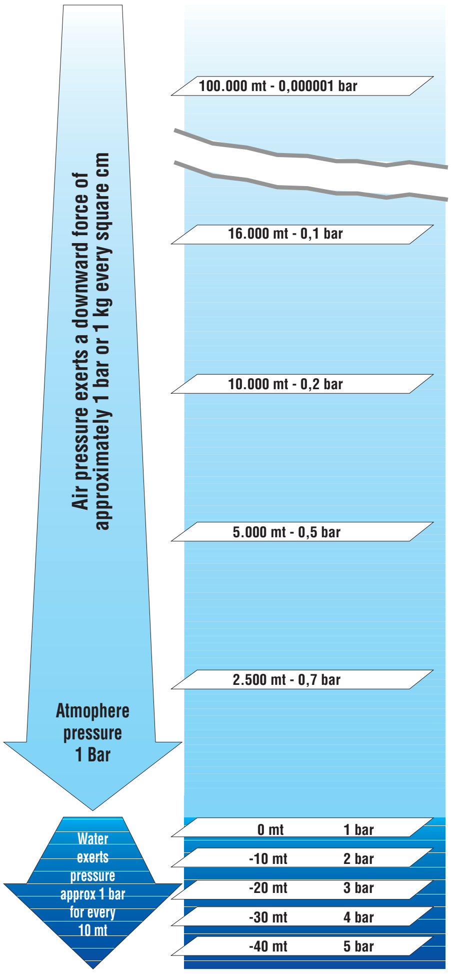
LESSON 1

CMAS

WORLD UNDERWATER FEDERATION

Basic physics

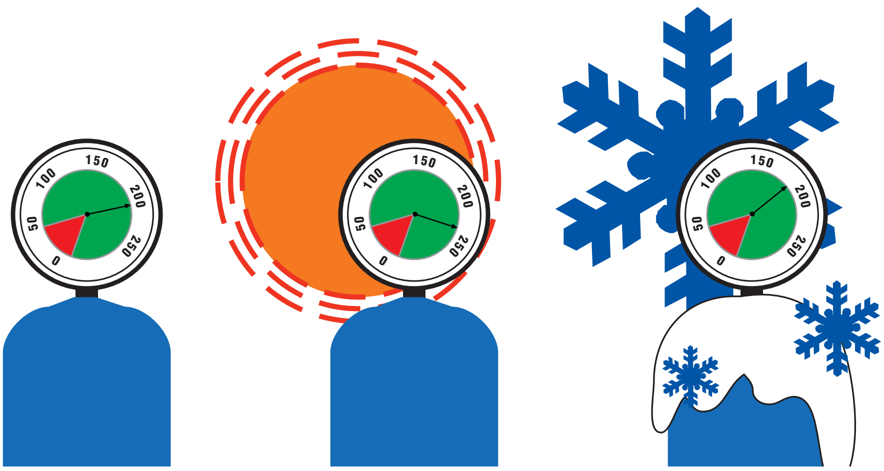
TORRICELLI 'S LAW



CHARLES 'S LAW

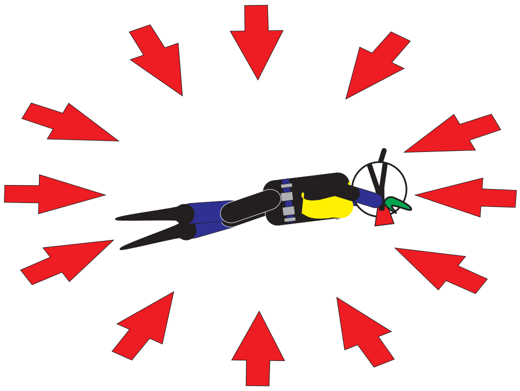
The pressure that a gas exerts on the walls of its container is determined by the momentum of the atoms and molecules of the gas, which in turn is determined by the temperature. As the temperature increases the atoms and molecules move faster, and so exert a greater pressure on the walls. If the walls are rigid, such that the volume of the container is held constant, then the relationship between pressure P and temperature T is given by Charles' Law:

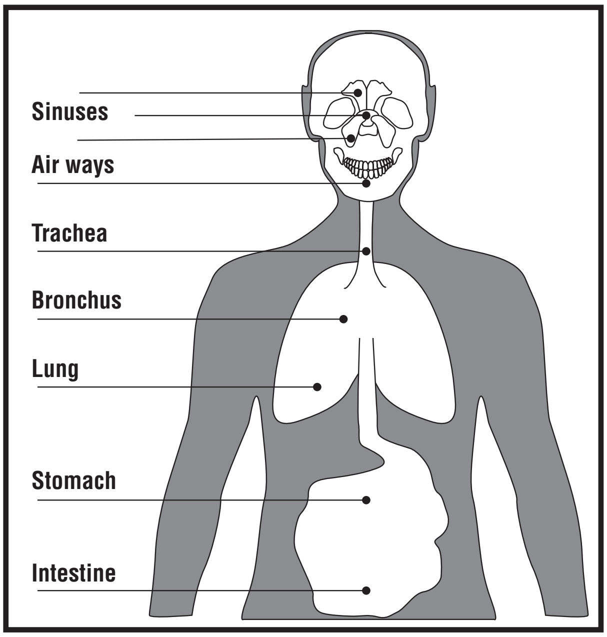
$$P = constant \times T$$

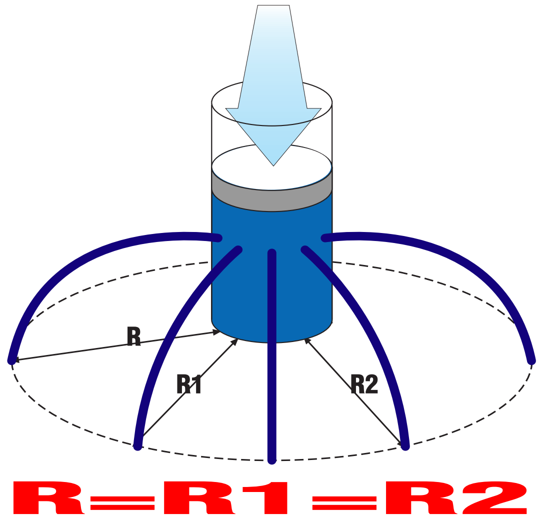


PASCAL'S LAW

“ If pressure is applied to a non-flowing fluid in a container, then that pressure is transmitted equally in all directions







within the container”

ARCHIMEDE ‘S PRINCIPLE

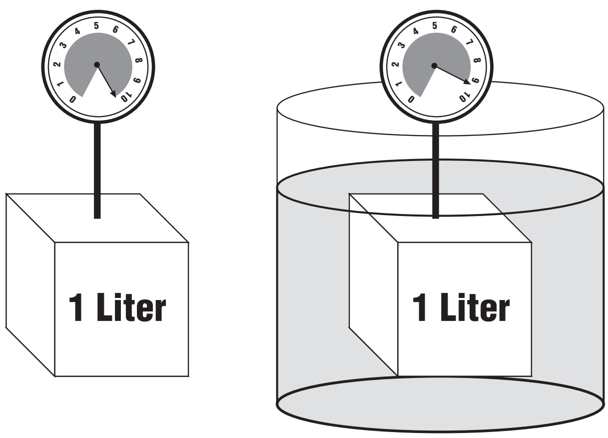
“ A body immersed in water will receive an up thrust equal to the weight of water it displaces”

In order to evaluate this balance is important to consider the relation between volume and weight of

a) the human body

b) the density of the liquid (fresh water, sea- water)

c) the neoprene suit (specific weight lower than normal body weight)



BUOYANCY IN WATER

Positive Buoyancy: the tendency of the body to float

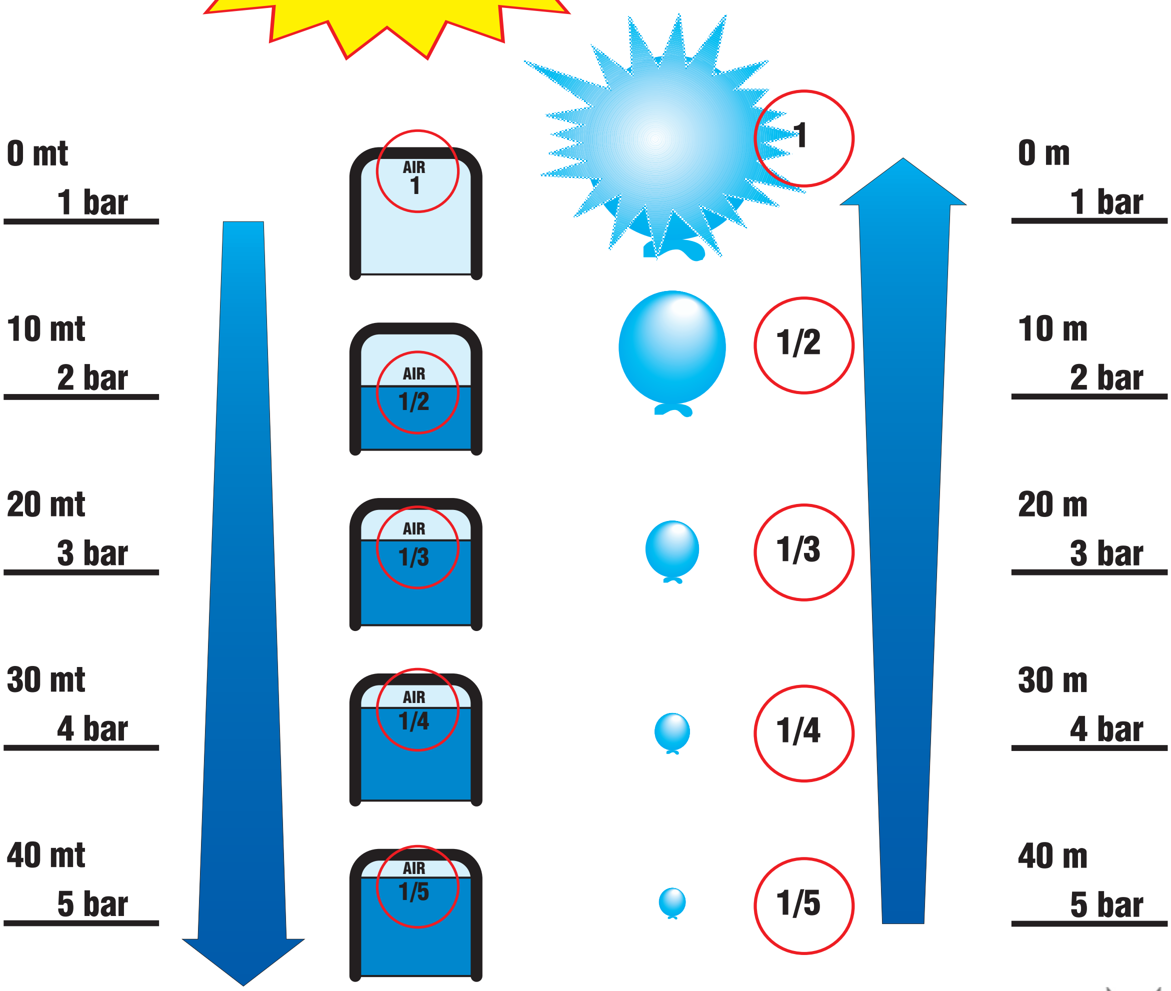
Neutral Buoyancy: the body neither float nor sink

Negative Buoyancy: the tendency of the body to sink

BOYLE'S LAW

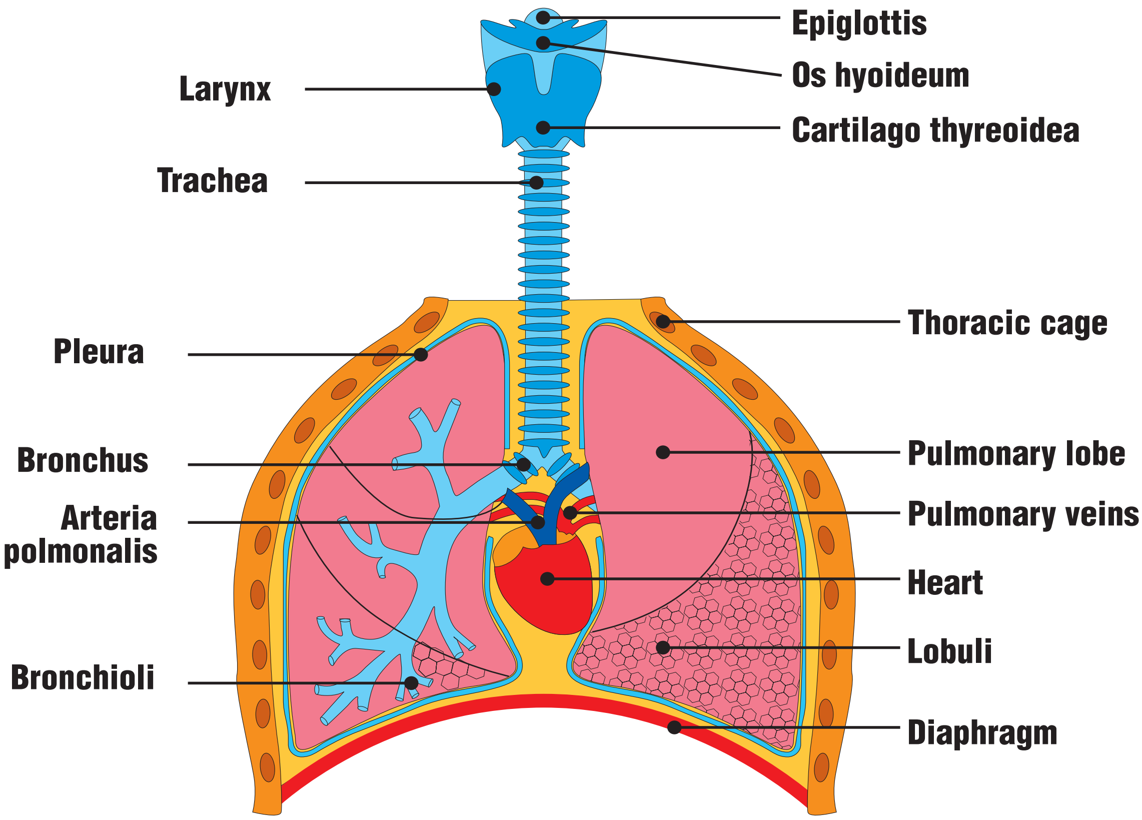
"At a constant temperature the volume of a gas varies inversely with absolute pressure while the density of a gas varies directly with absolute pressure"

