquids and Upthrust

When an object is placed in a liquid-filled container the level of the liquid rises. This rise is caused by the object pushing the liquid out of the way or displacing it as illustrated in Fig 1-4. Before the object touches the liquid the liquid is in equilibrium, where at any point in the liquid the weight of the liquid above is balanced by the upthrust from below. Once the object is partially immersed the upthrust which was opposing the weight of the displaced water will be applied to the object. This is why objects appear to weigh less when placed in a liquid. There is a direct relationship between the amount of liquid displaced and the upthrust; this is stated by Archimedes' Principle as follows:

STATES: DISPLACED LIQUIDS AND UPTHRUST

> **"When an object is wholly or partially immersed in a liquid, the upthrust it receives is equal to the weight of liquid displaced."**

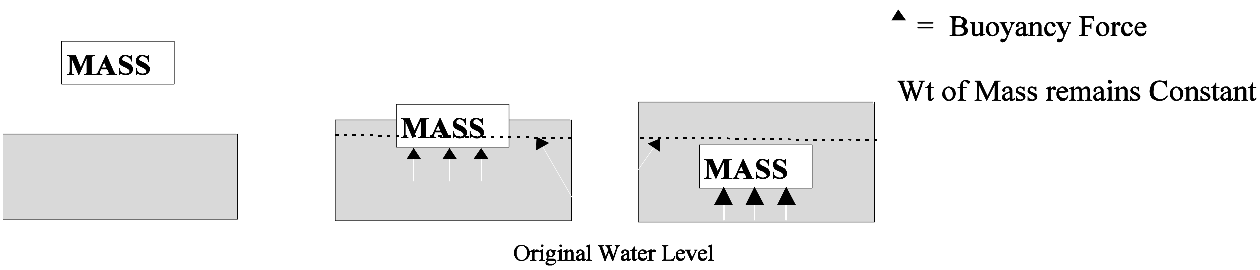


Fig 1-4. Displacement of Liquid

0111. Buoyancy

Whether an object floats or not depends upon the relative magnitudes of the weight and upthrust. There are three possible cases, see Fig 1-5.

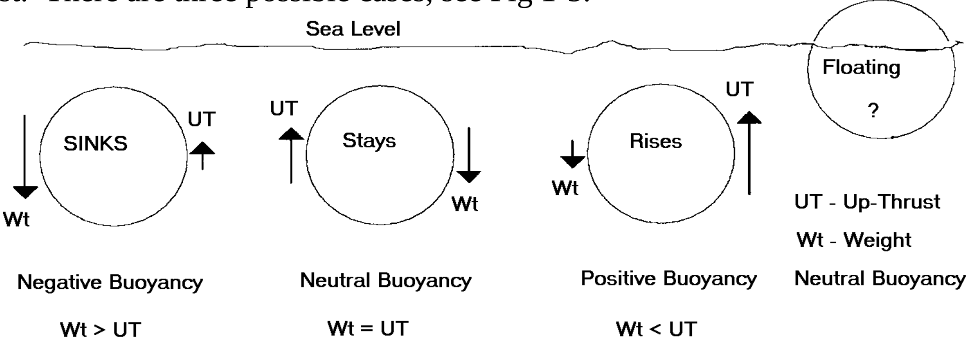


Fig 1-5. Buoyancy

a. **Negative Buoyancy.** The weight of the object is greater than the upthrust (weight of liquid displaced) and the object sinks.

b. **Neutral Buoyancy.** The weight of the object is equal to the upthrust and the object remains in its existing position.

c. **Positive Buoyancy.** The weight of the object is less than the upthrust and the object rises. As it reaches the surface, it rises out of the liquid, thus reducing the weight of liquid displaced and hence the upthrust. At some point the reduced upthrust will equal the weight of the object, which will then float in this position (Fig 1-5; position 2) in a state of equilibrium.

0112. Effect on Divers

a. **Ballast Weights.** Under normal conditions a diver in the water is positively buoyant. It is necessary to increase his weight by the addition of weights in order to bring him to a state of neutral or negative buoyancy when totally immersed. The weight required varies, depending on the type of equipment being used, amount of underclothing and area of operation (ie density of the water). With an open-circuit set, it is best if possible to be perhaps a kilogram overweight, because, by the completion of a dive, up to a kilogram of air may have been used up. It is important that the diver is aware of his/her ballast weight requirement at all times such that a slight negative buoyancy is achieved when leaving surface with the Buoyancy Control Aid (BCA)/ Buoyancy Control Device (BCD) (if used) fully vented and the UWSS comfortably vented. The practise of using excessive ballast weight to ensure negative buoyancy with the subsequent need to use the BCA/BCD and/or suit inflation to achieve neutral buoyancy when at depth, is to be avoided.

b. **Change of Buoyancy with Depth.** A self contained diver in an underwater swimming suit is buoyant because of the air in his lungs, air trapped in the suit and the natural buoyancy of his breathing apparatus. To assist his descent he vents his suit at the surface before swimming down. As the water pressure increases and compresses the air in his suit, his displacement is reduced, he is made more negatively buoyant and his speed of descent is increased.

c. **Suit Inflation and Dangers of Blow-Up.** If a diver on the bottom having slight negative buoyancy inflates his suit, he displaces a greater amount of water while his weight remains the same. When the weight of water displaced becomes greater than the diver’s weight he will assume positive buoyancy and float to the surface. As he ascends, the pressure of water will decrease and the air in his suit will further inflate and so displace more water, thus increasing the diver’s buoyancy and speeding his ascent. The diver has a means of deflating his suit by releasing air from his cuff and so checking this tendency to surface.

0113. Emergency Ascent

In an emergency there are two methods of increasing buoyancy:

a. By slipping the divers weights.

b. Increasing upthrust by using suit inflation, BCA/BCD/ABJ

The former is the preferred method as it gives a more controllable rate of ascent. The latter should only be used as a last resort See Para 0112(c)

0114. Spare.

SECTION 3 - GAS LAWS AND THE EFFECTS OF PRESSURE

0115. Gas Laws

a. **Boyle's Law.** Because gases are compressible, their volumes can be altered by a change of pressure. The amount by which the volume changes depends on the change of pressure and is explained fully in Boyle's Law, which states:

STATES:- **BOYLES LAW**

> **"For a fixed mass of gas at constant temperature the volume will vary inversely as it's absolute pressure."**

FORMULA:- PRESSURE (Bar Abs) x VOLUME (Any Unit) = CONSTANT

$$P_1 \times V_1 = P_2 \times V_2$$

b. From this law it follows that the density varies directly as the absolute pressure. In other words, if the pressure of a gas is doubled the density is also doubled, but the volume is decreased to one half of the original volume. It is most important that the diver should clearly understand this relationship between volume and pressure.

c. **Pressure Law.** It is not necessary to complicate this simple rule by taking into account the exact effect of changes in temperature, but it should be observed that if the temperature of confined gas is increased there will be a resultant rise in pressure and that if the temperature is decreased there will be a corresponding fall in pressure. Alternatively, if the pressure of gas in a container is increased by compression there will be a temporary rise in the gas temperature, and if the pressure is reduced there will be a temporary fall in temperature. The extent of this temporary rise or fall in temperature will depend upon the rate at which the pressure is increased or decreased. The higher the rate of increase or decrease in pressure the greater will be the corresponding rise or fall of temperature.

STATES:- **PRESSURE LAW**

> **"For a fixed mass of Gas at constant Volume, the Absolute Temperature is directly proportional to the absolute pressure."**

FORMULA:- $\dfrac{\textbf{PRESSURE (Bar Abs)}}{\textbf{TEMPERATURE (K)}} = \textbf{CONSTANT}$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

Note: *Absolute Temp (K) = °C + 273 K (Kelvin)*

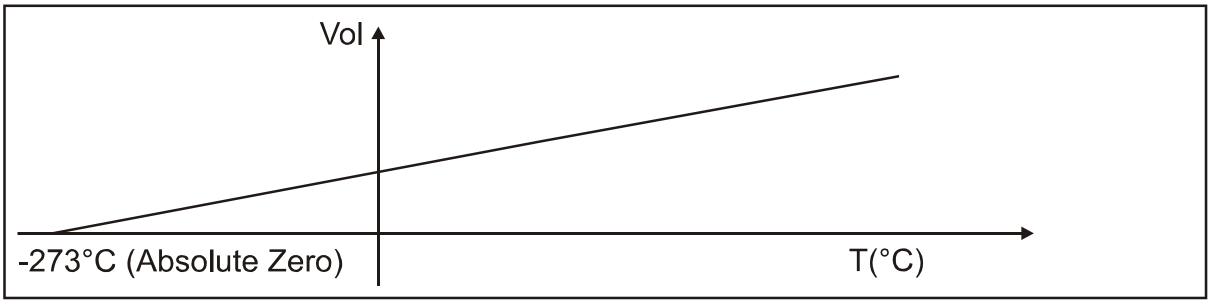
d. **Charles Law.** This law states that the volume of a given mass of gas at constant pressure is directly proportional to the absolute thermodynamic temperatures; equivalently, all gases have the same coefficient of expansion at constant pressure. This is approximately true at low pressures and sufficiently high temperatures as the ideal gas behaviour is appreciated. This is also known as Gay-Lussac's Law

STATES:- **CHARLES LAW**

For a fixed mass of Gas at a constant Pressure, the volume is directly proportional to the Absolute Temperature.

ie $$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Absolute Temperature:



Note. *Absolute Temp = °C + 273 K (Kelvin)*

Examples:

Q. What is the volume of a 1 litre sample of hot gas after passing through a constant pressure cooling coil which reduces the temp from 56°C to 24°C?

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{1}{(56 + 273)} = \frac{V_2}{(24 + 273)}$$

$$V_2 = \frac{(297)}{(329)}$$

$$= \underline{0.902L}$$

Q. Between 2 stages of an air compressor 10 L of gas initially at 30°C reduces in volume to 9.87L. What is the temp of gas after cooling in °C. **(26.06°C)**

0116. Compressibility of Gases (Departure from Gas Laws)

a. For theoretical purposes it has been established that gases at low density closely follow Boyle's Law and the Pressure Law, however, these equations are only strictly true for ideal gases, and even then only at low densities.

b. The point at which a gas deviates from an ideal state is dependent on temperature and pressure and forms what is known as a compressibility factor which must be applied to conventional gas calculations.

c. At high pressures (above 275 Bar), the molecules within a gas are forced to interact differently, thus changing the properties of the gas from its ideal state.

d. Therefore, when considering the contents of gas flasks such as the diluent and bail out pressure vessels of CDBA containing a Oxygen/Helium mixture, this effect must be taken into consideration. This has the result of giving a lower figure for gas content than would be expected from conventional gas calculations.

ie: When filled with 16% Oxygen, 84% Helium, the 2.87 litres diluent flask of the CDBA diving set has a nominal capacity of only 939 litres at the working pressure of 345 Bar and not 993 litres as expected. When filled with the same gas, the 1.5 litres bail out cylinder has a nominal capacity of 491 litres at the 345 Bar working pressure, not 519 litres.

0117. Effects of Pressure on Immersed Objects

a. Fig 1-6 illustrates the effect of pressure on the air in a cylinder open at its bottom end and lowered to various depths in water. If the cylinder is filled with atmospheric air at surface, and if no air is supplied to the cylinder on its way down, the volume and density of air in the cylinder will follow Boyle's Law as the pressure of the water increases.

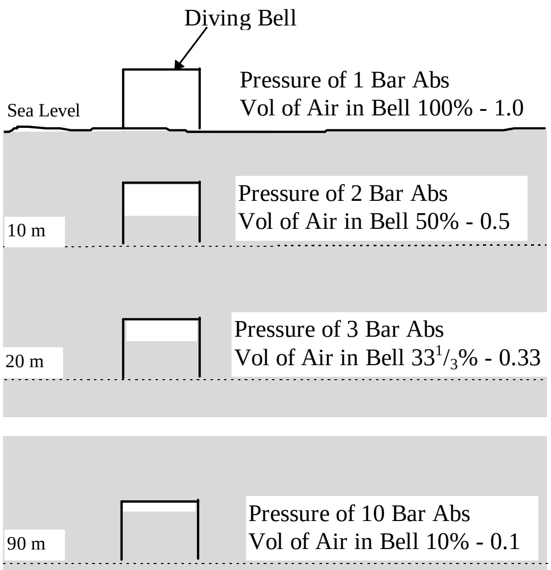


Fig 1-6. Relationship Between Depth, Pressure and Volume

b. At surface the pressure of air in the cylinder is 1 Bar. When the cylinder is lowered to a depth of 10m, the water exerts an additional pressure of 1 Bar, so the total absolute pressure on the air in the cylinder is 2 Bar. As a result the volume of air in the cylinder is reduced to one-half of what it was at surface and the density of the air is doubled. At 20m the water exerts a pressure of 2 Bar and the absolute pressure in the cylinder is 3 Bar, so the volume of the air will be only a third of what it was at surface and the density will be trebled. At a depth of 90m the water is exerting a pressure of 9 Bar and the absolute pressure in the cylinder is 10 Bar; the air volume is now only a tenth of its surface volume and its density is ten times as great.

c. It should be noticed that the changes in volume relative to pressure are much greater near the surface, eg for the change in pressure of 1 Bar from surface to a depth of 10m the volume of air is reduced by a half whereas a change of pressure of 1 Bar in descending from 30m to 40m reduced the volume from a quarter to a fifth, a reduction of only $^{1}/_{20}$ (5%) of its surface volume. This change in volume for each Bar of pressure becomes smaller the deeper the cylinder goes. The volume will expand correspondingly as the cylinder is brought to the surface.

d. It must be remembered that throughout the changes in volume, the actual amount or the 'mass' of the air in the cylinder remains the same - none has escaped - and that the change in volume is effected only by a corresponding change in the density of the air, caused by compression.

e. Fig 1-7 illustrates, in general principle, the effect of water pressure on different small objects submerged to a depth of 1 Bar. A solid ball would have a pressure acting upon it with equal force in all directions and would not change in shape or size. A hollow metal sphere filled with air at atmospheric pressure would also remain unaffected and the air inside would remain at atmospheric pressure, provided the shell of the sphere was strong enough to withstand the external pressure.

f. A soft rubber ball full of air at atmospheric pressure at surface would, however, be contracted by the water pressure as it descended, compressing the air inside to the surrounding water pressure. Thus, at a depth of 10m the ball would be only half its original size and the air inside would be at 2 Bar absolute pressure. The ball would of course recover its original size and internal pressure as it was brought back to the surface. The same ball could be prevented from contracting by supplying it with air from the surface at a pressure equal to the surrounding water pressure. The air pressure would have to be correspondingly reduced as the ball was brought to the surface or it would increase in size and probably burst. If the ball was filled entirely with water it would retain its original size and shape whatever its depth, as water is, for all practical purposes, incompressible and the water would always be at the same absolute pressure as the surrounding water.

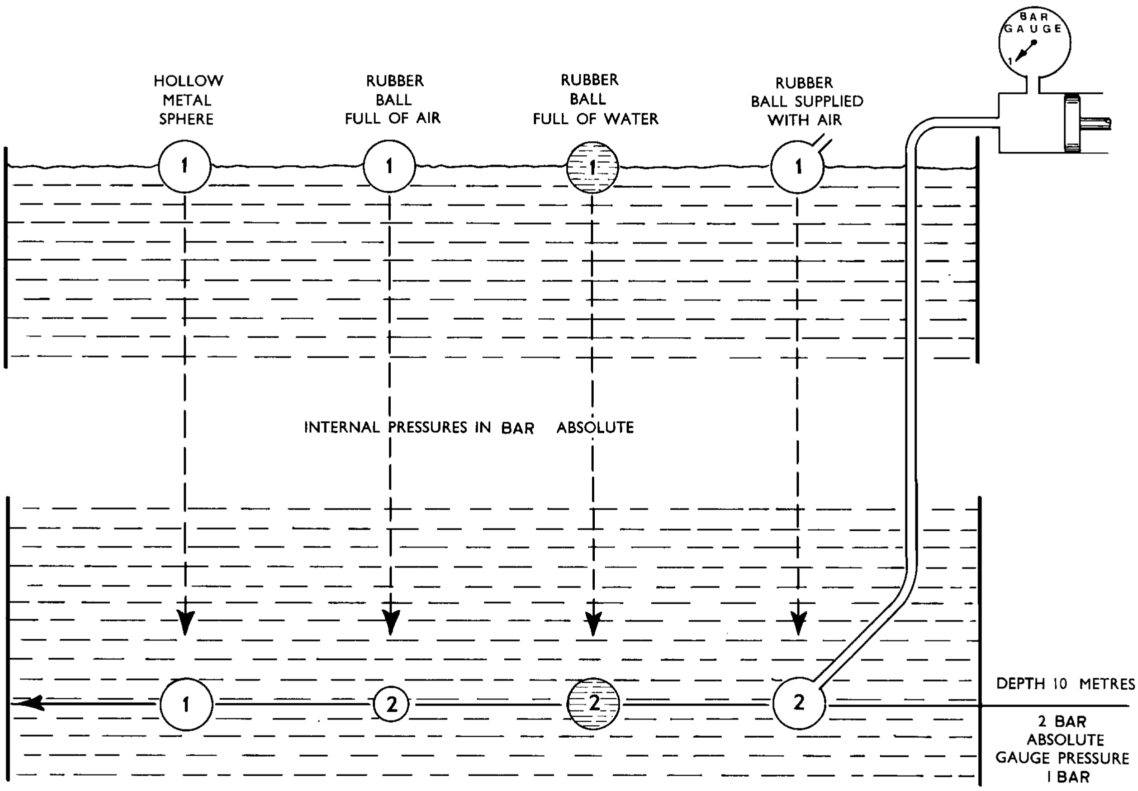


Fig 1-7. Effect of Pressure on Immersed Objects

g. When considering larger objects, the difference in pressure between the bottom and top of the object must be considered; for instance, a diver 1.8m tall and standing up underwater will have a difference in pressure between his head and his feet of approximately 0.18 Bar. The effect of water pressure on a large rubber ball filled with air at atmospheric pressure at surface would be to contract the bottom of the ball to a greater extent than the top: it is important to remember, however, that whatever shape the ball assumed Boyle's Law would still apply, ie if the pressure were doubled by the contraction, the volume of the air space would be halved. It should also be realised that the internal air pressure will, for all practical purposes, be uniform throughout the ball as the weight of air is negligible. However if the air is replaced by water the ball will not change in shape or size, but because of the weight of water in the ball the pressure at the bottom of the ball will be greater than that at the top.

0118. Effects of Pressure on the Body

a. It must be realised that changes in volume caused by changes in pressure, as shown previously, are greater the nearer the pressure is to atmospheric pressure. Therefore, the effects of pressure changes in the body caused by changes in depth are more noticeable when the diver is near the surface and accidents are much more likely to happen there. Any spaces that are gas-filled will be affected by change of pressure in accordance with Boyle's Law. A pressure difference as small as 0.05 Bar between the inside and outside of a body cavity can damage body tissue.

b. The gas-filled spaces in the body are: Sinuses, Ears, and Lungs. On occasions, gas may be present in the stomach and intestines, but, since the walls of these parts are flexible, no effect will be felt, except some discomfort on ascending to the surface. Gas filled cavities within the teeth may also occur if regular dental inspection is neglected. The diver may experience pain and discomfort during ascent and descent, as a result of cavities within the teeth.

0119. Sinuses

a. There are cavities, usually six or seven in number, in the bony structure of the skull. Their main function is to lighten the skull, but they also give resonance to the voice, as can be noticed by the change in voice in a person with a severe cold or catarrh. Their positions are shown in Fig 1-8.

b. The sinus cavities are lined with a mucous membrane similar to that in the nose and, to provide means of equalisation of pressure between the cavities and the mouth, are connected to the back of the nose and throat by narrow canals through the bone of the skull.

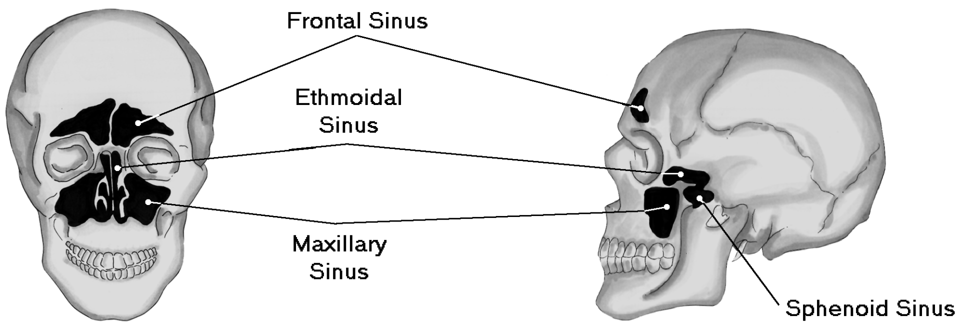


Fig 1-8. The Sinus Cavities

c. This means that normally there is a free flow of air to the sinuses from the back of the nose and throat. However, if the canal through the bone becomes blocked by mucus or swelling of the tissues, the flow will not occur. In these circumstances, the volume of air in the sinuses contracts on increase in external pressure, causing pain in the form of headaches and possibly damage to the sinus lining as a result of the lining wall bulging and forming blisters. These may burst causing the cavities to fill with blood. If that should happen, there will be a decrease in pain and the diver will feel more comfortable. However, on ascent, the air in the sinuses will expand and may force the blood out through the canal, resulting in a nose or mouth bleed.

d. Diving should be avoided when suffering from a cold, catarrh or throat infection, otherwise sinus trouble can be expected.

0120. Ears

a. Fig 1-9 shows the construction of the ear, and it will be seen that the eardrum separates the middle ear space from the outside, while this space is connected to the back of the throat by the Eustachian tube. Sounds received from outside cause vibrations of the eardrum that are transmitted by a chain of small bones, the ossicles, to the nerves of hearing contained in the inner ear.

b. The Eustachian tube is only lightly closed and usually opens, in the healthy individual, during the act of swallowing. Its function is to allow air in or out of the middle ear to maintain an equal pressure. However, under large pressure differences, the tube does not open freely and discomfort is felt as the drums are stretched inwards. This discomfort is overcome by opening the Eustachian tube and allowing air to pass into the middle ear to equalise the pressure on each side of the drum; this can usually be done by either swallowing or yawning, which opens the tube, or by blowing against a nose clip, which forces air through the tube. The act of clearing is evident either as a feeling of relief or as an audible click in the ear. During ascent the air escapes on its own and clearing is not usually necessary.

c. **'Ears'.** If the Eustachian tube becomes blocked by swelling or mucus, the pressures on the inside and outside of the eardrum do not balance. When this happens the drum bulges inwards and the stretching causes pain. If descent is continued there may be bleeding in the drum as the small blood vessels are torn, and relief will be obtained only when the drum perforates. 'Ears' is usually caused by catarrh or a cold, but sometimes clearing the ears too late brings it on; in this case, ascending a few feet may clear the ears and allow the descent to be continued.

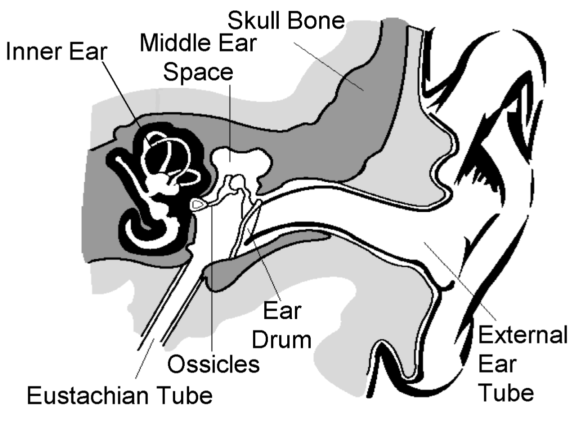


Fig 1-9. Diagram of Human Ear

d. The associated acute pain is usually sufficient to prevent a diver from descending and perforating his eardrums. This factor is unimportant, however, in emergency chamber pressurisation, and the pain soon turns to relief anyway as perforation occurs. Ears normally clear themselves automatically when a person is unconscious.

e. **‘Reversed Ears’**. This condition can occur on both descent and ascent:

(1) *On Descent.* If the Eustachian tube is clear and the external ear is blocked by the pad of a hood, by an earplug or by wax, the pressure change in the sealed-off external ear tends to fall behind that of the middle ear and the surrounding tissues. Because the eardrum is held from inside it cannot move outwards to equalise the pressure, and, as the tissue fluids transmit the pressure, blood blisters tend to form in the external ear canal to equalise the pressure. These may involve the eardrum and may also burst, causing bleeding from the external ear.

(2) *On Ascent.* If the Eustachian tube blocks off at a depth, then as external pressure decreases on ascent, the gas in the middle ear will expand to produce a positive pressure effect within the middle ear, sometimes resulting in dizziness.

CAUTION

1. AS WITH ‘EARS’, DO NOT DIVE WITH A COLD OR CATARRH.

2. DO NOT WEAR EARPLUGS OR BLOCK THE EXTERNAL EAR IN ANY WAY.

Note. *A perforated eardrum usually heals fairly rapidly, but a diver is unfit for diving until healing has taken place.*

0121. Lungs

a. The Lungs and their function are described in Section 5. For an average person the maximum capacity of the lungs is about six litres. When a person has exhaled as much as possible there is still an amount left known as the residual capacity; this for the average man is about 1.5 litres. The maximum usable capacity, known as **vital capacity**, is the maximum capacity less the residual capacity.

b. **Lung Squeeze.** When a diver descends, the increase in pressure causes a decrease in volume of the air in the lungs. At about 30m the volume of air will have decreased to the residual capacity. On further descent the chest and lungs will not contract any more, so, as the external pressure on the tissues continues to rise, fluid and tissues will be forced into the chest and lung air spaces to equalise the pressure and, in extreme cases, the ribs will crack and the chest will cave in. This is known as lung squeeze and is prevented by supplying gas at the same pressure as the surrounding water. It can occur only when a diver on surface supply has a sudden fall in the water and the pressure of the gas supply is not increased in time.

c. **Pulmonary Barotrauma (Burst Lung).** Decreasing pressure on ascent will cause the gas in the lungs to expand. If the gas is not allowed to escape the alveoli will rupture. For this to happen an excess pressure of as little as 0.3 Bar is required. Thus it is essential to breathe out on a free ascent or breathe normally when using breathing apparatus.

d. When the alveoli rupture the escaping gas (which may be air, oxygen, oxy-nitrogen or oxy-helium mixtures) will enter the chest cavity and cause the following symptoms:

(1) Pain in the chest behind the breast bone (usually within 10 minutes of surfacing).

(2) Difficulty in breathing.

(3) Bloody froth around the lips, from blood getting into the lungs after the alveoli are ruptured.

(4) The lungs feeling overstretched (sometimes the only symptom in minor cases).

e. If the escaped gas enters the pulmonary veins, it will be transported to the heart. Bubbles of gas in the arteries may cause a blockage to the blood supply to vital organs such as the brain and heart. This is known as **Arterial Gas Embolism**. Symptoms are:

(1) Rapid onset of unconsciousness.

(2) Convulsions.

(3) Weakness or numbing/tingling of limbs.

(4) Other symptoms related to central nervous system upset such as disturbance of vision, hearing and balance.

(5) Death.

Urgent treatment is required by recompression (to squeeze the gas bubble and thereby remove the blockage to the blood supply).

0122. Facemask Squeeze

This is the result of rapid descent in the water and not allowing any gas to bleed through into the facemask. The volume of gas in the mask will contract leaving a partial vacuum. Because of the rigid walls of the mask, it is the face that is sucked out, resulting in a swollen face, haemorrhages and bloodshot eyes.

0123-0124. Spare.

SECTION 4 - DALTON’S LAW OF PARTIAL PRESSURES, AND GAS POISONS

0125 Partial Pressures

a. Pressure in a gas is caused by the molecules present striking against the walls of the vessel containing the gas and trying to force it out. With a mixture, molecules of every gas present will be striking the container and so each individual gas present will be creating a pressure, known as the partial pressure of that gas. Thus in a mixture of gases, each member gas creates its own pressure and the total pressure of the mixture will be the total ‘striking force’ of all molecules present, i.e. the total pressure will be equal to the sum of the individual pressures.

b. It is important in mixture breathing to know the values of the partial pressures of the gases present, because if they are too high or, for oxygen, too high or too low, a diver may suffer from a variety of ill effects as a result.

0126. Dalton’s Law of Partial Pressures

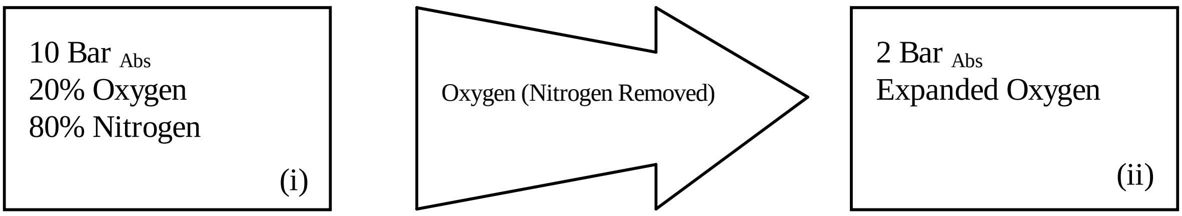
STATES:

> **“In a mixture of gases, the partial pressure of each gas present is equal to the pressure that gas would exert if it alone occupied the original volume.”**

<u>**DALTONS LAW FORMULA**</u>:

$$\text{Partial Press of Gas in Mix } (PP_{bar}) = \frac{\text{\% GAS IN MIX}}{100} \times \text{TOTAL PRESS OF MIX(Bars Abs)}$$

Fig 1-10. Partial Pressures



a. To understand this more fully consider Fig 1-10(i). Present in the container is a mixture of 20 per cent oxygen and 80 per cent nitrogen (almost air) at 10 Bar absolute (abs), i.e. a fifth of the mixture is oxygen and four fifth’s is nitrogen. Suppose it was possible to remove the nitrogen completely from the mixture. We would then have the situation in Fig 1-10(ii). The oxygen would have been able to increase in volume five times and so, by Boyle’s Law, its pressure would have dropped by a fifth, from 10 Bar abs to 2 Bar abs.

b. By Dalton’s Law, this means that in the original mixture the partial pressure of the oxygen (PO_2) was 2 Bar abs. If the oxygen was removed from the mixture, the pressure would drop to 8 Bar abs and this would be the partial pressure of the nitrogen in the mixture. Adding the partial pressures of the two gases together will give 10 Bar abs, the total pressure of the mixture. ie:

c. Using the formulea above, it will be noticed that the partial pressure of the oxygen is:

$$\frac{\text{\% Gas in Mix}}{100} \times \text{Total press of Mix (Bar abs)} = \frac{20 \times 10}{100}$$

$$= 0.2 \times 10$$

Therefore PP O_2 = **2 Bar Abs**

and that of the nitrogen

$$\frac{\text{\% Gas in Mix}}{100} \times \text{Total press of Mix (Bar abs)} = \frac{80 \times 10}{100}$$

$$= 0.8 \times 10$$

Therefore PP O_2 = **8 Bar Abs**

This is the general rule that follows from Dalton's Law for finding partial pressures:

The partial pressure of each gas present added together will equal the total pressure of the mixture

(PP N_2) + (PP O_2) = P Abs of Mix

ie 8 Bars + 2 Bars = 10 Bars

EXAMPLE:

Q. In a mixture of 60% Oxygen and 40% Nitrogen at 24m, what is the partial pressure (PP) of the oxygen. (*Note, 24 msw is equivalent to 3.4 Bar Abs*)

A. $$\frac{\text{\% Gas in Mix}}{100} \times \text{Total press of Mix} = \frac{60 \times 3.4}{100}$$

$$= 0.6 \times 3.4$$

Therefore PP O_2 = 2.04 Bar Abs

0127. Partial Pressures and Gas Poisons

a. As mentioned above, the effects of a gas on a diver depend upon the partial pressure of the gases being breathed. With a mixture, there are two ways in which the partial pressures can be altered:

(1) By changing the total pressure.

(2) By changing the concentration of gases present.

b. With mixture sets both alternatives present themselves, and the actual effects on the diver will now be considered.

0128. Oxygen

a. **Acute CNS Oxygen Toxicity.** (Acute Cerebral Oxygen Poisoning) This is brought on by breathing oxygen at too high a partial pressure. The exact cause is not known, but is thought to be the intoxication of the breathing centres of the brain. The symptoms are unreliable and the onset varies both from individual to individual and from day to day. It generally occurs at any depth where oxygen has a partial pressure greater than 2 Bar abs, and so diving is limited (depending upon the mixture being breathed), to a safe depth.

b. The most frequent order of appearance of symptoms is as follows: twitching of the lips; vertigo (dizziness); nausea (feeling of sickness); twitching of extremities; drowsiness; convulsions; unconsciousness.

Sometimes, however, convulsions may be the **one and only symptom**.

TREATMENT - see Chapter 13

c. **Chronic or Pulmonary Oxygen Poisoning**. This is brought on by breathing oxygen at increased partial pressures for prolonged periods. It manifests itself as lung irritation, and can lead to lung tissue damage if the exposure is continued. In normal diving this type of oxygen poisoning is rarely encountered except during hyperbaric treatments. This is fully discussed in Chapter 13. However when using closed circuit breathing apparatus with 100% oxygen several times a day chronic oxygen poisoning may be encountered. Appropriate guidance for this type of diving is given in Chapter 11. TREATMENT is to reduce the partial pressure of oxygen in the gas being breathed by the patient to below 0.5 Bar abs - preferably to 0.21 Bar abs.

d. **Hypoxia/Anoxia (Lack of Oxygen)**. This will occur if the partial pressure of the oxygen being breathed falls below 0.2 Bar abs and is nearly always caused by an excess of nitrogen; it is then known as DILUTION HYPOXIA. There are many possible ways in which this state may occur the more common being:

(1) Not clearing lungs and breathing bag before breathing from the set for 2 minutes at the surface;

(2) Not ensuring that the correct flow and/or correct gas or mixture is being used;

(3) Not flushing through before leaving the bottom or before leaving ‘stops’.

e. The first parts of the diver affected by the shortage of oxygen are the frontal lobes of the brain. A loss of awareness, judgement and responsibility results and so NO symptoms are apparent to the diver. However, to an observer symptoms and signs will be seen as follows: over-confidence and a ‘couldn’t care less’ attitude; loss of judgement and efficiency; dullness of senses; loss of memory; pallor of skin; blueness of extremities (owing to no oxygen arriving at these points); an increase in pulse rate (the body attempting to supply more oxygen to the system); unconsciousness.

TREATMENT - see Chapter 13.

f. Hypoxia is the most common form of gas poisoning, because of the many ways in which it can occur. It is also extremely dangerous, because the sufferer has no idea that anything is wrong and will carry on as normal. Hence it is imperative that diving regulations concerning 'purging the lungs' before entering the water and flushing through before leaving the bottom (and stops) are carried out to the full.

0129. Carbon Dioxide

a. Carbon dioxide is a poisonous gas. It is a waste product of combustion in the production of energy and its presence in the body stimulates breathing. A diver will produce approximately 1 litre of the gas per minute while swimming and under normal conditions the body is well able to get rid of this. Thus if it is present in excess it is always due to some failure of the diver or his equipment.

b. At atmospheric pressure, up to about 3 per cent of carbon dioxide can be breathed with no effect on the body. As the percentage is increased, the stimulation of the respiratory centres of the brain increases, resulting in an increased pulse rate and heavier breathing. At about 0.1 Bar abs the pulse rate slows down and the blood pressure drops, resulting in unconsciousness and, in extreme cases, death. Thus the onset of carbon-dioxide poisoning can be recognised by the increased breathing rate followed by breathlessness and exhaustion. On return to fresh air the symptoms soon disappear; however, the person may experience headaches and may also vomit for a while.

c. **Prevention.** Air-breathing sets have a very small dead space and hence there is hardly any possibility of getting carbon-dioxide poisoning. Closed-circuit breathing apparatuses, however, have a much larger dead space and with shallow breathing the carbon dioxide does not pass through the soda lime absorbent. With successive breaths, the concentration level of the carbon dioxide will rise, as the same gas is being rebreathed over and over again; thus to keep the level of the carbon-dioxide down, normal breathing is vital.

d. Care must be taken to ensure that the soda lime is efficiently removing the carbon dioxide from the gas. Inefficiency may be due to a number of factors as follows:

(1) The soda lime has been used beyond its effective life.

(2) The wrong grade of soda lime is used; then either the particles are too large, the flow rate will be too great, and there will not be sufficient surface area to absorb the gas, or the particles are too small and there is too great a resistance to gas flow.

(3) The canister has been insufficiently filled, thus leaving channels the gas will pass straight through.

(4) The absorbent may be damp, dusty, or may get wet in use.

(5) The specification of the soda lime is not that for which the set was designed.

e. Accumulation of carbon dioxide in confined spaces (eg diving bells and compression chambers) must also be avoided. Periodically, therefore, the stale air must be replaced with fresh without causing a change of pressure.

0130. Carbon Monoxide

a. Under normal conditions, this gas will not be present in any breathing apparatus. It is produced mainly in the internal combustion engine and forms part of the exhaust gas. The two most likely sources of it that concern the diver are a ship's engine and the air compressor itself. Thus care must be taken on the siting of the compressor's fresh air inlet with regard to the exhaust outlet. Also, although the inlet may not actually be near the exhaust fumes, the wind may blow some carbon monoxide into it. Even a very small partial pressure of the gas becomes intolerable. Thus 0.00001 Bar abs is taken as the upper safety limit.

b. Carbon monoxide when inhaled combines with the haemoglobin in the blood to form carboxy-haemoglobin, which is pink in colour and restricts the intake of oxygen into the bloodstream.

c. The onset of carbon-monoxide poisoning gives rise to the following symptoms: increasing or rapid heart rate due to lack of O_2; increase weakness; exhaustion with breathlessness; dizziness; fainting; general pallor but with a noticeable pink tongue.

d. Immediate treatment is required and consists of administering hyperbaric oxygen, giving artificial respiration if the diver is unconscious and the attention of a medical officer as soon as possible.

0131. Hyperventilation

a. Divers without breathing apparatus are known to practice hyperventilation to increase their endurance underwater; it is done by taking rapid deep breaths for a short period immediately before entering the water. This method does not, however, increase the oxygen content of the body as supposed but merely reduces the level of carbon dioxide; the result is a delay in the stimulation of the respiratory centres of the brain, which produces the impulse to seek more air.

b. On the surface at the start of the dive the diver will be breathing air with a partial pressure of oxygen of 0.21 Bar abs. As the diver goes down the partial pressure of oxygen in his breath of air will increase. During the dive the diver will be consuming oxygen for metabolism and the PO_2 will decrease, but he will not suffer from hypoxia as long as the PO_2 remains above 0.2 Bar. However when the diver is eventually forced to the surface by the build up of CO_2 in his bloodstream, the partial pressure of O_2 in his lungs will be at a relatively low level. On ascent the PO_2 will decrease in accordance with Boyles law, and may drop significantly below 0.2 Bar resulting in hypoxia, followed by loss of consciousness and drowning.

c. Thus the practice of hyperventilation in an attempt to increase endurance cannot be too strongly condemned.

0132. Other Gases

a. It may be possible to breathe small concentrations of various gases on the surface with no effect on the body but at depth the partial pressure of these gases will be greater and they may become toxic. For instance, oil fumes under pressure may irritate the delicate membranes of the lungs or in extreme cases cause pneumonia. Under pressure, the diver may become very susceptible to changes in gas pressures and so considerable care must be taken to ensure that the mixture being used is pure.

b. Chapter 7 states that any breathing gas used is to conform to Defence Standard 68-75/Issue 1 Breathing Gas Purity for Diving, which gives the degree of purity required.

0133. Inert Gases

a. Air as a diving gas can be considered as a mixture of oxygen and nitrogen, as the other constituents are not present in significant quantities. The oxygen is essential to life, but the nitrogen plays no part in the support of life, being a metabolically inert gas. Air is abundant and freely available, but as a diving gas it suffers from the disadvantage that nitrogen becomes narcotic at depths in excess of 30m, as described in sub-para c, below.

b. The available metabolically inert gases are listed below in order of increasing narcotic effects

Helium	HPNS, expensive, No narcotic effect to depths down to 400m
Neon	Expensive, greater density hence reduces gas absorption but once in is takes longer to get out (greatly increased decompression times required).
Nitrogen	Narcotic effects at depths in excess of 30m
Argon	
Krypton	
Xenon	Most pronounced narcotic effect
OTHER GASES	
Hydrogen	Explosive over 4% when combined with oxygen, need a flushing gas, more like LSD below 150m
Hydreliox	H_2, He, O_2 used to 700m (animals have gone to 1000m and back)

c. **Nitrogen Narcosis.** The onset of narcosis occurs at between 30m and 50m, and the initial effect is a feeling of light-headedness with increasing self-confidence. As depth is increased the diver will become more jovial, will have dizzy spells and his power of concentration will drop; he will not be able to do simple tasks and will pay less attention to personal safety. At about 80m he will probably go into a state of depression and will be incapable of clear thought.

(1) These effects are very similar to those of alcohol and the taking of the latter just previous to diving will increase the effect and the onset of the narcosis will occur at a shallower depth. Another predisposing factor is the condition of the diver; for instance anxiety may bring on narcosis much earlier.

(2) If oxy-nitrogen mixtures have to be used the only method of preventing the worst effects of narcosis is by continued practice, ie, continual deep diving, so the diver becomes accustomed to narcosis and remains in control.

(3) Treatment is not usually required, but under extreme circumstances the diver should be kept under close observation. On return to the surface the diver soon recovers, except for possible amnesia and extreme sleepiness.

(4) For this reason depth limits are imposed on inexperienced divers and all RN Divers are required to remain 'worked up' to maximum depth in accordance with current training standards (given in BR 5063 Chapter 11).

d. **Decompression Illness.** See Section 6.

0134. Spare.

SECTION 5 - ANATOMY AND PHYSIOLOGY

0135. Introduction

Anatomy is the study of the structure of living organisms and physiology is the study of their function. A diver must understand the basics of these to appreciate the increased demands that are imposed on the human body by the underwater environment.

0136. Cells and the Internal Environment

a. The body is made up of billions of cells which get the energy they require to live by using up food and oxygen. In the process, they produce carbon dioxide, water, heat and waste materials. Food and oxygen must be available in adequate amounts, and the waste products disposed of, for the cells in the body to survive.

b. In order to breathe underwater, man must take a supply of oxygen with him. Survival is promoted by understanding how the body adapts to the increased pressure which is imposed by being underwater.

0137. The Body Systems

a. The body is composed of a number of organ systems which work together continuously to maintain, as nearly as possible, a constant internal environment. These systems are summarised below.

b. **The Musculoskeletal System** (muscles and skeleton) provides the rigid structure of the body and imparts the ability to move.

c. **The Nervous System** (the brain, spinal cord and nerves) is made of highly specialised cells which use electrical signals to control and coordinate the muscles, glands and blood vessels. The nervous system is also responsible for receiving and processing information from the outside world via the sensory organs. The brain and spinal cord make up the Central Nervous System (CNS) and the remainder is known as the Peripheral Nervous System (PNS). The Autonomic Nervous System is a part of the PNS which unconsciously (automatically) controls internal organs such as the heart, lungs and bowel.

d. **The Digestive System** (mouth, throat, stomach, small and large intestine, salivary glands, pancreas, liver and gall-bladder) converts swallowed food into a soluble form which can be absorbed into the blood stream for transport to and use by the cells of the body. Material that is not digested leaves the body as faeces.

e. **The Urinary System**. The kidneys receive about a quarter of the blood pumped by the heart. They filter out cellular waste products which are dissolved in the blood and convert it into urine. This is carried by the ureters to the bladder for excretion via the urethra at a convenient time.

f. **The Endocrine System** (pituitary, thyroid, parathyroid, adrenal glands, pancreas and testes or ovaries) releases chemical messengers, known as hormones, into the bloodstream. These hormones control functions as diverse as sexual development, airway diameter and blood salt levels.

g. **The Circulatory System** (heart, vessels and blood) carries nutrients, oxygen and hormones to the cells of the body and removes the carbon dioxide and other waste products which they produce.

h. **The Respiratory System** (lungs and air passages) allows the exchange of gases such as oxygen and carbon dioxide between the air and blood.