NEVER HOLD THE BREATH

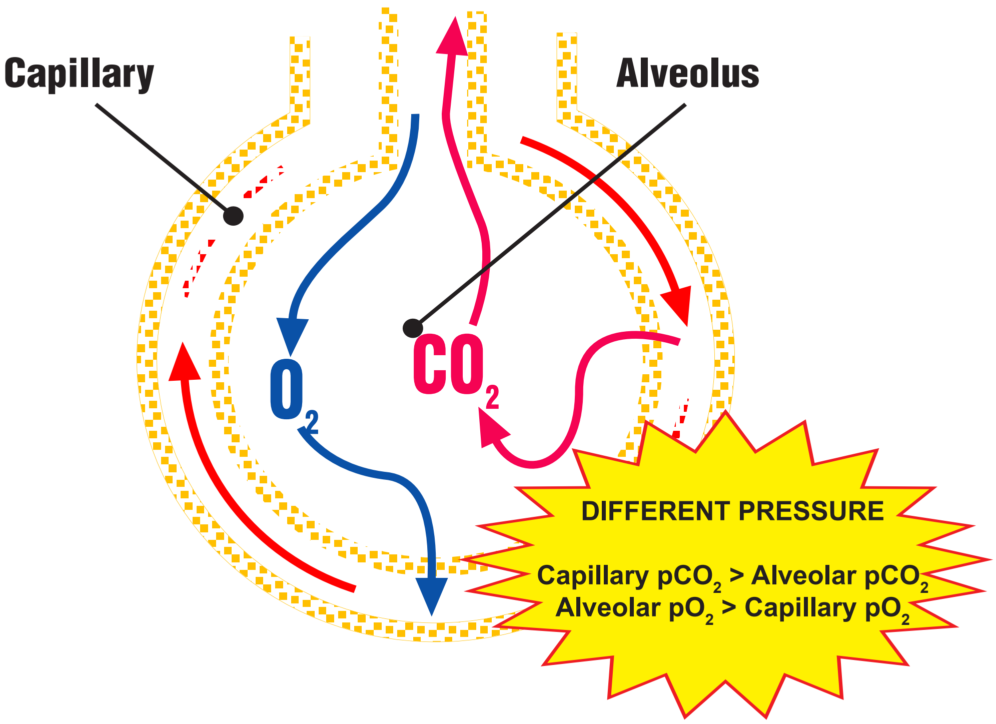


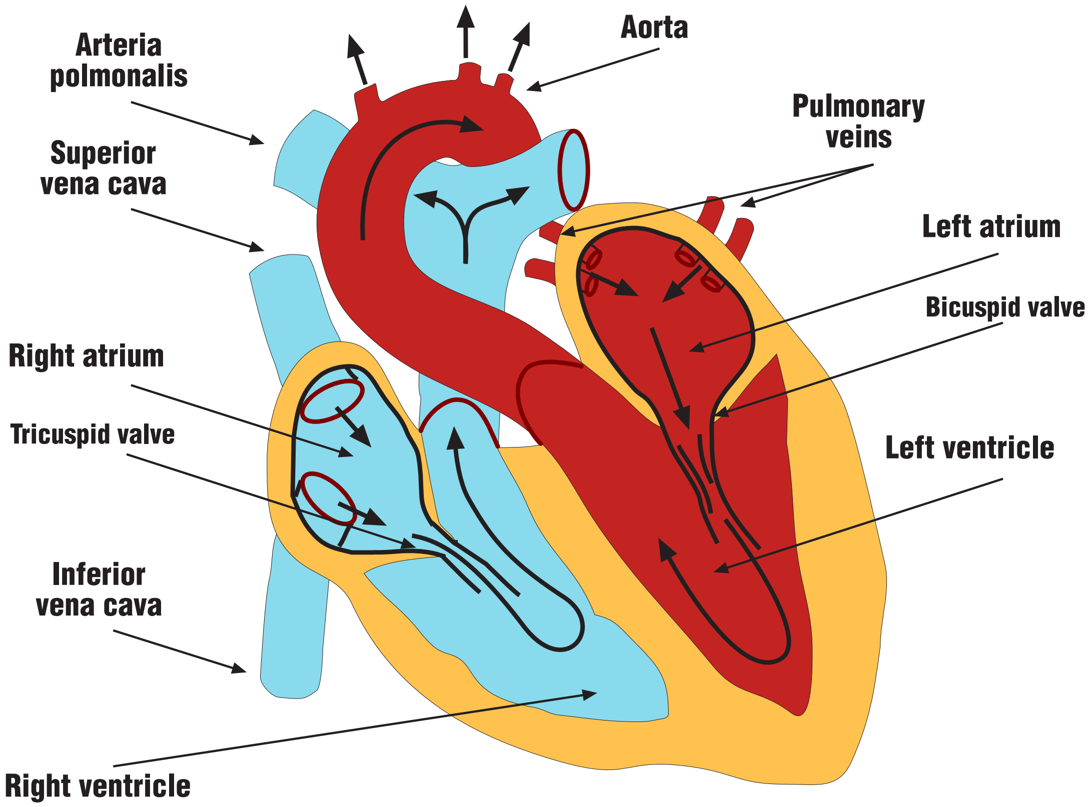
The human body

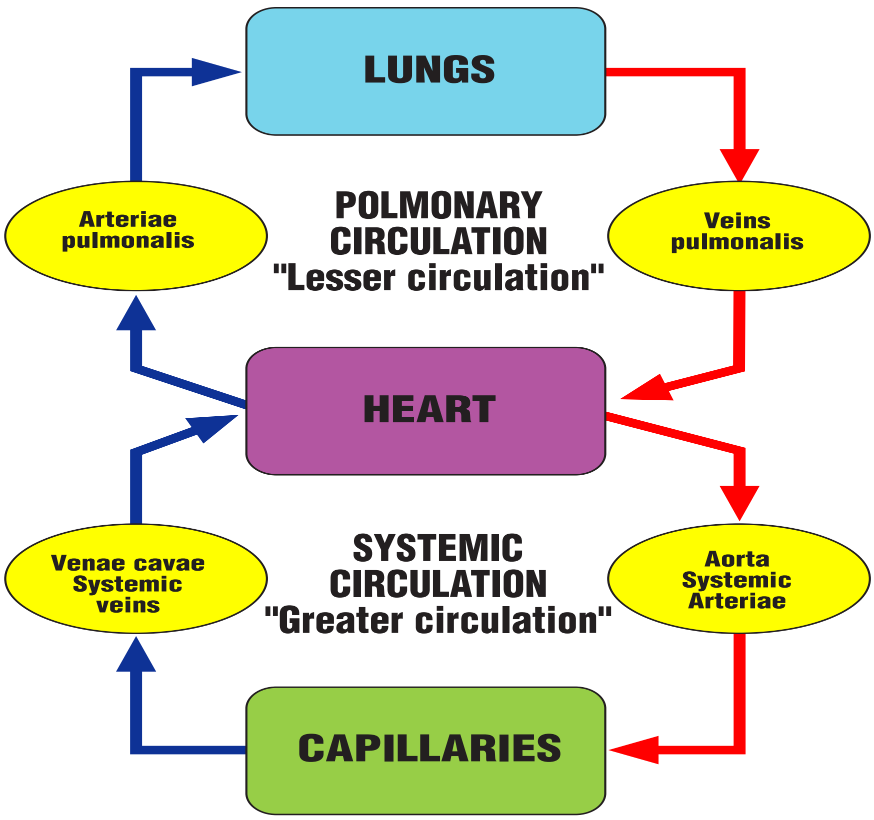
THE RESPIRATORY SYSTEM



THE ALVEOLI AND THE CAPILIARIES




Arteria
polmonalis
Superior
vena cava
Aorta
Pulmonary
veins
Left atrium
Bicuspid valve
Right atrium
Tricuspid valve
Left ventricle
Inferior
vena cava
Right ventricle

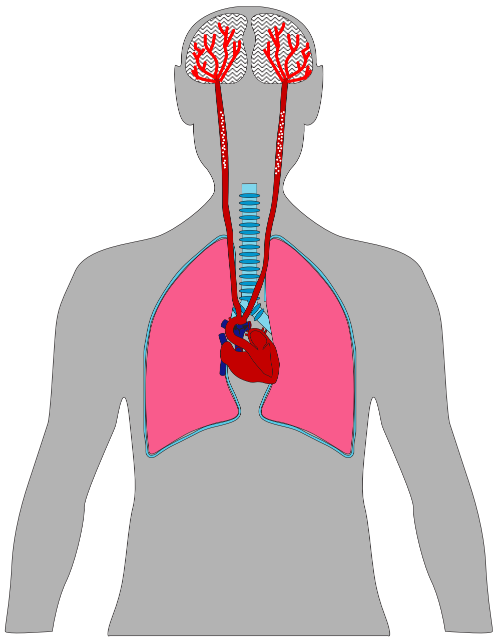

LUNGS
Arteriae
pulmonalis
POLMONARY
CIRCULATION
"Lesser circulation"
Veins
pulmonalis
HEART
Venae cavae
Systemic
veins
SYSTEMIC
CIRCULATION
"Greater circulation"
Aorta
Systemic
Arteriae
CAPILLARIES

Diving accidents

EMBOLISM

During ascent the air in the lungs tend to expand. If for any reason the breath is held during ascent in a Scuba diving this expansion of the air after having enlarged the lungs to their maximum causes a progressive distension of the pulmonary alveoli, if the diver continues to ascend without breathing out the overdistension of the lung can results in a pulmonary barotrauma (a wounding of the lungs caused by pressure) in this case the alveoli membrane is stretched to a such a degree that tiny air bubbles are able to pass into the blood stream, or can tear and cause the release of larger bubbles. Regular and continuous breathing is, however, sufficient to eliminate excess air and maintain normal lung volume. A risk of pulmonary overdistension occurs in the last ten metres below the surface where the variation in the pressure volume ratio is at his greatest. The reduction in pressure in the last ten metres of ascent towards the surface is 50% (from 2 to 1 atm), while the same distance, but from 20 to 10 metres, sees the 33% drop in pressure (from 3 to 2 atm). This considered, it is important remembering to never hold one's breath during ascent, even in the pool. The seriousness of a pulmonary distension depends on the effect that pressure has exerted on the walls of the pulmonary alveoli: distension or laceration of tissue.

The most serious consequence of pulmonary overdistension is the passing of air bubbles from the alveoli into the blood stream and is commonly known as air embolism syndrome. The air bubbles that pass from the lacerated alveoli to the adjacent tissues can, on the other hand, causes pneumothorax, mediastinal emphysema, subcutaneous emphysema.

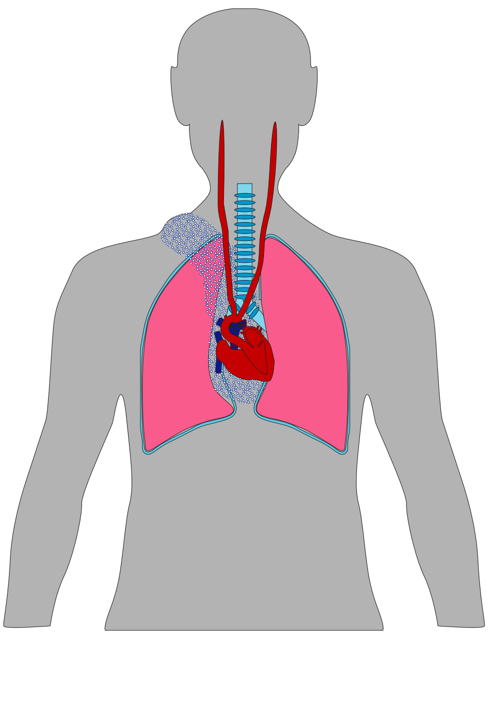


AIR EMBOLISM SYNDROME

The bubbles escaping from the laceration of the pulmonary alveolus, once they have reached and been pushed along the aorta, can reach any part of the body and may stop in the small vessels. This can block circulation of the blood, and therefore of oxygen in the areas below the embolus.

Symptoms and effects

Air embolism syndrome is generally traumatic and usually occurs in the first moments of surfacing or even before reaching the surface. The symptoms include dizziness, vertigo, impaired vision, breathing problems, heart disturbances, and paralysis.



PNEUMOTHORAX

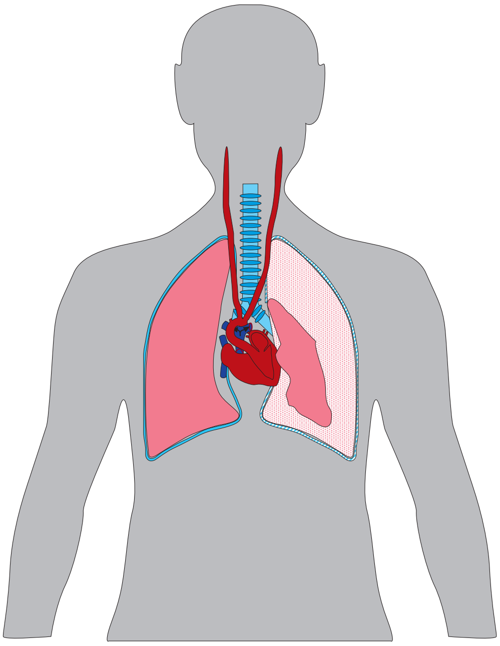
It occurs when considerable quantity of air that escaped from the alveolus remains trapped between pleura. The lung, then stop to function due to the lack of vacuum between the pleurae.

Symptoms and effects

The symptoms of pneumothorax consist of intense chest pain along with coughing of blood and considerable difficulty in breathing.

MEDIASTINAL EMPHYSEMA

When the air that leaves the exits from the alveoli head towards the inside of the rib cage, so remaining trapped between the tissues around the heart and the major large blood vessels and causing an irregular return of venous blood as well as abnormal pressure on the respiratory airways pulmonary sac, the result is mediastinal emphysema.

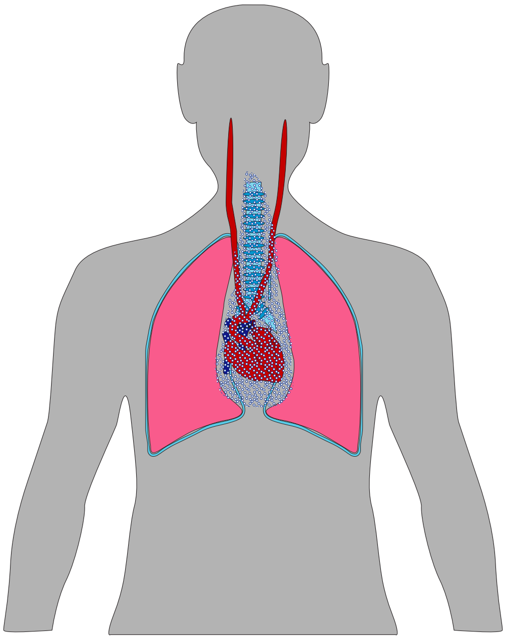


Symptoms and effects

The first symptom is a pain in the inside of the rib cage. In addition, the trapped air that presses against the lungs, the heart, and the large blood vessels, inhibiting breathing and circulation, causes breathing difficulties and possible loss of consciousness.

SUBCUTANEOUS EMPHYSEMA

Subcutaneous emphysema occurs when air bubbles that have escaped from a laceration of lung tissue are forced toward the neck causing it to swell at the front.



Symptoms and effects

The symptoms are a “sense of swelling” at the neck and a change in the sound of the voice.

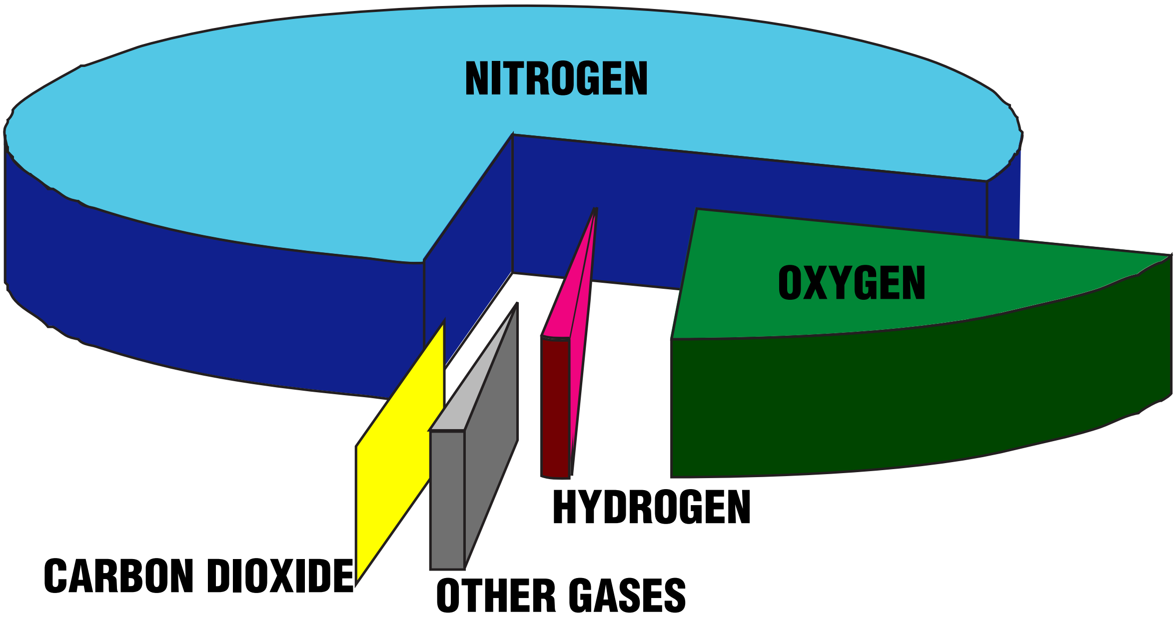
Subcutaneous emphysema is often associated with mediastinal emphysema.

TREATMENT OF PULMONARY OVERDISTENSION

The only effective treatment for air embolism syndrome is immediate recompression in a hyperbaric chamber and the administration of large quantity of water to make the blood more fluid and so reduce the risks of obstruction by the bubbles. The administration of oxygen or artificial respiration is of use only as first aid on the way to the hospital.

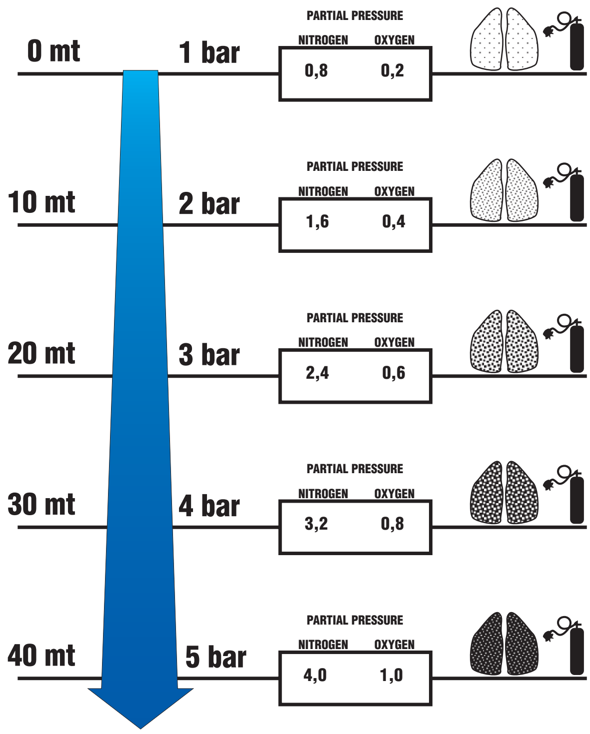
Absorption of gas in the human body

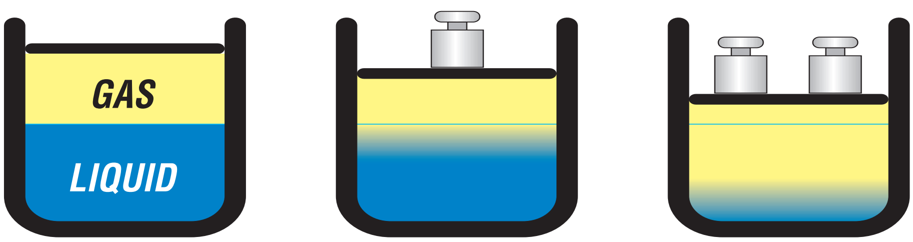
COMPOSITION OF THE AIR AT SURFACE LEVEL



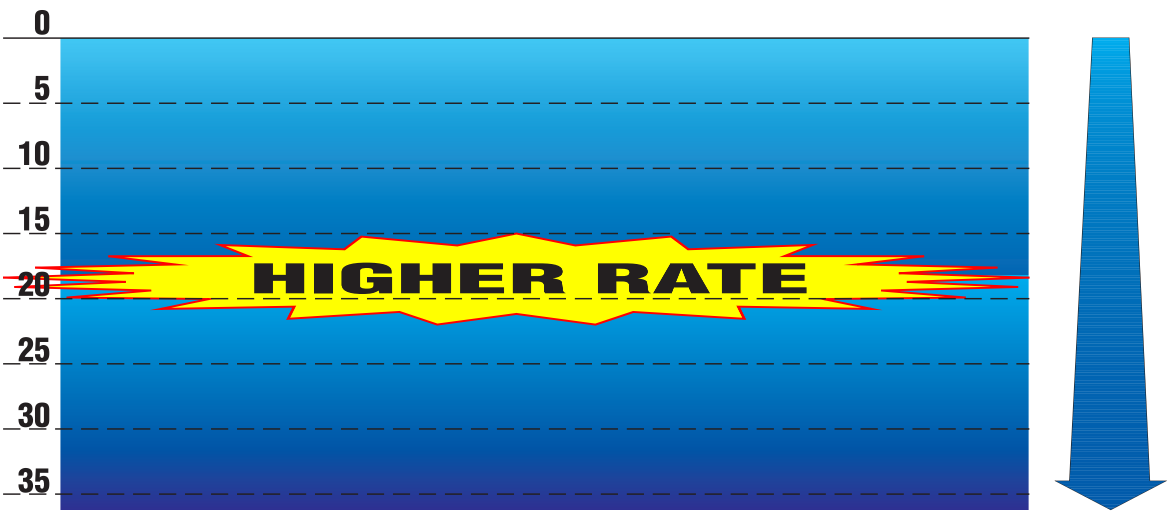
DALTON 'S LAW

" The total pressure exerted by a mixture of gases is equal to the sum of the pressures that would be exerted by each of the gases if it alone were present and occupied the total volume"





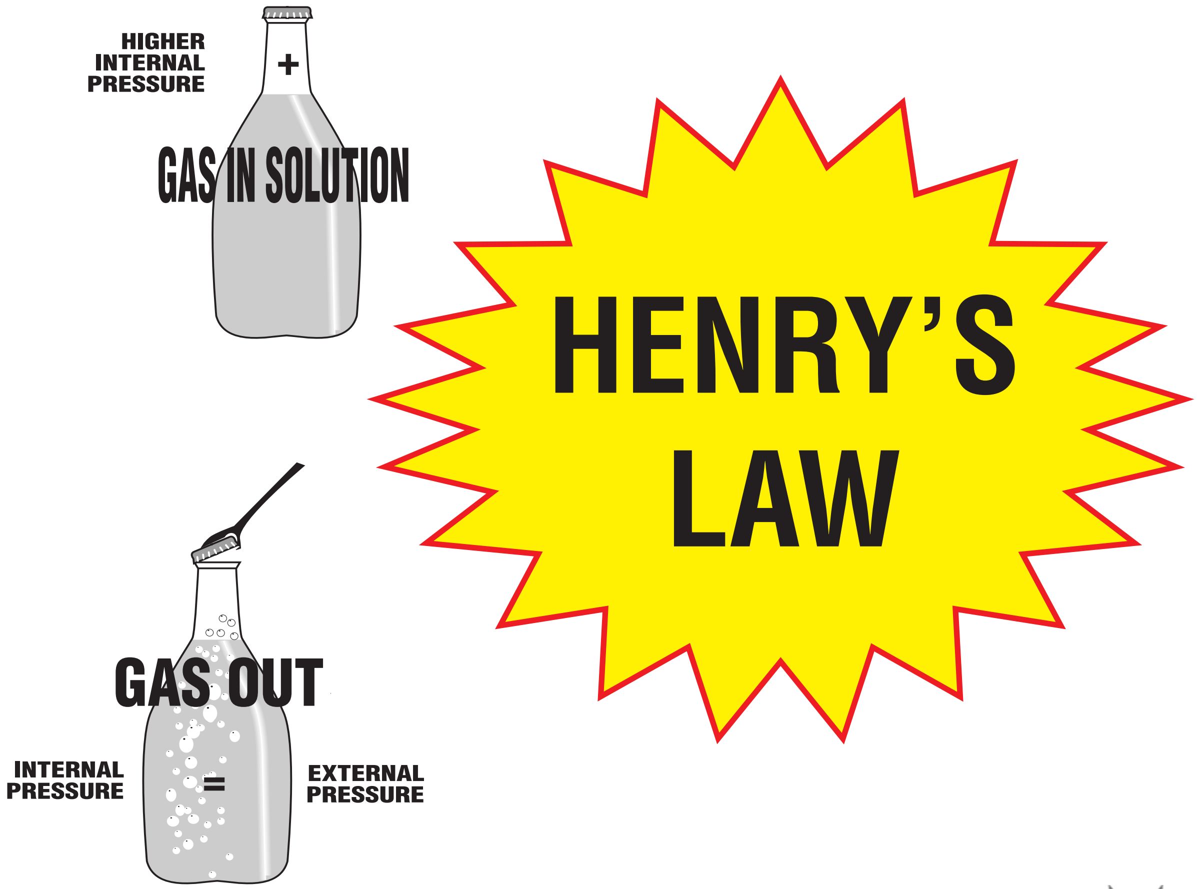
Nitrogen narcosis



Decompression sickness

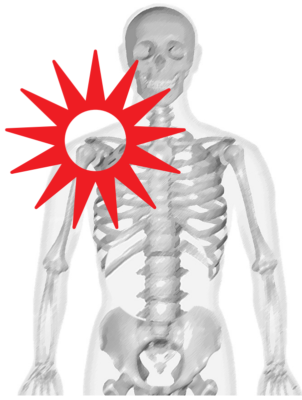
LEGGE DI HENRY

The increase in pressure during descent, corresponds to a rise in the partial pressure of the gas breathed. According to Henry's Law the pressure in the tissues increases at the same rate



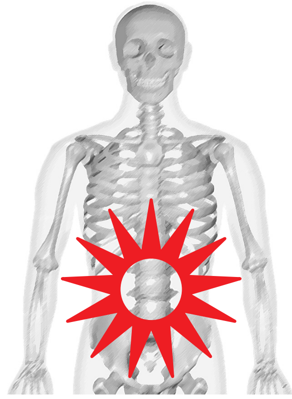
SKIN DECOMPRESSION SICKNESS

This can range from a mild rash to an angry measles like rash or a bluish marble like mottling of the skin. The mottling is associated with severe DCS and is caused by the bubble blocking the blood vessels of the skin. Mild cases may disappear even if untreated. However medical help should be sought if ANY symptoms are seen, the skin symptoms may be masking more serious neurological problems.



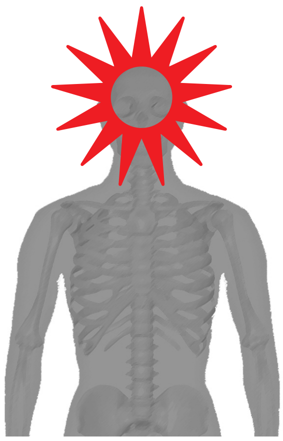
JOINT DECOMPRESSION SICKNESS

This usually starts as a feeling of tenderness or numbness at or near a joint, soon becoming a dull ache. The affected joint may swell and become red. The pain will increase over the next 12 or 24 hours and will not be relieved by heat or pressure – as a bruise may be. It is most common in the shoulder. Commercial divers are more prone to this type of DCS as it is more commonly associated with exertion and long duration's of diving. It is common among caisson workers. Medical help must be sought, as more serious neurological DCS may also be present.



CENTRAL NERVOUS SYSTEM DECOMPRESSION SICKNESS

The brain and spinal cord both have very large blood supplies and are both very susceptible to any bubbles in the blood stream. The symptoms for a CNS Decompression Sickness are varied and diverse. Some of the more common are; extreme fatigue, a strong feeling of malaise, pins and needles and numbness. Partial or total paralysis, loss of bladder function, blurred vision, confusion and even death can be the result of a CNS DCS. This is the most common type of DCS among sport divers and is usually associated with insufficient decompression.



FIRST AID

Contact the nearest Recompression Facility. 100% Oxygen must be given to the casualty as soon as possible after the incident & during the journey to the hyperbaric chamber. The application of pure oxygen guarantees greater oxygenation of the tissues and helps to lessen the risk of damage. In parallel with the administration of oxygen the casualty should be encouraged to drink fluid at a rate of about 1 litre per hour. Avoid diuretic fluids such as coffee or any alcoholic drinks. Still water or Isotonic sports drinks are best. Maintaining a good level of hydration helps the blood volume and reduces the risk of more bubbles forming.

Prevention of accidents

Diving should be considered as an enjoyable and relaxing activity. For this reason diving should be undertaken by divers with good levels of fitness and training at depths of not exceeding 20 metres. This will minimise the risks of decompression sickness. The rules for the prevention of decompression sickness can be divided as follows:

MEDICAL

A visit to the doctor should discover the presence of any pathological problem (for example epilepsy, diabetes etc.)

BEFORE DIVING

Avoid alcoholic or caffeine drinks (coffee, coke etc.) as they dehydrate you and cause diuretic problems
Always drink plenty of still liquids before diving, especially in summer
Avoid stress and excess physical exertion.
Avoid certain medicines or drugs; if in doubt consult your doctor.

DURING DIVING

Follow the tables and keep to the correct rates for descent and ascent
If you are tired end the dive & surface, tiredness causes an increase in the absorption of nitrogen
Avoid "see-saw" or "saw tooth" dive profiles
Be cautious if it is cold, this causes vascular constriction, dehydration, and stress, which increases the circulation activity

DURING ASCENT

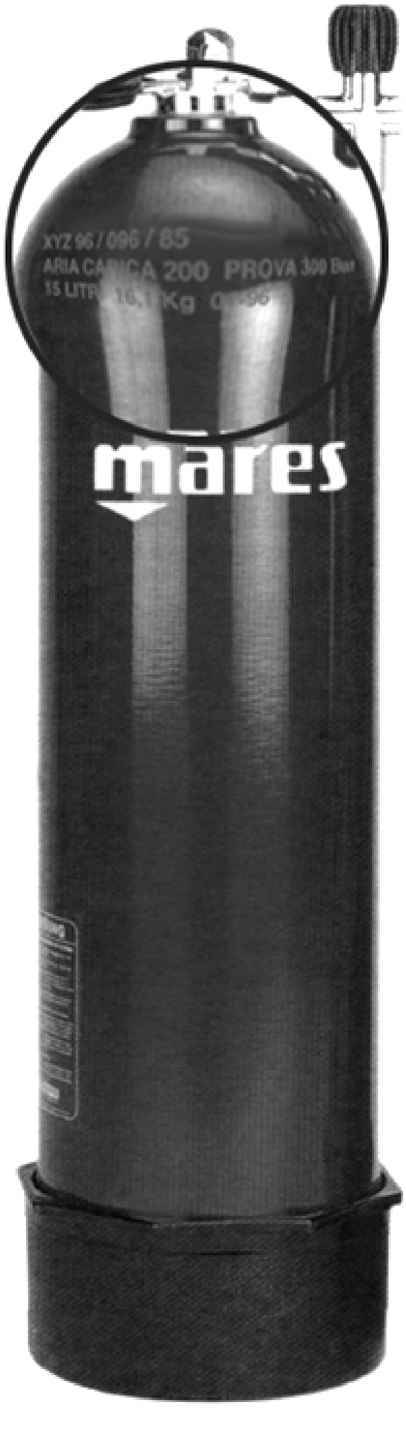
Keep to an ascent speed of 10 metres a minute, and obey any ascent alarm given off by instruments. Always carry out a safety stop at 3 metres for 3 minutes.

AFTER DIVING

Avoid heavy physical activity
No snorkelling after scuba diving
Don't fly immediately after diving
Re-establish normal body temperature