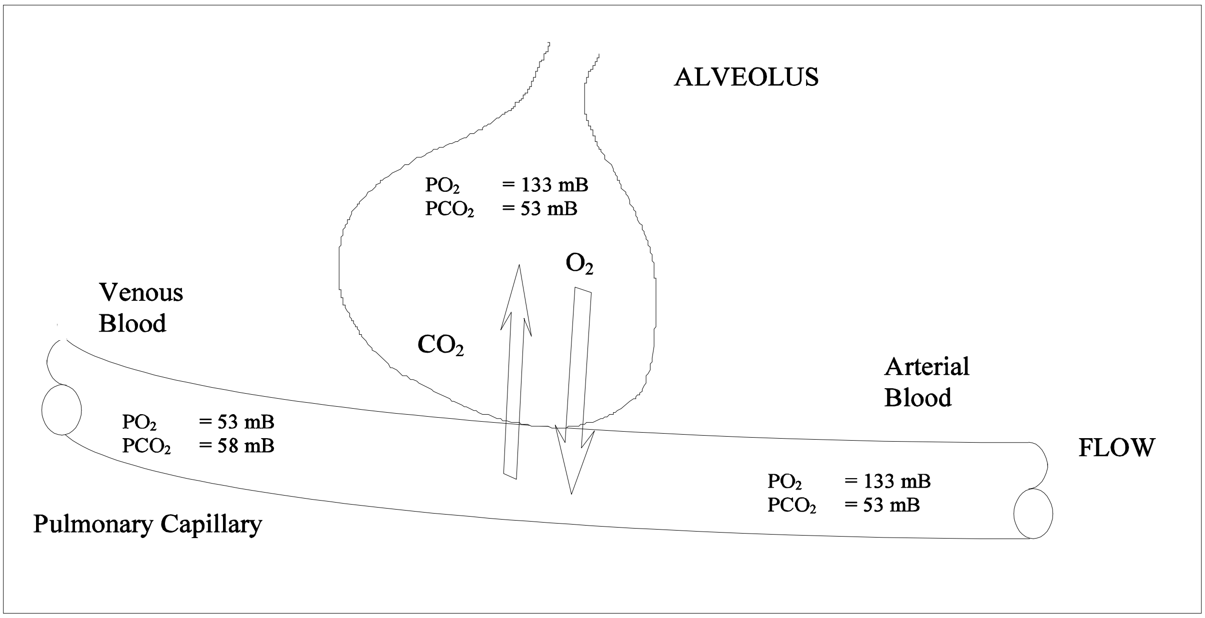
The two body systems of particular importance to exercise and diving are the circulatory and respiratory systems. These are now described in more detail.

0138. The Circulatory System

a. The heart is a hollow, muscular organ the size of a fist. It sits in the centre of the chest just behind the breastbone and in a space between the lungs which is called the mediastinum. In man, the right and left halves of the heart normally have no direct connection. Each half of the heart is divided into an upper chamber, the atrium, which receives blood from the veins and a lower chamber, the ventricle, which pumps this blood into the arteries. The ventricles are more muscular chambers than the atria and do most of the work of pumping.

b. The diffusion of gases between blood and air occurs through the thin walls of microscopic blood vessels called capillaries. These surround the tiny air sacs in the lungs known as alveoli. Similar capillaries in the body tissues allow gas exchange between cells and blood.

Fig 1-11. Alveolar Gas Exchange



PCO_2 (Partial Pressure of CO_2) PO_2 (Partial Pressure of O_2)

PCO_2 (Venous Blood) > PCO_2 (Alveolar) Therefore CO_2 passes from the blood to the Lungs.

PO_2 (Venous Blood) < PO_2 (Alveolar) Therefore O_2 taken up by blood from the Lungs.

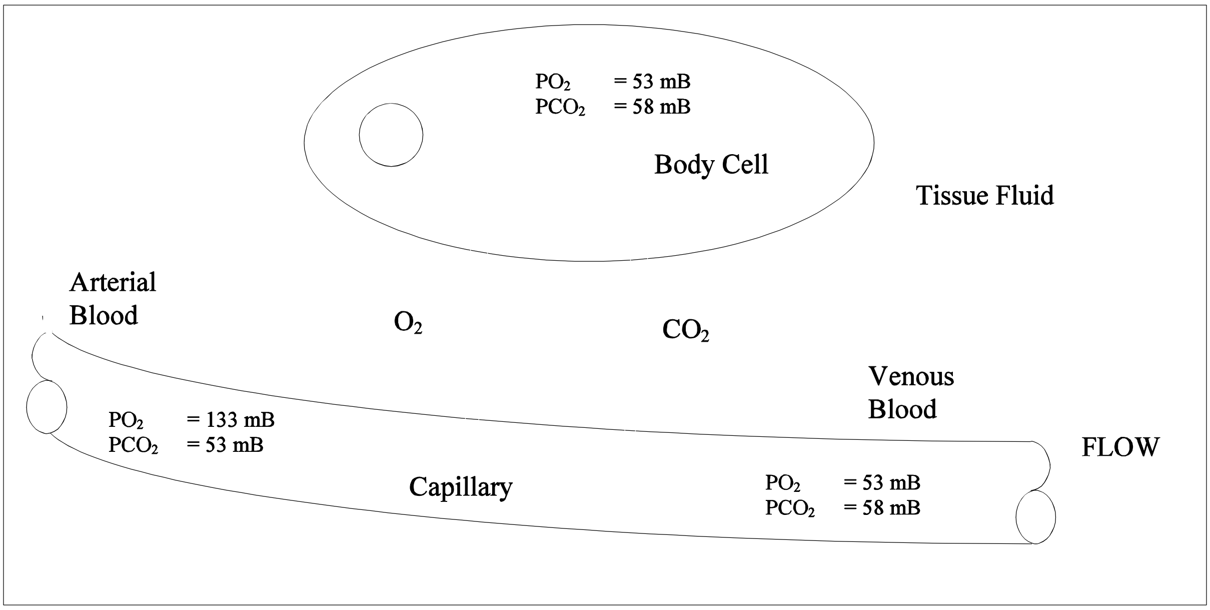


Fig 1-12. Cellular Gas Exchange

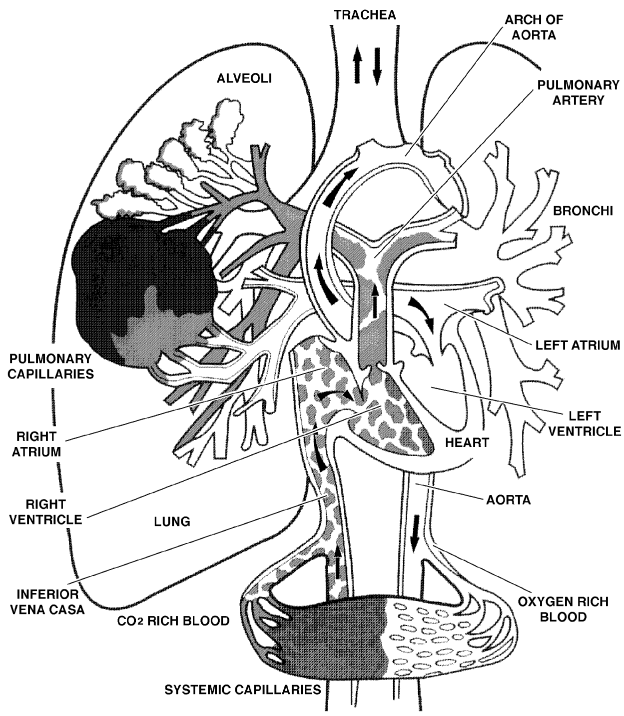
PCO_2 (Cell) > PCO_2 (Arterial) Therefore CO_2 passes from the cell to the blood.

PO_2 (Arterial Blood) < PO_2 (Cell) Therefore O_2 taken up by cell from the blood.

c. Oxygen-rich blood leaves the lungs and is carried to the left atrium of the heart by the pulmonary veins. The blood is then pumped into the left ventricle and from there, through a series of increasingly smaller arteries, to 'beds' of capillaries in the body tissues. Veins collect blood from these capillaries and join one another to form progressively larger vessels which empty back into the right atrium of the heart. From here blood is pumped into the right ventricle and back to the lungs (see Fig. 1-13).

d. The walls of arteries are rich in elastic and muscle fibres which makes them strong and resilient to the high blood pressures produced by the ventricles. The muscles within the walls of arteries are arranged so that the diameter of the vessels and so the distribution of blood within the body may be controlled. Veins need only thin walls because they carry blood at low pressure; they contain valves to ensure that blood flows in the right direction.

e. On each side of the heart there is a valve between the atrium and ventricle and between the ventricle and its outflow artery. These non-return valves ensure that blood is pumped in the correct direction.



The lungs' gas exchange system is essentially three pumps. A gas pump, the thorax, moves air through the trachea and bronchi to the lungs' air sacs. These sacs, the alveoli, are shown diagrammatically with and without their covering of pulmonary capillaries.

The heart's right ventricle, a fluid pump, moves blood which is low in oxygen and high in carbon dioxide, into the pulmonary capillaries. Oxygen, from the air diffuses into the blood while carbon dioxide diffuses from the blood into the air in the lungs. The oxygenated blood moves to the heart's left ventricle, another fluid pump, which sends the blood to the systemic capillaries which deliver oxygen to and collect carbon dioxide from the body's cells

Fig. 1-13. The Circulatory System

f. An average human body contains about 6 litres of blood. The blood contains billions of red cells to enable it to carry a sufficient amount of oxygen. These are microscopic disc shaped cells which are packed with haemoglobin, an iron-containing compound which binds loosely with oxygen. When blood is rich in oxygen the oxyhemoglobin gives it a bright red colour; a low oxygen concentration results in a bluish tinge.

g. A rare inherited disorder known as 'Sickle-Cell Disease' is caused by an abnormal haemoglobin: this results in the red cells assuming an irregular shape in conditions of low oxygen. Since these red cells are not very flexible, sickle-cell disease can result in tissue injury due to the blockage of small blood vessels. Therefore, individuals with this condition are not allowed to dive.

h. A small amount of carbon dioxide can be carried dissolved in the blood as carbonic acid and the rest is carried by the red cells.

SUMMARY OF THE FUNCTION OF THE CIRCULATION

The function of the blood circulation is to carry to the tissues of the body the substances they require and to remove from them their secretions and the waste products they produce in their activities.

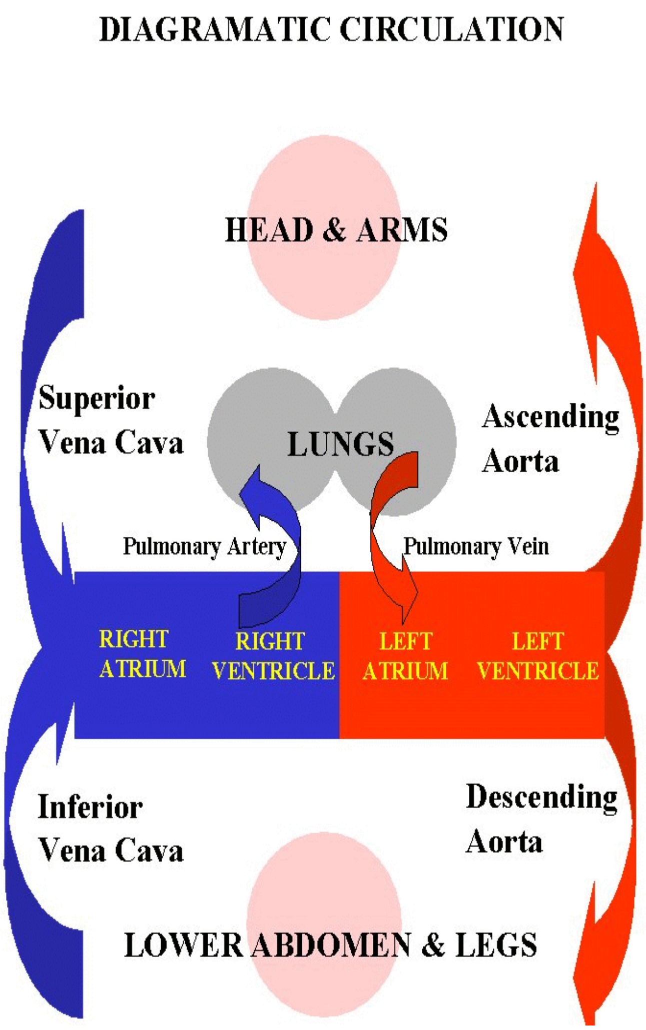


Fig 1-14. Diagramatic Blood Circulation System

Blood enters the Pulmonary Capilliaries which surround the Alveoli in the lungs via the Pulmonary Artery having been pumped from the Right Atrium then the Right Ventricle. The blood takes on O_2 and gives of CO_2 and then passes to the Left Atrium via the Pulmonary Vein. The blood is then pumped via the Left Ventricle into the main Artery (The Aorta). The O_2 rich Arterial Blood is then passed via the Arterial system to the bodies cells where the O_2 is passed to the cells and the CO_2 is removed. The now O_2 depleted and CO_2 rich blood (Venous Blood) is then returned to the Right Atrium of the Heart via the Vena Cava. On entry to the Right Atrium, the process is repeated.

i. The amount of blood in the body does not normally change very much. However, the rate at which it circulates depends greatly on the needs of tissues. The greater the rate at which oxygen is used up by a tissue, the greater the amount of blood which is supplied to it. As the body's demand for oxygen increases so the pulse rate and the volume of blood pumped by each beat of the heart increase accordingly. At rest, the heart normally beats roughly 70 times and pumps about 5 litres of blood per minute. During heavy exercise the pulse of a fit young man can exceed 180 beats and more than 20 litres of blood can be pumped each minute.

j. The blood pressure has to remain high enough to ensure an adequate supply of blood to the whole body but low enough to avoid bursting the more delicate blood vessels. The blood pressure is monitored by structures which lie in the carotid arteries (which supply the head and neck) and in the aorta (the body's main artery). Information from these is used by the brain to control blood pressure by means of hormones and the autonomic nerve supply to the heart and blood vessels.

k. Blood pressure is usually measured in millimetres of mercury (mm Hg). This reaches a maximum when the heart is contracting (systolic pressure), and a minimum value between beats (diastolic pressure). In a fit young man at rest the systolic pressure is about 120mm Hg and the diastolic pressure about 80mm Hg. Both pressures are usually measured and are written down as a fraction with the systolic above and diastolic below (eg 120/80). Both pressures increase considerably during exertion and excitement, but if they remain high at rest then there may be some abnormality. A certain amount of increase in blood pressure is natural with age because the arteries gradually lose some of their elasticity.

l. In an emergency, adrenaline is released by the adrenal glands into the blood in response to a nervous signal from the brain. This increases heart rate and blood pressure in readiness for intense activity.

m. The automatic control of blood pressure is occasionally upset by stress. A highly unpleasant emotion (for example, that brought on by pain or the sight of a gory injury) may have this effect. When the control is upset, the blood pressure may fall to the point where insufficient blood reaches the brain. This can cause dizziness, weakness, nausea and, eventually, loss of consciousness - fainting. This causes the victim to fall down, which lowers the head and thus permits more blood to reach the brain. Thus, consciousness usually returns within a few minutes.

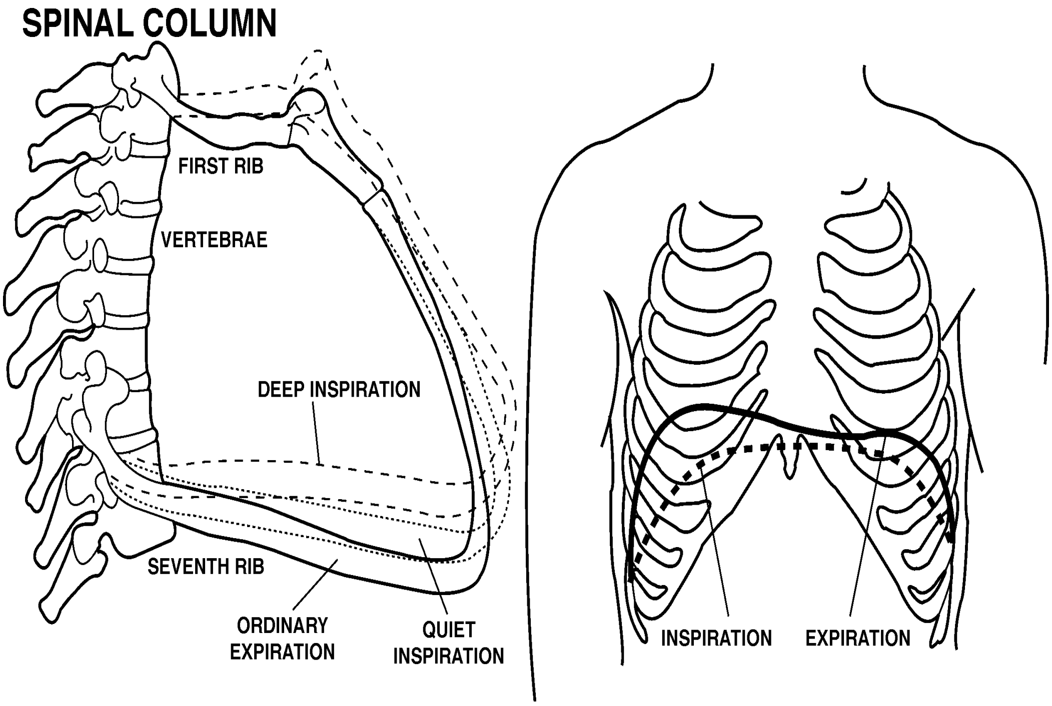
n. Collapse caused by fainting can often be averted by lowering the head - eg sitting down with the head between the knees.

o. Fainting may also occur if someone stands still for a long time (especially in hot weather) or very suddenly stops strenuous exertion. This occurs because blood pools in the lower part of the body and does not flow back to the heart sufficiently rapidly to allow the maintenance of an adequate blood pressure. Such fainting is uncommon while diving, because immersion in water supports the circulatory system so that pooling of blood does not occur. Light headedness may occasionally be experienced on leaving the water, particularly if the water was warm and there was heavy exertion during the dive. However, it is important to realise that collapse after diving may be caused by more serious disorders.

p. Shock is a serious condition which is caused by a loss of blood or plasma from the circulation. Severe internal and external wounds and burns commonly cause shock. When the body is unable to maintain the blood pressure, tissues are starved of oxygen and waste products build up. This can be fatal and must be treated rapidly. The pulse in someone with shock is usually weak and very rapid. Medical attention and fluid replacement are required urgently.

0139. The Respiratory System

a. **The Respiratory Apparatus**. The mechanism of breathing is shown in diagrammatic form in Fig 1-15. To breathe in, the ribs are lifted up by the muscles between them and the diaphragm is pulled down. This increases the volume in the chest cavity and air flows in. During exhalation, the muscles relax, the elasticity of the chest cavity causes it to contract, and air is blown out.



The process of inspiration involves both raising the rib cage (top) and lowering the diaphragm (bottom). Both movements enlarge the volume of the thoracic cavity and draw air into the lung.

Fig. 1-15. The Lungs - Inspiration/Expiration

b. There is a potential space between the outer surface of the lung and the inside of the chest wall which normally contains a slight vacuum. If either surface is ruptured then air will be sucked into this space when the chest expands. The resulting air-pocket is known as a pneumothorax; it may occur as a result of trauma, from a diving or submarine escape accident, or for no apparent reason. Very occasionally the tear in the chest wall or lung may act as a one way valve such that air is sucked in but is not allowed out of the pleural space. This causes the pressure in the chest to increase so that eventually normal lung begins to collapse. This is known as a tension pneumothorax which may be rapidly fatal unless treated (see Chapter 13).

c. **Control of Breathing**. As the work rate increases, oxygen demand and carbon dioxide production rise. Blood flow to the active areas is raised and, to maintain the levels of oxygen and carbon dioxide in the blood, the amount of air entering the lungs also increases. This is controlled by the respiratory centre in the brain which is sensitive to the partial pressure of carbon dioxide in the blood; if this is too high the centre causes the rate and depth of breathing to increase until normal carbon dioxide levels are reached.

d. Receptors in the carotid arteries and the aorta are sensitive to oxygen levels in the blood and send signals to the respiratory centre if the level is too low. This is a less sensitive response than that for carbon dioxide and does not usually affect the rate of breathing until the oxygen level is dangerously low.

e. Emotions such as excitement and fear may alter the respiratory rate independently of the above mechanisms.

f. **Oxygen Consumption**. It is obviously important to know how much oxygen is required, and carbon dioxide produced, by a diver in order that the adequacy of his air or gas supply may be determined.

g. Although there is considerable variability between individuals, a diver's oxygen consumption is largely determined by his work rate - see the table opposite.

h. The amount of oxygen a diver consumes per minute (i.e. the number of oxygen molecules) is independent of depth. However the volume of gas needed to provide a given number of molecules follows Boyle's law, so if the diver consumes 2 lpm at the surface he will only consume 1 lpm at 10m (twice the pressure and hence half the volume). Oxygen consumption is therefore usually expressed in terms of the volume of gas at the surface measured under standard conditions (Temperature 0^oC, barometric pressure 760mm Hg and with dry gas, known as STPD - Standard Temperature and Pressure Dry Gas).

Oxygen Consumption and Respiratory Minute Volume (RMV) at Different Work Rates

ACTIVITY		**O_2 Consumption l/min (STPD)**	**RMV l/min (BTPS)**
REST	RESTING ON BOTTOM	0.25	6
	Sitting quietly	0.3	7
	Standing still	0.4	9
LIGHT WORK	SLOW WALKING ON HARD BOTTOM	0.6	13
	Walking at 2 mph	0.7	16
	SWIMMING SLOWLY (0.5 Kts)	0.8	18
MODERATE WORK	SLOW WALKING ON MUD BOTTOM	1.1	23
	Walking at 4 mph	1.2	27
	NORMAL SWIMMING (0.85 Kts)	1.3	30
	MAXIMUM SPEED WALKING ON HARD BOTTOM	1.5	34
HEAVY WORK	SWIMMING (1.0 Kts)	2.0	40
	MAXIMUM SPEED WALKING ON MUD BOTTOM	1.8	40
	Running at 8 mph	2.0	50
SEVERE WORK	SWIMMING FAST (1.2 Kts)	2.5	60
	Running uphill	4.0	95

Notes:

1. Diving activities are in capital letters

2. The values shown for the amount of gas breathed each minute (RMV) are an average, there is considerable variation between individuals. To allow for a safety margin which takes account of this variability, higher values were used for light work and normal swimming in the preparation of the endurance graph for the self-contained open-circuit air-breathing set (Fig 1-27).

3. STPD means Standard Temperature and Pressure, Dry gas. The figures quoted relate to the medical standard of 0°C, 1 Bar abs. To calculate endurance on an oxygen cylinder it is necessary to convert these values to the engineering standard (20°C, 1 Bar abs). This may be done by multiplying by 1.08.

4. BTPS refers to gas volume at Body Temperature (37°C) and Pressure Saturated with water vapour. To calculate the endurance on open circuit SCUBA these figures must be converted to the engineering standard of dry gas at 20°C. This may be done by multiplying by 0.95.

i. The rate at which breathing gas is consumed (as opposed to just oxygen) will also depend on the depth of the dive. The amount of gas, or the number of molecules of gas, breathed depends on the number of molecules of gas in each breath and the breathing rate. As depth increases, even if the breathing rate and the volume of each breath stay constant, the number of molecules of gas in each breath increase such that a breath of 500ml at 10m contains twice as many molecules as the same breath taken at the surface.

j. One of the limitations of work capacity is the supply of oxygen to tissues; inefficient respiratory or cardiovascular systems, eg in those who are unfit, will limit work capacity. In an emergency, muscles may continue work for a short time without an adequate supply of oxygen. This process results in what is known as an `oxygen debt'; oxygen has to be consumed later to repay this debt. Another possible advantage of being in good physical condition is that a greater oxygen debt may be tolerated.

k. **Carbon Dioxide Output**. The production of carbon dioxide closely follows the consumption of oxygen. As with oxygen consumption, the number of carbon dioxide molecules produced does not change with depth. The ratio of the carbon dioxide produced divided by the amount of oxygen consumed is known as the respiratory quotient.

$$\text{Respiratory Quotient} = \frac{CO_2 \text{ Produced}}{O_2 \text{ Consumed}}$$

This can range from 0.7 to 1.0 depending on diet and work rate. The average value of the respiratory quotient for a working diver is about 0.9.

0140. Body Temperature and Heat Loss

a. A diver working in cold water experiences a continuous heat loss. One of the functions of a diving suit is to reduce this.

b. Man functions effectively over only a narrow range of body temperature around a normal level of 37ºC. This is maintained by the body's thermoregulatory mechanisms and behaviour - clothes, heating, cold drinks etc.

c. The metabolism of the body generates enough heat to warm 2 litres of ice-cold water up to body temperature every hour. During short periods of heavy work up to 10 times as much heat can be generated. Unless this heat is lost, the body temperature will increase. Small increases may occur without ill effect. However, once the temperature reaches about 41ºC cells become injured and serious illness can result.

d. The body loses excess heat in several ways. A small amount of heat is lost in the breath. More heat may be lost through the skin by conduction, convection, radiation and evaporation (sweating). This last mechanism is particularly important, since the rate of heat loss can be regulated. If the body is working hard, the blood vessels nearest the skin dilate to allow more blood to reach the surface and the sweat glands increase their activity to promote evaporative heat loss.

e. A hot and humid atmosphere reduces the effectiveness of most of these mechanisms and so limits the safe maximum workload which can be undertaken.

f. Heat regulation is particularly difficult for a diver. In warm tropical waters (temperature greater than about 32°C) the cooling systems of the body become ineffective and a working diver may develop heat exhaustion. Equally, the high thermal conductivity of water may cause excessive heat loss when a diver is working in cold water.

g. A sudden drop in skin temperature such as on entry into the water or the influx of cold water into a diving suit can result in a profound physiological response. An unprotected man plunged into very cold water will experience an immediate increase in pulse rate and blood pressure and a period of rapid, gasping breathing. Even competent swimmers may be unable to co-ordinate breathing and swimming movements and will inhale water. The rapid pulse and high blood response may result in circulatory failure in unfit people.

h. Immersion in water at 33°C will result in no net heat loss or gain from the body -so-called thermoneutral immersion. Immersion in water below about 23°C will soon result in the unprotected diver becoming chilled. Discomfort is followed by involuntary muscular contraction to produce heat - shivering. As cooling continues, a diver's ability to perform useful work becomes seriously impaired. Manual dexterity is reduced and the sense of touch is dulled. As shivering intensifies it brings on a general lack of co-ordination such that it may be difficult to keep a mouthpiece in place. With further cooling the ability to concentrate and think clearly is soon lost. At this stage a diver could easily make a fatal mistake.

i. In cold water or after prolonged immersion in cool water, heat loss can reach a point at which death occurs. In water at 6°C an unclothed man of average build will become helpless within 30 minutes and will probably die within an hour. An appropriately dressed diver, however, can work in very cold water for prolonged periods of time.

j. The ability of the body to tolerate cold environments is due to natural insulation and the body's built-in means of heat regulation. Body temperature is not uniform throughout. There is an inner core of nearly constant temperature, and a superficial region through which a temperature gradient exists from the core to the surface. Over the trunk of an average body the thickness of the superficial layer is about 2.5 cm. The limbs become part of this superficial layer when their blood flow is reduced.

k. Once in the water, man is largely dependent on the internal mechanisms to limit loss of body heat. Heat loss through the superficial layer is lessened by the reduction of blood flow through the skin. After some time, however, the control of skin blood flow is lost. As circulation and heat loss increase the body temperature falls and continues to fall even though some heat is produced by shivering.

l. A cold diver consumes oxygen more rapidly as food is burned to create heat.

m. The symptoms and signs of a falling body core temperature are shown below. The management of hypothermia is described in Chapter 13.

Symptoms and Signs of a Falling Core Temperature

Core Temperature	Symptoms and Signs
37°C	Cold sensation Pale skin caused by vasoconstriction; `Goose Bumps' Increased muscle tone Increased oxygen consumption
36°C	Sporadic shivering suppressed by voluntary movements Gross shivering in bouts Further increase on oxygen consumption Uncontrollable shivering
35°C	Voluntary tolerance limit in laboratory experiments Mental confusion Loss of volition; Drowning possible
34°C	Loss of memory Impairment of speech Reduced sensation Reduced motor performance
33°C	Hallucinations, delusions, clouding of consciousness Experience from shipwrecks and survival situations shows that 50% do not survive this stage Shivering impaired
32°C	Irregularities of heart rhythm Grossly impaired motor performance
31°C	Shivering ceases
30°C	Loss of consciousness - no response to pain
27°C	Death

SECTION 6 - PROBLEMS OF INERT GAS

0141. Introduction

The inert gases, listed in Section 4, combine with other elements only with difficulty. However, when a breathing gas is inhaled the inert gas, in practice nitrogen or helium, can diffuse into the blood in the same way as oxygen. The presence of inert gas in the bloodstream gives rise to the problems of decompression which will be discussed in this section, and when the inert gas is nitrogen there are also problems of narcosis.

0142. Nitrogen Narcosis

(For a fuller discussion of this problem, see Section 4).

a. It suffices to say here that at depths much exceeding 30m, nitrogen becomes narcotic. It has increasing effect as depth increases. The diver becomes light-headed, irresponsible and lacking in powers of concentration. In short, he exhibits effects similar to those experienced in alcoholic intoxication.

b. This leads to a limitation of depth to 24m for inexperienced divers or those who dive infrequently (see Chapter 7). By constant regular diving to depths of up to 54m, a diver may adapt to the narcotic effect of nitrogen and may perform better. However, some degree of clumsiness, ineptitude and irresponsibility must still be expected.

0143. Decompression

The term decompression applies to a reduction in pressure either from atmospheric pressure to sub-atmospheric, as when climbing to altitude in an aircraft, or from raised pressure back toward sea level, as when leaving bottom and starting the ascent after a dive. The importance of decompression lies in the effect it has on the dissolved gas in the body.

0144. Solution of Helium or Nitrogen in the Body

a. As stated above, helium or nitrogen (inert gases) in a breathing mixture will enter the bloodstream, and dissolve in the blood. This it will do in accordance with **Henry's Law** which states that:

"At a constant temperature, the amount of gas that will dissolve in a liquid is directly proportional to the partial pressure of the gas and the solubility co-efficient of the liquid"

b. At atmospheric pressure breathing air, about 1.25 gm (1 litre) of nitrogen is present in the body. It is in solution in the blood, and in the tissues. Since the amount of gas dissolved in a fluid depends upon the pressure, at 2 Bar absolute breathing air, the body will contain about 2.5 gm (2 litres) of nitrogen, at 3 Bar absolute 3.75 gm (3 litres). This is roughly true provided the time of exposure is long enough to allow saturation.

ie: For a diver saturated in air:

at 0 m there is approximately 1.25 gm (1 litre) of N_2 in the body;
at 10 m there is approximately 2.5 gm (2 litres) of N_2 in the body;
at 20 m there is approximately 3.75 gm (3 litres) of N_2 in the body, etc.

c. Of the nitrogen in the body, approximately half (at atmospheric pressure) is contained in the blood and watery tissues, while the remainder is held in the fatty tissues. However, although there is less fat than water in the body, nitrogen is 5 times more soluble (greater solubility co-efficient) in fat that in water, so a fat person will therefore absorb more nitrogen than a lean person.

0145. Saturation

a. When a person is exposed to a raised pressure, increased volumes of inert gas dissolve in the body; at first quickly and then more slowly; until no more gas will dissolve. This condition of equilibrium is called 'saturation' and the time taken to reach this state is the 'Saturation Time'. The saturation time will depend on the depth, and the gas or gases being breathed, and is of the order of 12 or more hours. Saturation is only relative to a particular depth however, for example if a person who has spent sufficient time at 4 Bar absolute (30m) to become fully saturated goes quickly to 8 Bar absolute (70m), that person will be only half saturated at the new depth.

b. Blood saturates quickly, but fat takes much longer. Tissues that saturate rapidly also de-saturate rapidly; tissues that saturate slowly also de-saturate slowly.

c. The amount of gas contained in the body thus depends on three factors:

(1) Pressure to which it has been exposed.

(2) Time spent at that pressure.

(3) The affinity of the tissues in the body for gas. (Solubility Co-efficient)

0146. Physical Effects of Decompression

a. If the pressure of a liquid, which has been partly or completely saturated with gas, is reduced, some of the gas comes out of solution. In the process, bubbles of gas are produced in the liquid. An illustration of this is the removal of the crown cap on a bottle of fizzy lemonade.

b. Also, any agitation causes bubbles to come off even faster, and if the liquid is allowed to stand, even for long periods, further shaking brings off more bubbles. This ability of a liquid to hold gas in excess of the normal amount for that pressure is known as **super-saturation**.

c. During a dive, nitrogen from the air or mixture (or helium from oxy-helium mixtures) goes into solution in the body at a steadily decreasing rate. On reducing pressure, when ascending fast, bubbles may be formed, producing the symptoms of decompression illness.

d. Professor Haldane, working in the early 1900s, advanced the hypothesis that bubbles would form in the body if the pressure of gas within the body was more than $2^1/_4$ times the pressure outside the body. He postulated that it would be safe to ascend directly from 10m (2 Bar abs) to the surface (1 Bar abs) without bubbles forming. This has since been shown to be incorrect. The maximum allowable safe ascent after **saturation** in air is 1.7 Bar to 1.0 Bar.

e. However, for the practical purposes of **non-saturation** diving described in BR 2806 Volumes 1 and 2, it may be considered safe to allow a diver to ascend to half his absolute pressure. This is known as his 'First Stop with Safety' and may be stated as follows:

Haldanes First Stop With Safety

In an emergency, a diver can ascend to half his absolute depth (or pressure).without bubble formation taking place.

ie at 50m (**6 Bar** $_{\mathbf{abs}}$) Diver can ascend to 20m (**3 Bar** $_{\mathbf{abs}}$)

at 10m (**2 Bar** $_{\mathbf{abs}}$) Diver can ascend to surface (0m) (**1 Bar** $_{\mathbf{abs}}$)

This is useful if it is necessary to bring up a diver in emergency, since while he is ascending his correct stops may be determined.

0147. Decompression Stops and Decompression Tables

a. Haldane used his hypothesis to produce the first set of decompression tables. A diver ascends, 'stopping' at intervals to allow the nitrogen in the body to be given off safely without forming bubbles. The first 'stop' is usually short, but, as the pressure within the body decreases, the gas comes out of solution at a slower rate and the time at a 'stop' increases, the longest 'stop' being just below the surface.

Principles of Stage Decompression

1. The Diver ascends to a predetermined depth

2. Tissue supersaturation occurs

3. The Diver maintains depth while the tissues off-gas.

4. Once inert gas pressure falls to a safe level, the diver can ascend to the next stage.

b. Haldane's original tables were reasonably safe and were in use for many years. However, the present tables of 'stops' have been developed in order to reduce the time spent on decompression and yet retain the greatest degree of freedom from decompression illness.

c. Table 11-Mod in Chapter 12 is the table most often used. It is extremely safe and decompression illness using this table is almost unknown. In these tables there is a risk below the limiting line, where decompression illness becomes more likely the longer the exposure. Intentional diving below the limiting line should be undertaken only when a compression chamber is 'on site' and even then only when circumstances justify the risk (Chapter 12).

d. Different tables are required for oxy-helium diving. These are contained in Chapter 12.

0148. Diving at Altitude

a. Ambient sea level pressure decreases with altitude. A dive conducted above sea level, which uses a depth and duration profile as calculated for the same dive at sea level, will generate a higher inert gas partial pressure in the body tissues. Therefore when diving at altitude if diving table depths are not adjusted to compensate, the risk of decompression illness is increased. See Chapter 12.

b. Details of these adjustments are given in Chapter 12. No adjustment is necessary at altitudes less than 100m.

0149. Symptoms and Signs of Decompression Illness

a. The diagnosis and treatment of Decompression Illness (DCI) is discussed in detail in Chapter 13 which should be referred to for further information.

b. Decompression Illness may be the result of:

(1) Failure to adhere to the published tables (eg a badly timed dive or inaccurate measurement of depth).

(2) A dive below the limiting line.

(3) An abnormal response by a diver to a properly conducted dive.

c. It is caused primarily by gas bubbles in the body which have the following general effects of body tissues.

(1) Damage to tissue structure.

(2) Blockage of small blood vessels and capillaries which interferes with the blood supply to tissues, organs or parts of organs.

(3) Secondary effects of the above giving rise to inflammation, swelling and possible haemorrhage.

d. The symptoms and signs of DCI are very wide ranging in presentation and severity. As a disease process it may give rise to abnormalities in every organ of the body. However, in general the symptoms and signs usually affect the following.

(1) *Nervous System.* Any aspect of function of the nervous system may be affected. This may be subtle and difficult to detect or may be obvious such as weakness or paralysis. Specific areas of the brain may be affected giving rise to personality changes, problems with memory, comprehension or speech. More obvious manifestations include visual disturbances and changes in perception of feeling (touch, pain, temperature). These may range in severity from mild subjective sensations of pins and needles to complete loss of the ability to feel (similar to the effects of a local anaesthetic). Problems with strength and muscle power may be experienced as well as difficulty with co-ordination of movements (clumsiness). Balance may be affected giving rise to 'the staggers'. Difficulty may be experienced in passing urine or faeces.

(2) *Musculo-skeletal System.* Symptoms involving discomfort in or around joints may occur. In general these may start as a mild awareness (niggles) which initially may be difficult to localise. Subsequently the pain may become more severe, of an aching or boring quality and become restricted to one or more large joint, usually the shoulder, elbow, hip or knee.

(3) *Skin.* The skin may be affected giving rise to symptoms of itching, often associated with a mottled rash, initially reddish in colour but taking on a dusky hue in the well established case. The rash is usually found on the shoulders and trunk. Occasionally swelling of the skin may also occur.

(4) *Constitutional.* Divers with decompression illness frequently complain of feeling ill or unwell with symptoms akin to influenza. General weakness, lassitude and poor appetite are the usual symptoms.

(5) *Cardio-respiratory System.* Severe decompression illness may affect the heart, circulation and lungs and is life-threatening.

e. Denial of the possibility that the diver has DCI is common and symptoms are often ascribed to cold, tight fitting equipment, physical strains from lifting gear and so on. Delay in seeking treatment is foolish and may make the condition more difficult to treat. It is wise to assume that any symptom arising within a few hours of diving is related to that activity and seek appropriate advice.

WARNING

ANY PAINS OR UNUSUAL FEELING OR BEHAVIOUR AFTER A DIVE SHOULD BE CONSIDERED TO BE COMPRESSION ILLNESS UNTIL PROVED OTHERWISE. WHEN IN DOUBT - RECOMPRESS. SEE CHAPTER 13 FOR TREATMENT GUIDELINES. GIVE THE PATIENT OXYGEN TO BREATHE AND SEEK ADVICE OVER THE USE OF PAINKILLING DRUGS - THESE MAY MASK SYMPTOMS.

0150. Symptoms and Treatment of Decompression Illness - Oxy-Helium Diving

The symptoms of decompression illness in oxy-helium diving are the same as those for oxy-nitrogen diving described above. Guidance on the avoidance and treatment of decompression illness during or after Oxy-helium diving is given in Chapter 12.

0151. Aseptic Necrosis of Bone

a. This is a long-term hazard of divers and also of compressed-air workers.

b. It must be realised that any person, such as a diver, who exposes himself to changes of pressure has a low risk of developing a form of arthritis in later months or years. Little is known of this complication except that it also occurs in compressed-air workers in whom there is no apparent connection between this ‘bone necrosis’ and a previous attack of ‘bends’.

c. It is possibly a form of decompression illness that causes no symptoms at the time of injury but which can progress to cause bone changes, or more uncommonly, damage to weight bearing joints such as the hip or shoulder. These lesions have occurred in those who have never dived with oxy-helium but only with air. It is a rare illness and occurs more commonly in groups who ignore good diving practice. In naval divers and other groups where attention is paid to correct decompression, the incidence of necrosis is very low, and persons progressing to the symptom stage are almost unknown.

0152-0154. Spare

SECTION 7 - MISCELLANEOUS PHYSICAL PHENOMENA

0155. Introduction

Since water is a medium of much greater density than air, a number of other physical phenomena occur, mainly connected with heat, light and sound.

0156. Underwater vision

a. A ray of light passing from a medium of one density into a medium of a different density at right angles to the surface of the second medium continues in a straight line called the ‘normal’. If, however, the ray strikes the surface at an angle other than a right angle, the ray is bent at the surface and this bending is called refraction. The degree of bending or refraction depends upon the difference between the densities of the two media. A light ray passing from air into the denser medium of water is bent toward the normal but when passing from water to the less dense medium of air the ray is bent away from the normal as shown in Fig 1-16a.

b. The diver is mostly concerned with the effect of the bending of light rays passing from the surrounding water to the less dense medium of the air in his facemask. This refraction will give a false impression of the position of underwater objects, which will appear to be larger than their true size and only about three-quarters of their true distance away.

c. In Fig 1-16b the diver is looking directly at object ‘A’ and the ray of light from the centre of the object travels along the normal line through the diver’s visor without refraction. The light rays from the top and bottom of the object, however, both strike the visor at an angle and are bent in the air of the facemask along the dotted lines, and the diver actually sees these points along the dotted lines at ‘T’ and ‘B’. ‘A’ will thus appear larger and, in consequence, nearer.

d. Fig 1-16c shows how refraction limits the diver’s vision underwater. When a diver stands in air, there is no difference between the densities of the media inside and outside his helmet and consequently no refraction, and his field of vision is shown by the full lines. Underwater, however, owing to refraction, only light rays between the dotted lines will reach his eye. A further result of refraction is the considerable distortion of objects viewed through the visor at an oblique angle, and, outside an angle of 48.6° from the normal, objects will not be observed at all because of total internal reflection.

e. **Penetration of Light in the Sea.** Even in the clearest water there is a limit to the depth to which light will penetrate. The brighter the day, the greater is the amount of light entering the water, but even so in clear water light does not penetrate below about 500 metres. There are two reasons for this loss of light; some of the light is absorbed by the water and converted to heat, and some is scattered or diffused by the many small particles suspended in the water. This diffusion, however, has a beneficial effect by casting light rays into caves and crevices, which otherwise, not being in the direct rays of the sun, would receive no light at all.

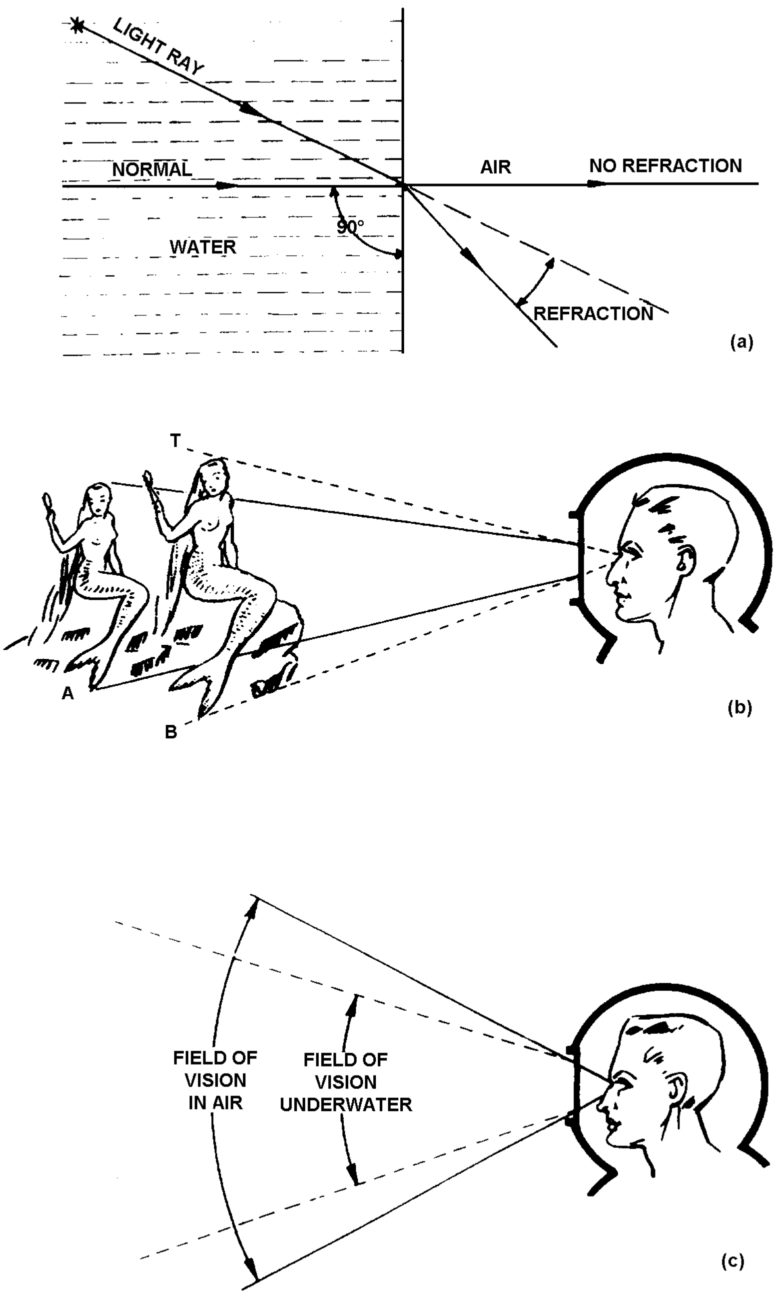


Fig 1-16. Effect of Refraction on Underwater Vision

(a) Refraction (water to air)

(b) Effect of refraction distortion

(c) Effect of refraction on field of vision

f. Absorption of light depends on wavelength; of the visible spectrum red light is absorbed most, and violet light least. This is why everything appears bluish-green underwater even at very shallow depths. An object that appears colourless and dull on the bottom may be found to be bright red when brought to the surface. Diffusion, on the other hand, is greatest with blue/violet light.

g. Colour absorption is a factor to be considered when carrying out underwater colour photography. If a reasonable colour rendering is required, some form of underwater lighting must be used. To strike a balance between absorption and diffusion, the best underwater lights are those of colours from the centre of the spectrum, and in practice yellow light is found to be the least deceptive.

h. When working in most areas the diver cannot avoid stirring up mud or sand, and light falling on these particles is diffused and forms an artificial fog, which greatly limits the visibility. Turbid or muddy water may also be found in layers and at times a relatively clear layer of water may be found under such layers.