Scuba equipment

CYLINDER

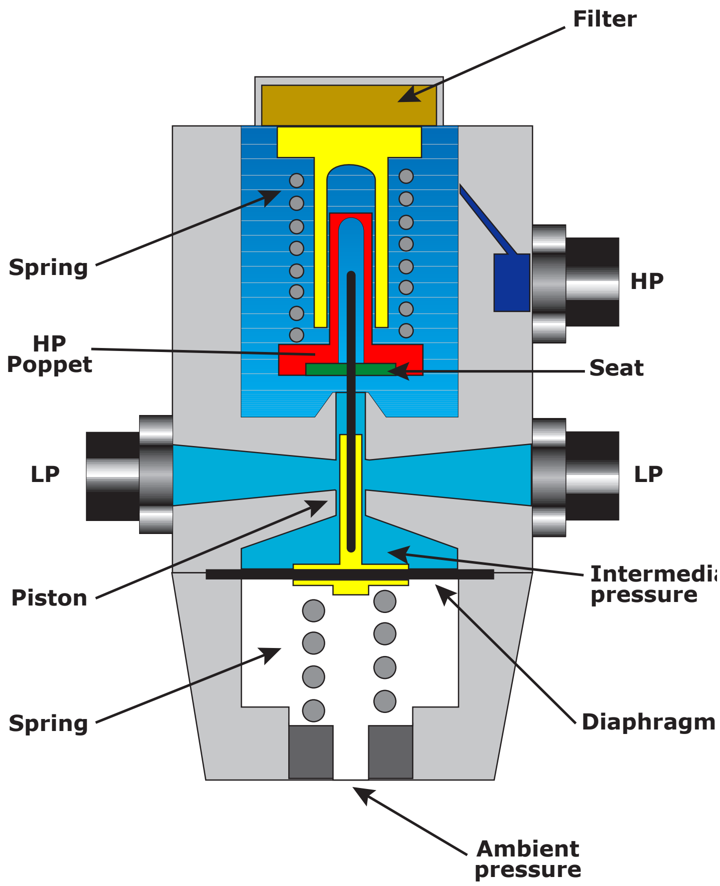


REGULATOR

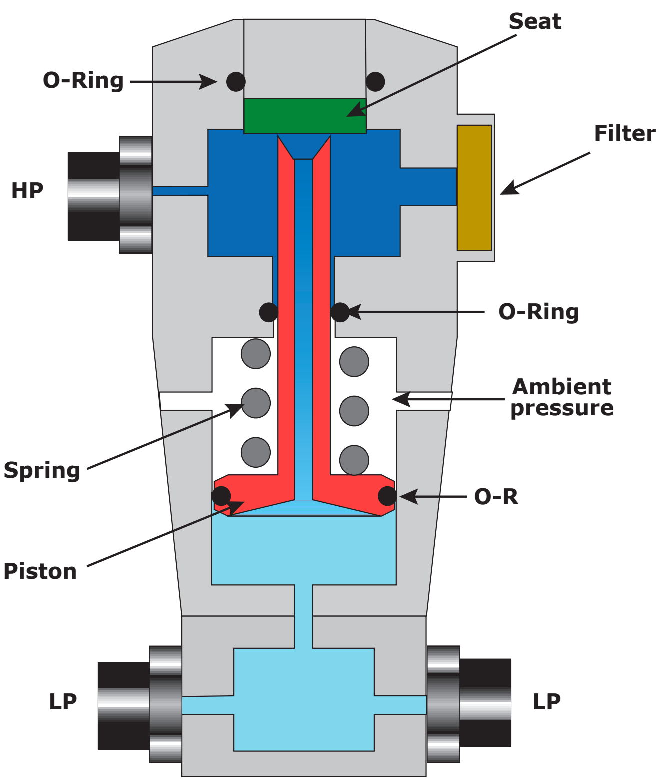
First stage

Second stage

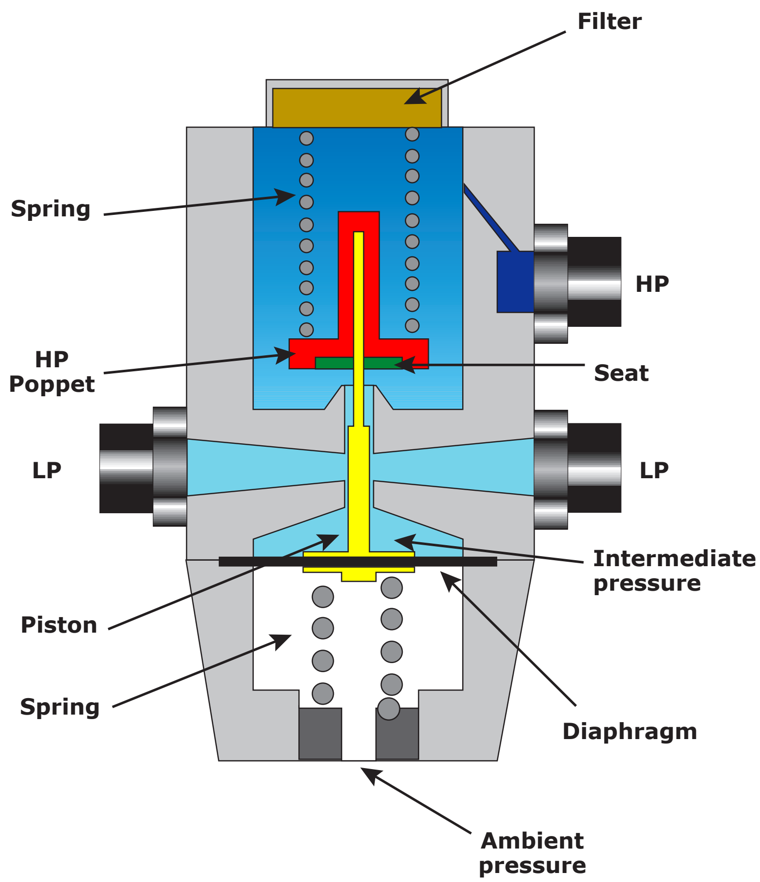
BALANCED DIAPHRAM FIRST STAGE



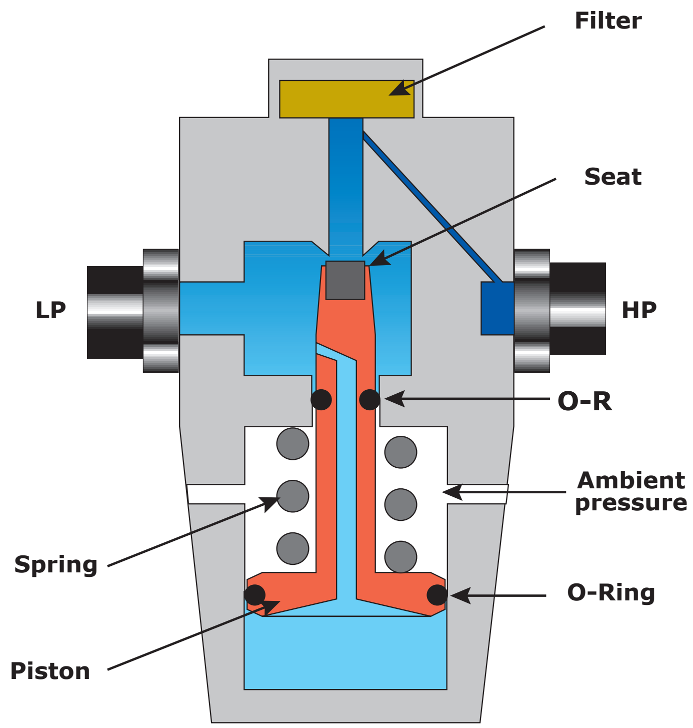
BALANCED PISTON FIRST STAGE



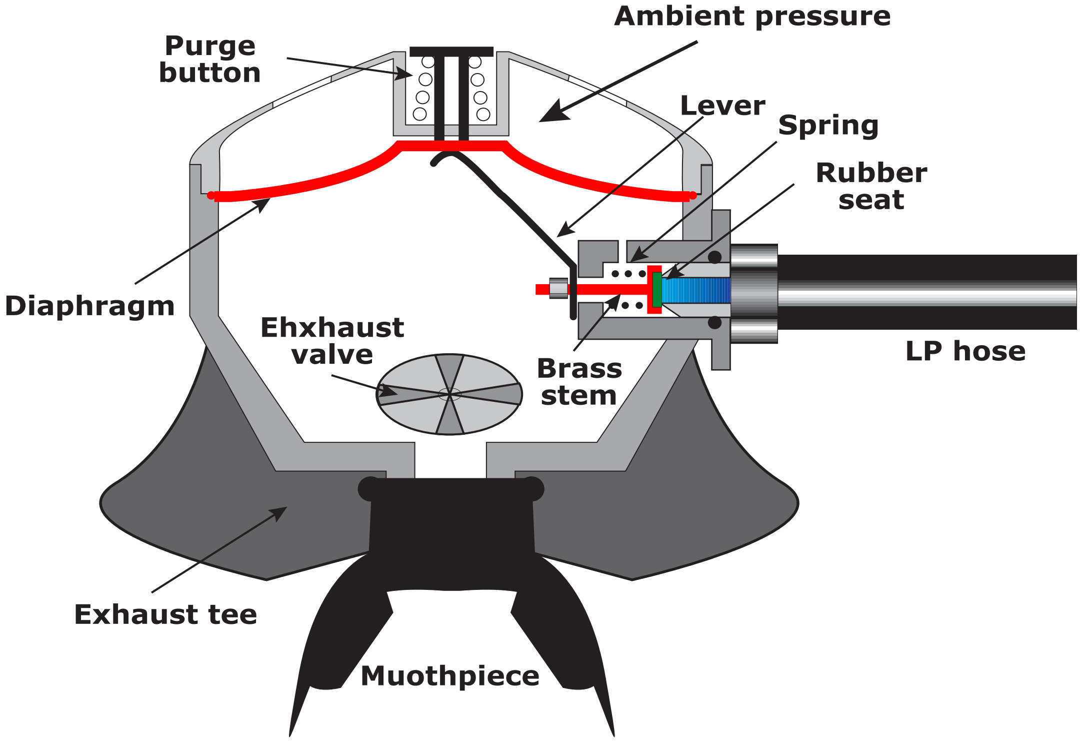
NOT BALANCED DIAPHRAM FIRST STAGE



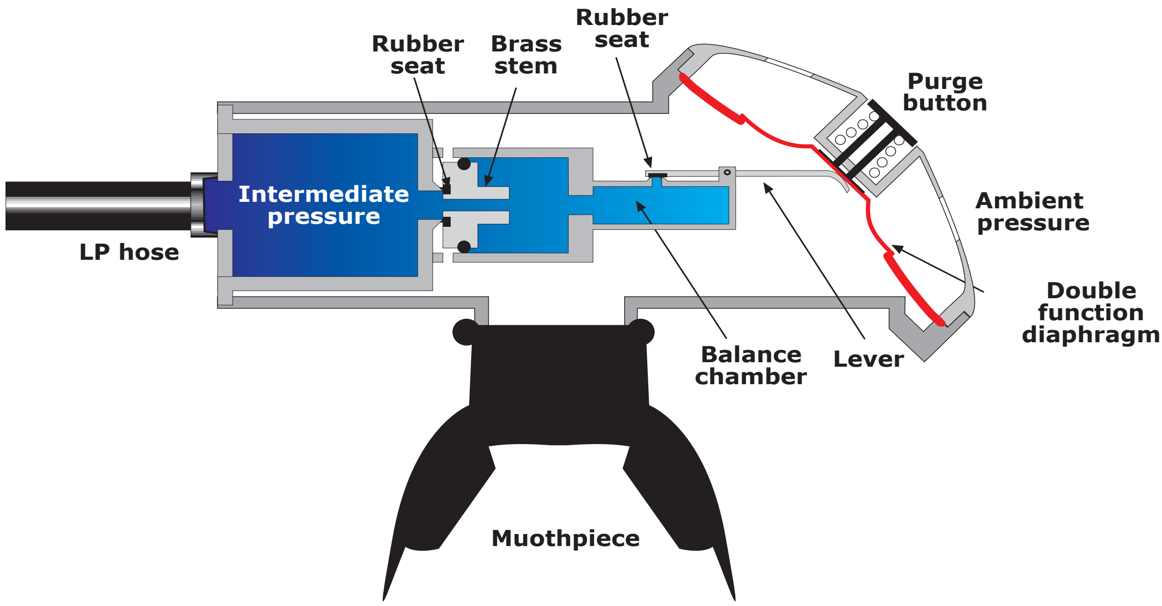
NOT BALANCED PISTON FIRST STAGE



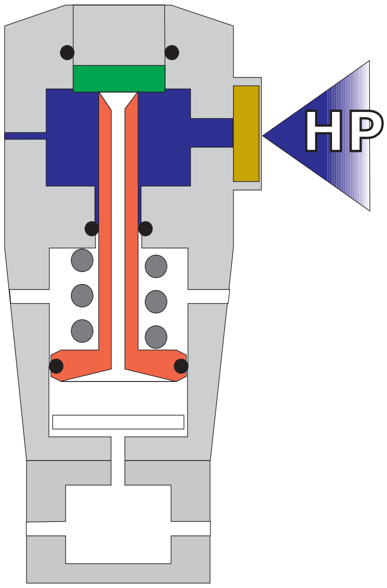
SECOND STAGE

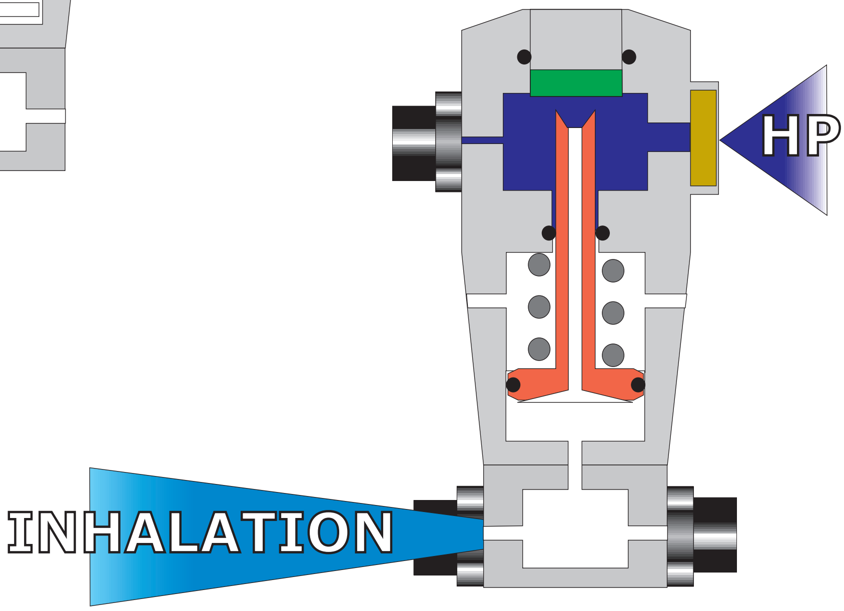


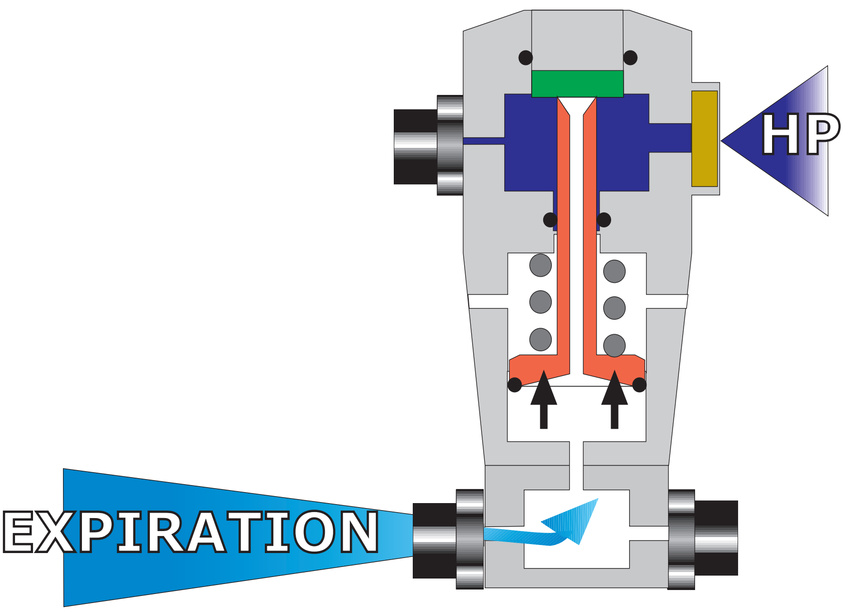
SECOND STAGE



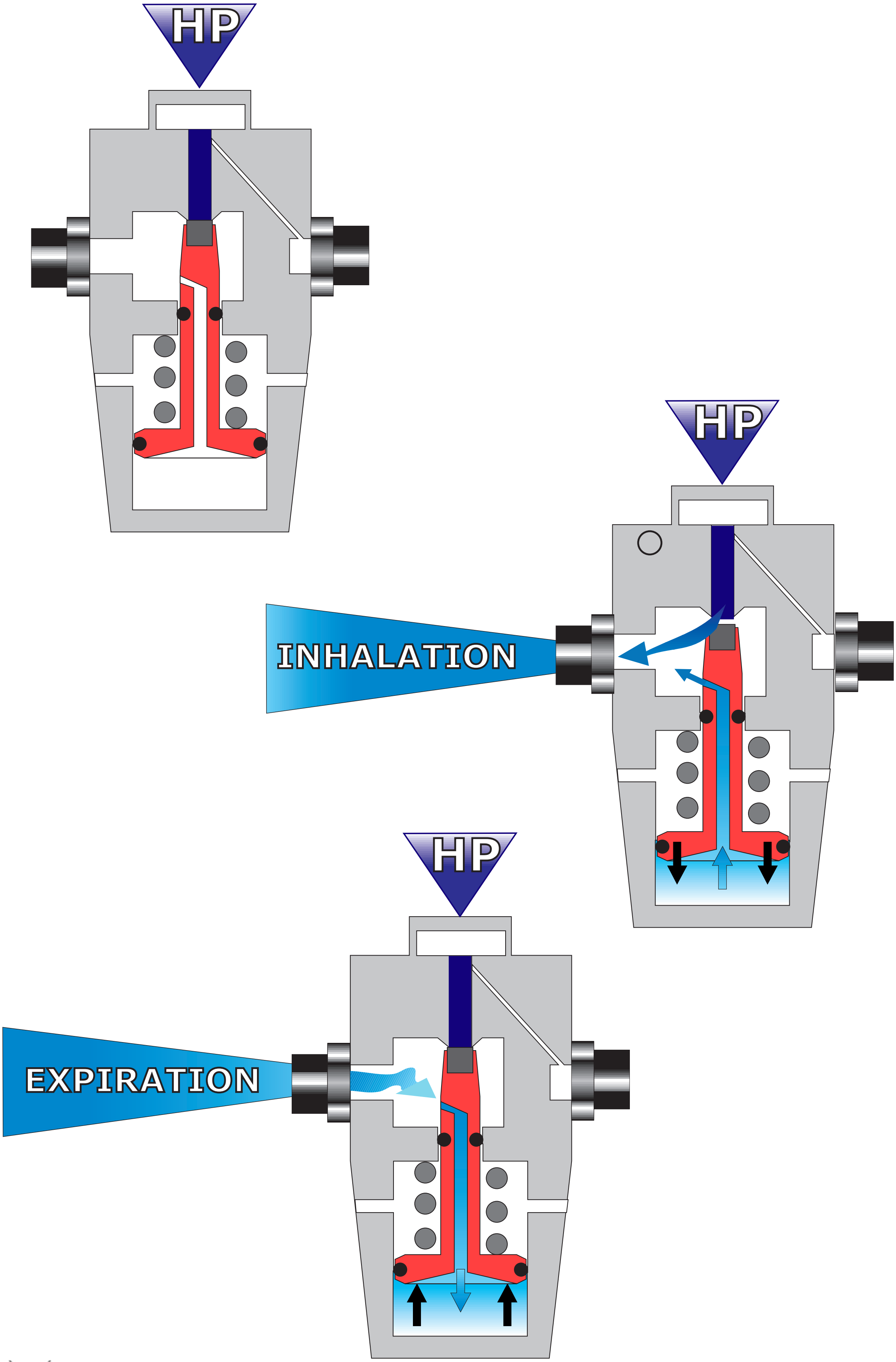
BALANCED PISTON FIRST STAGE



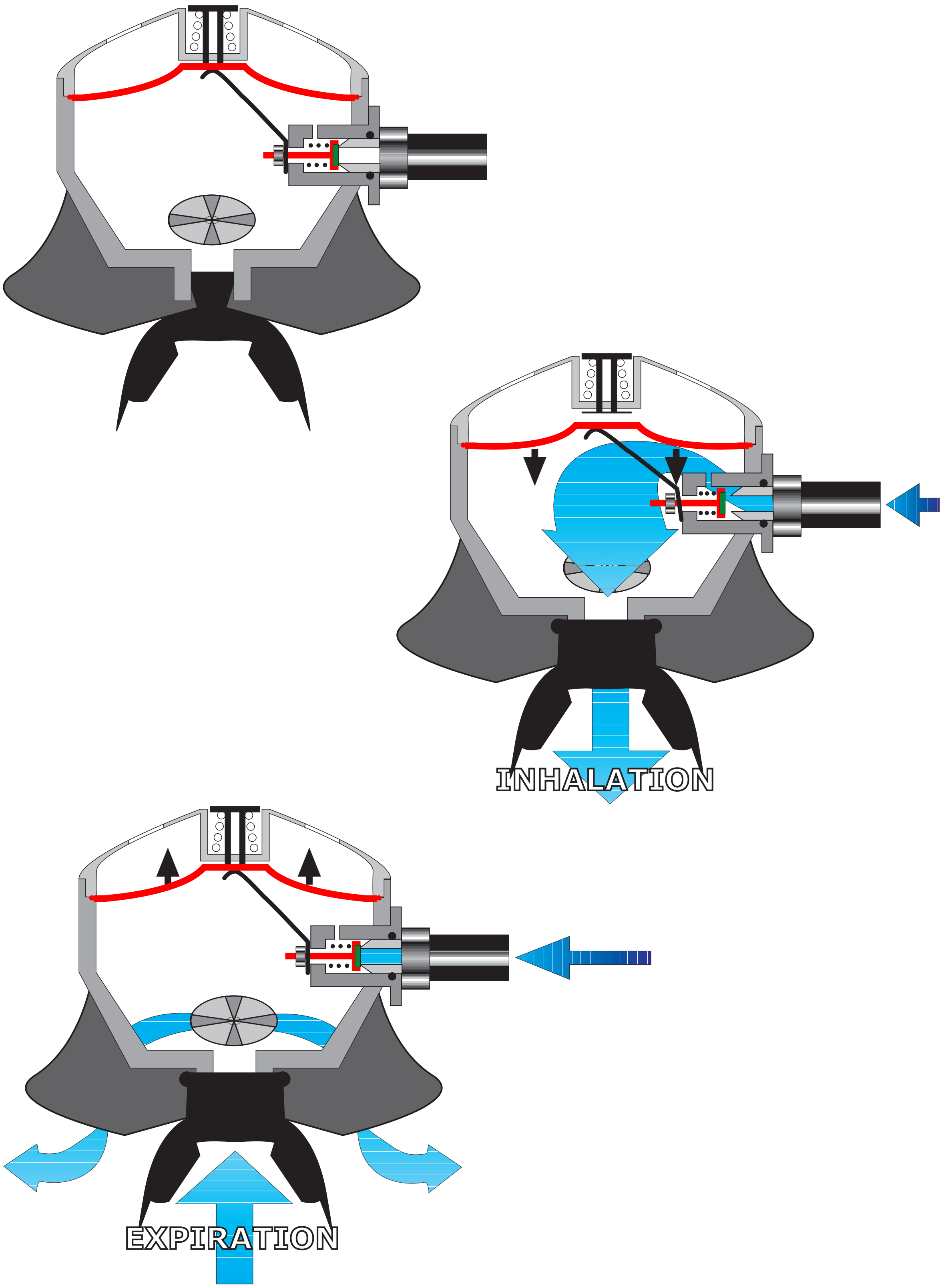




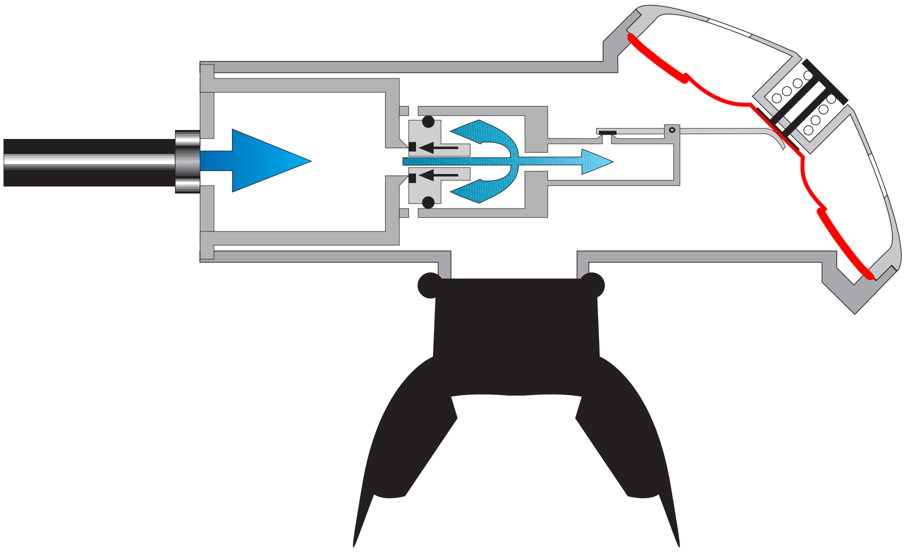
NOT BALANCED PISTON FIRST STAGE

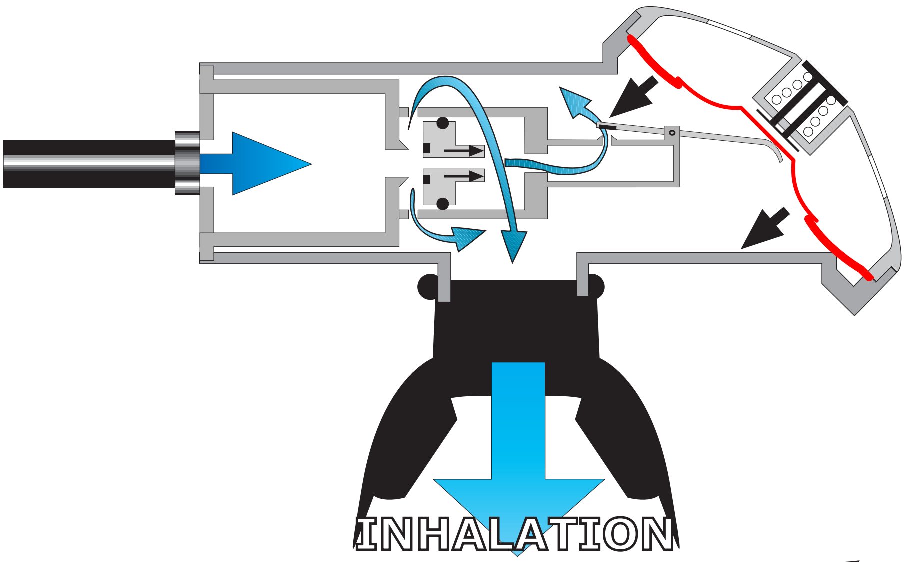


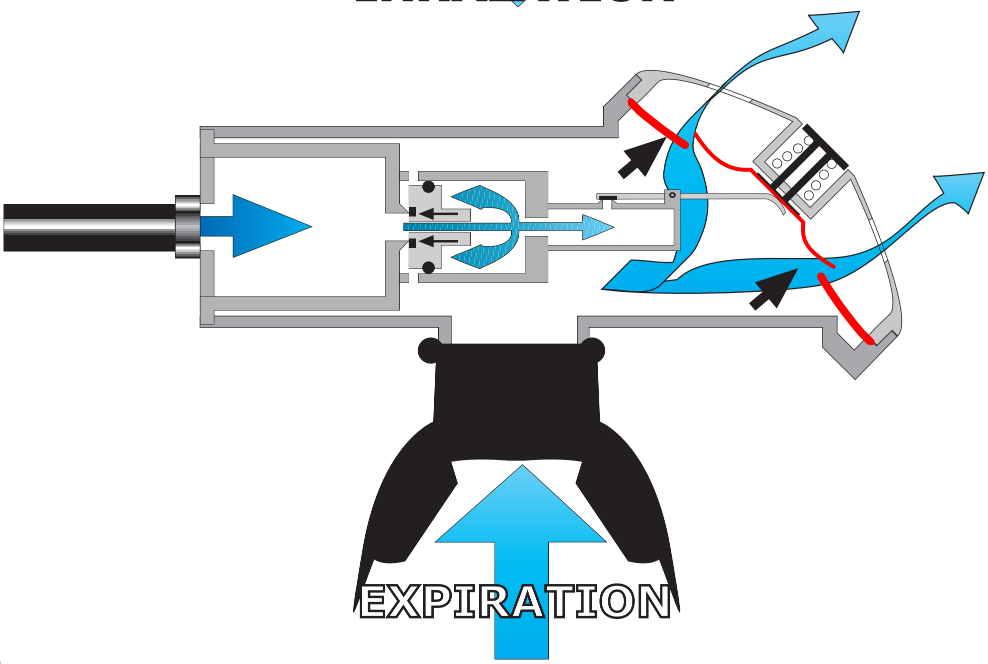
SECOND STAGE



SECOND STAGE







ALTERNATIVE AIR SOURCE (AAS)

A SECOND STAGE OR “OCTOPUS”

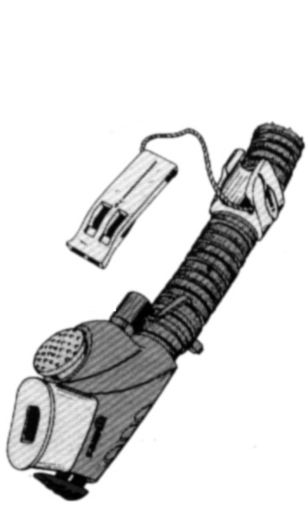
SPARE REGULATOR

ALTERNATIVE AIR SOURCE INFLATORS

INDEPENDENT SOURCE

PRESSURE GAUGE

BUOYANCY CONTROL DEVICE (B.C.D.)



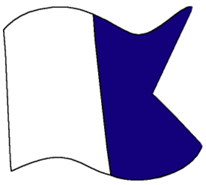
Device

DEPTH GAUGE

WATCH

KNIFE

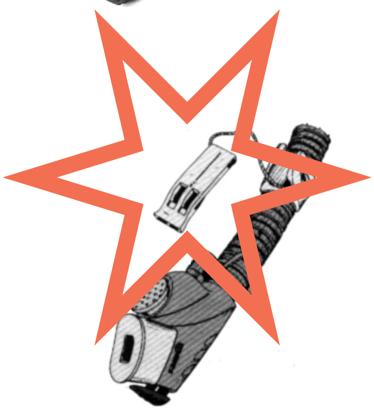
SURFACE MARKER BUOY



DIVING TORCHNG.

COMPASS

WHISTLE



BAG

KIT BOX

Preparation and assembly of scuba diving

CYLINDER
Keep the cylinder vertical, with the air outlet opposite the diver. When the diver is not holding a cylinder it must always be left lying down.
BCD
Fix the BCD onto the cylinder checking the position so as to avoids the valves hitting the back of the divers head when in the water.
REGULATOR
Before assembly a regulator check the condition of the O-ring, which should exhibit no cuts. At this point connect the regulator first stage closing gently the fitting system, while checking the exact position of the hoses. The second stages must be on the right. Connect the inflating hose of the BCD; put the pressure gauge and the second regulator in their supports in the BCD. Slowly open the valve while keeping the purge button pushed on one of the second stages and leave it when the air begins to get out. This operation is useful to extend the life of the regulator, because the pressure that reached the first stage is not released too strongly, now it is possible open the valve completely. Breathe a couple of time from both the regulators so as to check them. It is important to look at the pressure gauge when breathing, because if the pressure falls drastically this means that the valve is not completely open or something is obstructing the flow of air at the first stage. Inflate and deflate the BCD a couple of times in order to check the functioning of the valve. Once the equipment is assembled lie the cylinder down in a safe position.

Putting on the scuba equipment

SUIT
With a two piece suit put on the trousers first then the jacket, if edgings in soft neoprene are present roll them outwards to help the suit to slip on.
FOOTWEAR
Put the edge of the boot over the suit trousers. This ensures a better seal.
WEIGHT BELT
Always have a keeper on the opposite side of the weightbelt from the buckle to avoid to loosing the weights. The two main methods for wearing the belt are:
- passing the belt behind the back holding it with the right hand then grab the buckle with the left hand, lean forward and place the belt on the back, then fasten the buckle
- with the buckle to the left, take the two ends of the belt, step over it and repeat the previous procedures

It is very important to check that the buckle is on the right, because in an emergency it will always be clear how to release one's buckle.
FINS
The best position to put fins on is when one is sitting. If it is necessary to put them on while standing, do it with the help of a companion. It is important to remember that the left hand put on the right fin and vice versa.
MASK
To position the mask hold the skirt in position against the face with one hand, while the other positions the strap round the head. The headstrap must not be too tight as it could deform the mask, causing water to get in. With a hooded suit make sure that the edge of the mask is in contact with the face by passing a finger around the edge of the hood.
SNORKEL
The snorkel must be put on the left side so as not to obstruct a regulator.
GLOVES
In order to have a better control of dressing it is advisable to put the gloves on last.
PUTTING ON EQUIPMENT WHILE STANDING
To put on equipment while standing get a friend to take the weight of the cylinder thus making it easier to put on the BC and to hold it until the harness straps have been fixed.
PUTTING ON EQUIPMENT WHILE SITTING
This is a more practical and comfortable way of putting on the equipment but it is not always possible. It is generally possible when we dive from a large boat.
PUTTING ON THE EQUIPMENT IN WATER
Putting on the equipment in water is not too difficult but not advisable in rough water. In any case the use of a line is advisable. To speed up the fitting of equipment it is better to place the back against the inside support of the BC, the arms can be put through the jacket one at time and then it can be fastened. At this point a normal position can be taken and the line can be abandoned. This operation should be carried out as quickly as possible so as to leave space at the entry point for other divers.

In Water

ENTERING AND COMING OUT OF THE WATER

Several techniques exist for entering into the water. The use of these can depend on point to departure (from the bank or from the boat), and on the condition of sea, waves, or current. In general these techniques have always been developed with the safety of the diver as a primary consideration.

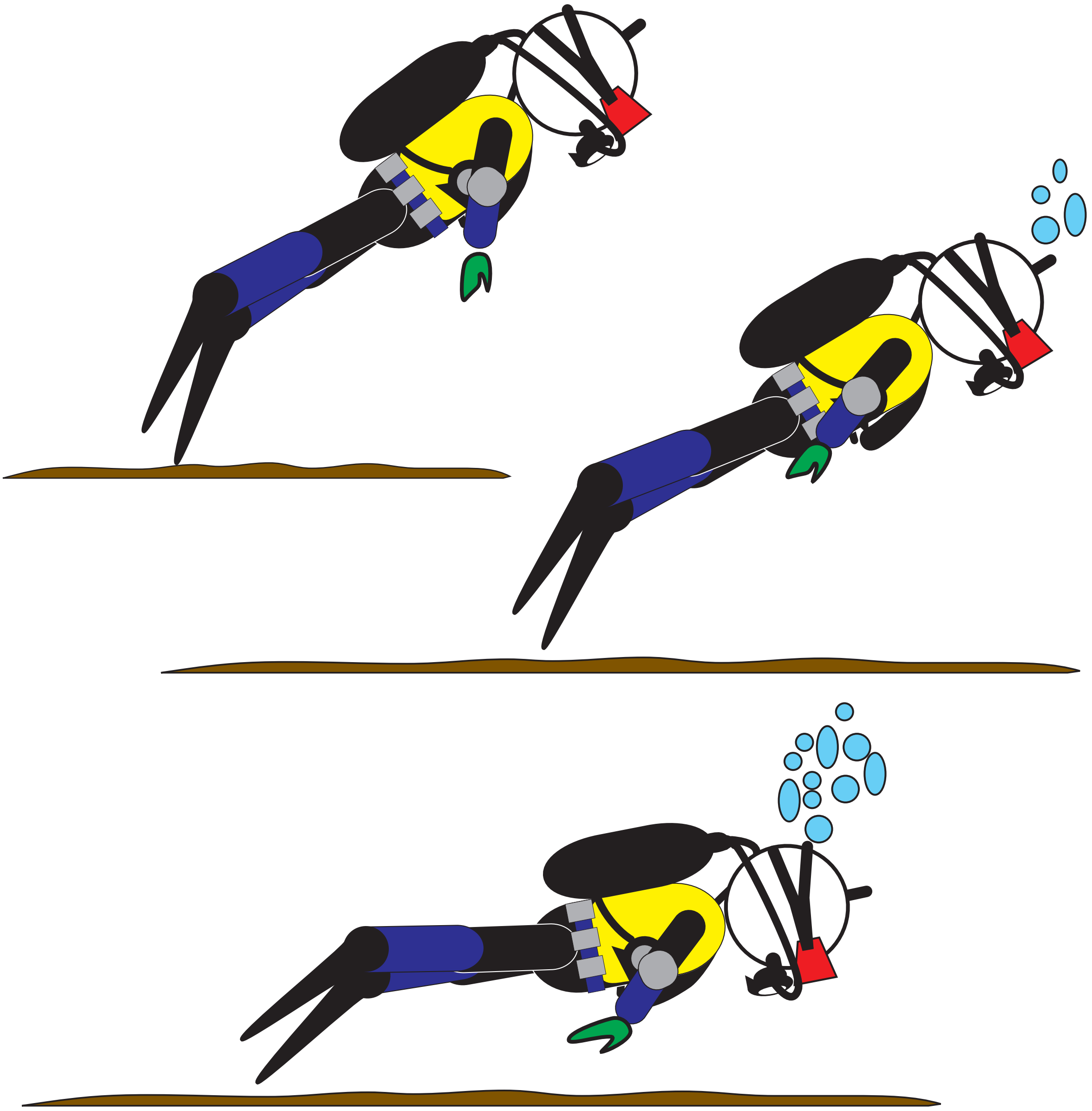
FROM A ROCKY SHORE

FROM THE BEACH

FROM A BOAT

FROM THE SHORE

FROM AN INFLATABLE



Safety procedures

At the end of the dive when the ascent begins it is important to be attentive to the vertical speed. The BC must be slowly deflated during ascent, because the air inside it expands and creates an increasingly positive buoyancy and subsequent loss of control of speed. It is extremely important to never stop regular breathing by holding the breath. On approaching the surface it must be checked that it is free from obstacles. These procedures must be clearly set down as rules so as to avoid difficulties and misunderstanding with diving companions and should anyhow be agreed upon with the diving companion and the group leader during the pre-dive briefing.