0157. Underwater Sound

a. In air, sound travels at about 335m per second, but the speed of sound varies greatly in different substances capable of transmitting it. In water, sound travels more than four times as fast as in air. Both air and water transmit sound well, but unfortunately all but one ten-thousandth part of the sound energy is lost when being transmitted from air to water; therefore, for divers to hear each other or to hear sounds from the air above them, the sounds must originally be very loud.

b. Breathing oxy-helium gas mixture or air at high pressures changes the voice to a higher pitch. The higher the pressure the greater this effect becomes until at great depths the voice becomes so distorted that telephone communication is almost impossible. This effect is due to the different speed of sound in gases of different densities. Devices have been developed to correct the change of frequency under these conditions and allow intelligible speech to be transmitted when using oxy-helium mixtures.

c. The fact that sound in water travels much faster than in air makes it almost impossible to pinpoint a source of sound underwater, and it is possible to obtain only a general idea of the direction.

0158. Heat Transfer Underwater

a. A diver may lose his body heat by conduction, convection or radiation, but mostly by conduction and least by radiation. See also Section 5.

b. **Conduction.** This is the direct transmission of heat through a substance or through materials in contact with each other. An unprotected diver will lose heat to the surrounding water by direct conduction through the skin, the rate at which he loses the heat depending upon the difference in temperature between the body and the water. If the water temperature is less than 32°C to 33°C, the temperature difference between the diver’s body and the water is such that if unprotected he will lose heat faster than his body can produce it and he will chill at rest.

c. **Conductivity.** This is a measure of the ease with which a material transmits heat. A material of very low conductivity placed between the body and the surrounding water acts as an insulator and reduces the conduction of heat from the body to the water. The insulation provided by wool clothing and foam-type materials results mainly from the fact that they contain a series of air pockets that place a layer of air between the body and the colder surrounding media. The confinement of air in these air pockets also greatly reduces the loss of heat by convection.

d. **Convection.** This is the transmission of heat by the movement of air or liquids. The unprotected diver standing more or less still underwater will lose heat, not only by conduction but also by the fact that the water in contact with his skin, warmed by conduction, will expand and, becoming slightly lighter than the surrounding water, will rise to the surface to be replaced by cold water. Thus convection currents are set up that take away the water warmed by conduction through the skin and the diver is continuously bathed in cold water taking its place. Provided the water temperature is not less than 15°C, a good-fitting wool undersuit may suffice to prevent the diver from being chilled. In colder water, insulation with a 'dead' air space must be provided by wearing a wool undersuit under a watertight suit or by wearing a 'wet' suit of cellular foam material that does not lose its insulating value when wet and which reduces convection effects on the diver's skin by trapping a film of water.

e. **Radiation.** This is the transfer of heat by invisible waves as experienced when standing in sunlight or in front of an electric radiator. The amount of body heat the diver loses by radiation is negligible compared with the loss by conduction.

f. The high thermal conductivity of helium (approximately 6 times that of air) draws heat away from the diver at a great rate. Therefore when using oxy-helium mixtures it is essential that the diver dresses appropriately for the circumstances.

0159. Hazards Associated with Cold Water

When water temperatures are very low, the diver is subject to the following effects: See also Fig 1-17

a. **Cold Stress.** The 'Cold Shock' effect occurs immediately the diver enters the water. The body temperature regulating mechanism will at first attempt to warm up the extremities by increased blood flow. Later vaso-constriction takes place at the extremities and these areas will become much colder as the body attempts to preserve core temperatures. The effects are:

(1) Loss of manual dexterity.

(2) Loss of hand-eye co-ordination.

(3) Reduced decision-making ability.

b. **Hypothermia.** When water temperatures are very low, the diver's body temperature may fall drastically after prolonged exposure and he may become unconscious. This condition s known as hypothermia and must be avoided at all costs. Suitable precautions must therefore be taken to keep the diver warm. See also Section 5.

0160. Hazards Associated with Hot Water

High water temperatures also pose hazards to the diver on the comparatively rare occasions when they are met. The diver is liable to heat exhaustion when the heat generated by the body (see Section 5) cannot be dissipated. This risk is present in water exceeding 30°C for a working diver, and in water exceeding 35°C for a diver at rest. See Chapter 7 for the regulations governing diving in hot water.

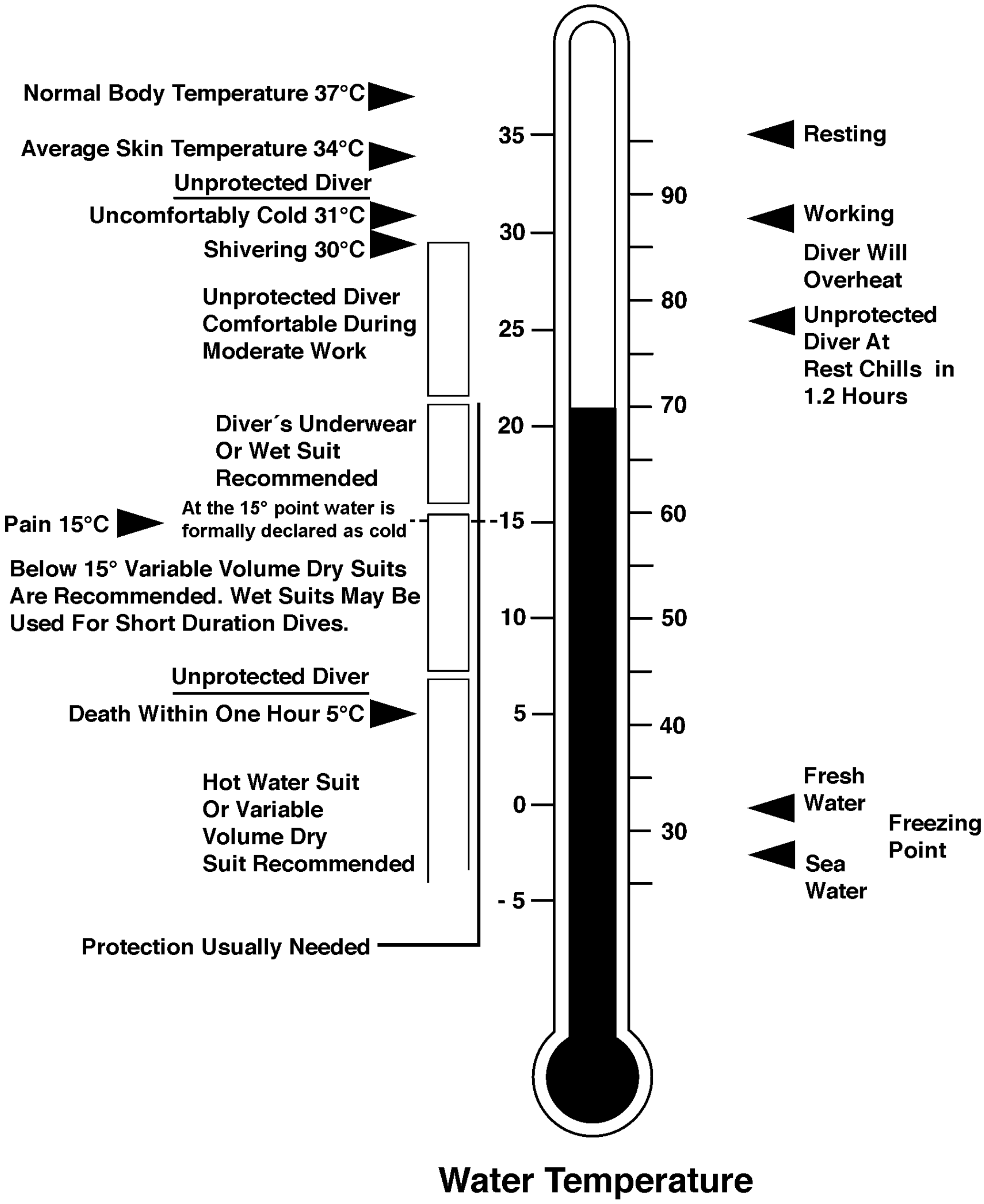


Fig 1-17. Water Temperature Protection Chart

0161-0164. Spare.

SECTION 8 - INTRODUCTION TO BREATHING APPARATUS

0165. Principles of Diving Breathing Apparatus

a. Breathing apparatus used by divers falls into two main groups: self-contained equipment, in which the diver carries his supply of breathing gas in cylinders, and surface-supplied equipment, where the breathing gas is supplied to the diver through a hose from the surface.

b. **Self-Contained Apparatus.** Self-contained diving apparatus has the advantage of making the diver far more mobile and giving him a much greater range of action. The apparatus can be used for breathing air but can also be designed to use other breathing gases of a higher or lower oxygen content than air. Although this produces a number of advantages, it also includes some disadvantages, which will be discussed more fully below. The suit worn by the self-contained diver has no part in the breathing circuit and merely gives protection from cold, wet and superficial injury. The breathing apparatus can, therefore, be used without a suit if climatic conditions allow. Self-contained breathing apparatus can be further divided into Rebreather (Closed or Semi-Closed) Equipment and Open-Circuit Equipments.

0166. Self-Contained Closed and Semi-Closed Circuit (Rebreather) Breathing Apparatus

In this apparatus the breathing gas, which may be either pure oxygen or an oxygen-inert gas mixture, is stored in cylinders at high pressure so that it occupies a reasonably small volume. There are three main variants of the rebreather diving equipment although they all use a similar method of removing carbon dioxide from the breathing circuit. These variants are:

a. **Closed Circuit Oxygen on Demand (LEBA (O_2) LAR 5)** Pure Oxygen is used as the breathing gas and the counterlung is kept topped up using a demand valve.

b. **Semi Closed Circuit, Constant Mass Flow** Pure Oxygen or a Pre-determined Gas Mixture is passed through a preset reducer that ensures a constant mass of gas is delivered to the counterlung.

c. **Closed Circuit, Fixed Partial Pressure of Oxygen (CDBA, LEBA (MG))** A constant partial Pressure of oxygen is maintained in the breathing circuit by the addition of Oxygen. The amount of Oxygen being added is controlled by Sensors in the breathing loop which monitors the oxygen content, generating the control signal which is used by the oxygen addition valve.

0167. Self-Contained Closed and Semi-Closed Circuit “Constant MassFlow” Breathing Apparatus

a. The principle of the first two diving equipments detailed above are basically similar and is outlined in Fig 1-18. Both equipments use a fixed Oxygen Content gas (100% or a NATO Standard). When the cylinder outlet valve is opened the gas flows through a reducing valve, which supplies a constant mass flow irrespective of depth, into a flexible breathing bag or counterlung positioned on the diver’s chest or back, at the approximate level of his lungs. The diver breathes the gas from the counterlung via a canister of carbon- dioxide absorbent and a breathing tube. When the diver exhales, his expired breath passes back into the counterlung through the carbon-dioxide absorbent, which removes the expired carbon dioxide but has no effect on the oxygen and nitrogen.

b. By breathing in and out of the flexible counterlung positioned level with his lungs the diver can breathe comfortably at any depth, as the counterlung is subjected to the water pressure at the diver's depth, and the breathing gas in the counterlung and in the diver's lungs will be at approximately the same pressure as that on the chest walls. If more gas was supplied than the diver could use and there was no other outlet for the excess gas, the counterlung would fill up and eventually it would be impossible for the diver to exhale against the excess pressure in the counterlung, which would soon burst. The same thing would happen when the diver ascended, because of the expansion of the gas in the counterlung with the external reduction of pressure.

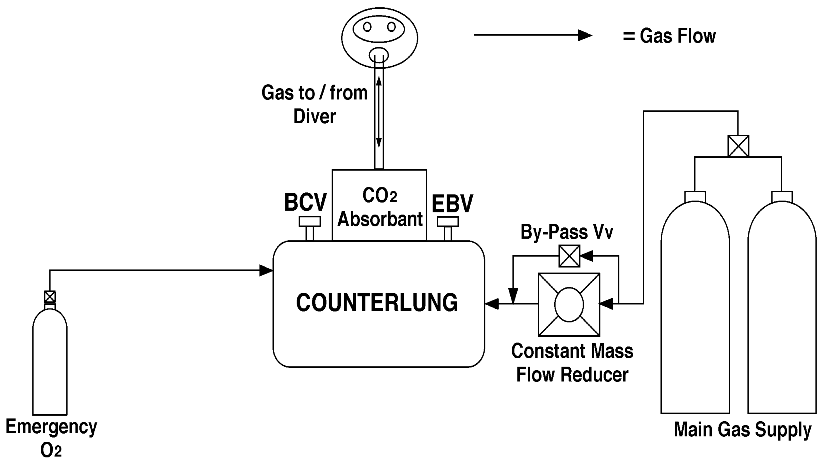


Fig 1-18. Simple Constant Mass Flow Rebreather

c. To prevent this, a relief valve is fitted in the counterlung. The valve is normally held closed by a light spring and the external water pressure. The valve lifts when the pressure in the counterlung is slightly above that of the spring plus water pressure.

d. **Pendulum and Two-Way breathing.** In the breathing apparatus described above, the diver breathes in and out through a single breathing tube and the carbon dioxide absorbent. This is known as pendulum breathing and has the disadvantage that a large 'dead space' exists between the mouthpiece and the canister; this means that the small amount of gas in the breathing tube at the end of an exhalation is drawn back into the lungs on the next inhalation without having been through the absorbent. For this reason the diver should avoid shallow breathing and make a conscious effort to breathe normally. By so doing he will make the 'dead space' as small a fraction as possible of the total volume of each breath, thus ensuring the removal of the maximum amount of carbon dioxide.

e. Pendulum breathing has the advantage that most of the gas passes twice through the absorbent at each breathing cycle; this not only ensures efficient absorption of the carbon dioxide but brings both sides of the granules into action and hence improves the endurance of the absorbent.

f. In some breathing sets (LEBA O_2 LAR 5) the diver inhales through one tube and exhales through another, the flow being controlled by non-return valves in the breathing tubes. In this case the gas passes only once through the canister at each breathing cycle. This is known as two-way breathing, which, provided the valves are close to the mouthpiece, has the advantage of cutting out most of the 'dead space' and giving cooler breathing.

g. **Choice of Breathing Gas.** The closed/semi-closed-circuit breathing apparatus may be used for breathing pure oxygen, an oxy-nitrogen mixture or an oxy-helium mixture. The principle of operation and the gases used in the Closed Circuit, Fixed PO_2 set such as the CDBA will be discussed later. For the Constant Mass Flow Diving Apparatus, the principles do not differ whichever gas is being used but the flow of gas and the method of using the apparatus do vary.

h. **Oxygen Breathing.** Pure oxygen would appear to be the ideal breathing gas. It supports life and will give the maximum endurance for a given amount of gas carried. However, oxygen becomes toxic with depth and it cannot be safely breathed at a partial pressure exceeding 2 Bar abs (see Section 4). For safe diving to greater depths oxygen must be diluted with an inert gas such as nitrogen/helium, so that its partial pressure at the depth involved does not exceed 2 Bar abs.

i. Pure oxygen may also be used in what is known as the 'on demand' technique, where no reducer is fitted. The diver fills the counterlung by merely opening and closing the cylinder valve; he then breathes from the counterlung until it 'bottoms', ie he cannot take a deep breath. He then refills the counterlung once more.

j. This method has the advantages of greater endurance and not leaving a trail of tell-tale bubbles on the surface. However, since this technique introduces hazards not present when a reducer is used, it is used only when conditions require that the presence of the diver remains undetected.

k. To ensure the safety of divers required to operate in a covert fashion, the "on-demand" technique has been modified in equipment like the LEBA O_2 LAR5, such that oxygen is added to the counterlung automatically when the pressure in the counterlung falls below a preset value.

0168. Closed Circuit, Fixed Partial Pressure of Oxygen, Rebreathing Apparatus (CDBA)

a. The Constant Mass Flow Rebreather although more gas efficient than an open circuit equipment, still has a continuous stream of gas being vented to the water. The ideal solution in terms of gas economy is the "Closed Circuit, Fixed Partial Pressure of Oxygen" rebreathing apparatus were oxygen is added only when required in order to maintain a predetermined safe partial pressure and to which an oxy-inert gas diluent is added as required to maintain the ambient pressure and system volume. The closed circuit, sensor-controlled rebreather (such as CDBA) is such an apparatus. Although the breathing circuit and CO_2 removal system of this type of equipment is similar to those found in most rebreathing apparatus, the main differences lie in the methods by which oxygen and diluent gas are admitted into the breathing circuit. A simple diagram describing this type of equipment is at Fig 1-19.

b. Oxygen partial pressure is monitored by specially designed electrochemical cells. In the CDBA equipment, the sensor consists of a sensing electrode, a counter electrode, a housing containing a basic electolyte and a teflon membrane. Oxygen molecules diffuse through the teflon membrane into the sensor where electrochemical reactions at the two electrodes produce an electron flow. This tiny current which is directly proportional to the oxygen level seen by the sensor, passes through a temperature compensating circuit and the resultant voltage signal is then passed to an electronic control unit and a display unit.

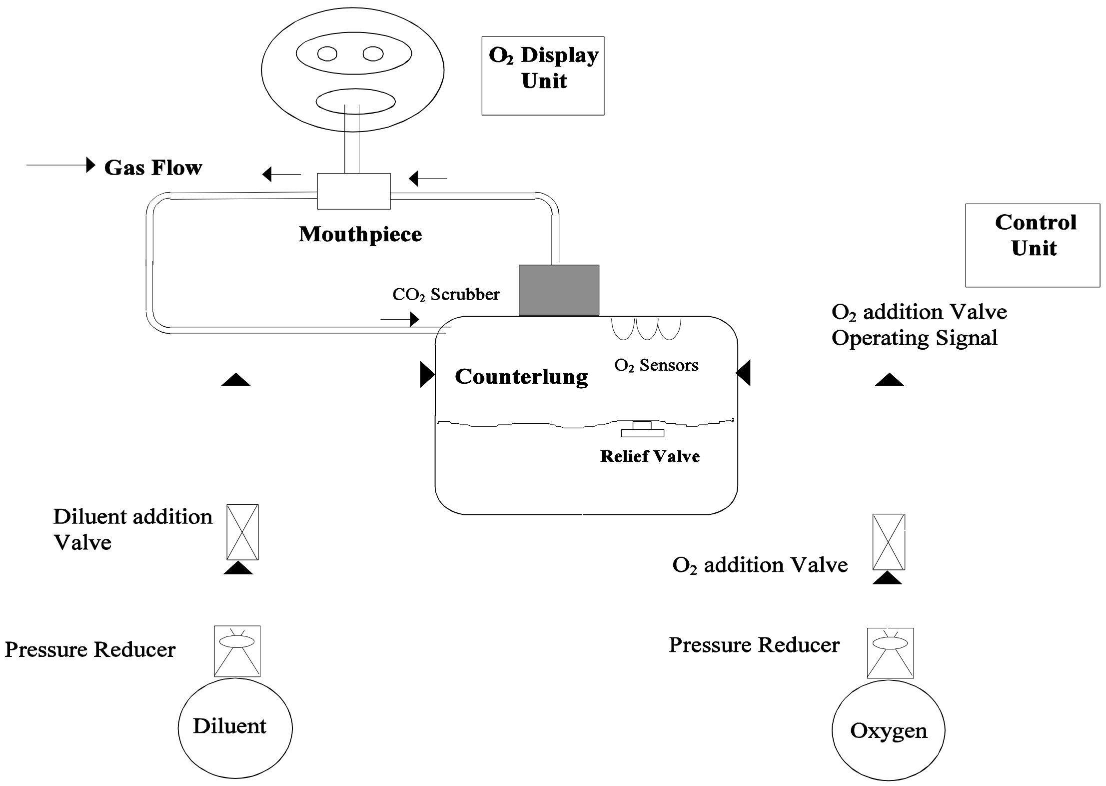


Fig 1-19. Simple Fixed PO_2 Rebreather

c. The Control Unit compares the Sensor outputs against a preset value corresponding to the desired PO_2 and then, if required, operates an O_2 addition valve to add oxygen and if necessary activate an alarm indicating that the O_2 content is outside the preset parameters. To ensure integrity, it is usual to have at least 3 O_2 sensors. Logic circuits ensure that the best signal from two is used for the various control and alarm functions.

d. Diluent (usually oxy-helium or oxy-nitrogen) is added to the breathing circuit as required by a demand valve which comes into operation when the counterlung becomes deflated. As with the previously described rebreathers, a relief valve releases countlung gas in the event of overpressure in the breathing circuit. Although not shown in the above simplified diagram, it is usual to have manually operated by-passes and controls fitted so that the addition of oxygen and diluent can be achieved by the diver should the automatic control unit fail.

e. The major advantages of this type of Equipment is the reduced decompression penalties of low gas consumption. When used in a self-contained mode, dive duration's of up to 6 hours at any depth are easily achievable, provided that the diver has adequate thermal protection and CO_2 absorbent. The development of this type of apparatus has now progress to the point where there are reliable units available in the commercial market, and they are beginning to see some commercial use as well as the obvious military application. The sport market has also shown a great interest in this type of rebreather. As the PO_2 is maintained at a constant value regardless of ambient pressure.

0169. Self-Contained Open-Circuit Breathing Apparatus

a. The principle of these air-breathing systems is outlined in Fig 1-20. Air from the supply cylinder flows through the reducing valve to the inlet of a demand valve, which opens only when the diver demands air by inhaling. When the diver inhales, air from the demand valve passes via an inhale breathing tube and non-return valve in the tube to the mouthpiece. The diver's expired air, containing the carbon dioxide, passes through a second non-return valve and an exhale breathing tube to the surrounding water; thus no special arrangements are required for the removal of the carbon dioxide.

b. **Reducer Flow.** In open circuit equipment the air supply is automatically adjusted for depth by the use of a hydrostatically compensated reducer. As the external pressure increases with depth the reducer automatically provides a corresponding increase in its outlet pressure. This unfortunately results in an increase in the mass flow of air which, while not interfering with the breathing system, is wasteful of air. The pressure of the air supply alters slightly with the position of the reducer in relation to the chest. When the reducer is higher, as when swimming normally, the supply pressure is less than when swimming on the back. In the latter case, since the reducer is deeper than the chest, it is at a higher pressure than the lungs and will supply air at high pressure.

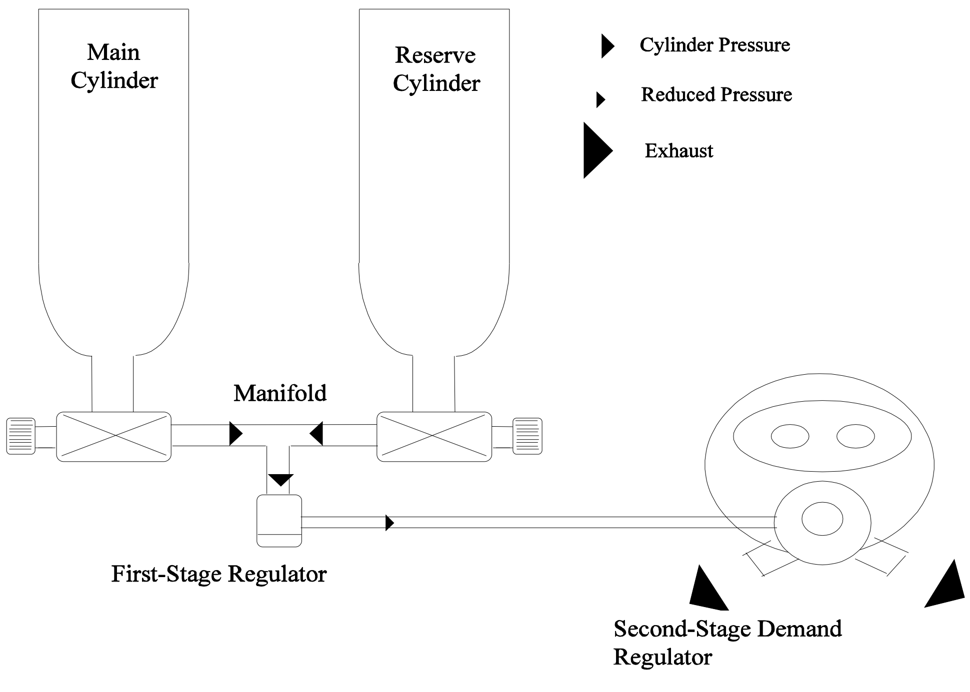


Fig 1-20. Simple Open Circuit Breathing System

c. **Endurance Warning.** The consumption of air is dependent both upon the diver's depth and his work rate; consequently there will be very large variations in the consumption of air, making almost impossible to give any realistic estimate of the endurance of the set. It is necessary, therefore, to introduce some method of warning the diver when he must surface while still having sufficient air to reach the surface and to carry out any decompression stops required. One such technique enables the diver to take his air from only one of the two cylinders, the main cylinder. When the pressure in this cylinder falls to about seven bar breathing becomes difficult. The diver then opens a valve that allows air from a reserve cylinder to pass into the main cylinder until the pressure in the two cylinders has equalised. He then closes the valve and continues his dive, breathing from the recharged main cylinder. When breathing again becomes difficult he carries out a second equalisation, then ascends with sufficient air to reach surface and carry out any stops.

d. While some equipments are fitted with a diver-operated reserve of air, others are fitted only with a pressure gauge from which the diver must estimate the time underwater he has left.

0170. Surface-Supplied Diving

a. Various types of surface-supplied equipments are in use in the Military diving organisations, typically these include:

(1) Kirby Morgan Bandmask Mk 18.

(2) Kirby Morgan Superlite 17B - Diving Helmet.

(3) Aga Divator Positive Pressure System (used in Contaminated Waters)

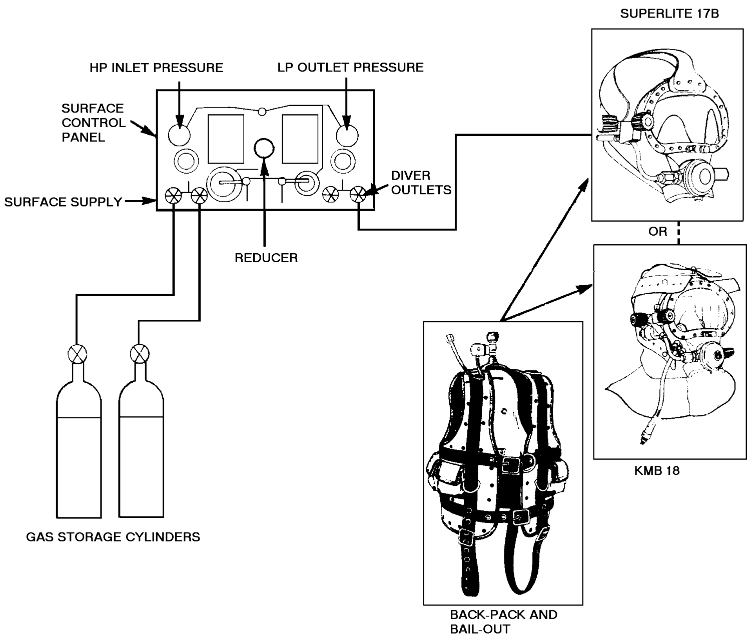


Fig 1-21. Surface Supplied Diving Equipment

b. In surface supplied diving, the diver is supplied with gas through a panel which incorporates a hand wound regulator to reduce the high pressure gas supply to a low pressure, compensated as required, for the depth at which the diver is operating. Gas supply can also be made to the panel from an onboard system using a reservoir supplied via a compressor. Gas supply panels used in service diving are capable of use with either KMB 18 or 17B.

c. An emergency gas supply is carried in a cylinder (bail-out) attached to the diver's harness. This supply is totally independent of that supplied by the panel. Exceptionally two divers can operate from a panel and will wear the same type of diving helmet or mask, however as shown in the Fig 1-21 different combinations can be used providing the operating pressures remain the same.

0171. Kirby Morgan Diving Equipment

a. There are two types of Kirby Morgan Bandmask (KMB) diving equipment used within service diving, the KMB 18, open circuit masks and the 17B, an open circuit helmet. The equipment shown in Fig 1-22 is indicative of KMB 18 and comprises a surface supplied open circuit mask fabricated from non corrosive ABS plastic. The mask seals on the face by an open cell foam face seal incorporated in a neoprene hood. The seal and hood are held on the face by a head harness.

b. The KMB 17B incorporates the same external features of KMB 18 in a hard shell helmet. The helmet is worn over a removable padded internal insert and is clamped down using an integral neoprene neck dam and seat placed on the divers head prior to donning the helmet. The neck dam and helmet are clamped together by a locking band. To prevent accidental separation the locking band is fitted with a safety interlock device.

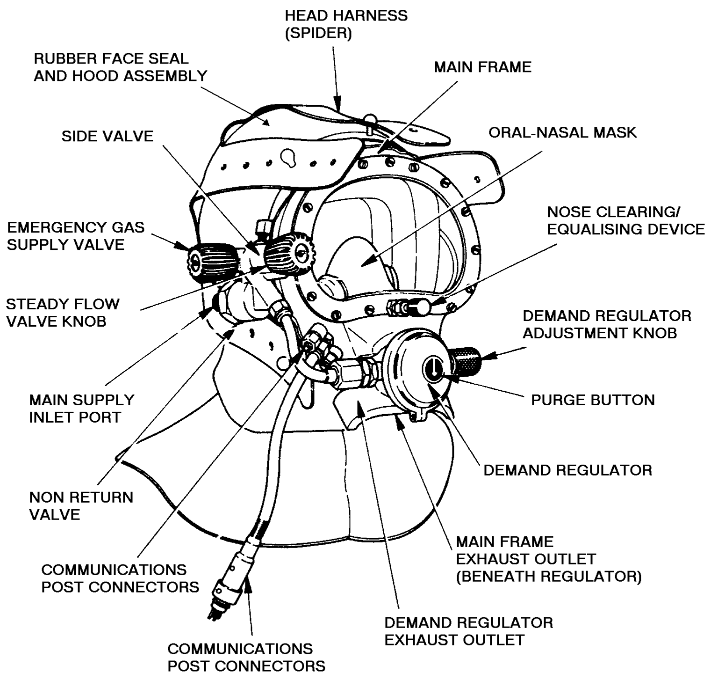


Fig 1-22. Representation of Kirby Morgan Bandmask Configuration

c. The diver receives his gas by hose from a surface control panel. The source of supply can be direct from a ship's supply or storage cylinder. Any service wet or dry suit can be worn.

d. The side block assembly directs the air to the demand regulator and also through the steady flow valve to the interior of the mask. It also incorporates an emergency valve which allows the diver to utilise an emergency gas supply (bail out) carried on the divers back. The demand regulator provides breathing gas upon demand and is adjustable to overcome the ambient pressure.

e. Both the masks and the helmet are fitted with an internal oral nasal mask to reduce dead space and prevent build up of CO_2. A nose clearing device is fitted which allows the diver to block his nostrils and equalise during descent.

f. Communications are achieved by employing transducers located in purpose made pockets within the KMB 18 hood (padded insert KMB 17B) adjacent to the wearers ears. A microphone is located in the oral nasal mask. These are linked via a marsh Marine connector and a wire cable to a communications box located at the dive control site.

0172. Spare

0173. Principles of Reducing Valves

a. The reducing valve is an essential part of all self-contained diving breathing apparatus. It serves to reduce the pressure of HP gas to some required lower pressure.

b. **Types in Use.** The reducing valves in use in the service are of two main types:

(1) A hydrostatically compensated valve used in air-breathing sets, which delivers a large flow of air at a constant pressure above that of the surrounding water. This results in the production of an increased mass flow of air with increased depth and a consequent waste of air.

(2) A non-compensated valve used in pure oxygen and mixture-breathing sets. This valve delivers a constant pre-set pressure of gas to the inlet of an acoustic jet, which ensures a constant mass flow of gas to the diver whatever his depth.

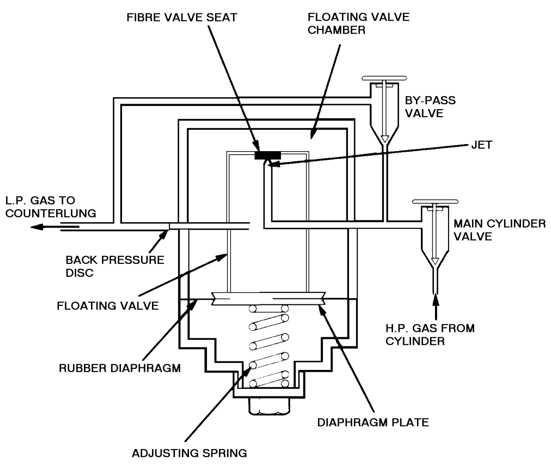


Fig 1-23. Simple Reducer

c. **The Simple Reducer.** All types of reducing valve are based on the operation of a simple reducer shown diagrammatically in Fig 1-23 on the previous page. This valve was originally used in firefighting breathing apparatus and in a modified form (Salvus ANS), in breathing apparatus for divers, charioteers, 'P' Parties, etc, during and just after the Second World War.

d. The floating valve moves within the chamber under the influence of two forces:

(1) The force of the spring tending to lift the fibre washer of the floating valve off its seating. The pressure on this spring is adjustable to alter the rate of flow.

(2) The back pressure of the gas in the floating valve chamber acting on the diaphragm of the floating valve. This back pressure is produced by constricting the flow of gas out of the chamber by means of the back-pressure disc, and forces the fibre washer down onto its seating, thus stopping the flow of gas from the bottles.

e. When operating, therefore, the valve 'floats', allowing gas to pass into the floating-valve chamber and keeping the pressure within it at a reasonably constant low value. By adjusting the tension on the spring, this intermediate pressure may be varied.

f. The flow of gas into the counterlung through the back-pressure disc will be proportional to the difference in pressure across the disc. This leads to the main disadvantage of the uncompensated reducer. As the diver descends, the pressure in the counterlung increases, decreasing the pressure difference across the disc. This decreases the rate of flow and eventually, when the pressure in the counterlung is equal to the pressure in the floating valve chamber, all flow will cease. Therefore, this type of reducer can only be used in shallow water.

g. Reducers for diving apparatus are designed to overcome this fundamental disadvantage. Two main types, as mentioned in sub-para b(1) and (2), have been developed.

h. **The Compensated Servo-Type Reducing Valve.** The principle of this valve is illustrated in Fig 1-24. The valve assembly comprises a large and a small valve. The large valve is a sliding gas-tight fit in its housing and seats in the orifice of the inlet to the reducer outlet chamber. The small spring-loaded valve seats in an orifice through the head of the large valve and its valve stem is held in contact with a valve plate by the valve spring. Two small holes are drilled through the shoulder of the large valve and admit air to the underside of both valves. The area of the orifice in the large valve seat is ten times that of the orifice in the small valve seat.

i. The valve plate is operated upon in one direction by the combined compression of the adjusting spring and the external water pressure, both of which tend to force down on the valve plate and the small valve stem, and in the other direction by the opposing air pressure in the reducer outlet chamber and the combined spring and air pressure under the small valve. The adjusting spring is set to give a certain flow of air at surface against a given back pressure in the outlet chamber.

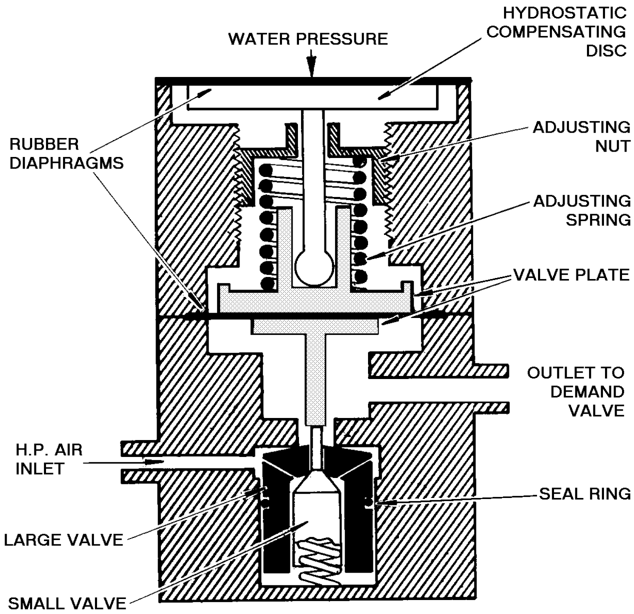


Fig 1-24. Compensated Servo-Type Reducing Valve

j. **Action of the Reducer.** If, while high-pressure air is supplied to the reducer, the combined spring and water pressure is sufficient to move the valve plate against the air pressure in the reducer outlet chamber, the small valve will be unseated and allow the pressure under the valves to escape through the orifice in the top of the large valve into the outlet chamber, causing a drop in pressure under the valves. The HP air on top of the large valve will now open the valve until it seats onto the small valve. This allows an increased flow of air into the outlet chamber to raise the outlet pressure. In the meantime, HP air passes through the two holes in the large valve to restore pressure under the valves.

k. When the pressure in the outlet chamber is sufficient to lift the valve plate against the combined pressures of the adjusting spring and the water, the small and large valves will follow the plate under the influence of the valve spring and the pressure of air under the valves. This will narrow or close the opening through the large valve seat and reduce the supply to the reducer outlet chamber.

l. The movement of the two valves to open is a typical servo movement in that the large valve moves the same amount in the same direction as the small valve. In closing, the two valves move together. Maintenance of the required outlet pressure is effected by the movement of the valve plate controlling the movement of the valves, which, in turn, control the volume of air passing to the reducer outlet chamber.

m. This reducing valve will provide the high air flow for open-circuit breathing, with only a small drop in outlet pressure, eg the reducer will pass a flow in excess of 400 1 pm at an outlet pressure of 3.5 Bar.

0174. Gas Supply Endurance of Diving Breathing Apparatus

a. **Surface-Supplied Apparatus.** For a given amount of work the air needed to ventilate the lungs is always the same at any depth, but, since volume decreases with depth, a greater volume of air must be supplied from the surface to give sufficient at the diver's depth. In these equipments the diver's endurance is governed only by physiological problems, provided the supply of air can be maintained.

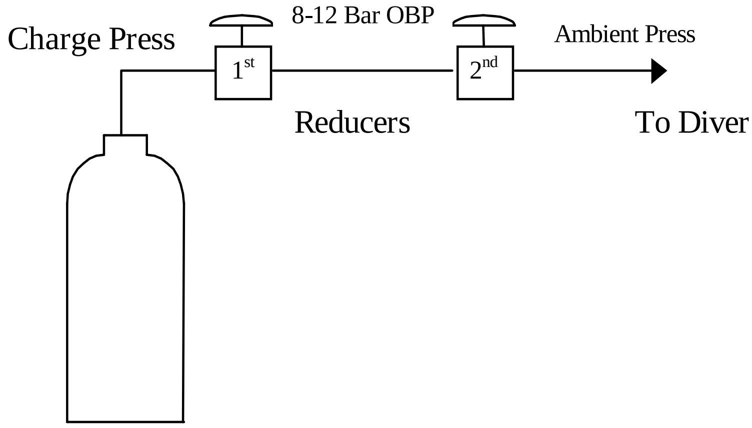
b. **Self-Contained Open Circuit Breathing Apparatus.** The endurance of an air set such as SABA depends on the capacity of the cylinders fitted, number of breaths the diver takes per minute, the volume of each breath and how often the BCA is inflated. These factors vary considerably with individual ability and degree of training, the amount of work being done, depth and temperature of water. An increased work rate, and/or working in cold conditions will result in a greater consumption of air and a resultant decrease in endurance. Depth also decreases endurance since each breath causes a bigger pressure drop in the cylinders than it would nearer the surface. The graph in Fig 1-25 is a rough guide to the endurance of this type of set with 7 litre cylinders fitted (SABA). The gas consumption assumed is higher than the values given in Section 5, para 0139 to provide a safety factor for variation between individuals.

c. **Calculation**. As the endurance is greatly dependant on depth and the divers breathing rate, it is difficult to accurately calculate. Any calculation will only give an approximate answer.

Volume of exhaled gas per minute at Pabs is RMV (Respiratory Minute Volume):

Therefore FSG exhaled per minute = RMV x Pabs (lpm)

<u>Gas Available to Diver</u>



First Stage is normally set between 9 and 12 Bar Over Bottom Pressure (OBP)

Note: *The OBP is a safety factor to ensure adequate air supply is available to the second stage reducer. (The first stage reducer will continue to supply air to ambient pressure regardless of the first stage settings)*

Second Stage reduces gas to ambient Pressure on Demand.

Therefore

Gas avail to diver at any depth = $FV \times (CP - ({}_{OB}P + P_{ambient}))$

Therefore Endurance Formula = $\frac{FV \times (CP - ({}_{OB}P + P_{ambient}))}{RMV \times P_{abs}}$

or Endurance Formula = $\frac{FV \times (CP - RP)}{RMV \times P_{abs}}$

Where Reserve Pressure (RP) is normally 25% of Working Pressure (often 50 Bar).

d. **Self-Contained Oxygen and Mixture Apparatus (Closed Circuit or Semi-Closed Circuit)**

(1) *Oxygen Breathing Set.* Since oxygen consumption does not alter with depth this set is the most economical of all and oxygen is used from it at a rate that depends entirely upon the amount of work done. An efficient swimmer may use less than the 1.5 1pm flow set on the reducer, and some gas will escape from the relief valve. Most divers, however, will use more than 1.5 1pm and will have to use the by-pass valve to supply the extra oxygen.

(2) *Mixture Breathing Set.* This set is nearer in principle to an air set since a mixture of oxygen and nitrogen is breathed, but unlike an air set the gas is collected in a counterlung. Since it would be possible to use up the oxygen in the counterlung and still have enough volume of gas to breathe, the reducer is set to give a flow sufficient to keep the oxygen pressure in the counterlung above 20% of 1 Bar under all conditions of work. The need for this extra flow cuts down the endurance of the set, as some gas containing oxygen is wasted. The greater the maximum safe depth required, the lower proportion of oxygen there must be in the mixture, and endurance, therefore, will depend mainly on the mixture in use - the higher the reducer flow setting the less the endurance.

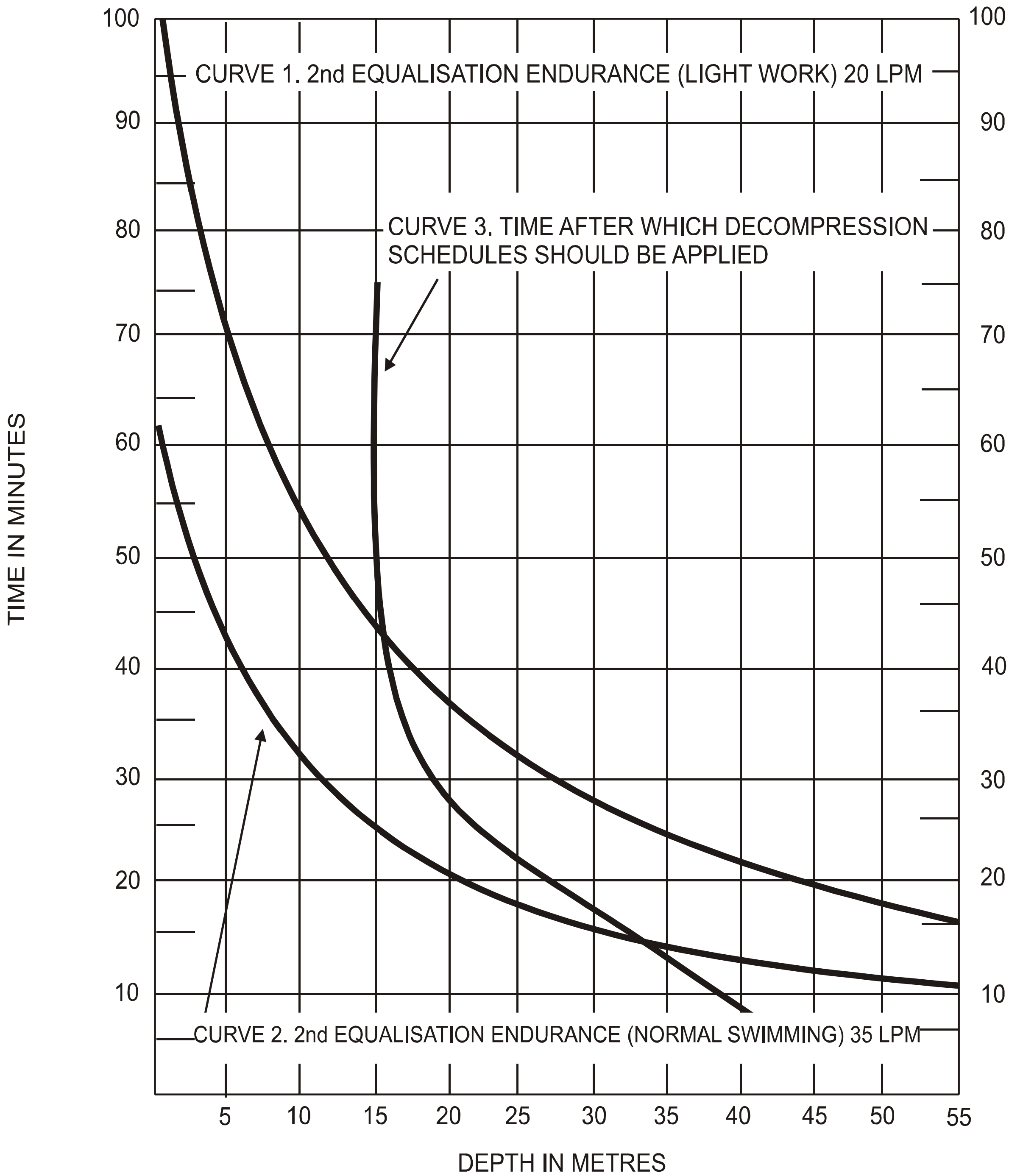


Fig 1-25. Endurance Graph - Self-Contained Open-Circuit Air-Breathing Set

SECTION 9 - THEORY OF MIXTURE BREATHING

0180. Introduction

a. Although self-contained closed-circuit rebreather equipment using pure oxygen is ideal for offensive operations, where the absence of bubbles makes detection difficult, it suffers from the severe depth limitation of 7m except for especially trained personnel (see Chapter 11) since the risks of CNS oxygen toxicity increases with increase of depth and time below this limit.

b. The maximum safe diving depth of any breathing mixture is governed by the point at which the partial pressure of the oxygen in the mixture reaches 2 Bar abs. For air, the maximum safe depth is 90m, not taking into account the effects of nitrogen narcosis. Diving to greater depths is made possible by diluting the pure oxygen with an inert gas such as nitrogen or helium, thus reducing the partial pressure of oxygen and reducing the risk of oxygen poisoning. The gas mixture produced in this way normally has a higher oxygen content than air and has a number of advantages over the use of air at these increased depths although when diving very deep, gases with an Oxygen Content less than air are used. Although it is possible to use these gas mixtures in Open Circuit Breathing Apparatus, it is a most inefficient use of these expensive gases. The Closed and Semi-Closed Rebreathers are well suited to using these mixtures and utilise Fixed Partial Pressure Technology.

c. The principle of operation of this type of diving equipment has been described in the previous section. This section will detail the calculations used to establish the working parameters of the Fixed Partial Pressure Rebreather.

0181. MAXIMUM SAFE DEPTH.

For short duration in water exposures, of any breathing mixture, is governed by the point at which the partial pressure of oxygen in the mixture reaches 2 bar abs. For air, the maximum safe depth is 90 m, not taking into account nitrogen narcosis. For prolonged working exposures in water, the partial pressure of oxygen in the mixture must not exceed 1.6 bar abs.

0182-0184 Spare

0185. Equivalent Air Depth (EAD)

a. When using oxygen-nitrogen mixtures in semi-closed circuit equipment, the percentage of nitrogen in the mixture being breathed is considerably lower than that present in air. In consequence, Henrys Law predicts that the amount of nitrogen absorbed into the divers body tissues at any given depth on a mixture will be considerably less than would be absorbed if he were breathing air at the same depth. The air decompression tables are made out specifically for 79% nitrogen (ie. air). Therefore, if the decompression stops from the air tables are used for O_2/N_2 mixed gas diving, the time spent decompressing will be unnecessarily long.

b. The equivalent air depth of an O_2/N_2 mixed gas dive is defined as the depth at which the partial pressure of nitrogen in compressed air would be the same as the actual partial pressure of nitrogen in the divers breathing loop at the depth of the dive.

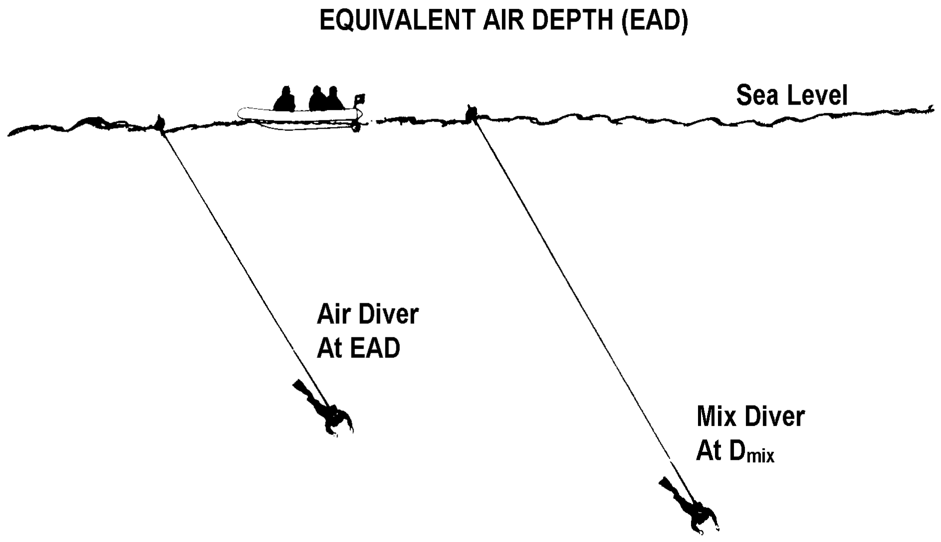


Fig 1-26. Equivalent Air Depth (EAD)

c. Let EAD be the Equivalent Air Depth, and let Dm be the depth absolute on a given gas mixture. Then, the partial pressure of N_2 in air at EAD equals the partial pressure of N_2 in the breathing loop (bl) at depth Dm when diving on the gas mixture.

But the partial pressure of a gas

$$\text{PP (Gas)} = \frac{\text{\% of gas by volume}}{100} \times \text{total pressure}$$

d. Since the pressure at any depth is directly proportional to the depth, it is possible to calculate EAD using depths throughout:

$$\frac{(N_2\text{\% in air})}{100} \times \text{EAD (ABS)} = \frac{(N_2\text{\% in breathing loop})}{100} \times \text{Dm (ABS)}$$

$$\text{Therefore: EAD (ABS)} = \frac{(N_2\text{\% in breathing loop}) \times \text{Dm (ABS)}}{(N_2\text{\% in air})}$$

Therefore:

$$\text{EAD (gauge)} = \frac{(N_2\text{\% in breathing loop} \times \text{Dm (ABS)})}{79} - 10\text{ m}$$

$$\text{EAD} = \frac{\text{\% } N_2 \text{ IN B/L } \times \text{ DEPTH OF DIVE (abs)}}{79} - 10$$

e. Thus, if the percentage of nitrogen in the breathing loop is known, the EAD may be calculated. Decompression stops can then be obtained from the tables for this depth instead of for the actual diving depth.

f. The greatest risk will occur when the percentage of nitrogen in the breathing loop is highest, ie. when the diver is working hardest and using the most oxygen. However, although the diver can use three litres per minute of oxygen for short bursts, it cannot kept up for long periods. Tests have shown that over a period of 30 minutes or more the diver should use no more than an average of 1.3 lpm. The percentage of nitrogen in the breathing loop can be obtained from this, and the EAD calculated. Interim EAD Tables for CDBA can be found in Chapter 12 Table A.

g. As CDBA has a PO_2 of 1.3, which is constantly maintained, irrespective of O_2 used, the percentage of O_2 in the breathing loop can be obtained as we can calculate the percentage of O_2, the N_2 in the loop can be extrapolated.

h. The use of equivalent air depths for calculating decompression stops when diving CDBA with air as the diluent gas yield savings in decompression times on Table 11 - Mod..

Example:

Calculate the EAD for a diver working at 30 m on CDBA with air as the diluent gas with a PO_2 of 1.3 Bar:

a. To calculate the % O_2 within the CDBA breathing loop:

$$= \frac{PO_2 \text{ x } 100}{\text{Bar Abs}} = \frac{1.3 \text{ x } 100}{4} = \mathbf{32.5\%\ O_2}$$

b. Calculate $\%N_2$ in the breathing loop:

$$= 100\% - O_2 \text{ Content} = 100 - 32.5 = \mathbf{67.5\%\ N_2}$$

c. Calculate EAD (Gauge) $= \frac{(\%N_2 \text{ content x msw Abs})}{\%N_2 \text{ in air}} - 10 \text{ msw}$

$$= \frac{(67.5 \text{ x } 40)}{79} - 10 = \frac{(2700)}{79} - 10$$

= (34.17 msw Abs - 10 msw)

= 24.17 msw (Gauge)

d. In practice this means that 27 m would be used as the table depth.

0186. Making Gas Mixtures

a. Under normal circumstances all gas mixtures used in diving are supplied direct from dockyard sources. However, under emergency conditions it may be necessary to make up mixtures, but it must be stressed that it is only in an emergency that home-made mixtures should be used.

b. The standard mixtures may be made by using: air and oxygen; two mixtures; a mixture and oxygen; a mixture and air.

c. Nevertheless, practical consideration will show that if only oxygen is available to mix with other gases, only mixtures richer in oxygen can be made. Conversely, if compressed air is used, mixtures less rich in oxygen can be obtained.

d. **Procedure.** The following procedure should be carried out to ensure the accuracy of the mixture required:

(1) Calculate the pressures required of the available gases that must be mixed to give the desired mixture. The formula used for this calculation will be proved below, but it should be realized that it can be used for any available gases.

(2) Carefully wash out the cylinder in which the mixture is to be made by partially filling it with the mixture of which the greater amount is to be used and releasing it to atmosphere. Avoid the use of cylinders that may have contained toxic gases.

(3) Put into the mixing cylinder more than the required pressure of the gas of which the greater amount is required. Allow the bottle to cool and check the pressure. Bleed off slowly to the correct bar reading.

(4) Put the second gas into the mixing cylinder until the final pressure required is reached; allow to cool. Top up with the second gas until, after cooling, the final pressure is reached. Do not overfill at this stage because bleeding off will reduce the proportion of the first gas in the cylinder.

(5) Thoroughly mix the gases either by leaving for 24 hours to allow mixing by diffusion or by rolling the cylinder for 20 to 30 minutes.

(6) The mixture must be analysed by portable or fixed gas analysis apparatus (for gas-content tolerances see DEFSTAN 68-75/Issue 1).

e. **Calculation of the pressure required to make a given mixture.** It is simpler to consider first the case where a mixture is required to be made either with air and some other mixture or with two mixtures. It is never necessary to use three mixtures.

Let:	% N_2 in the first mixture available	=X
	% N_2 in the second mixture available	=W
	% N_2 in the new mixture required	=Y
	% of 1st mixture required	=Z

Then, % of 2nd mixture required =(100 - Z)

Thus, % N_2 obtained from the 1st mixture present in the final mixture

$$= \frac{X \times Z}{100}$$

and % N_2 obtained from the 2nd mixture present in the final mixture

$$= \frac{W(100 - Z)}{100}$$

The sum of these percentages must be equal to the % N_2 in the new mixture, i.e.

$$\frac{X \times Z}{100} + \frac{W(100 - Z)}{100} = Y$$

$$\therefore \quad XZ + W(100 - Z) = 100Y$$

$$\therefore \quad XZ + 100W - WZ = 100Y$$

$$\therefore \quad XZ - WZ = 100Y - 100W$$

$$\therefore \quad Z(X - W) = 100(Y - W)$$

$$\therefore \quad Z = \frac{100(Y - W)}{(X - W)}$$

∴ Replacing the letters by the terms they represent

$$\text{the \% of lst mixture required} = \frac{100 \times (\%\ N_2 \text{ in new mix} - \%\ N_2 \text{ in 2nd mix})}{(\%\ N_2 \text{ in 1st mix} - \%\ N_2 \text{ in 2nd mix})}$$

∴ Pressure in bar of 1st mixture required:

$$= \frac{\text{Final Pressure} \times (\%\ N_2 \text{ in new mix} - \%\ N_2 \text{ in 2nd mix})}{(\%\ N_2 \text{ in 1st mix} - \%\ N_2 \text{ in 2nd mix})}$$

∴ Pressure in bar of 2nd mixture required

= Final pressure - pressure in bar of 1st mix required.

Notes:

1. To avoid negative quantities the 1st mixture in the calculation should always be the one with the most nitrogen.

2. If oxygen replaces one of the mixtures, it should always be the 2nd mixture.

3. If only oxygen and a mixture are available, only mixtures richer in oxygen can be made. If air and a mixture are available, only mixtures less rich in oxygen can be made.

0187. Summary of Formulae

1.	**EAD (MSW)** $= \frac{\% N_2 \text{ IN B/L} \times \text{DEPTH OF DIVE (abs)}}{79} - 10m$ *Note: When computing % O_2 for equivalent air depth, use 1.3 lpm as oxygen used*
2.	**Endurance** (SABA) $= \frac{FV \times (CP - RP)}{RMV \times P_{abs}}$ *Where Reserve Pressure (RP) is normally 25% of Working Pressure (often 50 Bar).*
3.	**Daltons Law of Partial Pressures (PP gas)** PP gas $= \frac{\%\text{Gas in mix}}{100} \times$ Total pressure of mix (bar abs)
4.	**Charles Gas Law** $= \frac{V_1}{T_1} = \frac{V_2}{T_2}$

0188. CDBA Closed Circuit, Fixed Oxygen, Partial Pressure, Rebreather Endurance

a. Calculating the endurance of CDBA, a Closed Circuit, Fixed Oxygen Partial Pressure rebreather, is relatively simple as the Diluent supply effectively ceases on reaching maximum depth and the average Oxygen usage rates are those detailed at Paragraph 0182.

b. As the CDBA has two dedicated supplies, 16/84 0_2He and Oxygen, calculations for both are required. A Safety Factor (SF) of 100 bar is to be subtracted from each gas contents gauge reading prior to the calculation process.

c. During a diving operation, should a divers Diluent or Oxygen supply drop to 70 Bar, through miss calculation or leakage etc, the dive is to be aborted immediately, the diver proceeding to the XBS or the surface as appropriate or directed by the diving supervisor. In this event the diver may choose/be directed to remain on the primary (closed circuit) breathing system or select the secondary (open circuit) breathing system for decompression stops.

Note. *During normal 'in water' decompression, using the primary breathing system, the CDBA oxygen supply may be taken down to exhaustion.*

d. The endurance calculations, detailed below, do not take into consideration either:

(1) use of by-pass valve, which should be limited due to the nature of the equipment.

(2) Diluent gas oxygen percentage (16% 0_2 in diluent gas) usage during the dive.

Example 1

(1) It is intended to conduct a repetitive dive to 40m on a CDBA. After an initial dive there is 300 Bar of diluent gas and 150 Bar of Oxygen available. (For the sake of this example a different diver is used to negate the requirement for combined dive regulations).

(2) **Diluent**

Maximum depth of dive 40m = 5 Bar Abs

Capacity of CDBA Breathing Loop = 8 Ltr

Gas required for dive:
5(Bar Abs) x 8 (Breathing loop) = 40 Ltr at 1 Bar

$$\text{Gas Required} = \frac{5\ \text{(Bar Abs)} \times 8\ \text{(Breathing loop)}}{2.87\ \text{(sphere capacity)}} = 14\ \text{Bar}$$

14 + 100 (SF) = 114 Bar of diluent required for a dive on Primary System.

(3) *Oxygen*

Oxygen available 150 Bar - 100 Bar SF = 50 Bar

50 x 2.87(sphere capacity) = 143 Litres available for dive

Total dive time from Table B, = 38 min

Oxygen consumption =1.3 LPM

$\therefore$ 0_2 consumption x Total dive Time
1.3 x 38 = 50 Litres

$\frac{50}{2.87}$ = 18 Bar   18 Bar of 0_2 required for dive

Example 2

(1) It is intended to conduct a repetitive dive to 57m on CDBA. After an initial dive there is 250 Bar of diluent gas available and 130 Bar of Oxygen available. (For the sake of this example a different diver is used to negate the requirement for combined dive regulations)

Diluent

Maximum depth of dive 57msw = 6.7 Bar Abs

Capacity of CDBA Breathing Loop = 8 Ltr

Gas required for dive:

6.7(Bar Abs) x 8 (Breathing loop) = 54 Ltr at 1 Bar

$$\text{Gas required} = \frac{6.7 \times 8}{2.87} = 19 \text{ Bar}$$

19 + 100 = 119 bar diluent required for a dive on primary system

Oxygen

Oxygen available 130 Bar - 100 Bar SF = 30 Bar

30 x 2.87 (sphere capacity) = 86 Litres available for dive

Total dive time from Table B, = 23 min
Oxygen consumption = 1.3 LPM

$\therefore$ 0_2 consumption x Total dive Time

1.3 x 23 = 30 Litres

$\frac{30}{2.87}$ = 11 Bar   11 Bar of 0_2 required for dive

CHAPTER 2

DEFINITIONS AND RESPONSIBILITIES

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CHAPTER 2

DEFINITIONS AND RESPONSIBILITIES

SECTION 1 - DEFINITIONS

0201. Definitions Applicable to Diving

Definitions used in these regulations are outlined below.

a. **'In Date' Diver.** A Royal Naval, Royal Marine, Royal Naval Reserve (RNR) Officer, Army or Territorial Army Officer or servicemen, qualified in diving who has both completed a satisfactory annual medical examination, including chest X-ray as required, and dived within the preceding 12 months (for Army see AGAI Vol 2 Chap 72). MCDOs and ratings of the Diver Sub-branch and certain Army divers are to be in possession of a valid FIRST AID CERTIFICATE. Evidence that a diver is 'in date' should be taken from the diver's log.

b. **Standby Diver.** A diver who is 'in date' fully qualified to dive to the maximum depth required in the event of the diver needing assistance, and fully qualified in the equipment being used by the diver.

c. **Qualified Attendant.** An officer, serviceman or civilian, qualified in diving who continuously keeps in hand a lifeline attached to a diver, or who continuously watches a float marking a diver or swimmer.

d. **Unqualified Attendant.** An officer or serviceman not qualified as a diver but fully conversant with the use of diving signals and the handling of a lifeline or breastrope. He continuously keeps in hand a lifeline attached to a diver or continuously watches a float marking a diver or swimmer.

e. **Spare.**

f. **Deep Diving.** Diving to depths greater than 60m.

g. **Attended Diving, Solo.** Diving in any equipment wearing a lifeline or breastrope (or airpipe designed to serve as a lifeline) and attended by an attendant. Boots or fins may be worn.

h. **Attended Diving in Pairs.** Divers using any self-contained breathing apparatus operating in pairs, attached to each other by a buddyline, with one diver wearing a lifeline and attended by an attendant. Fins only may be worn.

i. **Marked Diving.** Diving in any self-contained breathing apparatus wearing a lifeline secured to a float of more than 35 kg buoyancy. Boots or fins may be worn.

j. **Marked Swimming Solo.** Underwater swimming in self-contained breathing apparatus using fins and wearing a safety line secured to a light float at the surface.

k. **Marked Swimming in Pairs.** Underwater swimmers operating in pairs, attached to each other by a buddyline with one swimmer wearing a safety line secured to a light float at the surface.

l. **Free Swimming Solo.** Underwater swimmers operating alone unmarked and unattended and not attached to any other swimmers.

m. **Free Swimming in Pairs.** Underwater swimmers operating in pairs, unmarked and unattended, but attached to each other by a buddyline.

n. **Search Group Swimming.** Two or more underwater swimmers engaged in searching, all of whom are positively attached to the same safety line.

o. **Oxygen-Breathing Apparatus.** A diving apparatus supplying pure oxygen. This would normally employ a re-breathing system.

p. **Mixture-Breathing Apparatus.** A diving apparatus with any gases other than pure oxygen or air for its main supply.

q. **Compressed Air Breathing Apparatus.** A diving apparatus with air for its main supply.

r. **Spare.**

s. **Self-Contained Breathing Apparatus.** Any diving apparatus in which the main supply of gas is carried in high-pressure cylinders by the diver himself.

t. **Closed-Circuit Breathing Apparatus.** A self-contained re-breathing apparatus in which gas is not exhaled to the ambient environment.

u. **Semi-Closed-Circuit Breathing Apparatus.** A self-contained re-breathing apparatus in which some gas is vented to the ambient environment.

v. **Open-Circuit Breathing Apparatus.** A self-contained breathing apparatus in which gas is exhaled directly to the ambient environment and is not re-breathed.

w. **Built-In Breathing System (BIBS).** A system built in to a submarine or compression chamber for providing breathing gas through a number of mouthpieces by means of the open-circuit breathing principle.

x. **Booted Diver.** Any diver who is wearing boots instead of fins.

y. **Surface Supplied Diving Equipment.** A surface-supplied apparatus with a built-in emergency supply (bail-out) carried by the diver.

z. **Minehunting Diving.** The operation of divers as part of a minehunting system.

aa. **Vehicle-Escape System Air.** A diving apparatus used to escape from submerged vehicles. Air carried in high-pressure cylinders in the vehicle is its main supply, and a built-in emergency supply is carried by the wearer.

bb. **Army Diving Supervisor.** Will be either an Officer or an NCO of the rank of corporal or above who has passed the Army Diving Supervisors course at the DDS and is ‘in date’.

cc. **Unit Diving Supervisor.** Will be either an officer or senior NCO who has passed the Unit Diving Supervisors course at the DDS and is ‘in date’.

dd. **Army Diving Instructor.** An ‘in date’ supervisor who fills an instructional appointment at the DDS.

ee. **Spare.**

ff. **Surface Swimmer.** A diver or unqualified attendant familiar with surface swimming using an underwater swim suit and without breathing apparatus.

gg. **Combat Swimmer.** Any MCDO, Diver, RNR Diver, SBS or SBSSC who has received training in combat oxygen diving. RN divers to whom this applies must be in a unit possessing a pure oxygen capability (see BR 5063).

hh. **A Dive**. For the purpose of these regulations a person ‘dives’ if:

(1) He enters:

(a) Water or any other liquid.

(b) A chamber in which he is subject to pressure greater than 100 millibars above atmospheric pressure.

(2) In order to survive in such an environment he breathes in air or other gas at a pressure greater than atmospheric pressure.

0202. Definitions Applicable to Decompression

Definitions applicable to decompression are outlined below.

a. **Stop.** A calculated pause at a specific depth in the diver’s ascent to allow the dispersion of excess inert gases (nitrogen, helium) absorbed by the body.

b. **Decompression.** A decrease of pressure so regulated as to enable a diver to surface without contracting decompression illness.

c. **Air Decompression.** Decompression carried out in the water by a diver breathing air or an oxy-nitrogen gas mixture.

d. **Surface Decompression.** Decompression carried out in a compression chamber on the surface by a diver who has ascended without any or limited stops in the water to be recompressed in the compression chamber.

e. **Submersible Chamber Decompression.** Decompression carried out in a chamber which the diver has entered underwater and from which the diver may later be transferred under pressure to a compression chamber on the surface.

f. **Therapeutic Recompression.** The recompression of a diver suffering from decompression illness or arterial gas embolism and his subsequent decompression.

g. **Equivalent Air Depth.** The depth of water at which the partial pressure of nitrogen in air is the same as the partial pressure of nitrogen in the lungs of a diver breathing oxy-nitrogen mixture at the depth of the dive.

h. **Saturation Diving.** After a diver has been exposed to a pressure of gas for a certain period, the gas absorbed into his tissues reaches a state of equilibrium with the gas he is breathing and he is said to be 'saturated' for that pressure; from then on further time spent at the same depth no longer increases the time required for decompression. This principle, when applied, is termed 'saturation diving'.

i. **Transfer Time.** Time from leaving Seabed in water stop to arriving at chamber bottom must not exceed 5 minutes.

j. **Duration of Dive.** Time interval from leaving surface to leaving bottom.

k. **Total Time.** Time from leaving surface to arriving surface.

0203. Abbreviations

AAD	Army Advanced Diver
ABJ	Adjustable Buoyancy Jacket
ACAD	Army Compressed-air Diver
ACBS	Atmosphere Control Breathing System
ADI	Army Diving Instructor
ADS	Army Diving Supervisor
AGAI	Army General Administrative Instructions
APA	Annual Personal Assessment
BASAR	Breathing Apparatus Search and Rescue
BCA	Bouyancy Control Apparatus
BCV	Buoyancy Control Valve
BIBS	Built-in Breathing System (Compression Chamber)
BODS	Bail-out Diving Set
BU	Breathing Unit
CABA	Compressed-air Breathing Apparatus
CCBS	Closed Circuit Breathing System
CDBA	Clearance Diving Breathing Apparatus
CDE	Clearance Diving Element
CDRE MFP	Commodore Minewarfare and Patrol Vessels, Diving and Fishery Protection
CDRS	Chamber data Recording System
CDU	Clearance Diving Unit
CFM	Captain Fleet Maintenance
CNS	Central Nervous System

CO_2	Carbon Dioxide
CO SBS	Commanding Officer Special Boat Service
CPO(D)	Chief Petty Officer Diver
D	Diver
DABJ	Divers Adjustable Buoyancy Jacket
DCBA	Damage-control Breathing Apparatus
DCI	Decompression Illness
DDS	Defence Diving School
DMM	Dual Mode Mask
DMT	Diver Medical Technician
DOWR	Diving Operations At Work Regulations 1981
DPFT	Diver's Physical Fitness Test
DRS	Diver Recall Signal
DSM	Dual System Mask
DSWE	Director Ships Weapon Engineering
DUCS	Diver's Underwater Communications System
EAD	Equivalent Air Depth
EBV	Emergency Blow Off Valve
EOD	Explosive Ordnance Disposal
EOR	Explosive Ordnance Reconnaissance
ESDS	Enclosed Space Diving System
EXRE	Exit and Re-entry (Submarines)
FDG	Fleet Diving Group
FDS	Fleet Diving Squadron
FDU	Fleet Diving Unit
HBA	Habitat Breathing Equipment
HDLJ	Hazardous Duty Life Jacket
He	Helium
He/O_2	Helium & Oxygen
ID(A)	Inspector of Diving (Army)
IEDD	Improvised Explosive Device Disposal
INM	Institute of Naval Medicine
IRPCS	International Regulations for Preventing Collisions at Sea
LS(D)	Leading Seaman Diver
LEBA (MG)	Long Endurance Breathing Apparatus (Mixed Gas)
LEBA (O_2)	Long Endurance Breathing Apparatus (Oxygen)
LOSE	Light Oxygen Swimmers Equipment
MACA	Military Aid To Civil Authorities
MCDO	Minewarfare and Clearance Diving Officer
MCM	Mine Counter Measures
MHC	Mine Hunter Coastal
MOD	Ministry of Defence
MSD	Maximum Safe Depth
MSO(D)	Marine Services Officer (Diving)
MTM	Made to Measure Suits (Wet/Dry)
NDG	Northern Diving Group
NDU	Northern Diving Unit
N_2	Nitrogen
NMA	Naval Manning Authority
O_2	Oxygen

OC	Officer Commanding
OCSETT	Officer in Charge Submarine Escape Training Tank
PO(D)	Petty Officer Diver
PWO	Principal Warfare Officer
RABA	Re-chargeable Air Breathing Apparatus
RMSBSO	Royal Marines Special Boat Service Officer
RMSC	Royal Marines Swimmer-canoeist
RMSC1	Royal Marines Swimmer-canoeist First Class
RNTT	Royal Naval Treatment Table
SABA	Swimmer Air Breathing Apparatus
SAR	SEARCH AND RESCUE
SARD	Search and Rescue Diver
SARDLJ	Search and Rescue Diver's Life-jacket
SARDO	Search and Rescue Diver Officer
SASD	Special Air Service Diver
SASDS	Special Air Service Diving Supervisor
SBD	Special Boat Detachment
SBS	Special Boat Service
SBSSC	Special Boat Service Swimmer Canoeist
SBSSC1	Special Boat Service Swimmer Canoeist 1st Class
SBSO	Special Boar Service Officer
SCC	Submersible Compression Chamber
SDG	Southern Diving Group
SDU	Southern Diving Unit
SSDE	Surface-Supplied Diving Equipment
SETT	Submarine-escape Training Tank
SF	Special Forces
SFLJ	Special Forces Life Jacket
ShD	Ship's Diver
ShDO	Ship's Diver Officer
ShDS	Ship's Diver Supervisor
SDO(A)	Senior Diving Officer (Army)
S of D	Superintendent of Diving
SSDE	Surface Supplied Diving Equipment
ST	Selection Test
STASS	Short Term Air Supply System
TUP	Transfer Under Pressure
UDS	Unit Diving Supervisor (Army Only)
XBS	External Breathing System

0204. Spare.

SECTION 2 - DIVING RESPONSIBILITIES

0205. Command

Commanding officers of ships, Diving Groups and service equivalents are responsible for providing a safe diving environment for all diving operations, inclusive of Civilian Contractors, within their areas of Command. Authority for the detailed administration of diving matters and the conduct of diving operations may be delegated to subordinate officers, but such delegation shall in no way relieve them, (CO's and OC's) of overall responsibility for the safety, well being and efficiency of diving personnel under their command.

0206. Diving Officer

a. The officer selected by the Commanding Officer to be the Diving Officer is to be an 'in date' diving officer chosen according to availability and degree of qualification as shown in the following order of preference:

(1) **Navy:**

Minewarfare and Clearance Diving Officer
Warrant Officer (Diver)
Ship's Diver Officer
Warrant Officer Ship's Diver

Where no officer qualified in diving is borne, the most suitable officer normally the PWO(U) is to be detailed as Diving Officer.

(2) **Royal Marines:**

SBS Officer
RM Ship's Diver Officer

(3) **Army:**

Army Diving Supervisor (Officer)
Unit Diving Supervisor (Officer)

(4) **Special Boat Service**:

SBS Officer

Where no officer qualified in diving is on strength, a commissioned officer may be detailed by the Commanding Officer. He may not supervise diving except as authorised by para 0723.

b. The Diving Officer is responsible to the Commanding Officer for:

(1) The efficiency of all diving personnel, ensuring that the necessary training and practices are carried out.

(2) The full and accurate recording of all diving by each diver.

(3) The detailed organisation and preparation of all diving operations, including the proper briefing and instruction of the diving supervisor.

(4) The preparation and tests of diving equipment in accordance with current technical instructions and regulations, ensuring that maintenance, including that which is the responsibility of the MEO, is up to date. The MEO is responsible for the maintenance preparation and tests of diving equipment requiring the employment of a skilled technical senior rating.

(5) The upkeep of diving equipment stores and spare gear to the allowances given in the relevant schedules.

(6) The employment of the Diving Yeoman/Storeman.

c. He is to inspect the diving logs of all newly joined divers to verify their qualifications, medical fitness and experience. He is to inspect them regularly thereafter and ensure they are presented to the Captain or commanding officer for signature when required. He is to hold all Diving History Sheets for his divers (not Ship's Divers, see para 0407).

d. He is to ensure that no member of his diving organisation is set an underwater task outside the diver's ability to perform.

e. He is to make himself fully conversant with the contents of BR 2806 UK Military Diving Manual Volumes 1 and 2, appropriate equipment handbooks, and with all Defence Council Instructions, AGAIs (Army only), and all other orders affecting diving matters.

f. He is to provide advice to the command whenever it is necessary to employ civilian diving contractors for diving operations.

g. He is to ensure that the organisation for dealing with a diving casualty is exercised regularly.

h. He is always to inform the commanding officer before any diving operation commences.

i. SBS officers are not to be employed as the diving officer in Royal Navy ships or establishments unless qualified as a Ship's Diver officer. They may be employed as Unit Diving Officer in Royal Marines establishments. When SBSSCs are borne in RN ships or establishments the conduct of their diving is to be co-ordinated with the diving officer of the RN ship or establishment.

j. Army diving officers are not to be employed as the diving officer in Royal Navy ships or establishments unless qualified as a Ship's Diver officer, conversely RN and RM Diving Officers may not be employed as the Diving Officer for Army units unless qualified as a UDS.

0207. Principal Warfare Officer

The PWO is qualified to advise on the operational aspects of diving and clearance diving, but is not necessarily qualified to dive. If he is an RN lieutenant or above he may be detailed as diving officer as authorised by para 0206a, but can be made responsible for the personal supervision of a diving operation only if he is an 'in date', MCDO or Ship's Diver officer, or in exceptional circumstances under the terms of para 0723.

0208. Diving Supervisor

a. The diving supervisor is to be detailed for each particular task and is to be in full charge of the diving team for that task. He must be continuously at the scene of the task and must not enter the water. (See para 0723)

b. The supervisor must be one of the diving officers, ratings or NCOs authorised by para 0721, with the exception that unqualified supervision is permitted under the circumstances described in para 0723.

c. The dive supervisor is to be an 'in-date' diver. A supervisor who is temporarily unfit for diving may supervise provided that he is 'in-date' in all other respects.

d. A dive supervisor who is no longer 'in-date' will follow the instructions detailed below:

(1) If Fit to Dive - will not supervise until retrained in accordance with para 0313. (for Army para 0314)

(2) If Permanently Medically Unfit - supervisory status may be retained subject to review in accordance with para 0212c. (RN only)

e. All cases of doubt are to be referred to the S of D. (See Para 0211)

f. The diving supervisor is to ensure that he is fully conversant with the objectives and requirements of any task and with any special orders affecting the conduct of the task. He is responsible for ensuring:

(1) The safety of all members of his diving team. This is his primary responsibility.

(2) That at least the minimum permitted number of attendants and standby divers as laid down in para 0703 are present at the site during the whole of the task.

(3) That each member of his team is fully instructed in the task and fully understands any special orders affecting the conduct of his duties.

(4) That each member of the team is capable of carrying out the task allocated to him.

(5) That an accurate record of every dive under his supervision is kept.

(6) That when berthed adjacent to other vessels, notwithstanding that permission to dive has been obtained in accordance with the local regulations, it is confirmed that the Duty Officers of those vessels are aware that diving is to take place, and that they certify that no action will take place that could endanger the divers (e.g. basin trial) during the relevant period. (See also para 0904).

(7) That he has at least two Diver Recall Signals available to surface his divers in emergency (see para 0967).

(8) Strict compliance with BR 2806 UK Military Diving Manual.

(9) That each diver required to enter the water is ‘in-date’.

g. Dive supervisors may supervise other categories of divers to the limit of their supervisory qualification or that of the divers qualification, whichever is the lesser of the two, (ie a Ship’s Diving supervisor may supervise a Diver 2 on Ship’s diving tasks to a maximum of 21 metres using SABA.

h. Ships’ Diving Supervisors who are in operational billets and ‘in date’ for diving may claim Ships Diving Supervisors pay providing that they have supervised at least one dive during the period for which the claim is being made.

0209. Divers of all Categories

a. Every diver is to maintain a high standard of efficiency and fitness so that he is able to carry out his duty successfully and safely at short notice. MCD Officers, ratings of the Diver sub-branch, RNR Divers and certain Army divers, are to be in possession of a valid HSE Diving First Aid Certificate.

b. The diver is to ensure that he keeps ‘in date’ both medically and for diving, and that an up-to-date record is kept in his diving log. If he is not ‘in date’ either medically or for diving he is NOT to dive and the matter is to be reported to the diving officer, who will arrange for the necessary remedial action.

c. If a diver becomes unwell he is to report to the medical officer and inform the diving officer, and is not to dive until confirmed as fit to do so. There is nothing praiseworthy in attempting to dive while unfit or unwell. At best the diver risks only his life; at worst he also jeopardises the lives of others sent to his assistance.

0210. Responsibilities for Divers on Loan

When a diver from one ship, establishment or unit is lent to another, the borrower is to make it quite clear to the lender what tasks the diver is required to perform, and is fully responsible for the safety of the diver during the period he is employed in the diving task. The lender is responsible for the diver being in all respects qualified to carry out the task for which he is being borrowed, and for any equipment the diver takes with him being in efficient working order. For records see para 0409.

0211. Conduct of Service Diving Operations

a. The Superintendent of Diving (S of D) is the higher authority for Service diving and equipment including Army and SF except for diving equipment and procedures exclusive to SDO(A). S of D leads in all aspects of diving related to Health and Safety measures. This authority is exercised on behalf of the Ministry of Defence S of D being the focal point for contact with the Director Defence Health and Safety and the Health and Safety Executive.

b. Senior Diving Officer (Army). SDO(A) is responsible to MOD(A) for all aspects of the conduct of Army diving including safety.

0212. Permanent Unfitness for Diving

a. If a diver becomes permanently unfit for diving, either medically or temperamentally, his diving qualification must be removed. The Head of Diving and Hyperbaric Medicine, Institute of Naval Medicine, is to be informed of all divers assessed as permanently medically unfit to dive.

b. The Superintendent of Diving, Commanding Officers, and Officers Commanding are authorised to remove the diving qualification from an officer or serviceman who is considered unsuitable. Where there is doubt about the professional expertise of an MCDO, Diver sub-branch rating, RNR Diver, ships or SAR diver rating, either after a diving incident or as a result of his day to day duties, advice is to be sought from the SofD. The individual case will be scrutinised by the S of D who may recommend formal investigation (see para 0213 below), removal of the diving qualification, or a period of retraining. The removal of a diving qualification is to be reported as follows:

(1) MCDO - to MOD/DNOA(X) with a copy to S of D.

(2) Diver sub-branch - as detailed in para 0412/0413.

(3) SBSO/SBSSC - to CO SBS.

(4) Army Divers - Unit Administration Office with a copy to SDO(A). (See AGA1 Chapter 72.)

(5) Ship's Diving Officers - to MOD/DNOA with a copy to S of D

(6 Ship's Diving Supervisors/Ship's Divers to: NMA, Centurion Building, Grange Rd, Gosport PO13 9XA, with a copy to S of D.

(7) RNR (Diver) - as detailed in paras 0412 and 0413.

c. **Diving Supervisors.** An officer, senior rate or rating qualified to supervise diving who becomes permanently medically unfit may, for 6 months, retain his supervisory status at the discretion of his Commanding Officer as advised by Superintendent of Diving.

d. After this 6 month period has elapsed, then at annual intervals, the supervisory status is to be reviewed as follows:

(1) MCDOs and Divers (including RNR Divers) of the rate of Petty Officer or above by S of D Diving Inspectorate or nominated OC Diving Group.

(2) SBSOs and SBSSC ranks by CO SBS.

(3) UDS and ADS personnel by SDO(A).

e. The reviewing officer will determine whether supervisory status should be retained and will inform the individual's Commanding Officer or Officer Commanding as required. An entry is to be made in the individual's diving log to record the decision.

f. The supervisory status of ShDO and ShDS will lapse after the initial 6-month period.

g. Action to record the removal of supervisory qualification should be taken as laid down in para 0412.

0213. Unsafe Diving Supervision Practices

If during the course of a diving operation observed practices are considered unsafe, the dive is to be stopped and an investigation instigated. The following guidance is provided.

a. Advice and information in the first instance is to be sought from Commodore Minewarfare and Patrol Vessels Diving and Fishery Protection, (CDRE MFP)(S of D). If an investigation is carried out, the investigative team must contain at least one MCDO/WO(D) or a CPO(D) to give specialist advice.

b. The investigative team are to consider all the facts of the matter with due care. In making recommendations to the Commanding Officer the team are to consider whether removal of supervisory and diving qualifications is appropriate.

c. Cdre MFP and Commanding Officers are authorised to remove diving and supervisor qualifications from an officer or serviceman who is considered to be deficient in these areas.

d. Any diving supervisor participating, although not supervising, in a dive in which unsafe practices are employed may have his supervisory/diving qualification removed.

e. Application for diving supervision retraining can be made after a period of one year.

f. Authorities as detailed in para 0212 are to be informed if a supervisor/diving qualification is to be removed.

g. Action to record the decision should be taken as laid down in para 0412. (For Army see AGA1 Chapter 72.)

0214. Diving Yeoman/Storeman

a. A diving yeoman/storeman must be allocated from the ship's company to work under the direction of the Diving Officer. The function of a diving yeoman/storeman in the smooth running of ship's diving operations should not be underestimated. Whenever possible the diving yeoman/storeman should be a qualified ship's diver, however if this is not possible, any suitably trained person (preferably an operator mechanic) can be detailed off. If the diving yeoman is not a qualified ship's diver then he/she should be fully briefed by the Diving Officer as regards the duties and requirements of this job. Emphasis is to be placed on diver safety and safe handling of equipment and stores. A non ship's diver employed in this role is to be encouraged to train as a diver attendant and integrate fully into diving team operations. For Army Unit diving teams the storeman should be a qualified AAD. If no suitable AAD is available the nominated storeman will need to attend specialist diving stores training at DDS.

b. Whenever possible, the Diving Officer must ensure that adequate time is allocated to the yeoman/storeman to prepare and provide equipment for diving operations (see sub-para c below)

c. It is recommended that a minimum of 12 hours a week be allocated to the Diving Yeoman/Storeman to enable him to complete the tasks described in the following paragraphs. When diving operations are planned a further two hours must be allocated prior to diving to enable provision of diving and diving support equipments and a further two hours post operations to ensure it is correctly and safely stowed.

d. The diving yeoman/storeman is responsible to the Diving Officer for:

(1) The provision of properly functioning equipment for all diving operations.

(2) The cleanliness of diving stores, equipment and stowages, ensuring that all diving equipment is washed in fresh water after diving operations, stowed correctly and properly secured for sea.

(3) Assisting the Diving Maintainer with maintenance and ensuring that all diving sets are operational.

(4) The maintenance of adequate stocks of diving equipment in accordance with current ‘E Lists’.

(5) Provision of correctly maintained and operational ‘Swimmer of the Watch’ equipment to the Chief Bosuns Mate prior to leaving harbour.

(6) Receiving back into his care the equipment in (5) above, on entering harbour.

e. The diving yeoman/storeman is to be present during all diving operations.

f. Additional tasks outside those described above may be required, dependent on the diving operation and at the discretion of the Diving Officer.

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CHAPTER 3

SELECTION OF DIVERS, TRAINING AND MEDICAL REGULATIONS

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CHAPTER 3

SELECTION OF DIVERS, TRAINING AND MEDICAL REGULATIONS

SECTION 1 - CATEGORIES OF DIVER AND SELECTION REQUIREMENTS

0301. General Requirements

a. A continuing requirement exists for divers, but great care must be given to the selection and recommendation of suitable candidates, who must be over 18 years of age before taking an aptitude test or starting a diving course.

b. Because divers spend much of their time on their own, they must have a strong sense of responsibility and be reliable and intelligent. They must also be of good physique and physically fit. It cannot be over-emphasised that the candidate's character must be suitable before he is given one of the aptitude tests outlined in paras 0304 to 0307.

c. These tests are designed to prove the candidate's aptitude underwater; the results are taken into account, together with the candidate's character as shown in the written recommendation/report, when assessing whether he should be accepted for course. In no way do they relieve the RN Divisional Officer or the Army Officer Commanding of the responsibility for making recommendations appropriate to the man's character.

d. Before undergoing an aptitude test each candidate is first to be examined by a medical officer, who is to satisfy himself that the man is medically fit to undergo such a test (para 0327). Criteria for divers in accordance with **BR 1750(A)** are to be applied.

e. All aptitude tests are considered as diving training and are to be conducted with the full surface support team, unless dispensation has been obtained to do otherwise.

0302. Categories of Diving Officer

There are 6 categories of diving officer as described below:

a. **Minewarfare and Clearance Diving Officer.** The outlet for Diver to commissioned rank is to the Special Duties (SD) List. He must be a LS(D) or above. Seaman officers of the General List, Special Duties List and Supplementary List are eligible to qualify for MCDO, subject to successful completion of the aptitude test (para 0304).

b. **Warrant Officer (Diver).** Any CPO(D) who is educationally qualified may be selected for WO(D)

c. **Ship's Diver Officer.**

(1) Any Officer, Subordinate Officer, or Warrant Officer is eligible to apply to qualify as a Ship's Diver Officer. Subject to successful completion of the Selection test (para 0305) he may be placed on course.

The course includes instruction in diving supervision and if successfully completed qualifies an officer, and a subordinate officer, to supervise diving operations in accordance with para 0721.

(2) A qualified and 'in date' Ship's Diver Supervisor promoted to Officer or Warrant Officer automatically qualifies as a Ship's Diver Officer on promotion.