ASCENDING

NEVER HOLD THE BREATH

ON THE SURFACE THE B.C. IS INFLATED TO OBTAIN A POSITIVE BUOYANCY

SAFETY STOP
3 min
3 Mt

KEEP THE SPEED OF ASCENT SUGGESTED BY DIVE TABLES

BREATHING CONTINUOUSLY

FINNING WE START TO LEAVE THE BOTTOM AND TO RELEASE AIR FROM THE B.C. TO CONTROL SPEED

CONTROL THE ASCENT PATH

SIGNAL:
I AM OK
I GO UP

BREATHING

BUDDY BREATHING

NEVER HOLD THE BREATH

ONCE THE SITUATION UNDER CONTROL ASCENT IS DECIDED

WITH LEFT HAND BOTH DIVERS CONTROL THE SPEED OF ASCENT

THE DONOR PASSES OVER HIS ALTERNATIVE AIR SOURCE TO HIS BUDDY

THE RECEIVER CONTACTS THE DONOR

THE DIVER THAT HAS AIR LEFT JOINS HIS BUDDY WHO IS IN NEED OF IT

SIGNAL: THE AIR HAS RUN OUT LET'S SHARE YOUR AIR

ALTERNATIVE AIR SOURCE RESPIRATION

BLOW OUT AIR WHEN WITHOUT REGULATOR

EVERYTHING UNDER CONTROL ASCENT IS DECIDED

EMPTY THE REGULATOR AT EVERY STAGE

AFTER TWO RESPIRATIONS THE RECEIVER CONFIRMS, THE REGULATOR IS GIVEN BACK TO HIS BUDDY

IT IS THE DONER THAT PASSES HIS MAIN REGULATOR TO THE BUDDY

THE RECEIVER CONTACTS THE DONOR

THE DIVER THAT HAS AIR LEFT JOINS HIS BUDDY WHO IS IN NEED OF IT

SIGNAL: THE AIR HAS RUN OUT LET'S SHARE YOUR AIR

BREATHING ASCENT

BUDDY BREATHING ASCENT

NEVER HOLD THE BREATH

- CHECK THE ASCENT DIRECTION
- WITH LEFT HAND BOTH DIVERS CONTROL THE SPEED OF ASCENT
- EVERYTHING UNDER CONTROL ASCENT IS DECIDED
- THE DONOR PASSES OVER HIS ALTERNATIVE AIR SOURCE TO HIS BUDDY
- THE RECEIVER CONTACTS THE DONOR
- THE DIVER THAT HAS AIR LEFT JOINS HIS BUDDY WHO IS IN NEED
- SIGNAL: THE AIR HAS RUN OUT LET'S SHARE YOUR AIR

ALTERNATIVE AIR SOURCE ASCENT

BLOW AIR FROM MOUTH WHEN WITHOUT REGULATOR

- AFTER TWO RESPIRATIONS, THE DIVER PASSES OVER THE REGULATOR TO HIS BUDDY
- AFTER TWO RESPIRATIONS THE RECEIVER CONFIRMS, THE REGULATOR IS GIVEN BACK TO HIS BUDDY
- CONTROL OF ASCENT SPEED AND DIRECTION
- EMPTY THE REGULATOR AT EVERY STAGE
- IT IS THE DONER THAT PASSES HIS MAIN REGULATOR TO HIS BUDDY
- THE RECEIVER MAKES CONTACT WITH THE DONOR
- ONCE THE SITUATION UNDER CONTROL ASCENT IS DECIDED

EMERGENCY ASCENT

USING THE FINS AND B.C.D.

NEVER HOLD THE BREATH

- ONCE ON THE SURFACE THE WEIGHT BELT IS RELEASED TO OBTAIN A POSITIVE BUOYANCY
- CONTROL THE ASCENT PATH
- WITH THE RIGHT HAND THE WEIGHT BELT BUCKLE MUST BE LOCATED
- BREATHING CONTINUES
- FINNING WE START TO LEAVE THE BOTTOM AND TO RELEASE AIR FROM THE B.C. TO CONTROL SPEED
- SIGNAL : MY AIR IS FINISHED, I AM GOING UP
- THE DIVE BUDDY IS TOO FAR AWAY TO CARRY OUT BUDDY RESPIRATION

IT MUST NOT HAPPEN

EMERGENCY ASCENT WITHOUT BELT

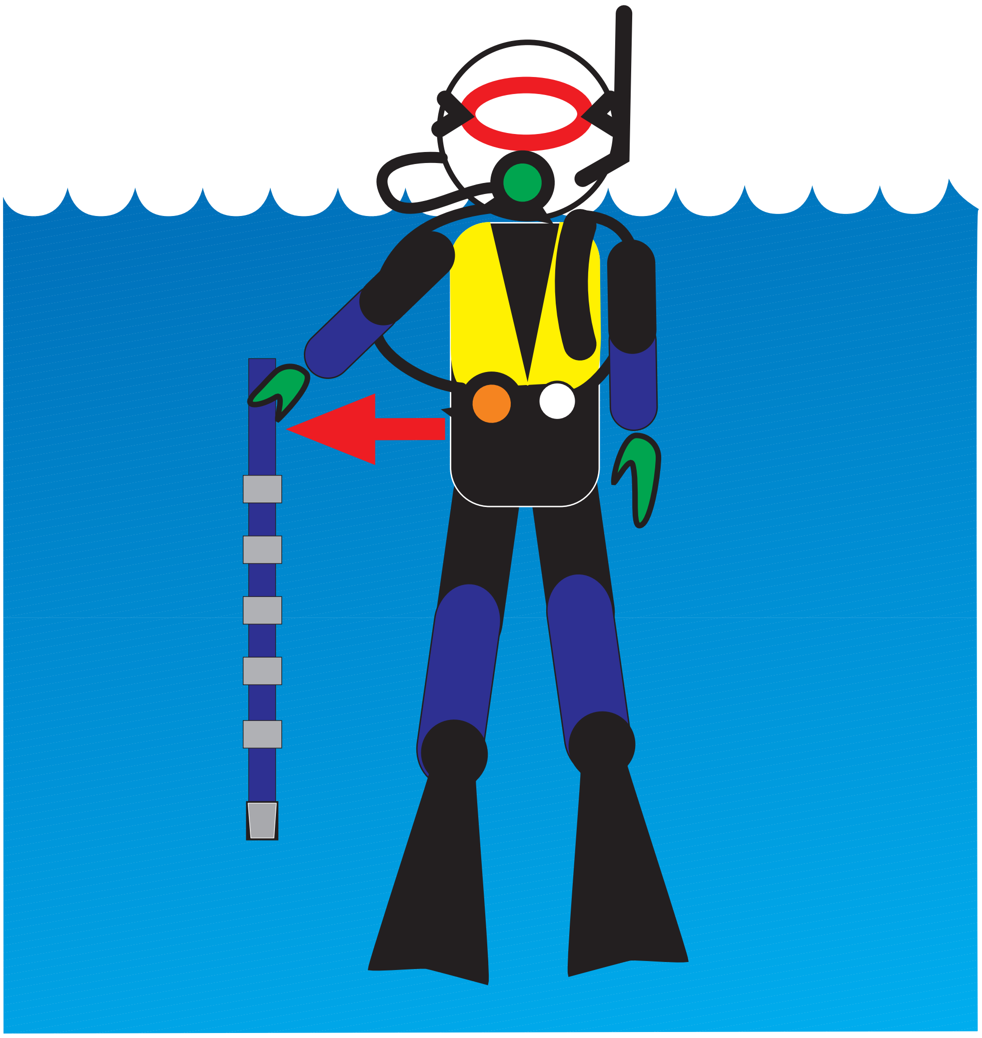
NEVER HOLD THE BREATH

- BEFORE REACHING SURFACE CUT DOWN SPEED
- CONTROL THE ASCENT DIRECTION
- CONTROL THE ASCENT RATE BY VENTING AIR FROM B.C.D.
- BREATHING CONTINUES
- RELEASE WEIGHT BELT TO OBTAIN POSITIVE BUOYANCY
- SIGNAL : MY AIR IS FINISHED, I AM GOING UP
- THE DIVE BUDDY IS TOO FAR AWAY TO CARRY OUT BUDDY RESPIRATION

IT MUST NOT HAPPEN

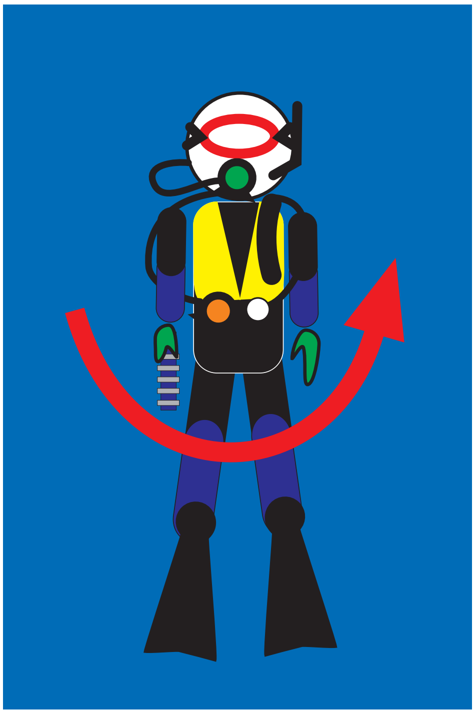
RELEASE OF THE WEIGHT BELT

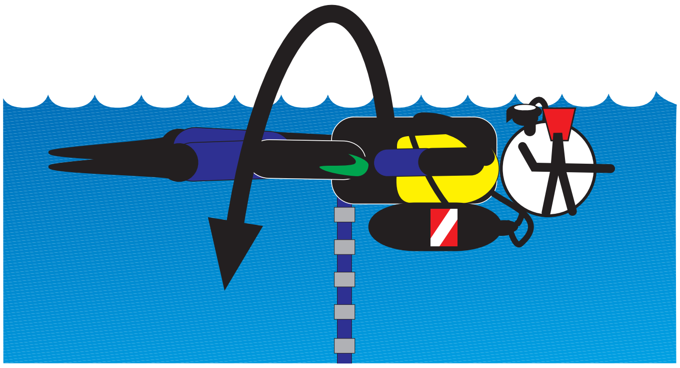
On resurfacing it may be necessary to quickly remove the weight belt to obtain positive buoyancy or to be able to come out of the water more easily. Having determined the position of the belt and the buckle, release the latter with your right hand while holding on to the belt so as not to let it slip away. If the belt must be abandoned, the operation should be carried out with the arm far from the body.



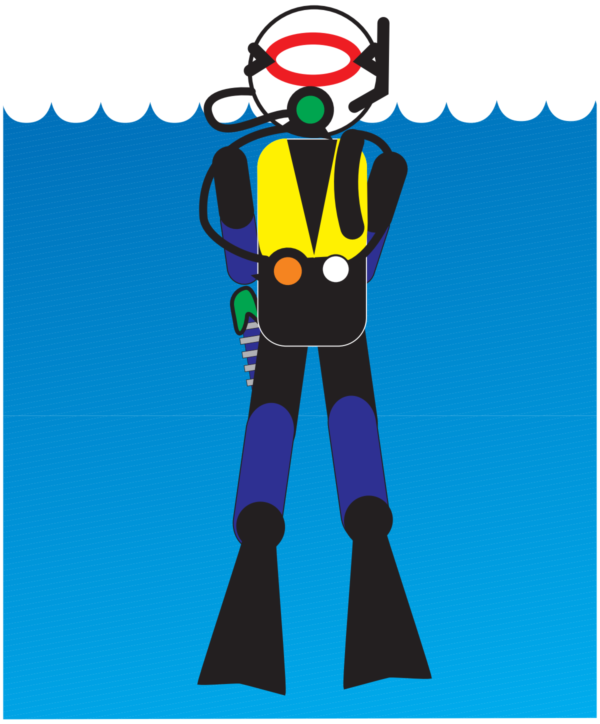
IN WATER WEIGHT BELT DRESSING

ROTATION



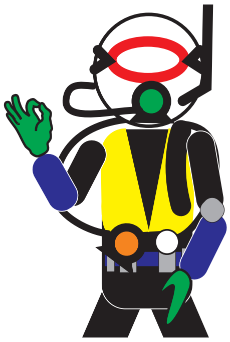


BACK PASSAGE

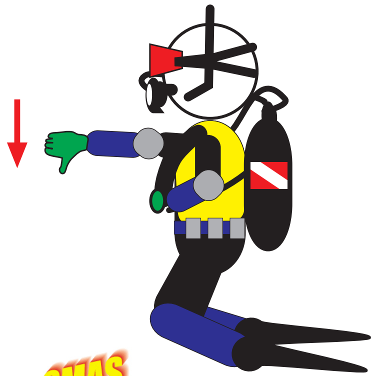


Signals

DIVING SIGNALS

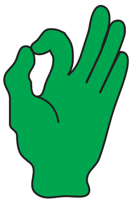


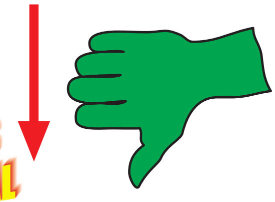
OK -Did you understand ?

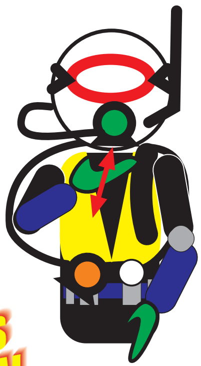


Down

Up



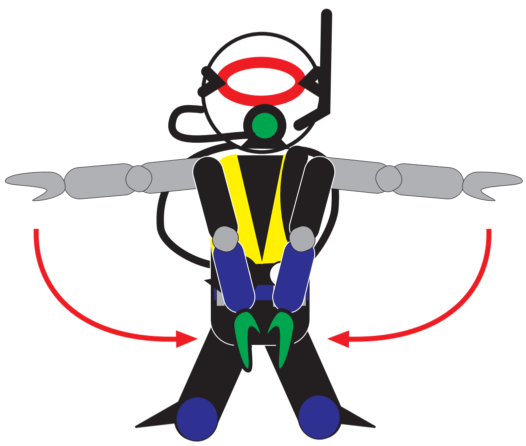




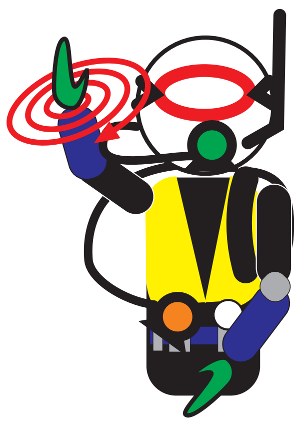
Out of air

Tie

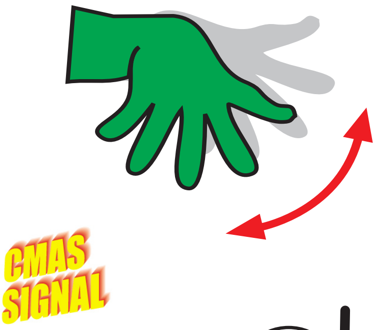
(can't) open my reserve

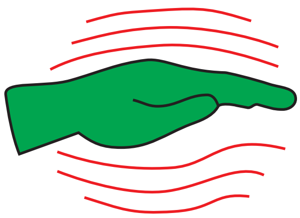


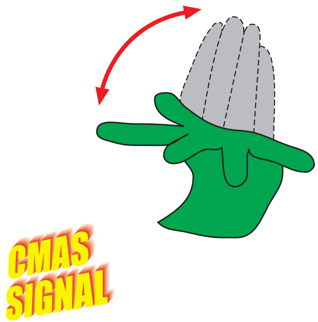
Everybody here



Dizziness







don't
der-

Inflate

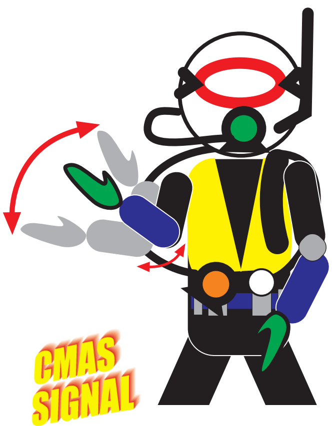
50 Atm

You

Me

Direction

Pay attention - Stop

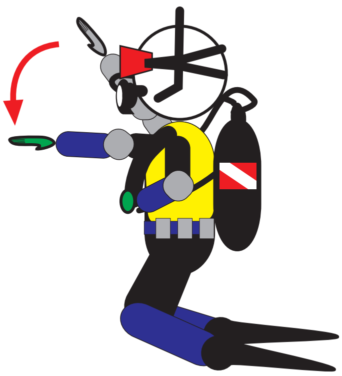


Slow down

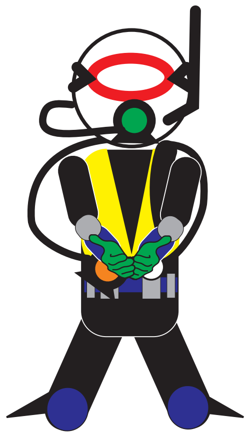
DIVING SIGNALS

No

Acceleration



Look (There..., Here...)



Boat

Cramps

Tank pressure

Half pressure

Shared respiration

LESSON 2

CMAS

WORLD UNDERWATER FEDERATION

Nitrogen and the human body

ABSORBING NITROGEN

Tissues of the human organism which are exposed to constant pressure for a long period of time become, according to Henry's Law, saturated with gases at that pressure. This means that when breathing in a mixture of gases, in this case air, the same percentage level of individual gases can be found dissolved in the blood steam and in the body tissues as the mixture contained in the air breathed.

ABSORBING AND RELEASING NITROGEN

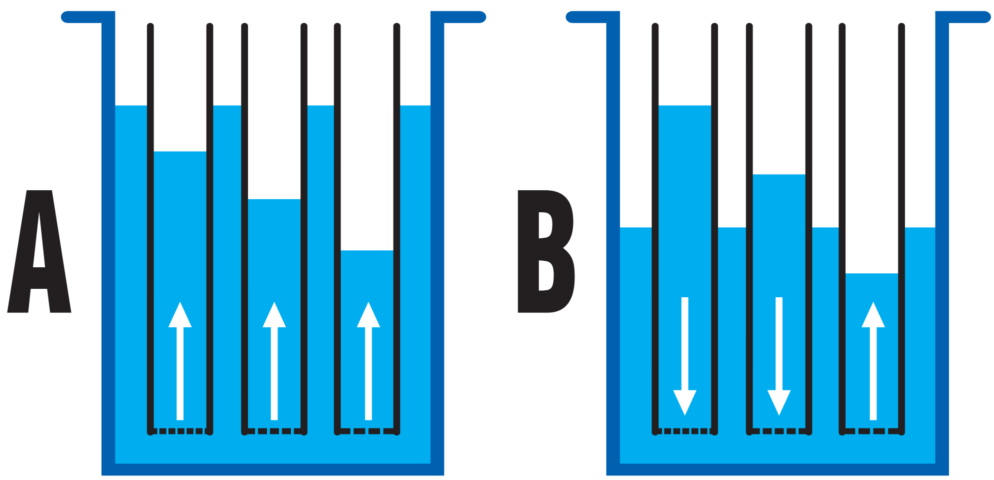
A – For a better understanding of the principles of the tissues' ability to absorb and release nitrogen in differing amounts of time, imagine the fast, medium and slow tissues as containers with a varying number of holes made in the base and then immersed in a basin. The pressure can be equated to the level of liquid in the basin. It can be seen that the speed at which the containers fill up is directly proportional to the number of holes in the base.

B –When pressure decreases, as if the level of liquid in the basin were lowered, the containers will behave differently. In fact, from the moment liquid level in the basin goes below the liquid level in the container, it will begin to empty. At this point, there will be some containers which will begin to empty at a speed that is proportional to the number of holes in the base, while other containers will continue to fill up as the level of liquid inside is still lower than the level of the liquid in the basin.

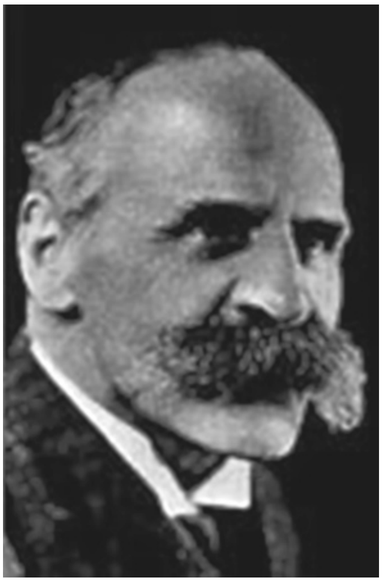
During a dive with breathing apparatus, throughout the descent and the time on the bottom, the scuba diver breathes in air at the same pressure as the environment. In his alveoli he therefore has a mixture of gases with a partially higher pressure than those normally present in the blood and tissues on land. Therefore, in accordance with Henry's Law, the gases tend to equilibrate their partial pressures, increasing therefore their pressure in the human body.

During ascent, the opposite situation occurs: with the fall in pressure, the gases in the blood stream and tissues tend to equilibrate their partial pressure with the air which is in the alveoli of the lungs. From the entire body, the gases in solution form begin to return to the lungs. This is the only place where, through the exchange of gases, they can be released through breathing. Of all the gases concerned, the most important to take into consideration is nitrogen.

Being an inert , non-metabolised gas and forming around 80% of the mixture we breathe, it is the gas which is most involved in these processes and the one which can create complications. Oxygen, the second component, percentage wise, of atmospheric air, is rapidly used by the human body and therefore does not create problems when released by the tissues. If the ascent and as a result the fall in pressure take place too quickly, the body does not have enough time to expel the excess gas before this starts forming micro-bubbles in the tissue and the blood. The greatest danger is when the size of these micro-bubbles increases at a rate that will damage the organism.



HALDANE'S PRINCIPLES



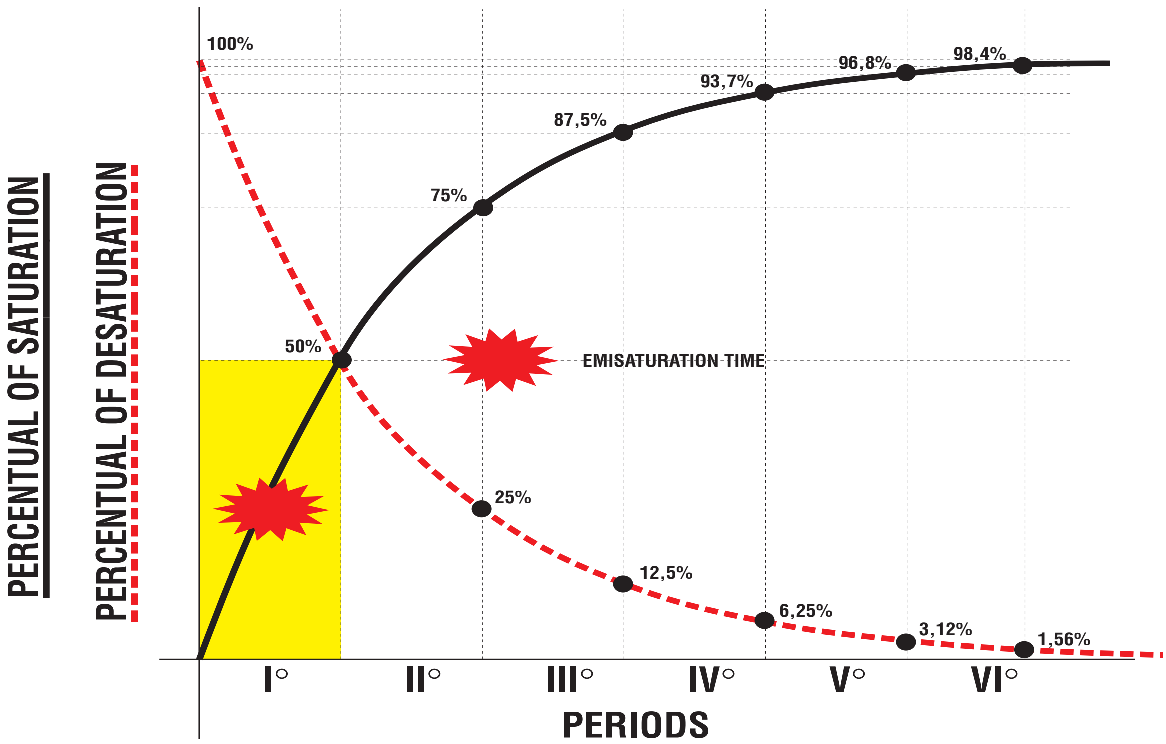
The principles that govern the absorption and release of nitrogen by our bodies when exposed to different ambient pressures derive from studies carried out at the beginning of the last century by J.S. Haldane, a Scottish physiologist. His experiments were even carried out on divers working outside the safety limits of the decompression tables that were then in use. These studies led to the formulation of three fundamental principles:
The division of the tissues into classes
The speed of absorption and release (half-saturation times)
The 2/1 ratio
Decompression can start with a sharp drop in ambient pressure.

DIVISION OF THE TISSUES INTO CLASSES

Not all the tissues in our body behave in the same way when exposed to variations in pressure. They can be divided into two main categories: fast tissues and slow tissues. Blood and the brain are amongst fast tissues, fat and bone tissues are amongst the slow. In calculating nitrogen absorption mathematically, theoretic values are given to a number of 5 compartments, into which all the tissues of our organism can be grouped.

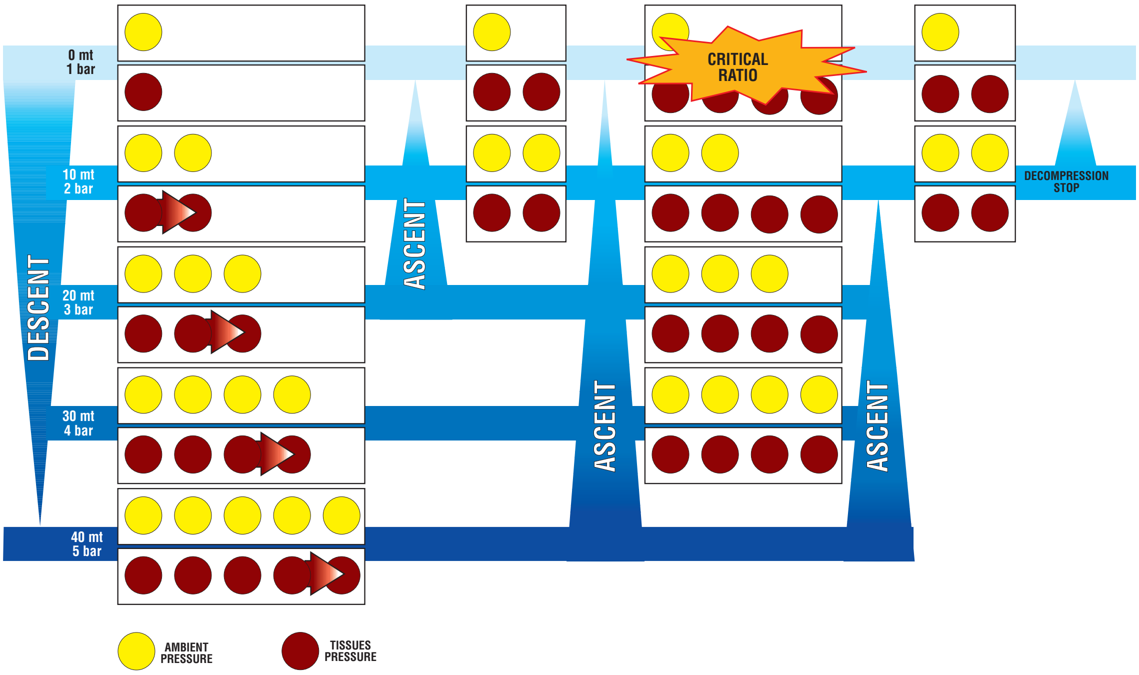
SPEED OF ABSORPTION AND RELEASE (HALF-SATURATION TIMES)

Tissue is divided into compartments according to the speed at which it absorbs nitrogen. The time necessary to reach an equilibrium with ambient pressure can be divided into periods. Each period is when a 50% saturation level is reached (half-saturation times). Conventionally, it takes six periods to reach complete saturation.
According to Haldane, tissues behave in the same way when resurfacing, with falling pressure, using the same principal but inversely.



THE 2/1 RATIO

Haldane demonstrated that, with a fall in ambient pressure and the consequent release of nitrogen into the tissues, the result was not necessarily an increase in decompression sickness. This was independent of the speed of the ascent, until, that is, there was a 2:1 ratio between the partial pressure of the nitrogen in the tissues and the partial pressure of nitrogen in the atmosphere (the critical overpressure ratio).
Therefore one could return to the surface at any speed within these limits. To continue the climb, one must wait until the partial pressure of the nitrogen balances with the ambient pressure at the new depth quota (using decompression tables).



DECOMPRESSION CAN START WITH A SHARP DROP IN AMBIENT PRESSURE

Divers at the time when the first of Haldane's studies were carried out were brought back to the surface taking 20 minutes for every 10 metres of depth, regardless of the amount of time spent underwater.
Haldane established, considering that the body can tolerate excess pressure in the tissues without particular problems, that ascending more quickly meant hastening the process of freeing nitrogen in the faster tissues and reducing absorption in the slower ones. He thus experimented with an ascent speed of 7-8 metres per minute, revolutionising divers' resurfacing methods, drastically reducing ascent times for shallow dives and reducing decompression accidents for deep dives.
His techniques made it compulsory to stop before reaching the overpressure ratio of 2:1. Thus step by step, decompression started to be used, with its related calculations, which led to the compilation of the first decompression tables.

With experience, these principles have been constantly adapted up to the present day. It has to be remembered that in Haldane's day, scuba diving was used exclusively for technical or military purposes, while nowadays most people dive as a leisure activity . Therefore, their needs and aims are completely different. The equipment used nowadays allows the sport to be carried by an enormous number of people, which was unimaginable until a few years ago. Consequently, the algorithms which work out nitrogen absorption have been recalculated and modified to also take into account the possibility of repeated or multilevel dives.

ADAPTATIONS OF HALDANE'S MODEL

The main adaptations that have been made to Haldane's model are:

AN INCREASE IN THE NUMBER OF THEORETICAL COMPARTMENTS
THE CRITICAL OVERPRESSURE RATIO
NITROGEN ABSOPTION AND RELEASE TIMES
NITROGEN IN THE BODY
ASCENT SPEED

AN INCREASE IN THE NUMBER OF THEORETICAL COMPARTMENTS

Considering the high number and the notable differences between the tissues in our body, modern studies have increased the number of compartments from the original 5 of Haldane, to the 6 of the U.S. Navy, up to the 16 used by Bühlmann.

Scuba diving computers that are now commercially available use algorithms which consider 8-10 compartments.

THE CRITICAL OVERPRESSURE RATIO

Not all tissues follow the pressure decrease ratio indicated by Haldane (2:1). In fact, while the faster tissues can resist up to values of over 3:1, the slower tissues are limited to a 1.5:1 ratio to avoid a rapid release of nitrogen by tissues leading to the formation of dangerous bubbles. The critical ratio of each tissue is called the "M Value". This indicates the differential of the partial pressure of the nitrogen which each tissue can support during ascent without risking the formation of bubbles in such a number or size as to be dangerous to the diver. The "M Value" is used to determine the data on the decompression tables and the algorithms on the dive computer, aimed at keeping every individual tissue below its critical overpressure ratio.

NITROGEN ABSOPTION AND RELEASE TIMES

In contrast to Haldane's findings, tissues have different nitrogen absorption and release times. It has been seen that these times are influenced by many factors that can result in substantial differences.

NITROGEN IN THE BODY

Haldane, with the means available to him at the time, did not have the possibility of verifying if there was nitrogen present in the body in the form of gassy micro-bubbles even after a dive that adhered to the tables. These micro-bubbles, being of a size that they could be handled without problems, and therefore without symptoms, they were not noted until the development of the Doppler system, which is able to record their presence, size and quantity in the body.

ASCENT SPEED

The maximum ascent speed is given by the maximum overpressure ratio. Therefore, this can vary with variations in the initial depth. In fact, the pressure differential is different between 30 and 20 m from that of 10m from the surface. However this calculation can only be worked out by the dive computer. Using the tables we must unquestionably follow the indicated maximum limit.