(3) An Officer previously qualified as a Ship's Diver while serving as a rating, may undertake supervisor training to qualify as a Ship's Diver Officer.

d. **Royal Marines.** Special Boat Service Officers are trained as assault swimmers on oxygen, mixture, and compressed air breathing apparatus and in free-swimming techniques within the requirements of the Special Boat Service. They also plan and conduct training and operations in these techniques.

e. **Army Diving Supervisor (Officer).** Officers of the Royal Engineers are eligible to apply to qualify as Army diving supervisors. These officers are qualified to supervise all Army diving in accordance with para 0721.

f. **Unit Diving Supervisor (Officer).** Officers of the Royal Engineers and certain other arms are eligible to apply to qualify as unit diving supervisors. These officers are qualified to supervise Army diving in accordance with para 0721.

0303. Categories of Diver

a. There are 12 main categories of diver:

(1) Diver.

(2) Ship's diver.

(3) Ship's diver supervisor.

(4) Search and Rescue Diver.

(5) Special Boat Service Swimmer-Canoeist.

(6) RNR Diver

(7) Army Diving Supervisor.

(8) Army Advanced Diver.

(9) Army Compressed-air Diver.

(10) Unit Diving Supervisor.

b. Full details of qualifications and conditions of service for RN divers are contained in **BR 1066**, Advancement Regulations, and in current DCIs (RN) which must always be consulted. Any additional information required, such as particulars of syllabi, can be obtained from the Commanding Officer, Defence Diving School. General details are given below.

c. **Diver.** This is a full Warfare sub-branch formed from the earlier Clearance Diving Branch. The abbreviation used to denote the Diver qualification is (D). The Diver dives in all types of Service diving equipment and his training includes Explosive Ordnance Disposal.

(1) The Diver qualification is open to ratings of all branches including the other Seaman sub-branches, current regulations regarding transfer should be consulted. There is also an avenue for Direct Entry Divers.

(2) The aptitude test described in para 0306 must be satisfactorily completed before application is made for the Diver course.

(3) Potential Divers may be recommended during their Ship's Diver course and may subsequently be allowed to transfer to the Diver sub-branch. They may also be recommended by their Commanding Officers to carry out the Diver Aptitude Test at any time after qualifying as Ship's Divers. Manning Clearance to transfer to the Diving Branch must be sought at an early stage from the appropriate desk offices in NMA GOSPORT.

d. **Ship's Diver.** All officers and ratings are eligible to apply to qualify as Ship's Diver. Royal Marines serving, or about to serve, in billets where they can be employed as Ship's Divers are also eligible. The selection test described in para 0305 must be satisfactorily completed before application is made for the course.

e. **Ship's Diver Supervisor**

(1) Ratings of the substantive rate of Petty Officer and above (and Royal Marines equivalent rank) on Ship's Diver course who display the potential for supervisor training, may be given the opportunity to qualify as a Ships Diver Supervisor, subject to the limitation of two supervisors per Ships' Diver course. Officers and Senior ratings who fail to achieve the standard as a supervisor, yet meet the required standard as a Ship's Diver will qualify as a Ships' Divers only.

(2) Where there are suitable senior ratings on a Ship's Diver course but insufficient capacity to provide supervisor training, Commanding Officers will be advised of the recommendation for further and subsequent training.

(3) Ratings of the substantive rate of Petty Officer and above (Royal Marines equivalent rank) who are recommended by their Commanding Officers as 'in date' and competent Ship's Divers, potentially capable of supervising diving operations will be considered eligible for additional training to qualify as Ship's Diver Supervisors.

f. **Courses.** Courses for Ship's Diver Officer/Ship's Diver/Ship's Diver Supervisor are promulgated by annual DCI(RN). Applications for courses are to be made by letter or signal to The Commanding Officer, Defence Diving School in the following format:

(1) Number of Ship's Divers currently borne. (To specify ShDO, ShDS and ShD strengths and include any temporarily medically unfit divers etc).

(2) Expected strength and composition of ship's diving team in six months' time (excluding those accepted for courses).

(3) The number of personnel already accepted for course (stating type).

(4) The ERD of present applicants and details of next draft (e.g. AB(S) BROWN 10/90 COLLINGWOOD).

(5) Number of personnel passed the Aptitude Test (AT) and awaiting course (not included in para c.(3)).

(6) Number of personnel now requiring AT and dates available. Date individual(s) passed Physical Fitness Assessment (DPFT).

(7) Date and type of course now being requested.

(8) Amplifying remarks (eg: ship commences BOST October 99).

(9) In addition, the length of time the candidate has left to serve in the ship is to be indicated. Candidates should have at least a year to serve at sea after qualifying and candidates from shore establishments should expect to serve at sea within one year from qualifying.

Notes:

1. The Training Planning Office at the Defence Diving School, Horsea Island, (Ext. 4011) holds up-to-date details of course vacancies.

2. When a course is fully subscribed, alternative courses will be offered and a waiting list kept in case of cancellations. If a candidate is unable to attend, the Training Planning Office Ext. 4011, at the Defence Diving School is to be informed immediately.

g. **Conditions of Acceptance of ShDO/ShD.**

(1) Candidates are to be examined in accordance with **BR 1750(A)** and current DCIs. Medical documents and a certificate of medical fitness to dive are to be forwarded to the CO DDS to arrive not later than one week before the course starts. A candidate will be removed from course if his medical documents do not arrive. On arrival at the DDS the candidate will be required to produce his Selection Test pass certificate and proof of having completed the DPFT fitness test as required by para 0308. Outline joining instructions for Ship's Diver courses are contained in DCIs and are amplified by letter to individual candidates.

(2) Qualified Ship Divers attending for Ship's Diver Supervisor training are to be conversant with BR 2806 and bring with them their diving log.

h. **Search and Rescue Diver.** Search and Rescue Divers are qualified aircrewmen. Selection is made from aircrewmen who have passed a SMAC 108 and SMAC 111 course. They must be a Ship's Diver with a minimum of 500 minutes of open water dives since qualifying.

i. **Special Boat Service Swimmer-Canoeist.** Swimmer-canoeists are trained as assault swimmers on oxygen, mixture and compressed-air breathing apparatus and in free swimming within the requirements of the Royal Marines Special Boat Service.

j. **RNR Diver** A fully career trained ex-RN Diver rating who has joined the RNR.

k. **Army Diving Supervisor.** Army diving supervisors are selected Army advanced divers of the rank of corporal or above, recommended by their Commanding Officer, who have qualified on a supervisors course at the DDS. Their training qualifies them to supervise diving operations in accordance with para 0721.

l. **Army Advanced Diver.** Army advanced divers are experienced Royal Engineers Army compressed-air divers, recommended by their Commanding Officer, who have successfully completed an Army Advanced Diving course at the DDS.

m. **Army Compressed-air Diver.** All officers and soldiers of the Royal Engineers and certain other Arms are eligible to qualify as Army Compressed-air Divers after training at the DDS.

n. **Unit Diving Supervisor.** Officers, WOs and SNCOs of the Royal Engineers and certain other arms are eligible to qualify as Unit Diving Supervisors. These Officers, WOs and SNCOs may supervise Army diving in accordance with para 0721 when qualified.

0304. MCDO Candidate - Conditions for Selection and Aptitude Test

a. Officers wishing to be selected for sub specialisation as a Clearance Diver are to undertake a Ships Diving Officers (ShDO) course. During the course candidates potential for MCDO will be continually assessed and reported upon. They must also complete the following:

(1) Interview by the Long Course Officer or Diving Training Officer (N)

(2) The Divers Physical Fitness Test (DPFT) instead of the Ships Divers Physical Fitness Test.

(3) Recommended for through training by the Course Officer.

b. It is a requirement for all students attending the Long Minewarfare and Clearance Diving Officers (LMCDO) Course to pass the DPFT prior to commencing diving. In view of the time lapse between ShDO Course and commencement of the LMCDO training , Commanding Officers are to ensure that Junior Officer are both medically fit for diving and can achieve the minimum standard for the DPFT prior to recommendation. This will help to reduce the number of students removed from course at an early stage and thereby reduce training wastage.

0305. Ship's Diver Candidate - Selection Test

a. The Selection Test (ST) is to be carried out by all candidates for ShDO/ShD courses in accordance with paras 0302, 0303 and 0308 (2.4 Km IFT). It is valid for one year. Training documentation produced by the Defence Diving School, Course Design Office is to be held by all testing units.

b. Applications for the ST are to be made direct to the testing units shown in para 0303, normally by telephone. Applications made by signal are to use the SIC LOB and the format given in para 0303f. At least one month's notice should be given.

c. The ST is conducted by Testing Units as follows:

(1) Portsmouth - By the Defence Diving School at the continuation training facility Horsea Island (Tuesdays and Thursdays). Applications to The Training Planning Office - telephone extension 4006 or 4011.

(2) Plymouth - By SDU 1 at the Diving Centre, HM Naval Base, Devonport (Tuesdays). Applications direct - telephone extension 65386.

(3) Faslane - By NDG (NDU 1 or 2) at the Diving Centre, Clyde Naval Base, Faslane (Thursdays). Applications direct - telephone extension 3309.

(4) Gibraltar - By Gibraltar CDE at the Diving Centre HM Naval Base Gibraltar. Applications by signal to HQBF Gibraltar.

(5) RNAS Culdrose - By SAR Diving School at RNAS Culdrose. Applications direct - telephone extension 2384.

STs are conducted throughout the year except during leave periods.

d. The selection test comprises:

(1) A fitness test.

(2) An interview.

(3) An explanation of the course and requirements of a Ship's Diver.

(4) A jump from 7m in a diving suit.

(5) A dry equipment run.

(6) Flooded face mask procedure (above water).

(7) Flooded face mask procedure (below water).

(8) Initial attended dives of not less than 30 minutes duration to a maximum depth of 9m.

e. Before undergoing the ST candidates are to be examined by a medical officer in their own ship, establishment or unit in accordance with **BR 1750(A)**. Results are to be recorded on Form F.Med 143. This examination is to include a full plate chest X-ray and a dental examination. The ST is not to take place without evidence of medical fitness to dive. Candidates failing the DPFT may be allowed to continue with the diving.

f. Candidates who have been accepted for ST should report to the nominated testing unit at 0840 in the case of Portsmouth, and at 0830 for the other testing units.

g. On successful completion of the ST a pass certificate will be issued, and the candidate's name will be added to the list of successful candidates held by the Training Planning Office at the Defence Diving School. A separate application for course is to be made in accordance with para 0303.

0306. Diver Candidate - Aptitude Test

a. Aptitude tests for the Diver sub-branch (Seaman Diver) are conducted at the Defence Diving School and last for one week. Dates of aptitude tests are available from the Diving Planning Office at the school and will be published by signal from time to time. Application is to be made by letter to The Commanding Officer, Defence Diving School. Preference will be given to qualified Ship's Divers but the holding of this qualification is not mandatory. Applications for test are to be made in accordance with **BR 1066** for candidates who wish to transfer from their present branches.

b. The aptitude test comprises:

(1) An explanation of the content of the test.

(2) A medical check.

(3) A mathematics test (and signals test for ShDs).

(4) A rules, regulations and signals test.

(5) Introduction to the equipment to be used.

(6) A compression chamber dive.

(7) Jumping into the water from 7m and surface swimming in UWSS.

(8) Stamina tests.

(9) Emergency Drills.

(10) Dives by day and night.

0307. Army Diver Candidate - Aptitude Test

a. The aptitude test is to be carried out by all potential Army divers. It is valid for two years.

b. The test is to be conducted at the DDS or at other units by the I of D(A) staff, as directed by SDO(A).

c. Candidates are to be examined by a medical officer before undergoing the aptitude test and results recorded on Form F.Med 143. This examination is to be carried out in accordance with AGAI Vol 2 Chapter 66.

d. The aptitude test comprises:

(1) An explanation of the course, and the role of an Army diver.

(2) Lectures in physics and physiology.

(3) A compression chamber dive to not less than 10m.

(4) Jumping into the water from 7m and surface swimming in a dry suit.

(5) A physical training/stamina test.

(6) Flooded face mask procedure (below water).

(7) A working dive using simple hand tools.

(8) A nil visibility dive.

0308. Diver's Physical Fitness Test (DPFT)

a. All divers must maintain a high standard of physical fitness. The following paragraphs describe the Diver's Physical Fitness Test (DPFT). This test is used to assess a diver's fitness and also ensures that the diver maintains an above average physical fitness level. Details of the fitness tests and an assessment proforma is at Annexes 3A.

b. It is stressed that the DPFT is the **minimum** fitness standard required. All divers are advised to train to a standard whereby they are able to do the DPFT comfortably.

c. **Aptitudes and Diving Training**

(1) RN personnel undergoing Ships Diver, SAR Diver, Diver 2 and LMCDO Aptitude tests will be required to pass the DPFT during the aptitude. Failure may result in the student failing the aptitude. However, a candidate may continue the diving phase if, in the judgement of the examining officer, the reason for the failure is a minor shortcoming and would not endanger the individual or diving companion during the aptitude. Candidates passing the diving phase are to retake and pass the DPFT prior to arrival at the Defence Diving School for formal Ships Diver training.

Note. *The examination of an individual's fitness to conduct the aptitude and subsequent training must contain an element of subjective assessment with regard to the potential of meeting the requirement with further fitness training.*

(2) Students attending all RN Diving Courses at the Defence Diving School will carry out a DPFT during week one of their course.

(3) For all initial diving courses (Ships Diver, SAR Diver and Diver 2) failure of the DPFT will result in a re-test after 7 days. Failure of the re-test will result in the student being removed from course and returned to unit (RTU).

(4) Students attending the LMCDO, PO(D) and LS(D) Professional Qualifying (PQ) courses are required to pass the DFPT on arrival, failure will result in removal from course.

(5) All RN and RM personnel attending DDS Diving Training Courses are required to be Med Cat P2 on arrival.

d. **Inspections**. All diving teams must be prepared to demonstrate their fitness during inspections.

0309. Spare.

SECTION 2 - TRAINING REGULATIONS

0310. Direction of Diving Training

a. Training of diving candidates for initial or higher qualification is to be carried out to approved syllabi under the direction of training officers as shown in Table 3-1.

b. Training Officers may delegate the supervision of diving training to a PO(D) or above, or a Royal Marines Swimmer-Canoeist 1st Class or a SAS diver supervisor, or a Submarine Escape Training Instructor qualified in Exit and Re-entry diving, or an Army Diving Instructor as appropriate.

c. The term 'Diving Training' includes the conduct of all forms of diving aptitude test, whether at or away from a diving school.

Table 3-1. Direction of Diving Training (Para 0310)

TRAINEE	TRAINING OFFICER
MCDO, Diver, RNR Diver Ship's Diver Officer, Ship's Diver Supervisor, Ship's Diver	Commanding Officer, Defence Diving School
SARD	SARDO at the Aircrewman's School
Army Compressed Air Diver, Army Advanced Diver, Army Diving Supervisor, Unit Diving Supervisor.	Commanding Officer, Defence Diving School
SBS Officer, SBS Swimmer-Canoeists	SBS Training Officer, RM Poole
Submarine-Escape Trainee, Exit and Re-entry trainee, Note 1	OCSETT or deputies

Note. *SETT staff to be trained in Exit and Re-entry must be in-date Ship's Divers.*

0311. Conduct of Diving Training

It is essential that diving training is carried out safely and without exposing trainees to unnecessary hazards. All relevant regulations from this Chapter and Chapter 7 are to be strictly observed during diving training.

0312. Lapse of Diving Qualification (Navy and RM)

If an RN Diving Officer, SBSO, Diver, RNR Diver, Ship's Diver or SBS fails to carry out any form of service diving for a period of 12 months, their diving qualification is deemed to have lapsed. If he wishes to resume diving he must be re-trained before he does so, see para 0313.

0313. Re-Training Lapsed Divers (Navy and RM)

a. Candidates for retraining are to be medically examined, as required by para 0328, and given a practical test at the Defence Diving School, or locally by an MCDO nominated by S of D's Diving Inspectorate. SBS officer appointed by COSBS.

b. During the test the candidate is to:

(1) Carry out flooded facemask routine, emergency surfacing drill and companion diver drill, wearing self-contained breathing apparatus.

(2) Show a thorough knowledge of diving signals and regulations.

(3) Complete an endurance dive in self-contained equipment.

(4) Complete the DPFT supervised by a member of the PT staff.

c. On completion of the test, the testing officer will recommend how much refresher training is required. If no refresher training is deemed necessary by the testing officer, the diver's qualification may be renewed subject to consultation with the Diving Inspectorate. The results of all re-assessments are to be forwarded either by letter to the Commanding Officer Defence Diving School, or by signal to DEFDIVSCH PORTSMOUTH.

d. Refresher training for Ship's Diver supervisors will normally be arranged to coincide with weeks 2 and 3 of a Ship's Diver course. Application should be made to the Commanding Officer, Defence Diving School for one of the courses listed in DCIs(JS).

e. Courses for the remainder will be arranged as necessary but will normally include weeks 1, 2 and 3. For Divers, RNR Divers and Ship's Divers, application should be made to the Commanding Officer, Defence Diving School, and for SBSSC's to the Commanding Officer, SBS Royal Marines, Poole.

f. Notification of re-qualification will be made to MOD (Directorate of Naval Officers' Appointments), the NMA, Centurion Building, HQRM or HQ DSF as appropriate. An entry is also made in the divers log.

g. The lapsed diver re-assessment will only be valid for one year from the date of the assessment.

0314. Lapse of Diving Qualification and Re-Training (Army)

When more than 8 months has elapsed since the last recorded dive the diver automatically loses his qualification. The individual may requalify at any time up to the 12 calendar month point by passing an APA. If more than 12 calendar months has elapsed since the individual last dived then advice on re-qualification should be sought from SDO(A).

0315-0316. Spare.

0317. Ship's Diver and Ship's Diver Supervisor Promoted to Officer

A Ship's Diver promoted to Officer or Warrant Officer cannot become a Ship's Diver Officer until he has successfully completed the Ship's Diver Supervisors course module. A Ship's Diver Supervisor automatically becomes a Ship's Diver Officer on promotion to Officer or Warrant Officer (see also para 0721).

0318. Diver First Aid Course

a. MCD Officers, ratings of the Diver sub-branch and RNR divers must not take part in any diving operation as a supervisor or diver unless a valid Diver First Aid Certificate, or an equivalent or higher level of medical qualification is held.

b. Throughout the training term Diver First Aid Courses, as approved by the HSE, will be run by the Defence Diving School. Successful completion of the course will result in the award of a Diver First Aid Certificate. If for service reasons a diver is unable to complete a Defence Diving School First Aid Course, an alternative commercial course may be acceptable. Approval to attend commercial training is to be sought from S of D prior to formal course application by an individual. S of D will assess the suitability of commercial courses, on an individual basis, in consultation with INM.

c. The certificate will be valid for a period of three years after which it will be renewed on successful completion of refresher training.

d. Diver First Aid Training Courses will be promulgated annually by DCI(RN) and Signal.

0319. Issue of Made to Measure (MTM) Diving Suits

a. On successful completion of the appropriate qualifying course, MCDOs, Divers, SBSSC's and Army Divers (DDS only) are entitled to be issued with MTM diving suits "dry and wet" type. SAR divers are entitled to a MTM 'wet' type only.

b. Full issue instructions for these suits are contained within **BR 96 Article 01123**. The issue of these diving suits is to be recorded in Kit record Book/Clothing Record Book (S.2910/AFB 1157).

c. MTM dry suits and wet suits may be exchanged after three years. Demands for such replacements are to be accompanied by a certificate signed by an MCDO/WO(D) for Divers, an SBS officer for SBSSC's, Unit QM for Army Divers' or the appropriate diving officer for SAR Divers, stating that the item to be replaced is unserviceable through fair wear and tear. If replacement of an item is required within three years of issue, the circumstances should be stated. Full issue and demand instructions can be found in **BR 96 Article 01123**.

d. Wet suits **are not** issued to Ship's Divers. Neoprene dry suits are not issued to Ship's Divers or Army Divers except under special conditions as approved by S of D or SDO(A).

e. (1) Army divers on the strength of the DDS are entitled to the issue of made-to-measure diving suits 'wet-type' and made-to-measure 'dry' suits.

(2) Army Drivers on the field strengths of the following units are entitled to the issue made to measure diving suits "dry only" type.

17 Port and Maritime Regt RLC
25 Engr Regt
33 Engr Regt (EOD) and
59 Indep Cdo Sqn RE

Note. *Control of issue of MTM Suits is through ID(A).*

(3) The following units are entitled to the issue of diving suits 'wet-type' in standard sizes:

62 (Cyprus) Support Sqn RE.

0320. Issue of Vest, Diver

a. On successful completion of an initial diving course all divers of any qualification (other than Army divers) are to be issued with a Vest, Diver, Nylon lined, zip-fronted type.

b. Issue of the Vest, Diver is to be recorded in Form S.2910 - Kit Record Book for RN and RM personnel.

c. Vests, Diver may be exchanged when unserviceable and demands for exchange are to be accompanied by a certificate signed by the Diving Officer of the ship or establishment clearly stating the item has been surveyed and is unserviceable through fair wear and tear. If replacement is required within a period of two years the reasons are to be clearly stated.

0321-0325. Spare.

SECTION 3 - MEDICAL REGULATIONS

0326. General

a. A high standard of fitness is required for all types of diving. Diving officers are to take an interest in the physical and mental health of their divers and keep in close touch with the medical officer. Divers, for their part, should always report colds or catarrh. It is better to stand off diving for a few days than risk being unfit for weeks, or even permanently. **BR 1750(A)**, Handbook of Naval Medical Standards, is the standard authority for Naval divers. For Army divers medical standards are laid down in **AGAI Vol 2 Chapter 66**. The appropriate publication must always be consulted.

b. Selected extracts of the regulations are included in the subsequent articles for information.

0327. Initial Medical Examinations

a. Before carrying out any diving aptitude or selection test all diving candidates are to have a preliminary medical examination in accordance with **BR 1750(A)** or **AGAI Vol 2 Chapter 66** as appropriate. The examination is to be performed by the medical officer of the Ship, Establishment or Unit responsible for routine medical care. Where doubt exists as to his fitness to dive, the candidate's medical documents should be referred, by the examining medical officer, to the Head of Undersea Medicine Institute of Naval Medicine. This is the final authority for fitness to dive.

b. Candidates for career diver training are required to have Long Bone Surveys at the time of initial qualification as a career diver in accordance with **BR 1750(A)**. The result of this examination is to be recorded in the diver's medical documents and in the Diver's Log.

c. The medical documents of personnel selected for diving course are to be forwarded to the DDS to arrive one week before the course is due to start. If this is not possible it is permissible for candidates to deliver their documents to the POMA at DDS on arrival. Failure of documents to arrive will entail postponement of, or removal from, course.

d. A final review and re-examination will be conducted at DDS before the course begins. On completion of the diving course, divers logs (S.1627) will be completed by medical staff with details of the examining unit and the name of the medical officer who conducted the examination. This entry is to be supported by an official unit stamp.

e. The medical documents of personnel selected for SAR Diver courses are to be forwarded to the PMO RNAS CULDROSE prior to the commencement of the course. A final review of medical documents and re-examination will be conducted at RNAS CULDROSE before the course begins.

0328. Annual Medical Examinations

a. All divers are to have an annual medical examination in accordance with **BR 1750(A)** or **AGAI Vol 2 Chapter 66** as appropriate, and a chest X-ray at the initial diving medical, thereafter as clinically indicated. It is the responsibility of individuals to see that they are 'in date' for annual examinations.

b. Where any doubt exists as to whether the diver continues to be fit to dive the case must be referred for opinion to the Medical Officer in Charge at INM for final decision.

c. Additional investigations are also required as part of the annual diving medical examination, depending on the category of the diver being examined. These tests include audiometry, vitalograph and if required or clinically indicated X-rays. If owing to sea or detached service, the additional investigations listed in **BR 1750(A)** cannot be performed, a diver may continue his diving duties if he is otherwise fit to do so. Diving may continue for a maximum of four weeks after the expiry date of his last medical. For Army divers see **AGAI Vol 2 Chapter 66**.

d. Career and RNR divers are required to have Long Bone Surveys at the intervals specified in **BR 1750(A)**.

e. In addition to the details which are recorded on the medical examination form the results of examinations are to be recorded in the Diver's Log, together with dates of chest, long bone and joint X-rays.

f. The examining medical officer will make an entry in the log book stating the fitness of the diver. Any restrictions that he may impose must be clearly indicated in the log book and explained to the diver. The name and establishment of the medical officer is to be entered. This entry is to be supported by an official unit stamp. A correct entry in the Divers Log is evidence of fitness to dive.

0329. Recommendations for Advancement of RN Divers

Divers qualified for higher rate must be 'in date' for the annual medical examinations given in para 0328 before being advanced.

0330-0335. Spare.

0336. Temporary Unfitness for Diving

a. The diver himself may decide that he is fit to resume diving after a minor illness provided that it lasts no more than five days, was not diving related and did not require medical advice or treatment. In all other cases a medical officers decision must be sought prior to the resumption of diving.

b. **Decompression Illness.** A period off diving is required after therapeutic treatment for decompression illness as laid down in para 1385d.

c. Any diver sustaining a decompression illness must be medically examined before resuming diving even though therapy appears to have been successful.

d. Any diver found, or suspected of, abusing a controlled substance is to be made temporary unfit to dive pending disciplinary action. Upon completion of disciplinary action the diver is to be referred to the Senior Medical Officer, Diving Medicine at the Institute of Naval Medicine for decision as to their continued fitness to dive.

0337. Aseptic Bone Necrosis

Details of any restrictions on diving by men who have aseptic bone necrosis are contained in **BR 1750(A)**.

0338. Permanent Unfitness for Diving

If a diver becomes permanently unfit for diving for any reason, the administrative measures laid down in para 0212 are to be followed.

ANNEX A TO CHAPTER 3

DIVER'S PHYSICAL FITNESS TEST (DPFT)

1. **Introduction**. The main aim of the DPFT is to ensure that all divers are physically capable of carrying out all of the operational duties expected of them in the Fleet. Table 3A-1 shows the activities undertaken and standards to be reached by individuals undertaking the test.

2. **Fitness Standard.** RN Divers are expected to maintain an above average standard of physical fitness and as such, this test can be used as a personal fitness yardstick.

3. **Conduct of the Test**. The DPFT should be conducted by a Physical Training Instructor (PTI).

a. **Constraints**. An exercise warm-up must always be completed immediately before starting the test.

b. **Criteria.** When the candidate has reached the pass criteria for each part of the test, then that part of the test is considered complete.

c. **Standard.** Candidates must pass all test activities and achieve the target times or number of repetitions required to obtain a pass.

4. **Allowance and Weighting**. The DPFT is job related and therefore, no allowance or weighting has been made for either gender or age.

Table 3A-1 Tests and Standards

Test Activity	Target Time or No of Reps to be completed	Elapsed Time	Remarks
2.4 km (1.5 miles) warm-up jog	15 minutes	15 minutes	Normally conducted as part of a squad
2.4 km run	10.5 minutes (Army 9.5 minutes)	25.5 minutes (Army 24.5 minutes)	Best personal speed
Recovery/preparation	2.5 minutes (Army 2 minutes)	28 minutes (Army 26.5 minutes)	Max of 2.5 minutes recovery time before next stage of DPFT
Recovery			As required
Heaves (Chin-ups)	8 4 ShD	N/A	Stop when criteria reached
Flat bench trunk curls	40 reps in one minute 30 ShD	N/A	Stop when criteria reached
Dips	16 8 ShD	N/A	Stop when criteria reached

5. Detailed Description of Tests

> **WARNING**
>
> **ALWAYS INCLUDE A WARM-UP PRIOR TO EXERCISE.**

a. **2.4 km (1.5 mile) Run**

(1) **Aim**. To test cardio-respiratory efficiency (stamina). This ensures that the diver has the physical fitness required to swim against a tidal stream over an extended period.

(2) **Method**. Warm-up run of 2.4 km in 15 minutes (may be conducted as a group). This is followed by a further 2.4 km personal best effort.

(3) **Failure**. Time taken for best effort run, is greater than 10.5 minutes. (9.5 for Army personnel).

b. **Heaves (Chin-ups)**

(1) **Aim.** To test shoulder (pull) strength. This assesses the divers ability to remove himself from the water unaided, or to remove equipment or an injured diver from the water.

(2) **Method**. Grip a secure fixed horizontal bar with arms fully extended and feet clear of the floor. Under grasp method must be used. Bend the arms and raise the body until the bottom of the chin is level with the top of the horizontal bar. Lower down to full arm extension. Repeat the exercise. Assisted heaves using swinging method will not be counted.

(3) **Failure**. Less than 8 heaves. ShD 4 heaves.

c **Flat Bench Trunk Curls**

(1) **Aim**. To measure trunk strength/endurance. Tests ability to lift objects from the water and as an indicator of overall fitness and stamina.

(2) **Method**. On a flat bench, curl the trunk up and forward until the upper body is vertical and then return in a controlled manner to the start position, where the shoulder blades must touch the bench. The feet should be secured at the upper end of the bench. The hands must touch the back of the head at all times during the exercise and a slight bend at the knees is permitted.

(3) **Failure**. Less than 40 trunk curls, ShD 30 trunk curls, completed in one minute.

d **Dips**

(1) **Aim**. To measure arm and shoulder (push) strength. Tests ability of diver to lift injured divers or diving equipment from the water.

(2) **Method**. Start with a straight arm position on parallel bars or any two secure hand grips mounted above waist level and shoulder width apart. With the body supported in the vertical position and the feet clear of the ground, lower the body to achieve at least a right angle between the upper arm and forearm. Return to the start position by straightening the arms. Repeat the exercise.

(3) **Failure**. Less than 16 dips. ShD 8 dips.

CHAPTER 4

RECORDS AND PAY

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SECTION 1 - RECORDS

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CHAPTER 4

RECORDS AND PAY

SECTION 1 - RECORDS

0401. Record of Diving

a. A complete record of all dives, including compression chamber dives, is to be kept in the diving record book Form S.288/AB576(A) for Army Divers. If conditions make this impracticable Form S.1628A (**Diving Supervisors Cards**) may be used, alternatively MCDOs and PO(D)s and above of the diver sub-branch, and RNR supervisors of equivalent rank/rate may use **BR 5063(SUPP)** Diving Supervisors Aide Memoire. Records formed using the cards or supplement must be transferred later to Form S.288 or AB576(A) as applicable. If there is insufficient space in the Form S.288 to keep a full record, a larger record book should be used, and the salient points transferred to Form S.288. If stops are necessary the diving supervisor is to keep the record.

b. The record is to contain full details of all events connected with the dive. Everything must be written down as it occurs and all times must be taken from the same clock or watch.

c. For record purposes the start and finish of a dive are to be considered as:

(1) *Start:* The time the diver leaves the surface (LS).

(2) *Finish:* The time the diver arrives at the surface (AS). During surface decompression this is to be taken as the time of emerging from the compression chamber and not the time of initially arriving at the surface. (Time spent in the compression chamber does not count towards SSP(D)).

d. No entry in the record book is ever to be erased. Erroneous entries are to be crossed out with a single line and initialled by the supervisor.

e. The supervisor is to ensure that he has an accurate watch for use in controlling and recording the dive.

f. When carrying out dives in a compression chamber:

(1) A narrative record is to be maintained to include all orders and reports when carrying out therapeutic recompression.

(2) Form S288/AB576(A) is to contain a transcription of the decompression stops given.

g. Forms S288/AB576(A) are to be used until all pages are completed. If for any reason this is not done any unused pages/sections are to be cancelled in such a way as to prevent fraudulent entries.

h. The cover of each form S288 should be annotated with the ship/unit and a local sequential serial number. The date of the first entry, and when completed, the date of the final entry.

i. Forms S288/AB576(A) are official documents subject to audit. They are to be retained for a period of at least 2 years from the date of the last entry and may then be destroyed.

j. **SAR Divers.** The S288 is to be completed by the Captain of the Aircraft whenever SAR Divers are deployed. This S288 is to be inspected by the diving officer on the occasions listed in para 0421b.

0402. Master Dive Record

a. The **BR 2806 (Record)** an official musterable document, enables ships or units to compile a master dive record for all diving related activities carried out. Section 8 of this book contains Dive Record Sheets essential for recording diving data. These forms are to be filled in and disposed of as directed in the Instructions for Use on page viii of the book. Where required information entered is to be a direct reflection of that entered in Form S288 for the dive(s). The diving supervisor is responsible for the accuracy of the data inserted.

b. **BR 2806 (Record)** is to be inspected quarterly by the Commanding Officer or Officer Commanding for Clearance Diving Groups and monthly by the Div O. This may be delegated to Officers-in-Charge of subordinate Clearance Diving Units.

0403-0405. Spare.

0406. Diver's Log Form S1627/Army Book 576

a. A Diver's Log is issued to every diver as his personal log. It is to be completed and kept up to date in accordance with the instructions contained in the log. It is to be signed on completion of each days diving, with the supervisors printed name and ship/establishment annotated. Blank pages are not permissible and gaps between entries are to be ruled through.

b. When a diver leaves the Service his log should be given to him with his other Service documents. If he becomes permanently unfit for diving, it should be marked as in para 0412 before it is given to him.

c. For naval divers the log is to be inspected and signed by the diving officer when a diver first joins, thereafter on the occasions laid down in para 0421b, and on leaving the ship or unit.

d. All divers are to ensure that the log contains the diver's name, personal number, a photograph which is a good likeness of him, and his signature.

e. For naval divers using old format logs, all entries in the 'Details of Diving Operations' column are to conform to the format detailed below. Each item of information is to start on a new line and may be identified in the log by sub-para number.

(1) Ship/unit of diver.

(2) Location of diver and name of ship/unit (if appropriate).

(3) S288 location and serial number.

(4) Task/nature of work.

(5) Time left surface.

(6) Time left bottom.

(7) Time arrived surface.

(8) Decompression Table used.

(9) Decompression schedule used (stop depth and duration).

(10) Environmental factors (including visibility, tidal stream etc).

(11) Remarks (including details of DCI or other injuries).

(12) Dive supervisor name/unit/signature.

The ‘Duration’ column is to be amended to read ‘Total Time of Dive (mins)’. For multiple dives in one day with the same details, a maximum of four dives may be recorded under one entry. Items (5), (6) and (7) above are to be entered in separate columns. Each Total Time of Dive (TTD) is to be entered separately.

0407. History Sheets (Navy)

a. A diving history sheet (Form S.1246M) is to be started for all RN Diver sub-branch ratings on successful completion of their first course.

b. The form is to contain details of qualifying courses, recommendations for higher diving rate and a general record of diving service in each ship in which the man has served. There is also a space for recording any diving operations of particular interest.

c. The diving officer should hold the history sheets of all his Divers and be responsible for their accuracy and upkeep. When a Diver leaves the ship or establishment the history sheet should accompany his other Service documents.

0408. Diving Certificates

a. Naval officers who successfully complete a diving course are to be given a certificate to that effect, except where this course is part of another qualifying course, and the fact is to be reported to Naval Manning Authority (NMA).

b. Royal Marines, and Army personnel are to be given a similar certificate and a report is to be sent to the authority who asked for the course.

c. Naval ratings, Royal Marines and Army other ranks who successfully complete a diving course are to have the relevant details entered on their Service documents.

0409. Divers On Loan

a. A diving officer who accepts divers from another ship, establishment or unit for the purposes of diving practice is also to arrange for the Diver’s Log, Form S1627/AB576, to be completed and forwarded to the diver’s own diving officer.

b. Divers who do not bring their diving logs with them will not dive.

0410. Spare.

0411. Biannual Return of Divers - Army Form G8265 (Revised 10/96)

The Unit Diving Officer is to compile a Biannual Diving Return on AF G8265 as at 31 March and 31 September each year, forwarding a copy to SDO(A). He is also responsible for informing the UAO of any changes to the status of unit divers which are likely to affect eligibility for AP-D at any time. Divers in units with no Diving Officer are responsible both for compiling their own Diving Returns (and forwarding them to SDO(A)) and informing the UAO of any changes that affect their eligibility for AP-D. In this latter case AF G8265 must be countersigned by the Unit Records Officer who is to check entries against the Army Diver’s Log AB576.

0412. Recording Removal or Relinquishment of Diving Qualifications

a. When a diver or diving supervisory has one or both qualifications removed, through becoming permanently medically unfit or some other reason, or if the qualification is relinquished voluntarily, the fact is to be recorded in the diving log in each of the following places:

(1) On the first page after ‘Personal Details’.

(2) After the last entry in the ‘Record of Diving Operations and Exercises’.

(3) After the last entry in the ‘Record of Medical Examinations’ if permanently medically unfit.

b. The log should then be given to the diver concerned for retention.

c. An entry recording the removal or relinquishment should also be made on the Service Record.

d. For Navy divers Form C173 is to be raised and forwarded to the NMA Centurion Building Grange Rd. Gosport PO13 9XA.

0413. Reports to Naval Manning Authority (NMA)

Whenever a Diver sub-branch rating is:

a. Declared permanently medically or temperamentally unfit for diving in accordance with para 0212.

b. Restricted in the depth to which the diver may ascend, if shallower than those normal for the rate.

c. Declared unfit for Sea Service.

The Commanding Officer or Officer Commanding is to inform NMA by signal, with a copy to The Commanding Officer, Defence Diving School.

0414-0419. Spare.

SECTION 2 - PAY

0420. Special Service Pay (Diving) - SSP(D)

a. SSP(D) is payable continuously to RN officers and ratings who have qualified in diving duties and who are engaged in diving (either operationally or for practice) and who remain fit to dive. A minimum standard of practice is required as detailed in para b. below

b. **Minimum Standard of Practice Required.** The required standard of diving practice for RN divers serving in operational diving billets is given in para 0702 . Naval divers serving in non-operational billets are, nevertheless, under a continuous liability to dive. The minimum standard of practice for the continuous payment of SSP(D) is as follows:

(1) *Career Divers, Ship's Divers in operational billets and SAR Divers.* 120 minutes underwater during the following period:

15 February to 14 June
15 June to 14 October
15 October to 14 February

(2) Diving to make up this period of 120 minutes is to take place on at least two days in each period. Conditions of practice are laid down in para 0423.

(3) Diving Officers or other Officers authorising SSP(D) are not to approve payment unless the requirement of sub-para (2) above is met, or a request to conduct one day intensive training is granted and completed satisfactorily, in accordance with sub-paras 4 to 6 below.

(4) In exceptional circumstances, ship's divers in non-operational billets may request to complete a programme of one day intensive diving training/assessment, conducted by staff at the Defence Diving School (Portsmouth), or at the recognised continuation training centre, eg Faslane, Devonport, Portsmouth, SAR Diving School Culdrose and Gibraltar, during each of the ledger periods in sub-para (1) above.

(5) Requests to attend a one day intensive training/assessment programme are to be forwarded, at the earliest opportunity, to the S of D under Commanding Officers signature. Reasons for requesting intensive training are to be fully explained.

(6) If dispensation is granted by S of D, it is the responsibility of the requesting individual/authority to arrange training with the DDS. The letter of dispensation is to be produced for checking by DDS staff.

On completion of the one day training and assessment the Diver's Log, S1627, will be endorsed that the diver is 'qualified to dive' (and receive SSP(D)). Failure of this assessment will require re-examination as required by the Defence Diving School.

c. **Search and Rescue Diver.** SAR Divers will receive both flying and diving rates of SSP concurrently.

0421. Payment of SSP(D) Navy

a. Full details of the regulations governing the payment of SSP(D) will be found in **BR 1950 Naval Pay Regulations** which must always be consulted. General details are given below.

b. Diving officers are to inspect and sign all diving logs (Form S.1627) and are to produce to the Supply Officer by the 15 March, 15 July and 15 November a nominal list of all qualified divers who have completed the necessary diving practice during the preceding four months. The nominal list will be the authority for crediting special service pay (diving) for the subsequent ledger period.

c. Diving time during course can be counted as qualifying time for payment, but special service pay (diving) or a higher rate of special service pay (diving) is to be credited only from the date of qualification.

d. If Form S.1627 indicates that the diver has not completed the necessary diving practice during the preceding period of 4 months, that name will not be included in the nominal list and payment of SSP(D) will be withheld for the whole of the immediately following ledger period.

e. Should a Form S.1627 for a subsequent four-month period indicate that the diver has once again carried out the necessary practice during that period, that name will be included in the nominal list and SSP(D) will be credited again from the beginning of the ledger period immediately following the 4-month period to which the new nominal list relates.

f. Should a diver become unfit to dive SSP(D) will cease to be paid:

(1) When divers are medically unfit to carry out in-water duties for reasons beyond their control, after a period of 91 days from the date on which they were first checked sick. (The balance of any 91 day period may extend into the subsequent 4 monthly diving period).

(2) When divers are otherwise declared unfit for diving duties - from the date declared unfit.

Note. *The 'unfit for diving' rates of Group 5 SSP(D) will continue to be payable to those medically unfit for diving duties from the end of the 91 day period provided they are entitled to Group 5 (Supervisors) rates of diving pay.*

g. In exceptional circumstances the S of D may recommend a waiver of SSP(D) for up to one pay ledger period. This procedure is intended to cover the extra-ordinary circumstances when groups or individuals are prevented from qualifying for SSP(D) due to unplanned or unforeseen operational tasks (ie deployment in time of conflict).

h. Applications for waivers, are not to be submitted as a matter of routine. Diving Officers are to scrutinise individual requests at first instance to identify those of a frivolous or unnecessary nature. It is emphasised that waivers are not applicable in cases where individuals have failed to achieve the minimum standard of practice through a lack of personal planning or in cases where an individual becomes medically unfit prior to the end of the ledger period. These rules will be strictly enforced.

i. Requests to the S of D for SSP(D) waivers, are to be forwarded under Commanding Officer's recommendation and signature and must contain the following information:

(1) The reason(s) why the diver failed to meet the qualifying time required.

(2) A copy of the individuals draft order and/or dates of absence (if applicable).

(3) Photocopied information from the Diver's Log to include:

(a) Front page - diving qualifications.

(b) Previous two years dive entries.

(c) Results of diving medical examinations.

(4) A diving waiver will only be granted once in any two year period.

(5) Waivers will only be granted for divers who are in date for diving as described at para 0201.b (In Date Diver).

0422. Payment for Deep Experimental and Trial Diving

a. The authority for additional payment for Deep and Experimental diving is **BR 1950 Naval Pay Regulations** which should be consulted for details and rates of payment. The general rules are given here for ease of reference.

b. Deep and Experimental dives (carried out at sea or in shore diving installations) are graded at five levels by either S of D or where necessary by the MOD(N) Personnel Research committees, as either:

Grade	Qualification
1	Experimental hyperbaric exposure not in excess of 42m where the total hyperbaric exposure time is less than or equal to 1 hour and has required the approval of the REC.
2	Experimental hyperbaric exposure not in excess of 42m where the total hyperbaric exposure time exceeds 1 hour but less than or equal to 2 hours and has required the approval of the REC.
3	Experimental hyperbaric exposure not in excess of 42m where the total hyperbaric exposure time exceeds 3 hours and has required the approval of the REC.

4 Experimental hyperbaric exposure in excess of 42m where the total hyperbaric exposure time is less than or equal to 2 hours and has the required the approval of the REC.

5. Experimental hyperbaric exposure in excess of 42m where the total hyperbaric exposure time exceeds 2 hours and has required the approval of the REC.

Note. *See Chapter 6 for details of the MOD(Navy) Personnel Research Ethics committee and its tasks.*

c. Grade 1 dives attract a special hourly rate of payment in addition to SSP(D). Grade 2, 3, 4 and 5 dives attract a lump sum payment per dive and a special hourly rate of payment in addition to SSP(D).

0423. Conditions of Diving Practice (Navy)

For time to be counted towards the minimum standard of practice required for the payment of SSP(D) (para 0420), the conditions given below must be satisfied.

a. The diver is to have performed some specific service task during the dive, for example underwater inspection of hull fittings, a compass swim, jackstay/seabed search etc. Recreational activity such as fishing is not a service task.

b. Dives made during course before qualification as a diver may be counted as qualifying practice.

c. Any dives made in a swimming pool, to conduct training in emergency safety drills or as part of a diving aptitude assessment test may be counted towards the qualifying minimum standard of practice, but ONLY 25% (30 minutes) of the required total may be made up of such dives.

d. Dives conducted in a Compression chamber do not count towards the total for the qualifying minimum standard of practice.

e. Continuation diving training (‘Monthly Dippers’) is conducted by units as listed in para 0305.

0424. Sports Diving (Sub-Aqua)

a. A service diver who is also a sports (sub-aqua) diver is to use his personal divers log S1627 (RN) or AB576 (Army) to record sports dives but such dives do not count towards the qualifying minimum standard of practise for SSP(D) or AP-D.

b. For all divers sports dive entries in the S1627/AB576 are to be clearly identified with the words SPORTS DIVE in block letters in the equipment used column. Red ink is to be used.

c. Army divers are to ensure that the cumulative time (hrs/mins) columns in the AB576 are ruled through with an ‘X’.

0425. Additional Pay - Diving AP-D (Army).

AP-D is payable continuously to those personnel who have qualified in Army diving duties at the former RE Diving Establishment (REDE) or at the Defence Diving School (DDS) and who remain ‘in date’ for diving practice, medically fit to dive and available for diving duties in accordance with AGAI Vol 2 Chap 72.

0426. Authority to Conduct Deep Diving

Special authority from S of D is required prior to conducting dives in excess of 60m. Authorised dives will attract Deep Diving Pay. Inadvertent depth excursions below 60m will not be classed as deep diving and will not attract Deep Diving Pay.

CHAPTER 5

SPARE

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CHAPTER 6

EXPERIMENTAL DIVING, RESEARCH AND DEVELOPMENT

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CHAPTER 6

EXPERIMENTAL DIVING, RESEARCH AND DEVELOPMENT

0601. Introduction

a. All experiments that involve human subjects must conform to the **Draft Code of Ethics on Human Experimentation** presented to the World Medical Association at Helsinki in 1961 and as amended thereafter. To comply with this code the MOD(N) Personnel Research Ethics Committee (MOD(N) PREC) has been established to provide Ethical scrutiny of all non-clinical research that involves human subjects conducted by or on MOD(N) personnel.

b. Research development, acceptance or operational trials of equipment, involving human subjects (eg anthropometric evaluations, workplace occupational hygiene surveys, diving equipment assessment) will normally require ethical approval unless:

(1) The equipment is a standard item of laboratory or operational equipment or has successfully undergone unmanned testing to the same physical (or greater) limits as the proposed manned trial and no substantial changes in design or operating principles have since been introduced.

AND

(2) Physiological monitoring is not required for the safety of the subject and provided they are conducted on knowledgeable subjects (eg staff and those who normally use such equipment). However, even for this type of study subjects must still be true volunteers. In particular, all those taking part as subjects in such experiments are to be fully informed and give at least explicit verbal consent.

c. In case of doubt, guidance should be sought from the Chairman of the appropriate committee (0602c).

0602. MOD(N) Personnel Research Ethics Committee

a. **Composition**. Membership of the MOD(N) PRECE is in accordance with the **Guidelines on the Practice of Ethics Committees in Medical Research Involving Human Subjects** published by the Royal College of Physicians of London and include:

(1) Medical members.

(2) Non-medical research workers.

(3) Lay members. (at least 2 members of the MOD(N) PREC will be persons not practised or trained in any medical or paramedical discipline.)

All members will be independent of the MOD(N) and not directly associated with any proposed experiment, investigation or trial. Both sexes should be represented on the committee.

b. The Chairman will be appointed by and report to, the Director of Science (SEA(DS(S)).

c. Reporting to, and operating under delegated authority from, the MOD(N) PREC are two advisory committees:

(1) The MOD(N) Advisory Committee for Underwater and Hyperbaric Personnel Research (MOD(N) ACUHPR).

(2) The Advisory Committee for Institute of Naval Medicine Personnel Research (ACIPR).

d. The Chairmen of the 2 Advisory Committees will normally attend meetings of the MOD(N) PREC. The Senior Medical Officer (Diving Medicine) will act as Secretary to the MOD(N) PREC with all correspondence addressed to:

Secretary to the MOD(N) PREC
Institute of Naval Medicine
Alverstoke
Gosport
Hampshire
PO12 2DL

0603. Administrative Guidelines for Ethical Approval and Conduct of Non-Clinical Research Conducted on Volunteers

Guidelines for the ethical approval and conduct of non-clinical research by or on MOD(N) personnel, which involve human subjects, have been produced by the MOD(N) PREC. Copies of the Guidelines may be obtained from the Secretary.

CHAPTER 7

REGULATIONS

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Para

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(Continued)

CHAPTER 7

REGULATIONS

0701. Safety Regulations - Application

a. This Chapter contains a set of mandatory regulations governing the conduct of diving exercises and operations to depths not exceeding 80m. These regulations, having evolved from new techniques and diving experience, cover a wide field of diving and are applicable to all Service diving.

b. It is MOD policy that military diving should comply with the Health and Safety at Work Act 1974 (HSAW 74), the Diving Operations at Work Regulations (DOWR) 1997 and future amendments so far as reasonably practicable. Members of the armed forces of the Crown, or visiting forces, on duty undertaking military diving operations, or operational training, are to comply with **BR 2806**. The **BR 2806** is registered with Health and Safety Executive (HSE) as the Military Diving Accepted Code of Practice (ACOP).

c. In the event that compliance with DOWR and **BR 2806** by members of the Armed Forces is not practicable and in cases of doubt as to the definition of operational tasks, advice must always be sought from the Commander in Chief Fleet or the Superintendent of Diving (Navy) & (Army) before any diving activity takes place.

d. Guidance on the provision of Military Aid to Civil Authorities (MACA) is provided in para i below.

e. **Dispensation to Deviate from the Regulations (RN).** This is to be requested from the Superintendent of Diving by signal if urgent, otherwise by letter. Dispensation granted by S of D will include a dispensation number and be given a validity period. Unless otherwise stated dispensations will normally be cancelled automatically on 31 December annually. Ships/Units are responsible for requesting an extension to any dispensation granted. A record of dispensation is to be kept in the Master Diving Record and will be mustered along with other diving related documents during diving inspection.

f. **Dispensation to Deviate from the Regulations (Army).** Dispensation to deviate from the regulations for Army personnel is to be requested from SDO(A), or in his absence I of D(A), by signal if urgent, otherwise by letter. Dispensation granted will be in letter or signal format and given a validity period. Units requesting dispensations are to keep copies of requests with the relevant reply in the unit diving file which is to be presented at the Unit's Annual Diving Inspection.

g. All personnel concerned with diving are to make themselves thoroughly conversant with the relevant Service regulations contained in **BR 2806** and strict compliance with which it is essential to ensure the safety of the diver. All personnel should, in addition, have a basic understanding of the content of the DOWR.

h. Submarine-escape training, including routine and therapeutic compression chamber operations and submarine-escape exercises and trials either ashore or at sea, are conducted by the Submarine-Escape Rescue and Diving Officer or his deputy under the authority of the Flag Officer Submarines (FOSM) as advised by S of D(N).

i. **Service Divers - Military Assistance to Civil Authorities (MACA)**. The provision of (MACA) is a properly constituted Service task. Examples are ships searches for Customs and Excise and immediate ship accident investigations for the Department of Transport. Guidance on the provision of such assistance is given below. This guidance does not apply to EOD diving tasks which are conducted under separate Military Aid to Civil Power (MACP) rules.

(1) *Contractor Registration*. S of D is registered with the Health and Safety Executive as the diving contractor covering all RN, RM and SF diving. The S of D registration number is 06002. The Officers Commanding Ships, Units and diving Groups are delegated as RN, RM and SF contracted representatives. SDO(A) is similarly registered as a contractor.

(2) *Contract*. A contract is deemed to exist if there is a verbal or written agreement between the OC, OIC (or dive supervisor acting as OICs representative) and the nominated representative of the civil authority concerned detailing the task objectives.

(3) *Diving Limits*. Only self contained air diving to 30m or surface-supplied air diving to 50m is to be conducted. Authorisation to use mixed gas must be obtained from S of D.

(4) *Type of Dive*. All divers are to be attended or marked.

(5) ***BR 2806***. In all other respects the regulations in this publication apply.

0702. Standard of Diving Ability

a. Only by the maintenance of a high standard of diving ability and supervision can any equipment be used safely and efficiently.

b. Commanding Officers, Officers Commanding and Officers-in-Charge of RN divers and attendants in operational billets or Army divers on establishment are, therefore, to ensure that they are given sufficient opportunity to keep in practice.

c. The following required standard of diving is applicable to RN divers:

(1) *Divers in Shore Based Clearance Diving Groups, Units and Elements.* As laid down in CAPES and **BR 5063**.

(2) *Divers and Ship's Divers in Operational Billets.* As required by CAPES.

(3) *SAR Divers.* SAR divers are to achieve the minimum training standards outlined in Table 7-1B, in addition to the minimum requirement of 120 minutes underwater per ledger period. When possible this must be done with ships or local diving teams, using SABA/BASAR.

d. **Ship's Divers in Submarines.** When on patrol it may not be possible for 'on crew' diving teams to reach the minimum training standards required. Table 7-1 below outlines minimum standards consistent with those required by Ship's Divers in the Fleet. Ship's Diving teams embarked in submarines are to make every effort to reach the minimum standards set out in the Table. Off-crew Diving teams must continue to train on submarines or by use of the appropriate clearance diving unit training centre, or the continuation training facility at Horsea Island.

Table 7-1A. Minimum Standards of Practice for Ship's Divers in Submarines

Serial	Frequency	Required Standard
Companion Diver Drills	1 per month	Assistance to be rendered to an unconscious diver in the water, including resuscitation and recovery. Each diver to conduct this drill to the satisfaction of the diving supervisor.
Dive to maximum depth	1 dive every three months	Each diver should dive to 21 metres every three months.
Total dive time	Per diving quarter	A minimum of 120 minutes per diver.
Day bottom search	1 per quarter	Dummy limpets are to be placed and the search to be conducted within the bogey time.
Night bottom search	2 per quarter	Dummy limpets are to be placed and the search to be conducted within the bogey time.

e. **Army Divers.** The required standard of diving practice is laid down by SDO(A) in accordance with operational needs and is published separately. See para 0425 for the minimum standard of practice for payment of AP-D.

f. **SBS.** The required standards of diving practice are laid down by CO SBS and published separately.

g. When, through shortage of numbers, a diver is prevented from diving, the assistance of the local continuation diving centre (for Army any, unit diving team) should be sought for diving practice.

h. RN and RM divers may not be able to maintain these standards, but they will continue to qualify for SSP(D) if they complete the minimum standard of practice outlined in para 0420.

Table 7-1B. Minimum Standards of Practise for Search and Rescue Divers

Serial	Frequency	Required Standard
Training Jumps Non-Weighted/Weighted	Per Diving Quarter	Each Diver is to carry out 24 jumps per quarter of which 12 must be weighted and 12 unweighted. These practises are to spread over at least four sessions, which must include one twilight and one night jump session for those qualified in night jumps. Sessions must be separated by an interval of not more than one week, and are to be combined with some practical underwater task.
Dive to Maximum Depth	1 Dive every three months	Each diver should dive to 30 metres every three months.
Total Dive Time	Per Diving Quarter	120 minutes mandatory for SSP(D) per diver. This figure is to be regarded as a minimum, not as a target. Ideally each diver should strive to achieve 240 minutes (33% at night/low visibility).
Companion Diver Drill	1 per month	Assistance to be rendered to an unconscious diver in the water, including resuscitation and recovery. Each diver is to conduct this drill to the satisfaction of the supervisor.
Alternative Air Source Drill	1 per month	Assistance to be rendered to a submerged, out of air casualty, providing an air source (Buddy Breathing or STASS) to the casualty. Each diver to conduct this drill to the satisfaction of the supervisor.
Rescues from Submerged Aircraft	Annually	Act as a safety diver during training serials at UETU (Dunker), HMS HERON. To carry out simulated casualty rescues from the unit on all six training serial scenarios.
Parachute Entanglement Rescue Drills	1 every three months	Assistance to be rendered to a distressed or unconscious entangled parachutist in the water.

Table 7-2A. Minimum Numbers to Support an RN Diving Operation (Para 0703)

Supervisor	In the Water	Supporting Personnel
MCDO/PO(D) and above	1 to 6 divers on a lifeline (Note 1)	1 attendant for each diver 1 standby diver 1 standby attendant
	1 to 6 divers on a gas hose (Note 1)	1 attendant for each diver Minimum of one qualified panel operator per 2 panels 1 standby diver 1 standby attendant
	1 to 6 divers when free swimming, marked diving and marked swimming (Notes 2 & 4)	1 standby diver 1 standby diver attendant
Leading Seaman(D)	1 to 4 divers on a lifeline	1 attendant for each diver 1 standby diver 1 standby diver attendant
	1 to 4 divers marked diving and marked swimming (Note 3)	1 attendant 1 standby diver 1 standby diver attendant
	1 to 6 divers for ship's bottom search, when secured to a necklace	1 attendant 1 standby diver 1 standby diver attendant
SBSO/SBSSC1	1 to 6 Divers on a lifeline	1 attendant for each diver 1 standby diver 1 standby attendant
	1 to 6 Divers free swimming, marked diving and marked swimming (Note 4)	1 attendant 1 standby diver 1 standby attendant
SBSO/SBSSC1	1 to 8 Divers on a lifeline at Horsea Island	1 standby diver 1 standby diver attendant 1 attendant for each diver
	1 to 10 Divers free swimming, marked diving and marked swimming at Horsea Island	1 standby attendant 1 standby diver 1 attendant
	1 to 16 divers when conducting aptitude and diving introduction in a swimming pool (Note 5)	1 standby diver in the water for every 4 diver trainees 1 attendant 1 surface swimmer

Table 7-2A. Minimum Numbers to Support an RN Diving Operation (Para 0703) (Cont'd)

Supervisor	In the Water	Supporting Personnel
ShDO/ShDS	1 to 4 divers on a lifeline	1 attendant for each diver 1 standby diver 1 standby diver attendant
	1 to 4 divers marked diving (not boots) and marked swimming (Note 6)	1 attendant 1 standby diver 1 standby divers attendant
	1 to 6 divers for ship's bottom search/search group swimming secured to a necklace	1 attendant 1 standby diver 1 standby diver attendant
SARDO/SAR Supervisor (additionally qualified as ShDS)	1 to 4 SARDs	1 standby diver 1 attendant for each diver

Table 7-2B. Minimum Numbers to Support an Army Diving Operation (Para 0703)

Supervisor	In the Water	Supporting Personnel
ADS/UDS	1 to 6 divers on a lifeline (Note 7)	1 attendant for each diver 1 standby diver
ADS	1 to 4 divers on a gas hose	1 attendant for each diver Minimum of 1 qualified panel operator for the divers and a separate panel operator for standby diver's panel 1 standby diver 1 standby divers attendant
ADS/UDS	1 to 6 divers marked swimming (Note 8)	Minimum of 1 surface swimmer (Note 9) 1 standby diver 1 standby divers attendant

Notes:

1. Increased to 8 divers when supervising Ship's Diver and Career Diver training at Horsea Island.

2. Increased to 10 divers (a maximum of eight floats) when supervising Ship's Diver and Career Training at Horsea Island. The standby diver must be a member of the Diver sub-branch.

3. Increased to 6 divers when undergoing continuation training at Horsea Island.

4. In certain SF and FDU 1 exercises/operations minimum numbers may be modified, with written authority from CO SBS (see para 0992h/i).

5. To enable communication from the supervisor to the divers an underwater microphone/loudspeaker unit is to be available and tested prior to each days diving.

6. In the SETT lifelines are not required The Diving Bell is to be available and the underwater loudspeaker switched on.

7. Increased to eight divers when supervising diver training at Horsea Island (excluding Aptitude training).

8. Increased to ten divers diver must be a member of the DDS course staff.

9. Can be increased according to supervisors risk assessment, ie fast water.

0703. Minimum Personnel Required

a. The number of divers required to be in the water at any one time will depend on the task. Minimum numbers and qualifications of personnel required to support a given number of divers are shown in Table 7-2 on the preceding page. If these requirements cannot be met diving must not take place except as authorised below.

b. **Exceptions**. For members of the Diver sub-branch, provided the supervisor is an MCDO/PO(D) or above, the following exceptions are allowed.

(1) *Brief Operations/Inspections*. These may be carried out if diving conditions are straightforward and there is minimum risk to the diver of becoming foul or requiring assistance. The dive is to be a no stop dive and depth must not exceed 30m. Equipment must be SABA. The diving team may be reduced to a supervisor, diver and standby diver.

(2) *Minehunting Diving*. To limit the number of personnel exposed to risk of mine explosion during minehunting operations it is permissible to reduce the dive team to a supervisor, diver, standby diver and an attendant if the planned dive is shallower than 42m and not involving decompression stops. If diving deeper than 42m or planning decompression stops no relaxation in the minimum number requirement is permitted eg supervisor, diver, standby diver, attendant and XBS/lazy shot operator. (See para 0784).

(3) *EOD Operations*. CDU's and designated Army units, when conducting 'spot dives' during EOD operations, the diving team may, subject to risk assessment, be reduced to a supervisor, diver and standby diver. See para 0785. (This will not apply when diving in CDBA.)

c. **Special Forces Diving**. When diving is being conducted in circumstances similar to sub-para (1) and the supervisor is an SBSSC1 or above the dive team may be reduced to a supervisor, diver and standby diver.

d. **Army Divers.** The supervisor may act as the standby divers attendant (not at DDS).

e. **SAR Divers.** See para 0783.

0704. Standby Diver - Availability

a. Whenever Service diving operations are being carried out, a standby diver is required at the surface. He is to be available at short notice and the necessary equipment is to be prepared and tested before diving takes place. He is to have a separate attendant and is to dive on an easily detachable safety line as an 'attended diver' (see Para 0703.d).

b. Before diving operations commence the standby diver must be fully dressed and his set prepared for immediate use. It is mandatory for all Ship Diver Operations for the standby diver to dive to 5 metres, using the standby divers equipment to confirm that he can clear his ears, and functionally check his equipment. For all other divers in regular practice the requirement to test the Standby Diver is at the Supervisors discretion. Repetitive dive rules for this 5 metre dive are given in Para 1207. If he experiences difficulty in clearing his ears another diver is to be detailed as standby diver and tested in similar manner. Alternatively, the test dive may be conducted in a compression chamber with the diver breathing oxygen and wearing a nose clip. In this instance there would be no limitation on his subsequent dives. The equipment will still require to be tested.

c. After testing, oxygen- and mixture-breathing sets are available for use by the, standby diver for a period of up to 6 hours.

d. Under the circumstances outlined in Para 0705 the standby diver is to be at immediate notice.

e. The standby divers lifeline must always be longer than the divers lifeline.

f. During marked swimming operations, the standby diver may wear a light/safety line attached to a float.

0705. Standby Diver - Immediate Notice

a. Under the following circumstances the standby diver is to be at immediate notice:

(1) When diving on wrecks.

(2) When tidal streams or river currents are too strong for sustained swimming. See para 0922.

(3) In any other cases when the diving supervisor considers there is a likelihood of the diver requiring assistance.

(4) When free swimming is taking place. (See paras 0782 and 0992.)

(5) When ice diving.

b. Immediate notice when referring to the standby diver is to be interpreted as follows:

(1) *Surface Supplied Equipment.* Standby diver dressed fully; helmet/mask off.

(a) KMB 17/18 - Emergency gas supply valve closed Control Panel valve open.

(2) *Self-contained Equipment.* Standby diver fully dressed and vented up, with facemask off:

(a) CDBA - O_2 and diluent main valves open. Bail out valve open, Supplementary valve closed. Slide valve to open circuit. Set stabilised.

(b) SABA - main cylinder valve open, reserve valve closed.

(c) BASAR - main cylinder valve open, reserve valve closed.

(d) LEBA (MG) - as per SOPs.

(e) LEBA (O_2) - LAR V - cylinder valve open.

(f) AGA DIV - cylinder valve open, Positive pressure lever towards housing (off).

c. There must be no relaxation in the readiness of the standby diver while at immediate notice.

0706. Standby Diver - Equipment and Qualification

a. Standby divers required by paras 0703 and 0704 are normally to use the same equipment as the diver(s) and are to be fully qualified in the equipment being used by the diver(s).

b. If there are exceptional reasons which make it impossible to comply with sub-para a above, the circumstances should be notified to S of D or SDO(A) as appropriate who may authorise local training of 'special' standby divers.

c. This local training is to include all aspects of emergency drills for the unfamiliar equipment, and an acquaint dive in a controlled environment such as a swimming pool.

d. On completion of the above training the diving log of the ‘special’ standby diver is to be annotated by his CO or OC: ‘Qualified to act as a standby diver to divers using ....’ and his name is to be forwarded to S of D or SDO(A) as appropriate. The qualification is to lapse on leaving the draft or appointment, and the annotation in the log book is to be deleted.

e. ‘Special’ standby divers are not authorised to dive in any equipment for which they are not fully qualified, other than during the acquaint dive in sub-para c above.

f. The standby diver is to be equipped with a torch unless the diving supervisor is certain that there is sufficient light at the maximum depth of the dive to allow a full appreciation of any emergency situation to be made.

g. For Army standby divers when using SABA or AGA Divator the test dive is to be in accordance with para 0704 b. When completed the waist strap is to be secured around the set. When the standby diver is ‘crashed out’ he is to put his weight belt on before the set. When wearing SABA, weights are pre-positioned in BCA jacket pockets.

h. Ship’s Diver standby training may be conducted at the SETT tank at Dolphin under the supervision of the DDS.

0707. Unqualified Attendants

a. To make the fullest use of the diving team, the diving officer should train as many unqualified attendants as there are divers borne. Servicemen selected for training should be of above-average intelligence and possess a good sense of responsibility.

b. They are to be fully conversant with all the duties required of a qualified diver when acting as an attendant (para 0975) and they are to be exercised with the diving team in accordance with the standards outlined in para 0702.

0708-0713. Spare.

0714. Unwillingness to Dive

a. An ‘in date’ diver who reports he is unwilling to dive for medical reasons is to be referred to a medical officer for examination. In the absence of any clinical reason for the diver being declared unfit to dive, his diving qualification is to be removed as temperamentally unfit.

b. An ‘in date’ diver who reports that he is unwilling to dive for other reasons (eg that he considers the task to be beyond his capabilities, or the environmental conditions unsafe) is to be referred to the Diving Officer of the ship/unit in which he is borne. Should his Diving Officer consider his reasons for not diving invalid his diving qualification is to be removed by his CO/OC, as temperamentally unfit. Cases of doubt should be referred to S of D or SDO(A) as appropriate.

c. The administrative action described in para 0212 is to be taken.

0715. Diving Safety Memoranda

a. The Diving Safety Memorandum, signalled by RNSUPDIV PORTSMOUTH to AIG 1184, exists to provide a means of rapid dissemination of diving related safety information. Subjects range from reminders of existing regulations to new information involving safety to the Diver's life.

b. Diving Safety Memoranda must be read by all diving supervisors/diving officers/divers and diving maintainers and must therefore, be circulated and suitably displayed. Even though specific information contained in a Diving Safety Memoranda may not apply to a particular ship or unit, the information will enhance overall safety awareness. An auditable record of review of the memoranda by diving personnel must be kept in each Unit's BR 2806 (Record). This record will be included with the documents checked during diving inspections.

0716-0720. Spare.

0721. Supervision of Diving Operations

a. Supervision of the different types of diving may be carried out to the depths given in Tables 7-7 to 7-10 of para 0737 by diving supervisors as shown in Table 7-3 provided the supervisor has undertaken the appropriate training and this has been recorded in his Diving Log. RNR Clearance Divers are authorised to supervise to the same limits as their RN equivalent.

b. **Supervision of Unqualified Personnel.** Officers, ratings and civilian personnel, who have not successfully completed an authorised diving course may only dive under the direction of a Training Officer (see para 0310).

c. **Subordinate Officer (Navy)**. A subordinate officer may be employed as a Ship's Diver Officer (SDO) and may supervise diving operations provided he has achieved an appropriate qualification following a course of instruction at the Defence Diving School.

(1) On successful completion of the 4 week Ship's Diver Course, a naval officer will qualify as a Ship's Diver Officer. An Officer undergoing this course is required to supervise diving and is not permitted to qualify solely as a Ship's Diver.

(2) To qualify as a Ship's Diver Officer, a subordinate officer on the Special Duties (SD) List who, as a rating, qualified as a Ship's Diver, must undergo the 2 week Ship's Diver Supervisor course as soon as is practicable after promotion.

(3) A subordinate officer on the SD List who qualified previously as a LS(D) or above while serving as a rating may continue as a diving supervisor as appropriate to his previous qualification (if previously qualified as a LS(D) an assessment must be carried out before the SDO qualification is awarded). He may be employed as a SDO and will be eligible for SSP(D) as appropriate to MCD officers in non specialist appointments or until as may be appointed as a MCDO on completion of specialist qualifying courses.

Table 7-3. Supervision of Diving Operations (Para 0721)

Diving Supervisor	Type of Diving
MCDO, WO(D)	All Service diving to 60m (Notes 4 & 5) and all experimental diving as directed by SofD.
CPO(D), PO(D)	All Service diving to 60m. (Notes 4 & 5)
LS(D)	Tasks using SABA to 30m (Notes 1 & 2)
SBSO, SBSSC 1	SBS diving operations (Note 3). Tasks using SABA to 30m.
ShDO	ShD tasks. SAR diving (see para 0783).
SARDO	SAR diving; ShD tasks.
Senior Rating SARD additionally qualified as ShD supervisor	SAR diving. ShD tasks.
ShD Supervisor	ShD tasks.
ADS	All Service compressed air diving down to 50m.
UDS	Unit diving team operations and training down to 30m using SABA which does not require planned decompression stops.
OCSETT and Deputies	Submarine escape training, exercises and trials; Exit and re-entry diving training, exercises and trials.

Notes:

1. Subject to holding a certificate of qualification. Award of this certificate is recorded in Form S.1246 History Sheet and Form S.1627 Diver's Log. Only non-complex tasks are to be undertaken (eg The supervision of continuation training, brief operations or inspections in straight forward diving conditions) Dives requiring planned decompression are not to be undertaken.

2. LS(D)s on the scheme of compliment of FDU2, once successfully completed training in the use of RABA are authorised to supervise free swimming operations using RABA in support of LR 5 launch and recovery to a maximum depth of 10 m. S1627 diving logs are to be annotated accordingly.

3. Dives requiring planned decompression are not to be undertaken.

4. RN Supervisors are not trained to supervise such Army tasks as fast water search and river reconnaissance. They should not be authorised to supervise such tasks except on the joint authority of the S of D and SDO(A).

5. Once converted to CDBA, CDBA diving will be routinely conducted to 60m, supervision of, and diving to 80m will be authorised on a selective basis by S of D.

0722. Supervision of Compression-Chamber Diving

a. Because diving in a compression chamber carries the same risk in respect of decompression sickness as diving in water, similar restrictions are imposed on its supervision as shown in Table 7-4 opposite.

b. When compression chamber diving is carried out during diving training it is to be carried out under the direction of the appropriate Training Officer (para 0310) who is to ensure that the correct level of supervision is exercised.

0723. Supervision in Exceptional Circumstances by an Unqualified Supervisor

a. In exceptional circumstances (not including routine or training dives) when no qualified diving supervisor is available, diving may take place provided:

(1) An RN/Army lieutenant, or above, takes charge of the operation in accordance with para 0208.

(2) An experienced 'in date' serviceman qualified in diving is present to act as technical adviser. He is not to enter the water.

(3) Compressed air breathing apparatus only is used.

(4) A depth of 18m is not exceeded except to save life (see para 0737d).

(5) Dives requiring decompression stops are not carried out.

b. These provisions may also be applied when:

(1) If the only qualified diving supervisor borne wishes to ascertain the progress of a diving operation or requires to carry out diving practice to keep 'in date'. In this case single diver operations only may be undertaken.

(2) There is an emergency underwater engineering task affecting the ships operational capability eg foul screw.

(3) There is a requirement to carry out a ships bottom search during Operation AWKWARD. This relaxation does NOT apply to AWKWARD exercises.

c. Before taking charge of a diving operation an unqualified supervisor is to read thoroughly all the applicable safety regulations in this section.

Table 7-4. Supervision of Compression Chamber Diving (Para 0722)

Supervisor	Type of Dive	Maximum Depth in Metres
MCDO, WO(D)	All forms of compression chamber diving including experimental diving. Except saturation diving until suitably qualified.	60 (except for experimental diving) - Note 1
CPO(D), PO(D)	All forms of compression chamber diving. Except saturation diving until suitably qualified.	60 Note 1
SBSO, SBSSC1	Compression-chamber diving Therapeutic decompression	50 Note 2 50 Note 1
ADS	Compression-chamber diving Surface decompression Therapeutic decompression	50 50 50 Note 1
OCSETT or Deputies	Training and therapeutic decompression.	50 Note 2 & 4
CPO ACMN (UETU Only)	Training and therapeutic decompression	50 Note 3 & 4

Notes:

1. May be extended to 70 m for Therapeutic Tables 65 and 71.

2. On qualifying as SBSO, SBSSC1 or Ship's Diver Officer and completion of Compression Chamber Supervisor's Course.

3. During temporary absence of the facility PO(D) and on successful completion of Ships Dives Course and Compression Chamber Supervisory Course at DDS.

4. Qualifications only valid for appointment/draft when qualifications are required.

0724. Supervisors from Other Nations

a. Exceptionally there may be occasions when qualified supervisors other than those included in Table 7-3 (para 0721) are available eg from armed forces of other nations. Such supervisors may be allowed to supervise UK divers with the approval of S of D or SDO(A) as appropriate, but only when the conditions in sub-paras b and c below are met.

b. **Clearance Diving Supervisors.** NATO qualified supervisors must have successfully completed a Clearance Divers qualifying course, detailed in ADivP-1(A)/MDivP-1(A). This defines the operational limits of supervisory qualifications. In addition the conditions of sub-para c are to be met.

(1) For non-NATO supervisors, the supervisor must have successfully completed a course similar to the diving module of the MCDO's or PO(D)'s course, and have been trained in self-contained mixed gas diving to depths of at least 50m. Certification must be clarified together with the limits of supervisory qualification. In addition the requirements of sub-para c are to be met.

(2) The depth limitations of RN divers and equipment are to be adhered to at all times.

c. **Conditions to be Met**

(1) Have successfully completed a short shallow water familiarisation using the relevant equipment at the Defence Diving School or with the unit they are seconded to.

(2) Have worked-up to depth in accordance with para 0738 and BR 5063, using RN equipment and practices, as determined by the Inspector of Diving.

(3) Completed a period of self study and be familiar with the detailed supervisory requirements of BR A2806 and other diving related BRs.

(4) Successfully complete a written examination, set by the Defence Diving School and a practical supervisory assessment as determined by the I of D.

(5) Supervisors expected to supervise minehunting dives are to understudy at least 6 minehunting dives, half of which must be at night. Dives are to involve actual and simulated decompression using in-water and surface techniques.

(6) When all the above requirements are met (sub-para c(5)) is not applicable if minehunting diving is not required), the specific approval of S of D is to be sought by letter or signal.

d. **Ship's Divers.** Ship's Diving Officers, Supervisors or equivalent from other nations are not permitted to supervise RN diving operations unless they have carried out the full Ships' Diving course at the Defence Diving School.

e. **SBS Supervisors from Other Nations**. The following conditions are to be met by supervisors from other nations before supervising SBS diving operations

(1) Be a Special Forces diving supervisor trained to equivalent standards of the SBS.

(2) Complete a familiarisation on Special Forces diving equipment and drills.

(3) Complete a period of self study and familiarisation with the supervisory requirements of BR 2806, other related BRs and Unit Standing Orders.

(4) Successfully pass an oral and practical supervisory assessment set by the SBS Training Squadron Diving Officer, Royal Marines Poole.

(5) Be recommended by the OC of the Unit to which the individual is attached.

(6) When the requirements above are met, approval to grant supervisory status is to be requested by letter or signal from S or D.

f. **Army Divers.** Approval is to be sought from SDO(A).

0725. Divers from Other Nations

a. Qualified divers, other than those included in the Table 7-5A eg from armed forces of other nations, may be allowed to dive with the approval of S of D but only when the conditions detailed below are met.

b. **Clearance Diving**

(1) NATO qualified divers must have passed a Clearance Diving qualifying course as detailed in ADivP-1(A)/MDivP-1(A) Chapter 11 para 0311 which also defines the applicable depth limits of diving qualification. In addition the conditions in sub-para c (and d if applicable) are to be met.

(2) For non-NATO divers, the diver must have completed a course similar to the RN AB(D) course where they have been trained in self-contained mixed gas diving to depths of at least 50 metres. Certification must be clarified together with the limits of diving qualification. In addition conditions in sub-para c (and d if applicable) are to be met.

c. **Conditions to be Met**

(1) As determined by the Diving Officer, have received instruction, completed a period of self-study and familiarised themselves with BR 2806 and other related diving BRs, including the single lifeline code.

(2) Been locally familiarised and worked up to depth, in accordance with para 0738 and **BR 5063** Chapter 11 using the relevant RN diving equipment (except CDBA - see sub-para d) as determined by I of D.

d. **CDBA Diving.** Nationally trained divers may dive using CDBA when they have successfully completed an S of D authorised CDBA conversion course at the Defence Diving School.

e. Once approval is given by S of D, an entry is to be made in the diver's log to state when he qualified to dive in each breathing equipment. Any restriction is to be noted.

f. **Ship's Divers.** Ships Divers who have passed a qualifying course (NATO or non-NATO) may dive using SABA to a maximum depth of 21m for the purpose of carrying out dive practise to keep in-date for qualification or pay, provided that:

(1) Familiarisation training has been given at one of the continuation centres listed in para 0305.

(2) Approval has been given by the Superintendent of Diving.

g. **Army Divers.** Approval is to be sought from SDO(A).

0726-0727. Spare.

0728. Compression Chamber Operators

Compression chambers must only be operated by qualified personnel. The appropriate instruction may be contained either within a career course, or as a separate course of instruction leading to the award of a certificate of competence. Evidence of qualification should be annotated in individuals diving log.

0729-0730. Spare.

0731. Authorised Breathing Gas

a. Any breathing gas used for diving is to conform to the requirements of Defence Standard - Breathing Gas Purity for Diving. This Defence Standard takes precedence over any other standard for breathing gases, and should be consulted when necessary. It lays down the requirements for essential purity and dryness for oxygen, helium, nitrogen, air or any mixture thereof for charging breathing apparatus used in diving by the Ministry of Defence.

b. Air samples are to be taken from the locations and at the intervals specified in BR 2807(4)A.

0732. Authorised Carbon Dioxide Absorbent

Where the use of carbon dioxide absorbent is specified, only Soda Lime conforming to Specification CS 2580B dated 20 May 1984 (issued by the Director of Materials Quality Assurance) is to be used unless an alternative is authorised by S of D. The correct grade is always to be used as follows:

a. Diving Apparatus and CO_2 scrubbers in Drager Duocom and Type C Compression Chambers - Grade D.

b. CO_2 scrubbers in Compression Chambers - Grade L.

0733. Authorised Breathing Apparatus/Equipment

a. Table 7-5 sets out the authorised breathing apparatus/equipments and their official abbreviation. Table 7-5A refers to the breathing apparatus/equipment and the category of service diver authorised to use them.

Table 7-5A. Breathing Apparatus/Equipment and Abbreviations (Para 0733)

Breathing Apparatus/Equipment	Abbreviation
Enclosed Space Diving System	ESDS
Clearance Diving Breathing Apparatus	CDBA
Bail Out Diving Set	BODS
Long Endurance Breathing Apparatus	LEBA
Lightweight Oxygen Swimmers Equipment	LOSE
Rechargeable Air Breathing Apparatus	RABA
Surface Supplied Diving Equipment	SSDE
AGA Divator	AGA DIV
Swimmers Air Breathing Apparatus	SABA
Long Endurance Breathing Apparatus (Mixed Gas)	LEBA (MG)

Table 7-5B. Authorised Breathing Apparatus for Different Categories of Diver (Para 0733)

Diver	Breathing Apparatus
MCDO, Diver	All forms of approved breathing apparatus - see sub-para b
SBSSC	BODS, SABA, LEBA (O_2) - LAR V, LEBA (MG) - LOSE, RABA - see sub-para b
SAR Diver	SABA, BASAR MOD A
Ship's Diver Officer Ship's Diver Supervisor Ship's Diver	SABA see Notes 3 and 4
ADS AAD	All forms of approved compressed air breathing apparatus - Note 1
UDS ACAD (Royal Engineers)	SABA, - Note 2
UDS ACAD (all other Army Units)	SABA

Notes:

1. An entry is to be made in the diver's log to state when he qualified to dive in each breathing apparatus.

2. These divers are not qualified to use any other in-service compressed air breathing apparatus, unless with SDO(A) authority, they have carried out further training at the DDS.

3. Ship's divers on the staff of the SETT are authorised to use RABA for exit and re-entry training.

4. Ship's Divers on the staff of the Underwater Escape Training Unit (FONA) are authorised to use BASAR MOD A during dunker training serials.

5. Divers on the scheme of compliment of FDU2 who successfully completed training in the use of RABA, are authorised to free swim solo in support of LR 5 launch and recovery to a maximum depth of 10 m. This qualification is to be annotated in S1627 diving logs.

b. Diving may be undertaken in other forms of diving apparatus, *eg. trials/foreign equipment,* but only with the specific dispensation, written or signalled, of the appropriate authorities shown below.

MCDOs, Divers, RNR Divers, Ship's Divers and SAR Divers	- Superintendent of Diving
SBSSC	- CO SBS as advised by S of D
Army divers	- SDO(A)

0734. Breathing Apparatus - Pre-Dive Check

a. The detailed procedure for the preparation of all breathing apparatus for diving is laid down in the relevant equipment handbook and/or Job Information Card. See also para 0980 for Army pre-dive procedures.

b. The fact that a diver's breathing apparatus has been prepared for him, does not relieve the diver of his responsibility to confirm that his set is correct before starting the dive.

c. In this respect the following can be accepted as confirmation:

(1) *Cylinders charged.* Date and time of charging/gauging, type of gas and the pressure written in chalk on the cylinder or pre dive tag, completed in wax pen.

(2) *CO_2 absorbent canister charged.* Date and time of charging written on the pre dive tag.

Note. *CDBA - The details above, and certification that the leak tests are well, are to be recorded on the pre-dive tag. No set is to be used unless a completed, signed up, pre-dive tag, with the correct serial number is attached.*

d. All other tests (leaks, valves, etc) must be personally conducted by the diver himself, assisted if necessary by his attendant. In particular connections are to be checked for correct fitting; for push fit half turn fittings, they cannot be pulled out; for spanner tight connections, they cannot be loosened by finger pressure; for hand tight connections, they are hand tight.

e. The final check for leaks must be witnessed by the Supervisor, or attendant, or buddy, (who are to report to the Supervisor) immediately after the diver has entered the water and before he descends.

f. If bottles have been charged but not re-assembled into the set within 30 minutes they are to be gauged prior to assembly unless the set is fitted with a gauge. If the set is not fitted with a gauge and has been assembled but left unattended for over 6 hours, or if the set appears to have leaked the bottles are to be re-gauged. Leakage will be revealed by signs such as the counterlung becoming fully inflated when the bottles are closed, or by the pre-dive ‘check for leaks’ test. If the bottles have been charged and blanked off they are to be re-gauged prior to use.

g. **CO_2 Absorbent in a CDBA**. If not used, will last for a period of 12 hours when the scrubber assembly was first charged, providing the following conditions have been met.

(1) The filling of the scrubber assembly was part of the full pre-use routine and the enclosed breathing loop was sealed by ensuring that the DSM slide valve was and remains in, the open circuit position.

(2) The set is protected, as far as practicable, from extremes of surface temperature.

(3) The set is not left in a position where tampering by unqualified personnel is possible.

0735. CDBA Oxygen/Helium and Air Diluent - Limitations

a. CDBA is capable of diving to 50m using air diluent and 91m when Oxy-helium (16/84%) is the diluent. For operational reasons the maximum operating depths are detailed in Table 7-6.

b. CDBA maintains a PO_2 of 0.75 Bar to 10m and 1.3 bar from 10 to 80m, due to a soft wear anomaly this will be displayed as 1.21 bar on the secondary display. The set automatically reverts back to 0.75 on ascent at 4m. The primary display will indicate a high or low PO_2 when readings are outside of set parameters ± 0.15 bar.

c. Whilst travelling through the water column, especially at the 10m depth during descent and at 4m on ascent, the primary display may indicate low or high readings. During travel these readings must be monitored on the secondary display and should be confirmed as transient.

d. At all times the PO_2 is to be maintained within the parameters as detailed in Table 7-6A. If the stated boundaries cannot be maintained during normal travel the travel is to be halted until the equipment stabilises once more.

Table 7-6. Maximum Depths for Air and Oxy-Helium Diluent Gases

Diluent	Maximum Depth
O_2/N_2 (Air)	30
O_2/He	80

Table 7-6A. Maximum and Minimum Permitted PO_2 for CDBA (Air and O_2/He)

Depth	Normal Set Point	Range	Min and Max Range
< 10	0.75	0.60 - 0.90	0.50 - 0.90
> 10 < 80	1.21	1.065 - 1.36	0.91 - 1.7

0736. Underwater Mission Endurance

a. **Self Contained Breathing Apparatus.** The endurance for a particular mission using self-contained breathing apparatus depends on three factors:

(1) Gas Endurance Time Limit

(2) CO_2 Absorbent Endurance Time Limit

(3) Oxygen Depth/Time Limits

Each of these Time Limits must be separately determined, then the mission endurance is established as the shortest of these limits. The Gas Endurance Time limits are calculated as laid down in para 0174. The CO_2 Absorbent Endurance Time Limits are dependent upon both canister design and water temperature and are stated in the relevant equipment handbooks.

Depth/Time Limits for mixed gas diving are governed by the appropriate decompression tables as long as the limiting line is not exceeded. The maximum safe depth for a particular breathing mixture assumes a diver completely at rest with a maximum PO_2 of 2.0 Bar. In practice the diver will be working so that his PO_2 at depth will be less than this figure. As decompression commences the PO_2 will drop even further. When breathing pure oxygen particular attention must be paid to the depth/time limits laid down in para 1102.

b. **Clearance Diving Breathing Apparatus - Endurance.** When air is used as the diluent CDBA is capable of diving to 50m (but will normally be limited to 30m, which may be extended to 40m by S of D on application) maximum depth capability is 91m when an oxy-helium (16/84%) diluent is used (for service reasons O_2/He diving is restricted to 80m)

c. Under normal conditions, the anticipated duration of the diluent supply will exceed that of the oxygen supply. When a fully charged oxygen vessel (205 bar) is used with an average oxygen consumption rate of 1.25 litres per minute (lpm), vessel duration will be approximately 7 hours, at an ambient pressure of 1 bar.

d. CO_2 absorbent duration is affected by the environmental operating temperature and depth. CO_2 absorbent duration decreases as temperature decreases and as depth increases.

e. The CDBA uses two separate power supplies. The primary electronics battery will provide an adequate operating voltage for more than 10 hours in 20°C water.

f. The secondary display batteries will provide adequate operating voltage for over 50 hours in 20°C water.

g. A fully charged CDBA has an in water endurance of 4 hours to any operating depth. this is governed predominantly by the CO_2 absorbent life.

h. When dives are conducted to 80m the maximum planned duration should be 15 minutes. This will ensure sufficient gas supplies to conduct a 20 minute schedule, with in water stops, should the diver run over.

i. **Repetitive Diving with CDBA.** When carrying out a series of repetitive dives as occurs in a minehunting operation the life of the CO_2 absorbent is to be assumed to have expired after an accumulated period of 240 minutes over a 6 hour period has elapsed calculated from the start of the first dive.

j. **Repetitive Diving with Self-Contained Open-Circuit Breathing Apparatus.**

(1) Repetitive dives using the same self-contained open-circuit breathing apparatus are not to be undertaken unless the Supervisor is CERTAIN the set has not been equalised. For Army divers the supervisor is to ascertain that there is sufficient air available for the dive. The supervisor must also be fully aware of the limited endurance for second or subsequent dives.

(2) When such diving takes place the initial breathing tests are not required (ie the set is NOT to be equalised before the dive). During the dive equalisations are to be carried out as normal, and the diver is to surface after the second equalisation.

k. **Surface-supplied Diving Equipments.** Generally speaking with surface-supplied equipments the diver's time underwater is limited only by compliance with the decompression tables, and his physical endurance in the prevailing environmental conditions.

0737. Tables of Authorised Diving Limits

a. The normal depth limits for RN diving are 50m on air, and 80m on oxy-helium mixtures. These limits are imposed because of the hazard of nitrogen narcosis and operational requirements. Diving deeper than 60m is defined as deep diving.

b. The following Tables 7-7 to 7-10 set out the various forms of diving authorised for normal diving, together with the approved breathing apparatus and the depth limits applicable to each type of Service Diver. However divers specially qualified in combat oxygen (Combat Swimmers) diving may use the depth/time limits given in para 1102. (RNR Clearance Divers are authorised to dive to the same limits as their RN equivalent). Depths are given in metres.

c. Divers qualifying are authorised to dive to these depths and forms in the course of their training.

d. In emergency, when the depth of water in which a diving operation is taking place is greater than the authorised limit for the men carrying out the dive, the standby diver may, at the discretion of the diving supervisor, dive to the limit of his equipment in order to save life.

e. Divers taking part in officially authorised trials may, under medical supervision, dive to such depths as the trial may require, and may if necessary use non-standard gas mixtures.

f. SBSO's and SBSSC may use mixture O_2/N_2 breathing apparatus to 24m on completion of the appropriate course. Search group swimming is restricted to 15m. Free solo swimming to 24m only when authorised by S of D or COSBS.

Table 7-7. Pure Oxygen Breathing Apparatus

Type Of Diver	**Diving**		**Swimming**				
	Attended - Solo or in Pairs (m)	Marked (m)	Marked Solo (m)	Marked in Pairs (m)	Free Solo (m)	Free in Pairs (m)	Search Group (m)
MCDO, WO(D), CPO(D) PO(D), LS(D), SBSSBSO SBSSC.	7	7	7	7	7	7	7
Diver 1	7	7	NO	7	NO	NO	7
Diver 2	7	7	NO	7	NO	NO	7

Note. *Personnel qualified in oxygen combat swimming may dive to 15m within the rules of para 1102.*

Table 7-8. O_2/He Breathing Apparatus

Type Of Diver	Diving			Swimming				
	Attended Solo (m)	Attended Pairs (m)	Marked (m)	Marked Solo (m)	Marked in Pairs (m)	Free Solo (m)	Free in Pairs (m)	Search Group (m)
MDCO, WO(D), CPO(D), PO(D), LS(D)	60 or 80 Notes 1 & 3	60 or 80 Notes 1, 3 & 6	42	42 Note 2	42 Note 2 & 6	42	42 Note 6	24
Diver 1	60 or 80 Notes 1 & 3	60 or 80 Notes 1, 3 & 6	42	42	42 Note 6	NO	15 Note 5	24
Diver 2	60 or 80 Notes 1 & 3	60 Notes 1, 3 & 6	42	24 Note 4	42 Note 6	NO	NO	24

Notes:

1. Attended diving solo or in pairs is only to be carried out in swimming rig. When swimming rig is used for solo diving, a safety line (para 0746) may be used in lieu of a lifeline.

2. May be increased to 60m when the operation requires little physical exertion.

3. Diving to 80m only permitted when authorised by S of D.

4. May be increased to 42m when the operation requires little physical exercise.

5. Exceptionally for DDS acting as career course staff may, after a 3 month ability assessment period, partner LS(D), PO(D) and MCDO students when conducting free swimming training.

6. If only one XBS is available, only no stop diving to a maximum depth of 42m may be conducted.

Table 7-9. Compressed-Air Breathing Apparatus

Type Of Diver	Diving		Swimming				
	Attended - Solo or in Pairs (m)	Marked (m)	Marked Solo (m)	Marked in Pairs (m)	Free Solo (m)	Free in Pairs (m)	Search Group (m)
MCDO, WO(D), CPO(D), PO(D), LS(D)	50	30	30	30	30	30	15
Diver 1	50	30	30	30	NO Notes 1 3 & 6	15 Note 3 & 9	15
Diver 2	50	30	30	30	NO Note 1	15 Note 2	15
SBSO, SBSSC.	30	30	30	30	30	30	NA
SAR Diver when operating or exercising in the SAR role	NA	NA	30	NA	30	NA	NA
ShDO, ShDS, ShD } Note 5	21	21 Note 8	18	21	NO Notes 1	15 Note 2	15
ADS, AAD	50	N/A	30	30	NA	NA	15
UDS, ACAD.	30	N/A	30	30	NA	NA	15

Notes:

1. Authorised exceptionally to carry out free swimming solo when required to operate in the role of SAR diver to save life (para 0783).

2. Free swimming in pairs may take place to a maximum depth of 15m when engaged in authorised ship bottom searches. This includes Search Scheme C in which the divers although not ‘buddied’, are in constant touch by means of the necklace line/jackstay.

3. Authorised EXCEPTIONALLY FOR DDS and NDG ONLY, after a 3 month ability assessment, then annotated in the S1627. The supervisor must be a PO(D) or above and a standby diver must be at immediate notice.

4. Ships divers on the staff of the SETT are authorised to use SABA and RABA to maximum depth of 30m in the SETT.

5. Ship’s divers involved in exit and re-entry procedures may free swim solo down to a maximum depth of 30m when taking part in planned exit and re-entry exercises, also when conducting maintenance and inspections in the SETT.

6. Authorised exceptionally to carry out free swimming solo when assisting with launch and recovery of submersibles.

7. Ship’s divers on the staff of the Underwater Escape Training Unit (UETU)(FONA) are authorised to free swim solo during dunker training serials.

8. Ship’s Divers are not authorised to dive in boots.

9. On successful completion of a LEBA(MG) training protocol and training in free swimming operations, partnered by a LS(D) or above, exceptionally authorised to free swim in pairs to 24m using LEBA(MG) when employed in FDU 2 in support of VSW operations.

Table 7-10. Compression Chamber Diving

Type Of Diver	Breathing As Directed In The Appropriate Table In Chapter 12 Section 5
Minewarfare and Clearance Diving Officer WO(D), CPO(D), PO(D), LS(D), Diver 1, Diver 2.	60 Note 1
SBSO, SBSSC1, SBSSC.	50 Note 1
ADS, AAD	50 Note 1
Ship's Diver Officer, Ship's Diver Supervisor, Ship's Diver, Search and Rescue Diver, SBSO, SBSSC, ACAD	30 Note 2

Notes:

1. This depth may be extended to 70m when acting as attendant during Therapeutic tables 65, 71 and when using the Type C Chamber for routine training dives.

2. This depth may be extended to 50m for:

a. Qualified Army divers acting as attendants in order to allow assessment of their ability at depth.

b. Attendants during therapeutic recompression.

c. Therapeutic decompression attendant training dives.

3. SETT staff and trainees may carry out compression-chamber dives as required by OCSETT to a maximum of 50m.

0738. General Depth Limitations

The following depth limitations, not applicable to compression-chamber diving, are imposed in addition to those outlined elsewhere in this manual:

Table 7-11. Depth Limitations

Depth In Metres	Limitations
24	Diving in excess of 24m may not be carried out unless the diver has exercised underwater in the previous 3 months
42	Diving in excess of 42m may not be carried out unless the diver has exercised underwater below 24m in the previous 3 months
60	Diving in excess of 60m may not be carried out unless the diver has exercised underwater below 42m in the previous 2 months and has authorisation from S of D.

0739. Pre-Dive Depth Check

a. Where diving is to take place on the seabed, the depth must be confirmed by sounding line prior to the dive.

b. Depths obtained by Echo Sounder, from a sonar marking outfit line, or from reference to a chart are not sufficient by themselves to give a reliable depth at the dive site.

0740. Spare.

0741. Wearing of Knives

a. When diving is taking place all supervisors, divers and attendants are to wear knives.

b. Depending on the task, the diver is to carry a knife of authorised pattern, either:

(1) Diver's knife, this is a large heavy-duty knife carried during general diving tasks.

(2) Diver's knife (non magnetic). A version of (1) with reduced magnetic signature for use in MCM and EOD Operations when the safety of the diver so requires.

(3) A special knife approved for the task, for example:

(a) The 'J' knife for SAR divers.

(b) Knives approved by CO SBS for SBS operations.

c. Adequate measures must be provided to prevent the knife from dropping out of its sheath and being lost.

d. Army Supervisors and attendants not in dry suits are to wear a RE pattern jacknife, or a knife with similar cutting ability or strength.

e. When using SABA or SDDE, if the knife is worn on the belt it is fouled by the overlay of the jacket, therefore the knife is to be mounted elsewhere, or a knife extension used.

f. Divers and swimmers may dispense with personal knives whilst in UETU pool providing knives are clearly marked and easily obtained within the training module and surrounding area.

0742. Diver's Lines - Marking

a. Lines used for controlling the depth of the diver are to be marked as shown below. These lines include; gas hoses; lifelines; safety lines and XBS/lazy shot ropes.

b. The following standard marking code is to be adopted. Lines are to be marked from a datum blue mark positioned approximately 0.8m (Navy) or 1.5m (Army) from the diver's end. The blue datum mark is to be positioned at the diver's shoulder when the life-line is secured. Lines are to be marked every 15m from the datum by one red band for every multiple of 15m, eg 45m mark would have three red bands. In addition, each 15m length is marked at each intermediate 3m by a yellow band for every multiple of 3 m plus the appropriate number of red bands, e.g. the 12m mark would have 4 yellow bands and the 36m mark would have 2 red bands and 2 yellow bands.

c. In addition, lines to be used by divers breathing oxygen are to be marked at the 7m mark with a single white band.

d. The lines are to be marked using turns of 20mm coloured adhesive tape 10mm apart. Rope, whether MMF or natural is to be marked by weaving the plastic tape through the strands and then taking two complete turns round the rope.

e. The tapes are to be so applied that the lower one, or first tape of a numerical combination to enter the water, is at the depth to which that combination refers.

0743. Diver's Lines - Securing

a. When diving in self-contained breathing apparatus, the line secured to the diver, or on a secure point on the diving equipment, whether it be lifeline, safety line or buddyline, is to be so fastened that the breathing apparatus can be ditched without being fouled by the line. Lines are to be secured to ensure they are easily detached. Care should be taken to ensure that the datum mark is positioned at the divers shoulder.

0744. Lifelines

a. When carrying out attended diving the diver is always to have a lifeline, or gas umbilical designed to serve as a lifeline securely attached to him (Article 0743) and attended at the surface. Lifelines are always to be attached to the diver using a bowline knot. Where divers umbilical or communications cable are designed to be used as lifelines the appropriate supply connections are to be used.

b. The lifeline for the self-contained diver must be not less than 8mm manilla or man-made fibre of at least equivalent strength. The length of the line will vary for the type of work for which it is intended.

c. On each occasion of use lifelines and Sam Brownes are to be inspected for damage and defective lines renewed. The distance between markings should be checked periodically, particularly on new lines that are stretching and the marks adjusted as required. All lines are to be marked in accordance with para 0742.

d. The diver is responsible for securing his own lifeline. The attendant is to check that the lifeline is properly secured to the diver, and is responsible that the inboard end is firmly secured on the surface. The lifeline is to be kept firmly in hand by the attendant throughout the dive (see para 0975).

0745. Buddylines

a. When two divers are being prepared to operate as a pair of swimmers, a buddyline is used to join them together. A special buddyline assembly is provided for this purpose.

b. The buddy line is always to be attached to that arm which will allow the set to be ditched if necessary, without it becoming foul.

c. During SBS training, exercises and operations specific types of special buddyline may be used provided they have been approved by CO SBS, and by the S of D.

d. Buddylines are to be thoroughly inspected at regular intervals for signs of rotting of the line or stitching or for any other signs of deterioration, and supervisors in charge of diving operations are to satisfy themselves on each occasion of use that the buddyline is properly attached to the swimmers and fit for use.

e. Buddylines are not to be disconnected until divers are clear of the water, or under the positive grasp of an attendant or until each divers BA and/or weight belt has been slipped and recovered and the diver is positively buoyant.

0746. Safety Lines

Whenever diving is being carried out without a lifeline (except when free solo swimming is authorised) the supervisor is to ensure that the safety lines used conform to the following minimum specification. Stronger lines may be used.

a. **Minehunting and EOD Diving.** The diver's safety line - 4mm polyethylene rope.

b. **Marked Swimming.** The diver's floatline (swimline) - 4mm polyethylene rope.

c. **Search Groups.** The searchline and necklace coupling line - 8mm polyethylene rope.

d. **Pair Swimming.** An approved buddyline assembly in accordance with para 0745.

0747. Diver's Buoyancy

a. Whenever possible, all divers and underwater swimmers are to be so equipped that when they have discarded all slippable weights they will have positive buoyancy.

b. This is particularly important when 'wet' suits are being worn, bearing in mind their loss of buoyancy with increased depth.

c. Because of the loss of buoyancy mentioned in para 0747(b) 'wet' suits are not to be used below a depth of 24m unless the diver is wearing an adjustable buoyancy jacket, when the depth may be extended to 30m (eg SABA).

d. SBSSCs may wear additional weights in a weight vest. They are to comply with the following rules regarding buoyancy when wearing dry suit.

Breathing Apparatus	ABJ/DABJ	Suit Inflation
LEBA (MG)	Yes	Mandatory
SABA	Yes	Mandatory
LEBA (O_2)	Mandatory	Optional

e. Except for a booted diver the number of weights should be so adjusted that the diver is neutrally buoyant.

f. When using a weight belt, the belt should be so worn that it is released by the opposite hand to that used for releasing the waist belt of the set.

0748. Suit Inflation

a. When diving or acting as a surface swimmer a fully charged suit inflation cylinder or direct feed suit inflation, is always to be worn with a dry suit (or Uni-Suit or equivalent) except when the suit is worn by SBSSCs using LEBA O_2 - LAR V (para 0747d) or by SARDs operating or exercising in the SAR role. Suit inflation prevents the suit pinching, provides additional buoyancy when required and also gives some protection against the cold.

b. The suit inflation cylinder and associated lifeline belt assembly is described in **BR 2807(2).** After fitting to the divers dress the cylinder valve should be operated briefly to ensure that there is a free passage of air into the suit.

c. Oxygen is never to be used for charging suit inflation cylinders because of the fire risk.

d. When SBSSCs wear the Uni-Suit or equivalent the suit inflation cylinder may be worn in a convenient position appropriate to the other requirements of the operation as laid down by COSBS.

0749. Marked Diving and Swimming

a. When marked diving or swimming is being carried out, the supervisor is to ensure that:

(1) The lifeline or safety line is long enough for the maximum depth of water in which the diver will be operating.

(2) A powerboat (inflatable craft/MIB/LIB) is in attendance in the vicinity of the float (see also para 0771).

(3) The standby diver is available. (See para 0704).

(4) All personnel are fully conversant with the emergency ascent routine before marked swimming takes place.

(5) There is a lost diver marker available.

(6) For Army diving the power boat is to be manned by the following minimum crew:

Supervisor (Helmsman) - he may stand when necessary to ensure maximum visibility
Standby diver
Standby diver's attendant
Surface swimmer (one per two divers).

(7) Army divers when compass swimming, singly or in buddied pairs are to wear or carry on the swim board a depth gauge.

b. During marked swimming the divers safety line may be tended from the surface. A separate attendant is only required for each safety line tended throughout the dive.

c. In marked diving or swimming in pairs, the diver wearing the lifeline or safety line is to enter the water first and leave it last. The second diver is, **when practicable**, to remain attached to the diver wearing the lifeline or safety line at all times while in the water.

d. If divers are to be moved in the water by an inflatable power boat the divers are to be held close to the bows and towed.

e. When marked swimming at night the divers float is to be marked with a chemical light (cyalume) or a divers indicating light taped to the stave.

0750. Safety of Personnel in Boats

a. **General**. Persons in charge of diving boats must be aware of the safety of all personnel onboard. It is particularly important that a risk assessment be carried out to determine whether the wearing of safety equipment such as life jackets or protective headgear is appropriate.

b. **Safety in Rigid Inflatable Boats (RIBs) and Inflatable/MIB Craft**. For divers operating in RIBS or MIB craft, crew qualification and the wearing of protective clothing and lifejackets must be in accordance with relevant Service regulations contained in BR 67 Manual of Seamanship and FLAGOs. The following exceptions apply to diving operations as appropriate.

(1) Protective clothing may be substituted by diving suits or neoprene drysuits. Zips are to be fully closed/sealed and a charged suit inflation cylinder fitted. Upperdeck Crewmans Suits (MCDOs and Diver sub-branch ratings only) may also be used.

(2) At the dive supervisors discretion, lifejackets are to be worn over diving suits whilst transiting to and from diving areas in RIBs/Inflatable craft. A risk assessment, relative to the prevailing weather conditions, is to be conducted by the dive supervisor.

(3) During diving operations divers dressed in diving suits are **NOT** to wear lifejackets.

(4) Lifejackets are to be worn over Upperdeck Crewmans Suits during boat transits to and from diving areas in RIBS/Inflatable craft. At the dive area lifejackets may be relaxed to relieve bulk at the discretion of the diving supervisor, only after a risk assessment relative to the prevailing weather conditions has been conducted.

(5) Protective headgear may be relaxed for diving operations provided no danger exists from overhead obstructions.

c. **Choice of Lifejackets**. The Hazardous Duty Lifejacket (HDLJ) is normally to be used by ship's teams for general diving tasks and by CD Elements embarked in MCMVs for Minehunting Diving (para 0784). HDLJ, Special Forces Lifejackets (SFLJ) or Assault Troop Lifejackets (ATLJ), as most suitable to the task, may be used by CDUs or other units during diving operations provided the dive supervisor or OIC has conducted a risk assessment. See Note.

d. **Safety in Boats Underway**. Divers using dry suits are to be fully dressed with all zips closed/sealed while the diving boat is underway. There are no restrictions in respect of wetsuits except that weightbelts are to be removed.

Note. *A properly inflated lifejacket is designed to ensure an unconscious casualty will float with his/her airway clear of the water. A buoyancy compensator may allow a casualty to remain on the surface but will not necessarily ensure that the airway is clear. Buoyancy compensators must not be substituted for lifejackets.*

0751. Use of Diver's Light

a. To improve diving safety, enabling the diver to illuminate the work area or the immediate vicinity, particularly in an emergency, a 'Personal Divers Light', (PDL) (NSN 0833-6230-99-8391831) is normally to be worn for all diving operations. The wearing of a PDL may be relaxed at the diving supervisors discretion if the underwater ambient light/visibility is good or appropriate alternatives are available.

b. The 'PDL' is fitted with rubber straps for security to the forearm. The diving supervisors may use their discretion with regards to the location of the light providing it is secure and easily accessible by the diver.

c. **Army Divers.** At night all Army divers are to wear a divers distress lamp secured to the right arm in such a way that the diver can reach the switch with ease. When carrying out marked swimming the diver's float is to be marked with a cyalume or saline light secured to the stave in such a way as to be visible to the surface crew. For special operations involving Army divers, lamps/cyalumes/lights may be dispensed with. Dispensation must be sought from SOD(A) for such operations.

0752. Facemasks and Nose Clips

a. Two types of facemask are provided for Service diving, the wide vision (full) facemask and swim mask (para 0930). Ship's Divers are only permitted to use SABA fitted with a full facemask except for special arrangements which apply to SETT staff and to Ship's Divers employed on specific tasks as approved by SofD. Other divers may use a separate swim mask, with free mouthpiece, if appropriate to the task and breathing apparatus. Use of a swim mask with CDBA is not permitted.

b. A nose clip must be worn when diving with a full facemask, unless full face mask contains an oral naval mask fitted with a nose clearing device. These enable the diver to clear his ears by blowing against them and to carry on breathing through his mouthpiece if his facemask becomes flooded.

0753. Warning Signals

a. For ships and craft engaged in operating divers, the following signals are to be shown, and preparations made, in addition to exhibiting the lights and shapes prescribed for a vessel conducting special operations (IRPCS-1972,(Amended 1993) Rule 27b and Rule 34d)

(1) *Day*. Display a rigid replica of International Code Flag 'A' which is not less than 1m in height.

(2) *Night and Day*. Sound at least five short and rapid blasts on a whistle or siren or by signal light, at least five short and rapid flashes.

b. When a diving boat is being used to operate divers in the vicinity of and under the positive control of a ship or craft displaying the lights and shapes prescribed in the International Regulations for Preventing Collisions at Sea and which is able to take action as in a(1)a and a(2) the diving boat need only show:

(1) *Day*. A rigid replica of International Code Flag 'A' which is not less than 1m in height when approached by other ships.

(2) *Night.* One all-round white light.

c. When a diving boat is used to operate divers and it is not under positive control of a ship or craft it is to:

(1) *Day*. Display a rigid replica of International Code Flag 'A' which is not less than 1 metre in height. Be prepared to make a warning signal as in a(3).

(2) *Night.* Display three all-round lights in a vertical line with the highest and lowest of these lights red and the middle light white. The lights should be spaced not less than 1m apart and the lowest light not less than 2m above the gunwale. If necessary sound five short and rapid blasts or by signal light five short and rapid flashes, when approached by other vessels.

Note. *During operational night attack exercises this requirement may be waived at the discretion of the OTC, provided that a ship or craft is nominated to exercise positive control over the Gemini as outlined in sub para b above.*

d. Any local signals in force concerning diving operations are also to be used.

0754. Spare.

0755. Precautions when Handling Oxygen

a. The potentially lethal consequences in using non-compatible equipment, components or greases with oxygen and oxygen enriched mixtures cannot be over emphasised.

b. When exposed to oxygen under pressure, materials not normally regarded as combustible may burn.

c. It is critical to safety that only designated oxygen clean parts, as listed in the appropriate BR are used when replacing components of oxygen equipment and that when cylinders are charged with oxygen or oxygen enriched gas this is done using authorised gas booster pumps and hoses only.

0756. Handling of High Pressure Gases

a. All gas whips (HP flexible hoses) used for charging cylinders or as supply hoses to RCCs or Panels are to be securely lashed along their length. This is to prevent them flailing around if they become detached while pressurised, causing hazard to personnel and equipment.

b. For hoses up to 2m in length:

(1) The safety lashing must be of sufficient strength to restrain the hose, and long enough to be capable of being attached at the supply end to a secure point, with the other end fitted with a shackle, karabiner, or spring clip of sufficient strength to hold a whipping hose. The connection must be attached to a secure point or the equipment.

(2) The safety lashing should be attached on the hose ends by means of a clove hitch 25mm from the swaged metal and fittings and secured along the length of the hose by means of half hitches at intervals of not greater than 100mm.

(3) To hold the clove and half hitches in position they are to be lashed on either side by means of tie wraps, tape or cordage. (If tie wraps are used, sharp edges resulting from cutting ends, are to be removed.)

(4) Lashings are not to be secured to high pressure piping.

c. Hoses greater than 2metres in length are to be lashed as in sub-para (b) above except that the safety lashings are to be clove hitched on hoses at a distance no greater than 230mm from the swaged end fittings and half hitched along the length of the hose at intervals not exceeding 460mm.

d. When charging small cylinders such as suit inflation, the cylinders themselves are not considered a secure point but are to be fixed to a bench or other suitable position with a minimum of two webbing belt loops.

e. Safety goggles and ear defenders are to be worn when charging gas cylinders, testing HP systems and equipment. When gauging or opening HP cylinders fitted with a contents gauge, users are to open valves slowly to gradually apply pressure, holding the pressure gauge away from the body and other personnel.

0757-0760. Spare.

0761. Meals and Alcohol

a. It must be recognised that following the consumption of alcohol the residual effect will not be removed from the blood stream for a number of hours. The efficiency of a diver may thus be impaired and it must therefore be considered in the same way as drinking and driving. It is the responsibility of the diver to ensure that his efficiency is not effected by the consumption of alcohol or drugs.

b. Diving is not to take place within:

(1) Six hours of the consumption of alcohol.

(2) Two hours of the consumption of a heavy meal.

c. Notwithstanding sub-para b(2), diving should not take place on an empty stomach. The diver should, if necessary, take a light snack shortly before diving.

d. Before diving is carried out, the diving supervisor must always ensure that the efficiency of a diver has not been impaired by the consumption of alcohol or drugs, including drugs prescribed for medical treatment.

0762. Dentures and Contact Lenses

a. **Dentures.** Full plate dentures should be removed before diving. Partial dentures may be worn if they are adequately secured to the remaining teeth, and contribute to effectively retaining a diving mouthpiece. There remains a remote possibility that they could become dislodged and cause an obstruction to the airway, which might prove fatal should the diver lose consciousness. Cases of doubt should be referred to a Service Dental Officer for his opinion.

b. **Contact Lenses.** Contact lenses are not to be worn by divers during diving operations governed by this manual.

0763. Diving in Cold Weather

a. Diving in very cold weather, especially in conditions of ice or with a high chill factor (a combination of wind speed and ambient air temperature) is a dangerous practice and should only be carried out when an essential task has to be performed and there is no other means of carrying it out.

b. Except in emergencies diving is not to take place when the conditions experienced are to the right of the safe diving cut off line as shown in Fig 7-1.

c. Planning considerations for diving in cold weather are given in paras 0921 and 0922.

0764. Ice Diving

a. Para 0763 states that diving in very cold water or in conditions of ice is a dangerous practice which should only be carried out when the task is essential. Supervisors and divers are to be fully familiar with the requirements for ice diving. Further information is to be found in BR 2807(1)(J), BR 2808(1) Chapter 5 Section 5 and Chapter 10 of this volume. Whenever ice diving is planned these references must be read.

b. **Personnel**. **Only MCDOs, Divers, RNR Divers and Army Divers may conduct ice diving**. All other service divers must seek approval from the appropriate Superintendent of Diving.

c. **Equipment Configuration and Familiarisation Training**. Prior to undertaking ice diving, familiarisation training must be conducted in a controlled environment with the SABA configured in accordance with BR 2807(1)(J). This reconfiguration must be done by a qualified in date diving BA maintainer. The configuration, operator and dressing procedures are as described in para 1019.

d. **Ice Diving**. Divers conducting ice diving are to continue to use SABA in its present configuration but are to observe the following:

(1) When checking for leaks the divers second stage should remain immersed and should remain so until the end of the dive.

(2) On completion of the dive the demand valve must be completely thawed and dried before re-use.

(3) If the second stage is allowed to remain in the air at water level it may freeze in the open position producing a constant flow (this will only occur in extremely low temperatures).

(4) In the event this occurs, the diver is to leave the water and take action as described in sub-para (2) above.

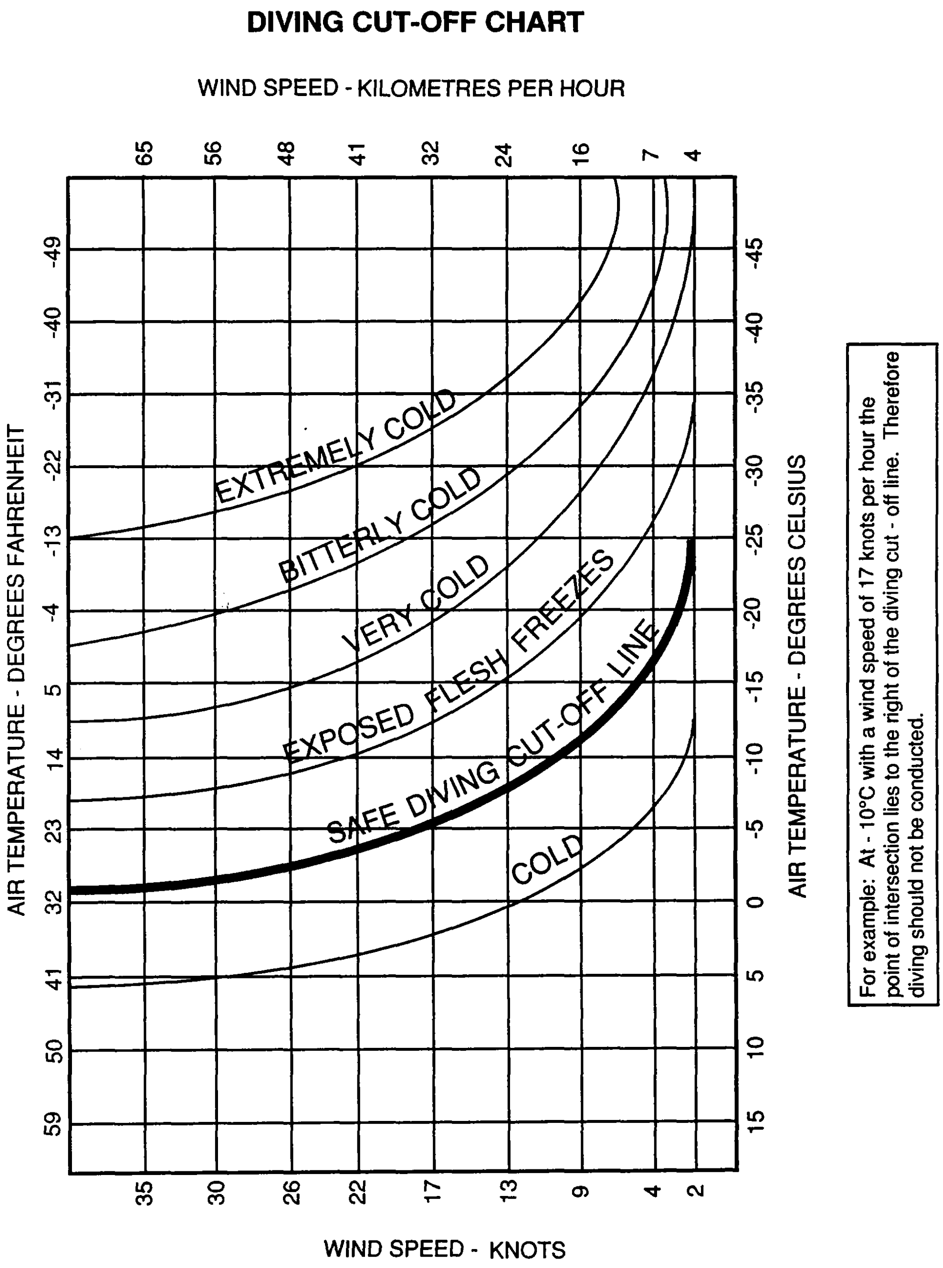


Fig 7-1. Diving Cut-off Chart

0765. Diving in Hot Weather/Hot Water

a. Diving in very hot weather or in high water temperatures is a dangerous practice which requires that additional precautions be taken to safeguard both the surface team and the diver(s) from heat exhaustion. See also paras 0921, 0922 and 1345.

b. All personnel involved in such diving operations should be sheltered from direct sunlight as far as is practical. Divers and standby divers deployed in inflatable boats should be draped in light coloured towels which should be kept wet. Diving apparatus should be treated similarly.

c. Proper hydration is essential and should be judged to have been achieved when urine is light straw in colour.

d. Work and performance will be considerably reduced. The following limits should not normally be exceeded.

Hard work	- 15 minutes total dive time
Moderate Work	- 20 minutes total dive time
Minimal Work	- 30 minutes total dive time

Provided that the approval of CO SBS has been obtained these limits may be exceeded during certain RMSBS exercises and operations.

e. When an ABJ/BCA is worn the depth may be increased to 30m when diving in overalls/blue under suits. (Ships Divers 21 m)

0766. Army Diving on Site Safety

For all Army diving operations the following facilities are required on site:

a. An O_2 resuscitator capable of delivering 100% O_2 to a casualty, checked out and ready to use. There is to be a spare O_2 cylinder on site if the pressure of the working cylinder is less than half its fully charged pressure. The working cylinder is to be changed over to a new one when its pressure is below one quarter of its original pressure unless it is actually being used to resuscitate a casualty when it may be used down to its residual pressure.

b. A comprehensive First Aid kit is to be immediately available, preferably in a waterproof container.

c. There is to be a nominated emergency vehicle positioned as close to the dive site as possible. It is to be capable of accommodating a stretcher and casualty receiving First Aid. It must be available at all times when diving is taking place. When diving from vessels the vehicle must be positioned at the point where that vessel would return to in the event of an accident.

d. A stretcher must be as close as practicable to the site and when diving from vessels it is to be positioned as at para 0766c.

0767-0770. Spare.

0771. Diving From Boats - Dangers

a. The danger to divers from turning boat propellers cannot be over-emphasised. The diver can be severely injured and lines can become fouled. The danger is particularly acute with outboard motors because of their high speed of revolution.

b. For this reason diving from powerboats with propellers turning is not to take place unless a propeller guard is fitted or as authorised in sub-paras c and d below.

c. There is a tendency for the propeller of small craft, such as Fleet Tenders and MFVs, to turn when the engine is running in neutral, because of creep through the gearbox. Therefore, during diving operations from these craft engines must normally be stopped. If it is necessary to run them (eg to provide power for the winch), divers must be warned to keep well clear of the propeller each time they go over the side.

d. For certain SBS operations, when there is no alternative, the diving safety boat may be a rigid inflatable craft with high powered outboard motors which cannot be fitted with propeller guards. Approval to use these craft for diving safety may be given by either COSBS.

e. For certain FDG VSW operations, the diving safety boat may be a rigid inflatable craft with high powered outboard motors which cannot be fitted with propeller guards. Written approval for the use of these craft may be given by COFDG as appropriate.

f. When Army divers are working from a Combat Support Boat (CSB) its engines must be switched off, and it may only be used as a platform.

g. At the discretion of the CO and, or the Diving Supervisor, when conducting routine MCM/EOD Clearance Diving Operations and Training, the engine must be running throughout diving operations, particularly during recovery of divers for surface or therapeutic decompression. As the diving supervisor is also the coxswain and is normally required to assist with the diving task and diver recovery, the kill cord requirement may be relaxed. When conducting Ships Diver operations, and then only in exceptional circumstances where no dedicated coxswain is available, if the coxswain is the ships diving supervisor, the kill cord requirement be relaxed but only to facilitate diver recovery. This relaxation only applies to inflatable craft MIB/RIB supported diving.

0772. Diving on or Near a Ship's Bottom

When divers are required to dive on or in the vicinity of a ship's bottom, the precautions outlined below are to be taken:

a. The dive supervisor is to ensure that the appropriate 'safe to dive' precautions have been taken and that he has full knowledge of the area in which the diver will be operating. In accordance with para 0904 he is to inform the engineer officer before the diver enters the water.

b. **Look-outs.** A look-out is always to be stationed on each side of the ship. Look-outs are to be briefed on their duties by the diving supervisor before any diving commences.

c. **Diving in the Vicinity of Propellers/Thrusters.** When work is on, or in the vicinity of propellers/thrusters, suitable arrangements are to be made to ensure that they cannot be rotated/operated, and also where controllable pitch propellers are fitted that the pitch cannot be altered. The shafts are to be locked and hand turning gear engaged in ships where this can be done. In steam turbine ships, if it is essential to dive in the vicinity of the propellers during the shutting down or cooling periods, the special precautions laid down in para 0773 must be observed.

d. **Diving in Vicinity of Main Inlets**. Due to the possible suction effect on divers and their gas hoses when diving in the vicinity of main inlets, the diving supervisor is to ensure that diving in the vicinity of main inlets is carried out only under the following conditions:

(1) *Self-contained Divers and Divers Using Surface Supplied Diving Equipment.* Divers using either surface supplied or self contained equipment are not to approach within 15m of main inlets unless the main circulators are running at or below the safe speed laid down in the ship's book. Ship-bottom searches that would take the divers within this range of the main inlets must, therefore, be carried out only when the main circulators are stopped or turning at or below this safe speed. Should it be necessary to dive for prolonged periods adjacent to or on the main inlets, the main circulators should, whenever possible, be stopped and the main inlet and discharge valves shut.

e. **Work in Vicinity of Ship's Stabilisers.** Before divers are allowed to work in the vicinity of the ship's stabilisers, the marine and electrical engineer officers of the ship are to be informed and the following action is to be taken and reported to the diving supervisor:

(1) The stabiliser breaker is to be opened at the switchboard and a warning board reading DO NOT CLOSE - DIVER IN WATER is to be fixed to the breaker handle.

(2) Additionally, where possible, the stabiliser is to be housed and the locking pin inserted.

f. **Work in Vicinity of Sonar.** Sonars must not transmit whilst the work is undertaken. See para 0790 for information about diver safety distances from sonar transmissions.

g. **Work on Surfaced Submarines.** In addition to the above precautions it should be ensured that:

(1) The after-hydroplanes cannot be operated.

(2) Torpedo bow or stern caps are not operated nor are watershots fired.

(3) Main vents are cottered.

(4) Main ballast tank kingston valves are not operated.

(5) Main ballast tanks are not blown.

h. **Cathodic Protection.** The Impressed Current Cathodic Protection System (if fitted) must be switched off before divers enter the water and switched on immediately diving is completed. BRs 4504 and 6506 are relevant.

0773. Diving Near Propellers While Shutting Down

a. This regulation applies to all steam-turbine-driven ships, because of the requirement to keep the turbine turning while cooling down. The requirement varies in duration, depending on the class of ship.

b. In the initial stages of shutting down, the turbine is turned by steam, which causes the propeller to rotate momentarily at a speed that would be extremely dangerous for divers in the vicinity.

c. No diving therefore is to take place under the ship when steam is on the turbine.

d. **Diving During the Shutting-down Period.** If the diving operation cannot be delayed until the start of the cooling-down period, the following conditions are to be observed.

(1) Engine-room throttle and nozzle valves are to be shut tight and lashed and, where possible, additional isolating valves in the main steam supply are to be shut.

(2) Turning gear is to be engaged and shafts turned continuously or at frequent intervals as appropriate to the class of ship.

(3) A constant watch is to be maintained in the engine room on the appropriate temperature and pressure readings to ensure that steam leakage past the throttle valves is not taking place. Should leakage be suspected, the diving supervisor is to be informed immediately and the divers brought inboard while the turning gear is taken out and turning under steam is resumed.

(4) Divers are not to enter the water until the engineer officer has informed the diving supervisor that steam has been shut off from the engines and turning gear engaged.

(5) Divers are to operate in pairs, connected by a buddyline. The divers and attendants to are be warned that propellers are being turned and that great care is to be taken that neither the lifeline nor the buddyline is caught around a propeller blade.

(6) Surface supplied diving is not to be employed.

e. **Diving During the Cooling Down Period.** During the cooling down period, which may be up to 4 hours, or longer, it is necessary that the propellers be turned continuously by electric turning gear. The rate of turning of propellers is approximately one revolution in 5 minutes. Care is still required therefore to keep lines and ropes clear of propellers. Under these circumstances diving may proceed, provided the regulations in sub-paras d(4), d(5) and d(6) above are observed.

f. **Liaison.** It is fundamental in this operation that a continuous and close liaison is maintained between the engineer officer and diving supervisor.

0774. Crossing the Keel

a. An 'attended diver' is never to cross the keel from the side on which he is being attended. If a job has to be done on the opposite side of the ship he is to be called up to the surface and sent down again from the other side.

b. 'A' brackets and propeller shafts constitute a similar hazard. The diver is not to pass between the shaft and the hull or through the 'A' bracket in case the lifeline becomes fouled.

0775. Recovery of Torpedo Dispensers

a. Due to the operating constraints of large submarines it may not be feasible for them to surface between torpedo firings to allow for recovery of dispensers. Therefore, to allow recovery to take place, Clearance Diving Units only are authorised to dive on the submarine providing that all the following conditions are satisfied.

(1) *General*

(a) Submarine must be no deeper than periscope depth.

(b) Sea state must not exceed 3 (slight).

(c) Visibility must be at least 3 miles.

(2) *By Submarine*

(a) Periscope manned continuously by CO or XO.

(b) Two way communications established with diving support craft.

(c) Main propulsion available but stopped.

(d) Secondary propulsion (Eggbeater) available but stopped.

(e) Water ram discharge rams housed, air shut off to discharge system, and system drained down.

(f) Bowcaps tagged out. Flap valves shut.

(g) Foreplanes tagged out.

(h) Sonar safe to transmit keys withdrawn.

(i) Ship's company warned by main broadcast (repeated) 'Submarine at periscope depth. Divers operating on hull. No submarine system is to be stopped or started without direct approval from the Control Room'.

(3) *By Diving Team*

(a) Two way communications established with submarine.

(b) The divers to be fully qualified Leading Seaman (Diver) or above, and to be free swimming but ‘buddied up’.

(c) Standby diver at immediate readiness.

b. The supervisor is to obtain permission to dive from either the CO or XO of the submarine before the dive is started. During the dive one of the pair of divers is to keep the recovery line in hand continuously, and the supervisor is to report to the submarine when:

(1) The divers have left surface.

(2) The divers have surfaced.

(3) The divers have been recovered.

(4) At any other time he considers it necessary for the safe conduct of the task.

0776. Diving from Vessels Using Dynamic Positioning

a. Diving from vessels using Dynamic Positioning (DP) (Maintaining station over the seabed by use of computer controlled thrusters) poses considerable hazards to surface deployed divers because thrusters may stop, start or change the direction of thrust at any time. Accordingly such diving must be undertaken only if the vessel is fitted with a fully Duplex system conforming to the DOE Guidelines, and when no alternative method of carrying out the task is possible. Alternatives include the vessel breaking DP to anchor or moor, or carrying out the dive using an SCC or a suitable boat.

b. If divers have to be deployed from a vessel using DP the following precautions must be observed:

(1) The diver must always be attended.

(2) The Supervisor must be fully aware of the hazard areas into which neither the diver nor his lifeline or umbilical must be allowed to enter. A diagram of the vessel showing these areas is to be displayed at the diving station.

(3) Direct, continuous communications (open line) must be established between the dive supervisor and the ship control position. Any system alarms should be passed to the supervisor immediately (using the ‘traffic light’ system, if fitted, as an alerting device).

(4) The maximum length of lifeline or umbilical from the attendant to the diver must be 5m less than the distance to the nearest thruster. If the task cannot be carried out within this restriction, then any thrusters within the range of the lifeline/umbilical must be stopped and measures taken to prevent their inadvertent re-starting during the dive.

c. On mono-hull vessels, all diving in depths from the surface to 10m below the operating draught of the vessel should be carried out over the side and NOT through the moonpool unless it is conducted from the SCC or a wet bell.

0777. Diving in Support of Submersible Operations

Divers may free swim solo to a maximum depth of 15m using compressed air breathing apparatus when assisting with the launch and recovery of submersibles. (See para 0737 and Table 7-9.)

0778. Underwater Engineering Tasks

a. When divers are required to carry out underwater engineering tasks on ships or submarines they are to be considered as working directly for the unit concerned when allocated to that task. They are fully accountable to the Commanding Officer of that vessel, notwithstanding that the request for divers may have come from an administrative or other authority. The ship or submarine is to provide a dedicated liaison man to ensure that the requirements of the diving team are met in order to expedite the task.

b. The procedures for tagging out and removal of underwater obstructions detailed in **Fleet Engineering Orders** are to be followed at all times.

0779. Fixed Cathodic Protection of Jetties

a. Cathodic Protection (CP) systems are installed underwater to protect structures from corrosion by means of electrically supplied anodes. The protective effect takes some hours or days to establish and they are rarely switched off unless special circumstances require.

b. Impressed current CP systems present a hazard to divers not only because they represent a non-isolated circuit but also because they are normally incidental to the tasks being carried out.

c. The following precautions are to be taken:

(1) Impressed current systems must be closed down, tagged out and confirmed as such by the dive supervisor before divers may work on such systems.

(2) Divers working in the vicinity of active systems (1-5m) must wear a full drysuit/unisuit, hood and gloves.

(3) The risk presented by active CP systems must be emphasised to the diver(s) by the supervisor and the position of all elements discussed in the pre-dive briefing.

(4) Where divers are required to work within 1m of an active system, where visibility is poor or where there is a risk of approaching or touching an anode, the system is to be closed down as in sub-para c(1) above. Only in ideal conditions of visibility and tidal stream should a system remain active. Under these conditions the diver should remain at a minimum of 1m distance from the anode(s).

0780. Spare.

0781. Diving Near Culverts and Other Inlets

a. Before commencing diving operations in the vicinity of docks, locks and basins, the diving supervisor is to take the following precautions:

(1) Ascertain the position of culverts and inlets which could endanger the divers in the event of penstocks or sluice valves being operated.

(2) Ensure that the authorities in charge of persons in a position to operate penstocks or sluice valves - the operation of which would constitute a risk to divers - are fully informed of the area and time of any diving operations.

(3) Ensure that warning signals visible to both those ashore and afloat are prominently displayed.

b. These precautions must never be overlooked even in areas thought normally to be perfectly safe.

0782. Free-Swimming Operations

a. Free swimming solo and free swimming in pairs is to be carried out only when operational or exercise requirements justify the risks involved in unmarked swimming.

b. In addition the following conditions must be met before operations or exercises can commence:

(1) *Ships and Authorities to be Warned.* When the operations or exercises extend beyond the immediate vicinity of the safety boat or ship, authorities concerned and ships in the area are to be informed of the time and area of operations before they start.

(2) *Safety Boats.* At least one power boat, which must be capable of anchoring in the deepest water swimmers are likely to encounter, is to be under way in the area of the operation.

(3) *Supervisor.* The supervisor is to be where he can best control the swimmers and the safety boats. He is not to be in the water.

(4) *Standby Divers.* The minimum number of standby divers required is laid down in para 0703. They are to be dressed for underwater swimming and are to be ready at immediate notice, if it is impracticable for the standby divers to remain at immediate notice throughout the whole period of the dive they are to be dressed for surface swimming with breathing apparatus ready for immediate use. They are to be embarked in the safety boat or where they can be of immediate use. Should it be necessary to send the standby diver in search of a missing man, he is to have an easily detachable safety line that will enable those in the boat to direct the search and which can be attached to the missing man when found. He is to have a separate attendant and should be capable of diving in the deepest water the swimmers will encounter.

(5) *Use of Diver's Indicating Light.* At night each diver is to carry a Diver's Indicating light (para 0934) which can be activated to indicate his position.

(6) *Use of Distress Lamp and Emergency Flare.* Each swimmer is to carry a Diver Distress Lamp (para 0933) or an Emergency Flare which can be used to indicate his position in an emergency by day or by night. Flares are to be replaced and used in accordance with para 0937. The Emergency Flare, if worn, is to be easily detachable and ready for use.

(7) *Dispensations.* During certain SF and FDU 1 Operations and Training, the requirement for a boat capable of anchoring and a standby diver capable of diving in the deepest water the swimmers are likely to encounter may be impracticable. When there is no alternative the CO SBS or CO FDG as appropriate, may approve a waiver. Such a waiver must be supported in writing and clearly stated at the pre-dive brief. Waivers may be stated in SOPs if so required provided they are approved by CO SBS or CO FDG, in consultation with the Superintendent of Diving.

c. The conduct of free-swimming operations is described in para 0992.

0783. Search and Rescue Divers

a. **Safety of the Diver.** In his operational role the SAR diver is authorised to carry out free swimming solo. No specialised supervision, standby diver or safety boat are required. When no trained SAR diver is available other qualified divers may, exceptionally, act in the SAR role to save life.

b. When diving practices are being carried out (para 0702), the following precautions are to be observed.

(1) *Training Jump, with a Non-weighted Diver who is Positively Buoyant and in Sea State 3 or Less.* As for sub-para a above, but an extra aircrewman or SAR diver if available is to be embarked to carry out a double lift if required.

(2) *Training Jumps with a Weighted Diver, or with A Non-weighted Positively Buoyant Diver in Sea State 4 or More.* Full supervision and safety requirements as for ship's divers. The supervisor and standby diver are to be in a powerboat in the immediate vicinity of the jumping area.

c. **Diver's Responsibility.** Before emplaning, the diver is to check that his set is operational and is to report the state of his set to the captain of the aircraft before each sortie.

d. **Decision to Dive.** The decision whether or not to dive rests with the captain of the aircraft.

e. **Helicopter Operations with a Ship.** A SAR diver when borne is to be standing by on the upper deck of a ship when that ship is operating with helicopters at close quarters.

f. If no SAR Diver is borne a diver from the diver sub-branch (if carried onboard) is to be detailed to carry out this task.

g. Exceptionally a suitably briefed ship's diver may be detailed for this task although he will not be experienced enough to conduct a rescue from submerging or submerged aircraft.

h. A supervisor and standby diver are not required on the upper deck in addition to the SAR diver, but they are to report to the scene if an emergency occurs. A ship's diver acting in the SAR diver role may not enter the water until the supervisor and standby diver have arrived at the scene.

i. **Conduct.** Instructions for the conduct of SAR operations are contained in para 0993, AEW/ASW Sea King Flying Guide, Pt 6 Ch 10 and communications procedures in para 0967.

j. **Records.** All jumps by SAR Divers, including practice jumps, are to be recorded in Form S.288. The number of jumps is to be stated, together with details of whether they are weighted or unweighted, day, twilight or night.

0784. Minehunting Diving

a. **Personnel.** When carrying out minehunting operations to 42m or less, at the diver supervisor's discretion the diving team may be reduced to a supervisor, diver, standby diver and attendant (see para 0703b.(2)).

b. The following criteria are to be met for all minehunting operations to a maximum depth of 60m.

(1) The ship is to remain within 300m of the diver, or closer if required but no closer than 75m,

(2) The compression chamber is to be at immediate notice for use.

(3) A second Inflatable/MIB is always to be rigged as a seaboat which must be capable of being deployed within 5 minutes.

(4) A MCDO or a member of the Diver sub-branch is to be onboard, immediately available to the Command to provide advice during the dive and act as OMCC operator in the event of a diving incident or surface decompression.

c. When carrying out minehunting operations in excess of 60m to a maximum depth of 80m, the diving team is not to be reduced from a minimum of five personnel. In addition to the criteria detailed at para 0784b 80m minehunting diving is not permitted unless:

(1) Full command brief to be conducted.

(2) CO on the bridge with diving expertise at hand.

(3) Experienced OOW closed up monitoring both Ship's position and Inflatable MIB/RIB.

(4) Conning run conducted by second boat and crew prior to 80m diving operations.

(5) Ship to remain within 200m of the dive boat, or closer as required, but no closer than 75m.

(6) Wind and sea condition permit the minehunting Inflatable MIB/RIB to lay on the ICOS line without the requirement to stem wind/tide.

(7) Ships company fully briefed on diver emergency recovery procedures and procedures have been practised within the previous month.

(8) At night, adequate 'hands free' lighting available to illuminate dive boat.

(9) Second Inflatable MIB?RIB and crew at immediate notice.

(10) ICOS line to be recovered by ship on completion of dive.

(11) Type 'C' available at immediate notice.

d. **Diving Practise - Dives to a maximum depth of 60m**. Commensurate with depth, the following minimum standards of diving practise are to be met by the diver and standby diver before minehunting diving to a maximum depth of 60m takes place. However, the final decision to dive remains with the diving supervisor and his judgement of the divers capability.

(1) Diving in excess of 24m may not be conducted unless the diver(s) have exercised underwater in CDBA in the previous 2 months.

(2) Diving in excess of 42m may not be conducted unless the diver(s) have exercised underwater twice in CDBA, in excess of 24m in the previous 2 months. (One dive to include XBS O_2 stops, which may be simulated)

e. **Diving Practise - Dives in excess of 60m**. In addition to the criteria set out above, when diving in excess of 60m, the dive is not to be conducted unless the diver(s) have exercised underwater twice in CDBA, in excess of 42m in the previous 2 months. However, the final decision to dive remains with the diving supervisor and his judgement of the divers capability.

f. **Minehunting Diving Weapon Training**. If the criteria at d.(1 and 2) and e. have not been met, a dedicated minehunting diving Weapon Training is to have been conducted within one month before operational minehunting diving below 60m is permitted.

g. **80m Qualification.** To enable Diving Elements to qualify to 80m and maintain that qualification the following are to be achieved

(1) *Qualification to 80m.* Complete SofD covered 80m CDBA assessment, (SofD approval required iaw Para 0737 Table 7-8 Note 3). The following are pre-requisites for the assessment:

(a) Complete all appropriate PRISM/CAPES Serials for the preceding diving quarter.

(b) Achieve requirements of BR 2806 Vol 1 Para 0738 Table 7-11.

(c) Comply with BR 2806 Vol 1 Para 0784e.

(2) *Maintaining 80m Qualification.* Diving elements are to conduct a minimum of one 80m Weapon Training period per diving quarter. This is to be conducted as a whole ship serial. The 80m qualification awarded to the ship will lapse if this is not achieved. Ships failing to maintain 80m capability must re-qualify iaw Para 0784g.

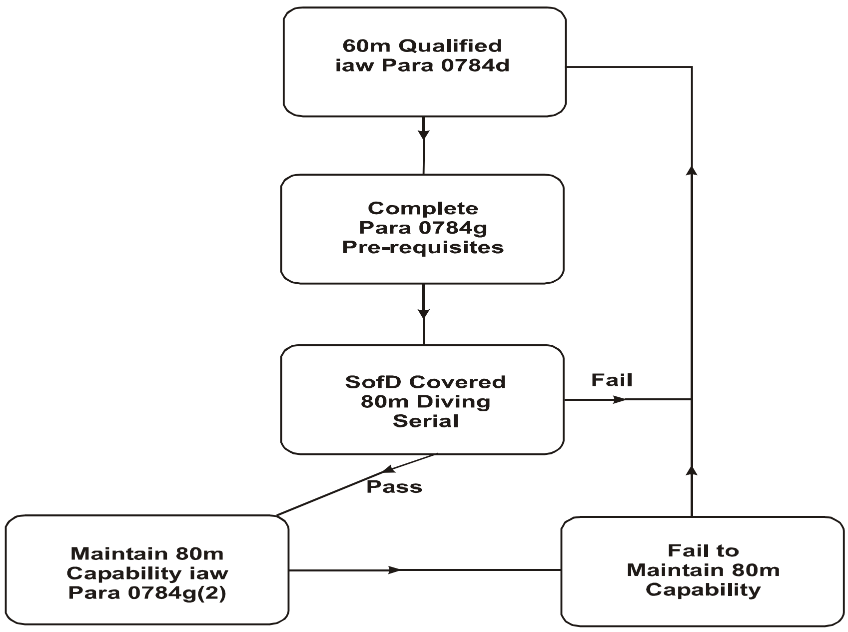
(3) *Pre-requisites before conducting 80m diving.* The following must be achieved prior to conducting an 80m weapon training period:

(a) Complete all appropriate PRISM/CAPES Diving Serials.

(b) Achieve requirements of BR 2806 Vol 1 Para 0738 Table 7-11

(c) Achieve all diving requirements of BR 2806 Vol 1 Para 0784.

(4) SofD is to be informed by signal prior to any period of diving in excess of 60m.



h. **Compression Chamber Minehunting Diving.** Ships fitted with OMCC/DUOCOM compression chambers may conduct diving operations to 60m subject to the criteria at para 0791. Diving operation deeper than 60m may only be conducted in a Type ‘C’ chamber is on site.

0785. EOD Diving

a. When diving is being conducted on ordnance or suspected ordnance, which is known to be or may be live, the diver will normally make his dive as a marked swimmer. If appropriate to the risk assessment of the task made by the diving supervisor, the relaxations of para 0703b(3) may be applied.

b. These relaxations apply to CDUs and designated Army Units engaged on operational tasks and do not apply to Ship’s Divers when employed in Explosive Ordnance Reconnaissance.

0786. Diving in Vicinity of Nuclear-Powered Vessels

a. Diving operations may be required on and around Nuclear Powered Vessels. When such operations are undertaken the vessel may be in either:

(1) Plant State ‘A’.

(2) Plant State ‘B’.

b. Generally operations are conducted when the vessel is in Plant State ‘B’ or lower, although it is sometimes necessary to conduct operations when the vessel is in Plant State ‘A’ and either critical or sub critical. Radiological and possible contamination hazards exist in both Plant States but it is in Plant State ‘A’ that personnel are subject to the greatest risk. Ship’s Divers borne on the books of the vessel concerned will be trained and aware of radiation hazards, however divers from other diving agencies may not be and this factor is to be borne in mind when planning operations and if necessary appropriate advice sought from the Base or vessel’s Health Physics Staff.

c. **Health Physics Brief.** A Health Physics brief for all diving team members must be given prior to their first dive on a nuclear powered vessel and must include the following topics:

(1) Principles of Radiation Protection.

(2) Identification of the hazard ie the Reactor Compartment.

(3) Declination of the hazard ie the area where divers will be at most risk.

(4) Quantification of the hazard, based on Plant History and Polar Plots.

d. **Pre-Dive Briefs.** The diving team must receive a comprehensive brief from the vessel’s First Lieutenant, Officer/Petty Officer of the Day or Watch prior to the start of the dive. The team are also to be briefed by Health Physics Staff on the radiological implications of the dive, hazardous areas to avoid (if possible) and the time allowed on task if it is necessary to work in a hazardous area. A dosimetry brief and check similar to that given to personnel entering a radiation area must be given. These briefs are in addition to the pre-dive brief given by the diving supervisor (para 0970).

e. **Control of Exposure.** The control and exposure of all personnel to radiological hazards is to be managed in accordance with the As Low as Reasonably Practical (ALARP) principle.

f. **Dosimetry**. The following types of Dosimeter, dependent on Base Area and individual vessel policy, are available for issue to diving teams:

(1) Thermoluminescent Dosimeter (TLD).

(2) Quartz Fibre Dosimeter (QFD).

(3) Electronic Digital Dosimeter (GAMMACOMMS).

g. **TLD Issue.** Each diver, when part of a CDU or Element that regularly work on Nuclear Powered vessels must have a personal TLD issued to him. The TLD is to be monitored each month by the Base Environmental Support Department (BESD). A similar system is enforced for a Vessels own ship's diving team.

h. **Additional Monitoring.** If diving operations are to take place and the reactor is critical (Plant State 'A'), an additional TLD is to be issued to each diver undertaking the dive. On completion of diving operations the additional TLDs used by the divers are to be despatched for immediate reading by the Defence Radiological Protection Service with a request for an immediate report. A dose against task is therefore obtained and a comparison with a QFD or a Digital Dosimeter will be available.

i. **General Conduct of Diving Operations.** Before diving on any nuclear powered vessel the diving supervisor is to ensure that the base or vessel radiological safety staff are contacted to confirm the scope of the task and possible hazards. If not offered, guidance on correct dosimetry must be sought. Diving must not take place until the required level of dosimetry has been established.

j. **Wounds and Cuts.** Personnel are not to dive with open cuts, wounds, grazes or skin conditions. All cuts or wounds sustained during the dive are to be reported to the DRPS/Health Physics Staff immediately.

k. **Diver Monitoring.** On leaving the water divers are to be monitored for contamination. This is a potentially contentious area where consideration may have to be given to monitoring the diver away from public gaze.

l. **Records.** QFD or other daily dosimetry is to be read on completion of the dive. Details of the results are to be recorded on a Dosimetry Record Card by the Vessel's or Base health Physics Staff.

m. **Diving Operations and Pre-dive Clearance - Vessel Alongside.** Before diving takes place on or in the vicinity of nuclear vessels alongside in either Plant State 'A' or 'B' the following mandatory regulations and precautions must be observed in addition to normal pre-dive checks:

(1) The vessels Commanding Officer is to grant permission for diving operations to take place.

(2) All systems which are radiologically pertinent are to be tagged out prior to the start of diving operations.

(3) Other nuclear vessels in the vicinity or alongside are to tag out discharge valves and their plant states are to be ascertained.

n. **Diving Operations at Sea.** The regulations and precautions outlined above must be complied with although the tag out of radiologically hazardous systems may not be possible in all cases. In this case advice is to be sought from the vessels Radiation Safety Officer. The vessel will invariably be in Plant State 'A'.

o. **Plant State 'A' - Diving Operations.** Diving operations normally conducted when in Plant State 'A' are as follows:

(1) Towed Array Sonar Stub fit and removal.

(2) Hull Searches.

(3) Tile Surveys.

(4) Underwater Ship's Husbandry.

p. **Plant State 'B' - Diving Operations.** When in Plant State 'B' the following operations are usually conducted:

(1) Docking down.

(2) Propeller changes.

(3) Planned maintenance on underwater fittings.

0787. Diving Operations - Remotely Operated Vehicle Intervention

a. **Remotely Operated Vehicle (ROV).** In addition to its independent inspection capability, the ROV can be a useful diver aid. Its ability to visually monitor the diver has been shown to be a positive safety benefit. Sensible and practical application of the instructions given below will prevent the ROV from becoming a hazard to the diver.

b. Problems may arise during operations where it is decided to use an ROV for independent inspection (with a diver in the water), or for diver monitoring alone. Some of these are as follows:

(1) Entanglement of diver and ROV umbilicals.

(2) Injury to a diver through collision with the ROV.

(3) Electric Shock.

(4) Obstruction of the diver by the ROV or its umbilical.

Where possible to prevent or minimise these potential problems, the instructions contained in the following paragraphs are to be applied.

c. **Protection of Personnel.** The following restrictions apply:

(1) Line insulation monitors fitted with circuit breakers must be used. Any insulation fault must be reported immediately to the diving supervisor.

(2) Areas of high voltage on ROVs such as terminations and penetrators should be clearly marked so as to provide a warning to divers.

(3) All thrusters must be fitted with securely fixed guards to prevent the ingress of a diver's fingers, umbilical or equipment.

d. **Communication Interface.** There is to be a direct communications link between the diving supervisor and the ROV supervisor/pilot.

(1) In addition the diving supervisor must be able to see the picture seen by the ROV pilot.

(2) Where practicable the ROV deployment system is to be sited an appropriate distance away from the diver entry point to minimise the chance of umbilical entanglement.

e. **Responsibilities.** A chain of command must be clearly established and understood by all personnel concerned with both operations. The requirements are as follows:

(1) The dive supervisor will always have authority over the ROV supervisor/pilot when dual operations are being carried out.

(2) On-site operational procedures must be set up in advance and any subsequent changes properly authorised and made clear to all concerned before they are implemented.

(3) When ROVs are used to support divers, pilots must be experienced in diver related operations, or, less experienced pilots should be actively monitored by a suitably experienced ROV supervisor.

(4) Members of both the diving and ROV team should be aware of the potential hazards and operational constraints of working with an ROV.

(5) The dive supervisor must ensure that the ROV supervisor/pilot understands relevant diving emergency procedures and their implication and that ROV emergency procedures are understood by diving personnel.

(6) The ROV must only be deployed or recovered with the authority of the diving supervisor. Precautions must always be taken to avoid the possibility of umbilical fouling.

(7) ROV movement must be co-ordinated by the dive supervisor and the ROV supervisor/pilot. The ROV should only leave its underwater site when cleared to do so by the diving supervisor.

(8) The safe-to-dive certificate must include provision for ROV operation.

f. **General Procedures.** The following procedures are to be used where applicable:

(1) The ROV may be used to survey the worksite to assess potential hazards and provide operational information, in which case it may then be used to guide the diver.

(2) In the event of the ROV umbilical becoming entangled, the diver may if the situation allows, take instructions for remedial action from the dive supervisor who must liaise with the ROV supervisor/pilot. It must be remembered that the ROV umbilical will be carrying electrical power, which if possible must be electrically isolated before any such operation.

(3) If the ROV supervisor/pilot is unable to determine the relative position of the ROV due to poor visibility, high currents or for any technical reason, he must immediately inform the diving supervisor.

0788. Diving in Contaminated Waters

a. Dive supervisors must be aware of the possibility of contamination at dive sites. Some degree of contamination is almost always present in harbours and guidance is given below on hazard identification, risk assessment and risk reduction measures for divers and surface support teams.

b. **Hazards**. There are four main categories of hazard:

(1) *Microbiological*. The main threat is from bacteria (e.g. salmonella, E Coli), viruses (e.g. Hepatitis A) and protozoa (e.g. amoebae, parasites). Routes of entry to the body are by water ingestion (e.g. open circuit breathing apparatus), inhalation and skin absorption (e.g. cuts and grazes). Possible illnesses, contracted as a result of exposure, range from external ear infections to gastroenteritis.

(2) *Chemical*. This category includes petroleum products (UN Class 3), corrosives (UN Class 8, e.g. acids) and poisonous substances (UN Class 6). The nature of the hazard will vary, depending on the chemical composition, but the particular effects on the diver, his equipment and the water must be determined.

(3) *Physical*. This includes garbage floating in the water, causing obstruction or carrying a particular hazard (e.g. syringes). Water temperature is also included since bacteria thrive in warm water.

(4) *Radiological*. The hazard is self-explanatory. Special rules apply to diving in the vicinity of nuclear powered vessels. See para 0786.

c. **Risk Assessment.** The following factors will contribute to the dive supervisors risk assessment:

(1) Urgency of task (i.e. operationally essential).

(2) Identification of hazards.

(3) Personal protective equipment available.

(4) Diving equipment available.

(5) Diving procedures.

(6) Surface decontamination.

d. **Risk Reduction.** The measures detailed below can be effective in reducing the risk from microbiological contamination. Diving in the presence of a toxic chemical threat will require more detailed precautionary measures.

(1) All exposed personnel to be in-date for protective inoculations e.g. tetanus typhoid.

(2) Positive-pressure breathing apparatus (e.g. AGA), or a demand-type helmet (i.e KMB Superlite 17) to be used by the diver.

(3) Dry diving suits, including hoods and gloves, to be worn by the diver.

(4) All cuts and grazes to be covered by waterproof dressings, even if under the diving suit.

(5) Respiratory and body protection for surface support team to be considered.

(6) Diver in-water time to be minimised.

(7) On completion of the dive, all diver equipment to be washed down and/or decontaminated.

(8) No exposed personnel to eat or drink until washed down/decontaminated.

(9) Any post dive symptoms/illness to be reported.

(10) The standby diver must be protected in the same manner as the diver.

e. **Advice**. In all cases advice should be sought from appropriate authorities (e.g. medical, water authority, harbour board) as to the exact nature and degree of contamination.

f. **Approval**. Before diving in heavily contaminated waters approval is to be sought from Sof D or SDO(A) as appropriate.

0789. Diving in Underground Drainage Installations

a. There are occasions when search operations have to be carried out in Underground Drainage Installations, they include searches for bombs or IEDs, searches for bodies, and reconnaissance of flooded cavities. Detailed instructions on the conduct of these operations will be found in BR 2808(1).

b. If the search involves diving, all normal diving regulations apply and in addition the diver is to wear a breathing apparatus delivering a constant pressure to a full face mask with oral-nasal delivery (eg AGA Spiro/Divator), a dry suit, and gloves.

c. Other regulations are as follows:

(1) The drainage system must be fully vented and tested for dangerous gas before entry by personnel.

(2) Storm water drains must not be entered during, or until 24 hours has elapsed after, heavy rainfall.

(3) Naked lights and non-waterproof torches must not be used in or near the entry to a drainage system.

(4) The decontamination drills given in BR 2808(1) must be carried out immediately after leaving the system.

(5) All members of the team, both divers and support party, must be fully briefed on the symptoms of illnesses which may be caused by working in polluted water.

0790. Safety Distances from Sonar Transmissions

The following sonar restrictions are to be applied when divers are in the water:

a. **Exercises**. For all exercises the following safe distances are to be observed: 15m for a hooded diver and 40m for a non-hooded diver from any source of sonar transmissions. Ships with sonars 2050 or 2016 are **NOT** to transmit.

b. **Operations**. In exceptional circumstances, whilst it is operationally essential to continue sonar transmissions when divers are in the water the safety distances quoted above may be reduced to those shown in Chapter 8 of BR 5063. The distances quoted in Chapter 8 were established by trials. More powerful modern Sonars should be treated with extreme caution.

0791. Compression Chamber - Requirements

a. Prior to the start of diving operations the location of the nearest available two compartment compression chamber is to be determined, and contact made with its operators. The location of MOD Two-Compartment Compression Chambers (2CCC) can be obtained from the nearest Area Clearance Diving Unit. If further assistance is required it can be obtained from the Superintendent of Diving, telephone Portsmouth Naval Base (023 92 722351) extension 4145, or 023 92 224148. A list of NATO authorities responsible for initiating treatment of diving casualties in their area, with their areas of responsibility and signal address can be found in ADivP-1(A)/MDivP-1(A).

Note. *The information pertaining to compression chamber location is no longer contained within ATP 10(D) BRIT SUPP 2.*

b. If a dive is planned with a duration time which will result in a decompression schedule requiring stops, a compression chamber must be on site. ‘On site’ means that the diver is to be able to leave maximum depth, or in the case of CDBA, the last stop, ascend at the correct rate, and be pressurised to chamber bottom within 5 minutes. If a compression chamber is not available on site **ONLY no stop diving** to a maximum depth of 42m may take place.

c. If the actual depth and bottom-time of a dive are within the no decompression limits but the Diving Supervisor chooses to use a longer or deeper table which would result in wet decompression stops (eg for cold, hard working dives) then a chamber is not required, provided the dive does not exceed 42m. However the restrictions on a diver's movement imposed by para 1206 are to be strictly observed, see sub-para f below.

d. The requirement in para b above may be met by a One-man/Two-man Duocom compression chamber provided that the following conditions are satisfied:

(1) Only single diver operations are undertaken, to a maximum depth of 60m.

(2) A casualty can be transferred to a two compartment chamber by a transfer under pressure evolution within 4 hours of entering the one-man or Duocom chamber. Due consideration must be given to the time required for recovery of diving equipment, travelling, berthing and cranage of the chamber (ie When conducting operations from MCMVs it is considered that the maximum range from a Type A or B TUP recompression chamber is 3 hours steaming, approximately 40 miles).

e. Attention is drawn to paras 1206 which require a diver, after diving deeper than 42m, to remain within four hours' travelling time of a chamber if the dive was above the limiting line, and in the immediate vicinity of a chamber if the dive was below the limiting line. These requirements may be satisfied by a one-man chamber.

0792. Decompression of the Diver

a. Decompression is mandatory for any dive covered by the decompression schedules, and stops must be carried out strictly in accordance with the appropriate table.

b. On completion of a dive the restrictions imposed in Chapter 12 Section 1 on the diver's subsequent employment and movements are to be strictly observed.

0793. Surface Decompression

The procedures and requirements of surface decompression are fully described in Chapter 12 Section 4.

0794. Therapeutic Recompression

a. Therapeutic recompression, when required after a diving accident, is to be treated in accordance with the instructions in Chapter 13.

b. In all cases involving therapeutic treatment the most experienced diving supervisor available (ADS for Army diving) is to take charge of the compression chamber. He is responsible for the running of the chamber and the choice of therapeutic table to be used.

c. If a medical officer experienced in diving medicine is on site, or can be consulted by radio or telephone the diving supervisor should generally follow his advice unless there is a sound operational reason for not doing so. Such reasons should be recorded in the chamber log.

d. In complicated cases the schedule of the therapeutic tables may be altered on the authority of a diving medical specialist.

CHAPTER 8

UNUSUAL INCIDENTS, ACCIDENTS AND MATERIAL FAILURES

CONTENTS

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CHAPTER 8

UNUSUAL INCIDENTS, ACCIDENTS AND MATERIAL FAILURES

SECTION 1 - UNUSUAL INCIDENTS AND ACCIDENTS

0801. General

a. This section deals with the action that has to be taken, both immediately and subsequently, in the event of a diving accident, an unusual diving incident or material failure of equipment.

b. **Reports.** It is important to follow both the letter and the spirit of the instructions given in the subsequent articles on investigation and preparing and forwarding reports.

c. Reports should be made on all unusual incidents, including those of a minor nature and those where the cause appears to be obvious. It is only by compiling a comprehensive record of such diving incidents that the research and development authorities will be able to discover a trend in equipment or drills leading to a particular type of accident.

d. The main aim of calling for these reports is not to institute disciplinary action but to gain information from which diving as a whole can be made safer and more efficient.

e. In this context the S of D or SDO(A) must always be sent a copy of the report direct by the originator.

f. **Decompression Illnesses.** All cases of decompression illness or pulmonary barotrauma must be regarded as unusual incidents and the appropriate investigations and reports initiated. This applies to all cases treated whether in a ship, in any MOD establishment or on detached duty, either of civilians or Service personnel, and whether or not recompression therapy is required.

0802. Initial Action

a. In the event of a diving accident or incident the diving supervisor is to take the appropriate first aid action described in Chapter 13.

b. He is then to take steps to obtain the services of a medical officer, if one is not already in attendance, using the signal format laid down in ADivP-1(A)/MDivP-1(A) when appropriate.

c. When possible an eye witness of the incident should be available to assist the medical officer with his diagnosis and subsequent treatment. He should accompany the patient if he is sent away for treatment.

d. Any unusual diving incidents in the Minor War Vessels Flotilla are to be reported by signal to CDRE MFP outlining the circumstances and action taken.

0803. Reports of Unusual Diving Incidents or Accidents

a. For any unusual accident or incident (including therapeutic recompression) when S333 action is required, S of D is to be informed by the quickest means possible. A written report, under a CO’s covering letter, is to follow using the S 333 series of forms which comprise:

(1)	S 333 Part 1	Summary of Accident/Incident
(2)	S 333 Part 2	Supervisors Statement - by the Diving Supervisor or Diving Officer
(3)	S 333A	Equipment Report - as required by para 0811.
(4)	S 333B	Medical Report - by the Medical Officer who attends the casualty.
(5)	S 333C	Statement of Witness - by all personnel involved in the incident including the diving supervisor and the diver.

b. In addition to the S 333 series of forms the relevant page(s) of the Form S.288/AB576(A) for Army Divers is(are) to be photocopied and sent along with the forms as required to S of D or SDO(A) as appropriate.

c. Such reports are complementary to any preliminary investigation, Ship's investigation, or to the report of a Board of Inquiry. They are to be completed while memories are still fresh and forwarded as shown in the table below under cover of a letter giving outline details of the incident and any actions taken. All forms are to be treated as ‘In Confidence’ when completed.

d. Statements of witnesses are not to be altered, nor is the handwriting to be corrected for typing, without the prior approval of the witness. If the statement is typed it must be read and agreed by the witness before he signs it.

e. In addition, where defective material is connected with the incident copies of Form S 2022 or AF G8267A are to accompany Forms S 333.

f. MOD Form 2000/Centralised Health and Safety Proforma (CHASP) should also be rendered when appropriate. (See JSP 442)

g. In cases of doubt, S of D or SDO (A) as appropriate Diving Inspectorate staff must be consulted.

h. Reports required after treatment of civilian cases are detailed in para 1383.

Table 8-1. Reports after Diving Incident or Accident (Para 0803)

TO	FORMS REQUIRED					WHEN FORWARDED
	S 333 Part 1	S333 Part 2	S 333A	S 333B	S 333C	
S of D or SDO(A) as appropriate	1 Note	1	1		1	Without delay. Copies will be forwarded to INM as required
Accompany Patient (Medical Docs/INM on completion)	1 Note	1		1		
Accompany Equipment	1 Note	1	1			As soon as reasonably possible (see para 0812)
Be retained by Ship/Unit	1	1	1		1	
Administrative Authority	1	1	1		1	Copies to be forwarded on completion of incident

Note. *The relevant page(s) of the Form S288/AB576(A) for Army Divers is(are) to be photocopied and sent along with the forms as required to S of D or SDO(A) as appropriate. See (para 0803b).*

0804. Serious Accidents - Additional Action and Reports

a. In the case of any serious accident, that is an accident which results in:

(1) Death.

(2) Serious injury.

(3) Symptoms of acute decompression illness as defined in para 1351.

(4) A diagnosis of arterial gas embolism. (See para 1351).

The following actions are to be taken in addition to providing the reports required by para 0803.

b. A report is to be made immediately, by the quickest means, to the Administrative Authority with a copy to the S of D or SDO(A). This report is to include the divers name and rank or rating, the apparent extent of injury, whether a medical officer is in attendance, and a brief statement of the remedial action being taken. If sent by signal the following format is to be used:

Precedence	Immediate
Protective Warning	Unclassified
Action Addressees	OPCON Authority
	Administrative Authority

Information RNSUPDIV PORTSMOUTH
DEFDIVSCH PORTSMOUTH (Army Diving Only)
INM ALVERSTOKE
NAVSPCOMD BATH

SIC LOL/H3O

Subject Diving Accident

DLO BATH for UWS 4
DEFDIVSCH for SDO(A)

1 Vessel or unit involved and location.

2 Details of accident and symptoms of casualty.

3 Assistance required.

4 Further details.

a Divers name/rank or rate.

b Brief details of equipment failure/malfunction or defects in breathing gas(es).

c Remedial action being taken.

c. If a serious accident occurs in the United Kingdom, the commanding officer should obtain the services of either, or both of the following:

(1) A medical officer experienced in diving medicine - Point of contact the Head of Undersea Medicine at the Institute of Naval Medicine (INM).

(2) A technical specialist from DERA (Alverstoke) - Point of contact the S of D.

Requests for such specialists should be made by telephone, and confirmed by signal.

d. These authorities can be contacted as follows:

(1) By signal of the appropriate priority to RNSUPDIV PORTSMOUTH, S of D or DEFDIVSCH for SDO(A) or INM ALVERSTOKE for Head of Undersea Medicine.

(2) By telephone to Portsmouth Naval Base Exchange - Portsmouth (023 92) 818888 - and asking for:

In working hours: The S of D or SDO(A) (Defence Diving School) and/or the Head of Undersea Medicine at INM Alverstoke.

Out of working hours: SO2 N3 (Duty Fleet Controller) Northwood who will arrange for those authorities to be contacted.

e. If a serious accident occurs outside the United Kingdom, the Commander-in-Chief Fleet will arrange for a medical officer experienced in diving medicine and an experienced MCDO to attend. Advice on the selection of these officers should be sought as detailed in para 0805.

0805. Board of Inquiry - Composition

a. Boards of Inquiry into diving accidents for the RN and RM are to include an experienced MCDO (of at least the rank of Lieutenant), and a medical officer experienced in diving medicine. Advice in selection of these officers should be sought from the S of D for the MCDO, and from MOIC INM Alverstoke.

b. For the Army the composition of the board is the same except that the most experienced Army diving officer, as advised by SDO(A), should take the place of the MCDO.

c. If suitable diving or medical officers are not immediately available, the details of the accident are to be reported to the Ministry of Defence by signal so that a decision may be made whether or not the circumstances warrant flying out a specialist officer to sit on the board.

0806. Loss of Consciousness

a. If in a diving accident or incident a man loses consciousness underwater or shortly after completing the dive, in circumstances where decompression illness and arterial gas embolism can be ruled out, and a preliminary investigation cannot attribute this to an identifiable material defect, the case must be treated as seriously as one of unexplained loss of consciousness on shore. The man is to be referred to a medical specialist to eliminate any possible medical factor that might not have come to light in previous medical examinations. Fleet and Command medical officers are to be asked to recommend a suitable medical officer to make the specialist examination.

b. The results of these examinations are to be collated and forwarded with medical report (Form S 333B) of the incident.

0807-0809. Spare.

SECTION 2 - DEFECTS AND MATERIAL FAILURES

0810. Defects and Material Failures - Reports

a. It is most important that all malfunctions or failures of diving equipment, whether resulting from errors in drill or any other cause, are correctly and promptly reported. Experience has shown that investigations into apparently minor irregularities in drill or trivial malfunctions of equipment can sometimes lead to the discovery of important weaknesses. The procedure to be followed is outlined below.

b. **Material Failures Not Connected with Diving Incidents.** Failures of diving equipment not connected with a diving incident are to be reported as follows:

(1) *Navy, RM and Army*. Reported on Form S.2022. Copies to be forwarded as described below:

Copy 1:
DOPSE/UWS 1PT
(FAO: UWS 4 N3)
ELM 2b # 199
MOD Abbey Wood
Bristol BS34 8JH

Copy 2: (Navy/SF)
Squadron Staff Admin

Copy 2: (Army)
Inspector of Diving (Army)
Defence Diving School
Gunwharf Building, Horsea Island
Cosham, Hants PO6 4TT

Copy 3:
Inspector Engineer (D)
FDSHQ
Reclaim Building, Horsea Island
Cosham, Hants PO6 4TT

Copy 4:
Retained in unit originator file.

(2) *Army*. For equipment supplied and supported from Navy Sources, reports are to be made on Form S.2022 as detailed in para a(1) above. For equipment supplied from Army sources, reports are to be made on AFG8267A and forwarded in accordance with Material Regulations for Army, Vol 2, Pamphlet 2.

c. **Material Failures Connected With Diving Incidents.** Where failure is associated with a diving incident, reporting action is required as in para 0811 and 0812.

d. The defective material is to be forwarded as stated in para 0812, unless any items are required to be retained for investigation by a Board of Inquiry. In that case the material is to be forwarded as soon as the Board has completed its investigation.

e. In cases of doubt concerning the action to be taken or the disposal of material the advice of S of D, Diving Inspectorate or SDO(A) as appropriate should be sought by telephone or signal.

0811. Action Required on Recovery of Equipment

a. When equipment is recovered after a diving incident, it is initially to be handled no more than is required to remove it from the diver and to secure it as described below, after first conducting an intensive visual inspection noting any irregularities. On no account are any closed valves to be opened. If material failure is in any way suspected, Form S 333A is to be completed as soon as possible at the dive site by the dive supervisor or another diver nominated by him. This diver is to be experienced in the use of the equipment. The reporting officer is to check the information once entered.

b. When a portable compressor is in use, note the position of the exhaust outlet and other sources of noxious fumes in relation to the compressor itself.

c. **SABA/BODS**

(1) If a pressure gauge is fitted, note the reading.

(2) Close the main valve, noting the number of turns required to close it. Check that the reserve cylinder valve is shut, noting the number of turns required to shut if open. Check that the BCA emergency cylinder valve is shut, noting number of turns to shut if open.

(3) Do not remove the first stage regulator from the manifold.

d. **CDBA**

(1) Note all pressure gauge readings.

(2) Note primary and secondary display readings.

(3) Close main O_2, Diluent and Bail Out cylinder valves noting numbers of turns.

(4) Note position of Supplementary valve and close if open.

(5) Note position of Slide Valve and place in Open Circuit position, tape in position.

(6) Remove Primary and Secondary batteries, sealing each instruments batteries in a separate plastic bag to accompany the equipment.

e. **XBS (if involved in incident)**

(1) Note gauge reading and position of selector valve.

(2) Close O_2 and O_2/He valve noting number of turns.

f. **BASAR MOD A**

(1) Note the pressure gauge reading.

(2) Close the control valve noting the number of turns required to close it. Check that the reserve cylinder valve is shut. Note the number of turns required to shut it if it is open.

(3) Check the stabilising jacket and the emergency air inflation cylinder valve is closed noting the number of turns required to close it if open.

g. **LEBA(O2) - LAR V**

(1) Close the main cylinder valve, and if applicable the by-pass and emergency cylinder valves. Note the number of turns required to close each valve. Note the pressure gauge reading (LAR V).

(2) Note the position of the mouthpiece cock and switch it to atmosphere.

(3) Seal the buoyancy control valve and emergency blow off valve (CDBA), taking care not to alter the setting of the valve(s) or to exhaust any gas from the counterlung.

h. **LEBA (MG)**

(1) Note LED Status reading.

(2) Note position of DMM and ensure the selector valve is placed in the open circuit position.

(3) Note readings on the Display Module (Oxygen, Diluent and PO_2 readings)

(4) Turn the Display Module off in the correct sequence.

(5) Close all cylinders noting the number of turns on each cylinder.

(6) Disconnect battery from set to prevent accident re-start and loss of data.

(7) Seal set battery in a plastic bag to accompany the equipment.

i. **RABA**

(1) Note the pressure-gauge reading.

(2) Close the control valve noting the number of turns required to close it.

(3) Do not remove the reduction valve from the manifold.

(4) If the HP air has been supplied from a storage cylinder(s), shut the cylinder valve, noting the number of turns required, and set the cylinder aside for its contents to be analysed and the charging outlet examined.

j. **Hybrid SSDE (KMB Heliox - 18B Mask/SL-17B Helmet).** When the equipment is recovered after a diving incident, it is to be handled no more than is necessary, except to remove it from the diver for immediate examination. On no account are any closed valves to be opened. The type and state of the divers dress must be recorded. On completion the following actions are to be carried out:

(1) *Surface Control Panel.* From the panel gauges, note the main air supply HP inlet pressure and the LP outlet pressure to the diver(s).

(2) Note the number of turns required to close the main supply cylinder.

(3) If opened, note the amount of turns required to close the reserve supply cylinder.

(4) Note the number of turns required to close the main supply inlet valve.

(5) If opened, note the amount of turns required close the reserve supply inlet valve.

(6) Disconnect the HP hoses, gauge and record the contents of the reserve cylinder.

(7) Seal the main reducer on the panel.

(8) Note the amount of turns required to close the divers outlet valves.

(9) Disconnect umbilical at the panel and seal the end.

(10) Note if communications are working

(11) Note the condition of the diver’s jacket and the number of turns required to close the bail-out cylinder valve.

(12) At the mask/helmet sideblock, note the number of turns (if open) required to close the steady flow valve and emergency valve.

(13) Leave the divers mask/helmet connected to the umbilicals.

(14) Note visual damage to mask.

(15) Carefully seal up the Dial-a-Breath control.

(16) Obtain a sample of the main air supply.

k. **AGA DIVATOR**

(1) Note the pressure gauge reading.

(2) Check position of reserve valve handle.

(3) Check position of positive pressure lever.

(4) Close the cylinder valve, noting the number of turns required to close it.

(5) Do not remove the Regulator unit.

l. **ESDS.** When the equipment is recovered after a diving incident, it is to be handled no more than necessary, except to remove it from the diver for immediate examination. On no account are any closed valves to be opened. The type and state of the divers dress must be recorded. On completion the following actions are to be carried out:

(1) *Surface Control Panel.* From the panel gauge, note the main air supply HP inlet pressure and the LP outlet pressure to the diver(s).

(2) Note the number of turns required to close the main supply cylinder.

(3) If opened, note the position of the quarter turn valve of the reserve supply cylinder.

(4) Note the position of the quarter turn valve of the main supply inlet.

(5) If opened, note the position of the quarter turn valve of the reserve supply inlet.

(6) Disconnect the HP hoses, gauge and record the contents of the reserve cylinder.

(7) Seal the main reducers on the panel.

(8) Note the position of the divers quarter turn outlet valves and close if required.

(9) Disconnect the umbilicals at the panel and seal the ends.

(10) Note if communications are working.

(11) Note the conditions of the divers harness and the position of the change over lever, check gauges on bailout cylinders and note pressures, record the number of turns required to close bailout cylinders.

(12) Leave the divers mask connected to the umbilicals.

(13) Note visual damage to mask.

(14) Obtain a sample of the main air supply.

m **Equipment Despatch.** After the equipment has been sealed and prepared for investigation it is to be:

(1) In the case of an RN diving accident/incident forwarded (unless items are required by a Board of Enquiry) to the nominated investigating authority, normally DERA Alverstoke, as advised by S of D staff (see para 0813) and Table 8-2.

(2) In the case of an Army diving accident/incident the equipment is to be forwarded to DERA as outlined in sub-para (1) above and IofD(A) informed.

0812. Material Investigation After an Incident

a. On the recovery of the equipment Form S 333A is to be completed as detailed in para 0811 unless it is determined, by an experienced dive supervisor that there is no possibility of equipment failure. In this case Form S 333A is not required.

b. If it is found that the incident has been caused by; an obvious mechanical defect, a defective gas supply, the CO_2 absorbent, or there is any cause for doubt, the defective material or complete apparatus is to be sent as directed by S of Ds Diving Inspectorate for detailed investigation and analysis. The material or apparatus is to be carefully packed and forwarded by the quickest, possible means.

It is to be accompanied by gas (including air) samples from the storage cylinders used, the samples being clearly marked to show their origin. Where applicable an unopened sample container of CO_2 absorbent from the same lot as that used in the breathing equipment is also to be sent. Form S 333A completed by the examining officer, and a copy of Form S2022, is to be forwarded with the equipment.

c. It should be noted that if sample cylinders of breathing gas are sent by air the instructions in JSP 327(2) must be followed.

0813. Equipment Investigation

a. On receipt of the breathing apparatus and samples and formal tasking from S of D, DERA (Alverstoke) will conduct examinations and tests. Initial investigation reports are then passed to the S of D. These will comprise some or all of:

(1) Equipment Inspection Report - stating any mechanical defects found.

(2) Equipment Test Report - stating any degradation of designed performance found.

(3) Gas Analysis Report - stating the chemical analysis of:

(a) Gas remaining in the breathing apparatus cylinders.

(b) Gas remaining in the counterlung (if applicable).

(c) Gas samples from the storage bottle(s).

(4) CO_2 Absorbent Activity Report - stating the results of activity tests on the CO_2 absorbent from the breathing apparatus, and from the sample container.

b. Subsequently a formal DERA Technical Memorandum will be forwarded to the Superintendent of Diving. This will cover all aspects of the equipment investigation.

0814. Subsequent Action

a. If DERA's Technical Memorandum indicates that a defect was present that is likely to endanger other divers, S of D will report the matter by signal to the appropriate authorities giving sufficient details of batch number, source of supply, etc, to enable similar materials and equipment to be checked. Examples are: gas in storage cylinders of wrong composition, CO_2 absorbent found to be defective. A Diving Safety Memorandum will be issued if appropriate.

b. S of D staff will also extract from the DERA Technical Memorandum such details as may be necessary, and forward these to the originator of the S.333 Reports or the Administrative Authority, or both, together with S of D comments on the incident.

0815. Limits of Impurities in Breathing Gases

These are laid down in current Defence Standard for Breathing Gas Purity for Diving, see para 0731.

0816. Summary of Reports

The reporting action required to be taken by the ship or establishment concerned after an incident or material failure is summarised below.

Table 8-2. Reporting Action by Ship or Establishment After Incident or Material Failure (Para 0816)

Incident	Reporting Action (Navy)	Reporting Action (Army)
Material failure without diving incident	Form S 2022 to be sent in accordance with current regulations (BR 1313). Defective material to be dealt with in accordance with S 2022 procedure.	Form AF G8267A to be sent in accordance with current regulation. Defective material to be forwarded as directed by IofD(A)
Diving incident (including all therapeutic treatment)	Forms S 333 to be forwarded in accordance with para 0803.	Forms S 333 to be forwarded in accordance with para 0803.
Diving incident with material failure	Forms S 333 to be forwarded in accordance with para 0803 with a copy of Form S 2022. Forms S 2022 to be sent in accordance with current regulations (BR 1313). Defective material to be forwarded as directed by S of D staff.	Forms S 333 to be forwarded in accordance with para 0803. AF G8267A to be sent in accordance with Material Regulations for Army, Vol 2, Pamphlet 2.

Note. *Prior to completing forms, refer to para 0810.*

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CHAPTER 1	1-1/1-2	Original
	1-3/1-4	Change 1
	1-5 to 1-8	Original
	1-9/1-10	Change 1
	1-11 to 1-20	Original
	1-21 to 1-80	Change 1
CHAPTER 2	2-1 to 2-16	Change 1
CHAPTER 3	3-1 to 3-18	Change 1
	3A-1/3A-2	Change 1
CHAPTER 4	4-1/4-2	Change 1
	4-3/4-4	Original
	4-5 to 4-12	Change 1
CHAPTER 5	5-1/5-2	Change 1
CHAPTER 6	6-1/6-2	Change 1
	6-3 to 6-4	Original
CHAPTER 7	7-1 to 7-58	Change 1
CHAPTER 8	8-1 to 8-14	Change 1
INDEX	Ind-1 to Ind-12	Change 1
LIST OF EFFECTIVE PAGES	LEP-1/LEP-2	Change 1

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