Decompression Tables

DIVE LETTER GROUP	3	4,5	6	7,5	9	10,5	12	15	18	21	24	27	30	33	36	39	42	45
A	60	35	25	20	15	5	5											
B	120	70	50	35	30	15	15	10	10	5	5	5	5					
C	210	110	75	55	45	25	25	15	15	10	10	10	7	5	5	5	5	5
D	300	160	100	75	60	40	30	25	20	15	15	12	10	10	10	8	7	
E		225	135	100	75	50	40	30	25	20	20	15	15	13	12	10	10	
F		350	180	125	95	60	50	40	30	30	25	20	20	15	15			
G			240	160	120	80	70	50	40	35	30	25	22	20				
H			325	195	145	100	80	60	50	40	35	30	25					
I				245	170	120	100	70	55	45	40							
J				315	205	140	110	80	60	50								
K					250	160	130	90										
L					310	190	150	100										
M						220	170											
N						270	200											
O						310												

DEPTH (metres)

DIVE LETTER GROUP / NEW DIVE LETTER GROUP	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
A															0:10 12:00
B														0:10 2:10	2:11 12:00
C													0:10 1:39	1:40 2:49	2:50 12:00
D												0:10 1:09	1:10 2:38	2:39 5:48	5:49 12:00
E											0:10 0:54	0:55 1:57	1:58 3:22	3:23 6:32	6:33 12:00
F										0:10 0:45	0:46 1:29	1:30 2:28	2:29 3:57	3:58 7:05	7:06 12:00
G									0:10 0:40	0:41 1:15	1:16 1:59	2:00 2:58	2:59 4:25	4:26: 7:35	7:36 12:00
H								0:10 0:36	0:37 1:06	1:07 1:41	1:42 2:23	2:24 3:20	3:21 4:49	4:50 7:59	8:00 12:00
I							0:10 0:33	0:34 0:59	1:00 1:29	1:30 2:02	2:03 2:44	2:45 3:43	3:44 5:12	5:13 8:21	8:22 12:00
J						0:10 0:31	0:32 0:54	0:55 1:19	1:20 1:47	1:48 2:20	2:21 3:04	3:05 4:02	4:03 5:40	5:41 8:40	8:41 12:00
K					0:10 0:28	0:29 0:49	0:50 1:11	1:12 1:35	1:36 2:03	2:04 2:38	2:39 3:21	3:22 4:19	4:20 5:48	5:49 8:58	8:59 12:00
L				0:10 0:26	0:27 0:45	0:46 1:04	1:05 1:25	1:26 1:49	1:50 2:19	2:20 2:53	2:54 3:36	3:37 4:35	4:36 6:02	6:03 9:12	9:13 12:00
M			0:10 0:25	0:26 0:42	0:43 0:59	1:00 1:18	1:19 1:39	1:40 2:05	2:06 2:34	2:35 3:08	3:09 3:52	3:53 4:49	4:50 6:18	6:19 9:28	9:29 12:00
N		0:10 0:24	0:25 0:39	0:40 0:54	0:55 1:11	1:12 1:30	1:31 1:53	1:54 2:18	2:19 2:47	2:48 3:22	3:23 4:04	4:05 5:03	5:04 6:32	6:33 9:43	9:44 12:00
O	0:10 0:23	0:24 0:36	0:37 0:51	0:52 1:07	1:08 1:24	1:25 1:43	1:44 2:04	2:05 2:29	2:30 2:59	3:00 3:33	3:34 4:17	4:18 5:16	5:17 6:44	6:45 9:54	9:55 12:00

REPETITIVE DIVE DEPTH (metres)	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
12	241	213	187	161	138	116	101	87	73	61	49	37	25	17	7
15	160	142	124	111	99	87	76	66	56	47	38	29	21	13	6
18	117	107	97	88	79	70	61	52	44	36	30	24	17	11	5
21	96	87	80	72	64	57	50	43	37	31	26	20	15	9	4
24	80	73	68	61	54	48	43	38	32	28	23	18	13	8	4
27	70	64	58	53	47	43	38	33	29	24	20	16	11	7	3
30	62	57	52	48	43	38	34	30	26	22	18	14	10	7	3
33	55	51	47	42	38	34	31	27	24	20	16	13	10	6	3
36	50	46	43	39	35	32	28	25	21	18	15	12	9	6	3
39	44	40	38	35	31	28	25	22	19	16	13	11	8	6	3

BASED ON
U.S. NAVY
DIVE TABLES

SAFETY STOP
3mt/3min

If, during the 1st course, we only used the tables for dives within the safety limits, now we have to apply them to plan immersions that involve time/depth ratios that will necessitate decompression stops, essential for our organisms to eliminate the excess nitrogen. The fundamental rule remains nevertheless to respect an ascent speed of 10 metres a minute.

Mt.	Min	9	6	3	Gr
12	210			2	N
	230			7	N
	250			11	O
15	110			3	L
	120			5	M
	140			10	M
	160			21	N
18	70			2	K
	80			7	L
	100			14	M
	120			26	N
21	60			8	K
	70			14	L
	80			18	M
	90			23	N
	100			33	N
24	50			10	K
	60			17	L
	70			23	M
	80		2	31	N
	90		7	39	N
27	40			7	J
	50			18	L
	60			25	M
	70		7	30	N
	80		13	40	N
30	30			3	I
	40			15	K
	50		2	24	L
	60		9	28	N
	70		17	39	O
	80		23	48	O
33	25			3	H
	30			7	J
	40		2	21	L
	50		8	26	M
	60		18	36	M
36	20			2	H
	25			6	I
	30			14	J
	40		5	25	L
	50		15	31	N
39	15			1	F
	20			4	H
	25			10	J
	30		3	18	M
	40		10	25	N
	50	3	21	37	O
42	15			2	G
	20			6	I
	25		2	14	J
	30		5	21	K
	40	2	16	26	N
45	10			1	E
	15			3	G
	20		2	7	H
	25		4	17	K
	30		8	24	L
	40	5	19	33	N

TERMINOLOGY

DESCENT SPEED

The speed at which the diver descends starts from the surface. A maximum speed of 20 metres a minute is recommended.

MAXIMUM DEPTH

Maximum depth means the deepest point reached during the immersion, even if the time spent at this depth was only a small part of the total dive.

IMMERSION TIME

Immersion time means the time period between the start of the descent to the beginning of the ascent.

ASCENT SPEED

The speed that the diver must keep to when moving towards the surface, both to resurface definitively or to reach another depth during the course of the dive.

NO DECOMPRESSION DIVE

This is when an dive is carried out without exceeding the limits imposed by the tables, respecting the ascent speed and the safety stop. This type of dive is called an "dive within the safety limits."

DIVE LETTER GROUP

This indicates the residual saturation level of nitrogen in the tissues at the end of the dive or after a period of time on land. It is needed therefore to calculate the penalty to be taken into consideration for successive dives. The dive group is shown by a letter, from A to O

SURFACE INTERVAL TIME

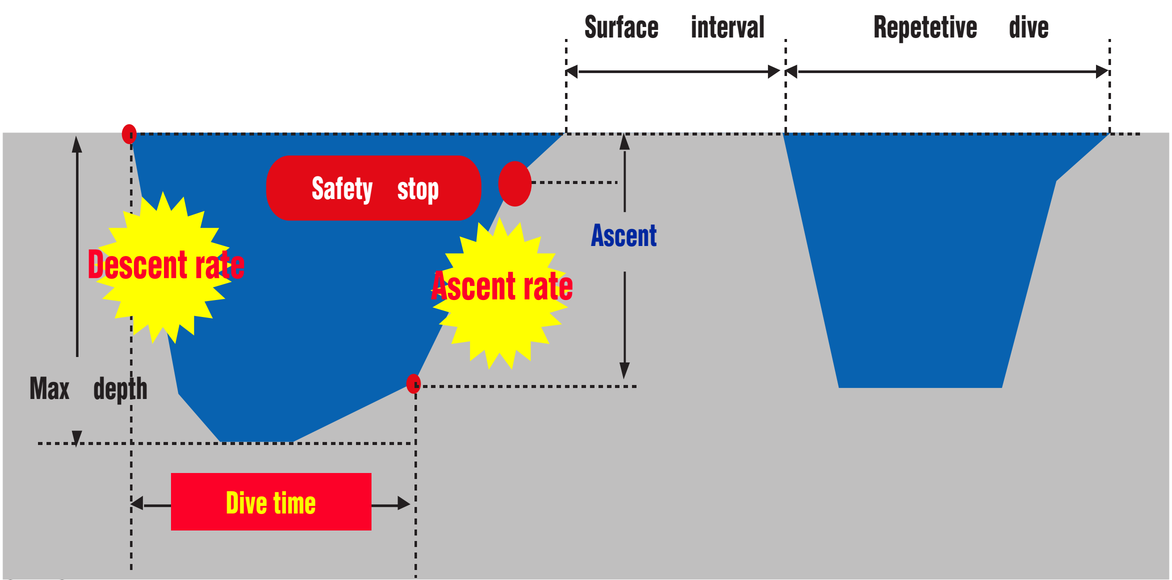
The time spent between the end of one dive and the beginning of the next.

REPEATED DIVES

This term defines any dive that is carried out between 10 minutes and 12 hours from the last. This means that the tissues are not completely desaturated of nitrogen. If a dive takes place within 10 minutes of the last, it has to be considered as part of the preceding dive.

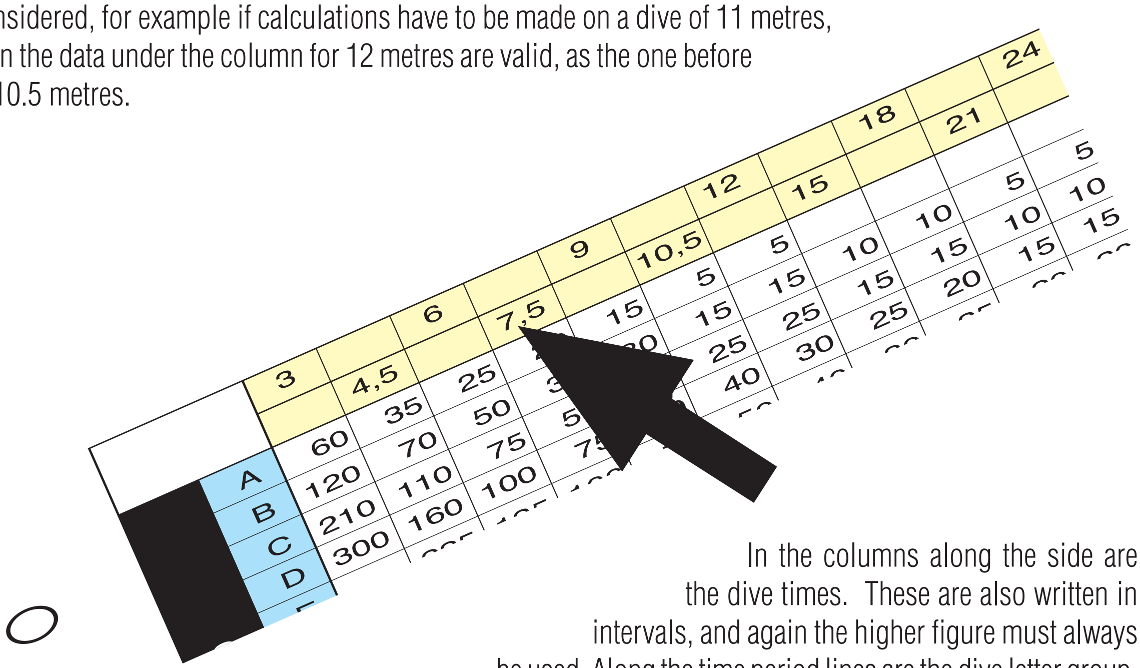
DECOMPRESSION DIVE

When a dive has with a time/depth ratio that exceeds the limits specified in the tables, decompression must be carried out.



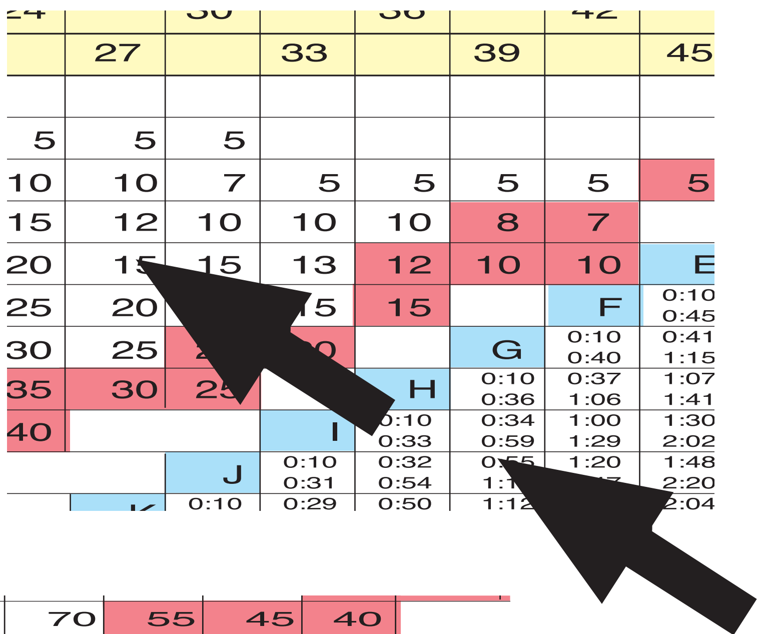
USE OF THE TABLES

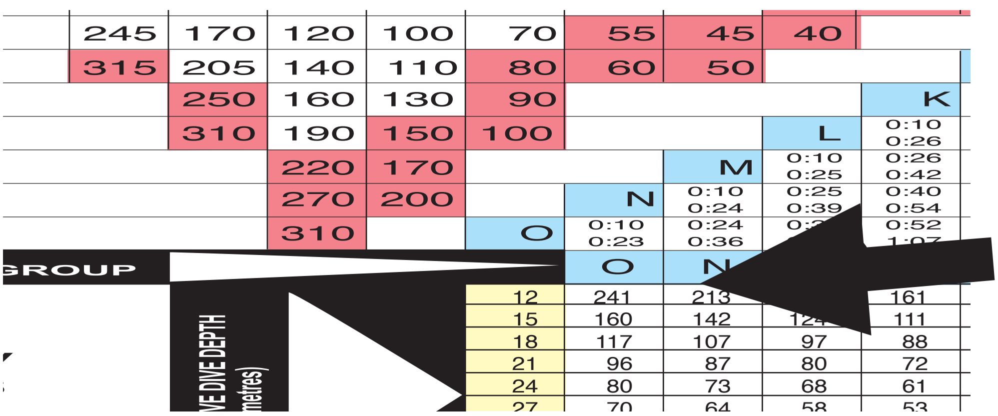
The decompression tables, as has already been said, correlate the time and depth of the dive. Along the top line the maximum depth is shown, in intervals from 1.5 to 3 metres. The higher figure must always be considered, for example if calculations have to be made on a dive of 11 metres, then the data under the column for 12 metres are valid, as the one before is 10.5 metres.



In the columns along the side are the dive times. These are also written in intervals, and again the higher figure must always be used. Along the time period lines are the dive letter group, which relate to the dive that has just been carried out, and which must be taken into account in the case of repeated dives.

On the far right, shown in hours and minutes, are the surface interval times. Having pinpointed the correct box, by looking down the column, the new dive letter group can be found, which is also shown in letters. The meeting point between these and the planned depth of the successive dive shows the number of penalty minutes or RNT (Residual Nitrogen Time).





THE DOPPLER LIMIT

The Doppler monitoring device provides proof of the formation of bubbles following the majority of dives, within or exceeding the safety limits.

A display of the quality and quantity of the bubbles in circulation allows you to identity the risk of decompression illness before it can do any damage that could result in foreign bodies in the organism or a blockage in circulation.

DOPPLER EQUIPMENT

An ultrasound Doppler device is made up of a transformer able to emit an ultrasound wave and a receiver to collect the signal reflected by obstacles to the emitted ultrasound. Thus, because the gassy bubbles have a higher reflecting ability than blood cells, the sound signals from the bubbles can be distinguished from those of the moving blood particles. The bubbles therefore can be counted directly through headphones, or by using suitable equipment for filtering sound.

BUBBLES AND DECOMPRESSION ILLNESS

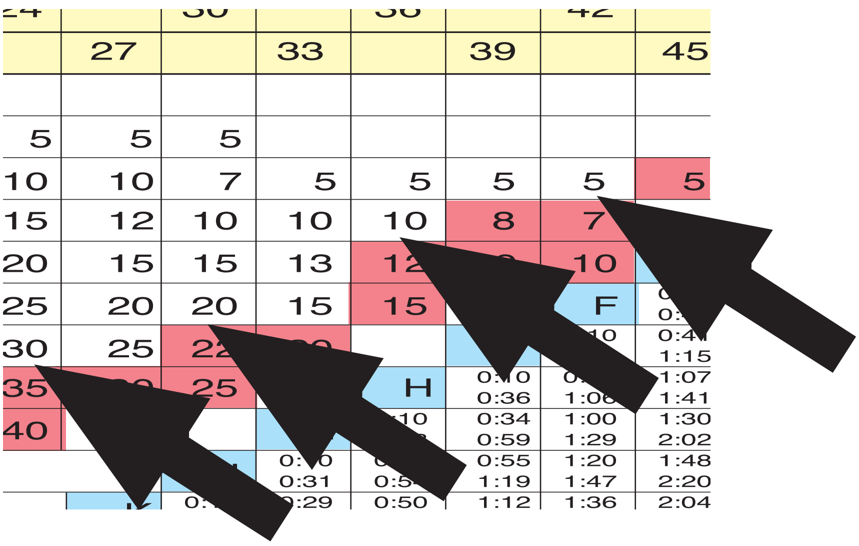
The Doppler results are not able to predict the individual risk of decompression illness after a specific dive, in that the Doppler device reveals only bubbles of a certain size that pass the point where the probe is positioned; it is not able to ascertain the presence of bubbles outside the range or of bubbles trapped in the tissues and therefore not circulating.

The Doppler device is however a fair predictor of the entire level of bubbles present in the body. Given that the correlation between bubbles and decompression illness has been proved statistically, Doppler monitoring has often been used to verify and correct different types of decompression tables.

These studies have led to the formulation of a new safety limit with lower time limits for the same depth in respect to the data on the US-NAVY tables.

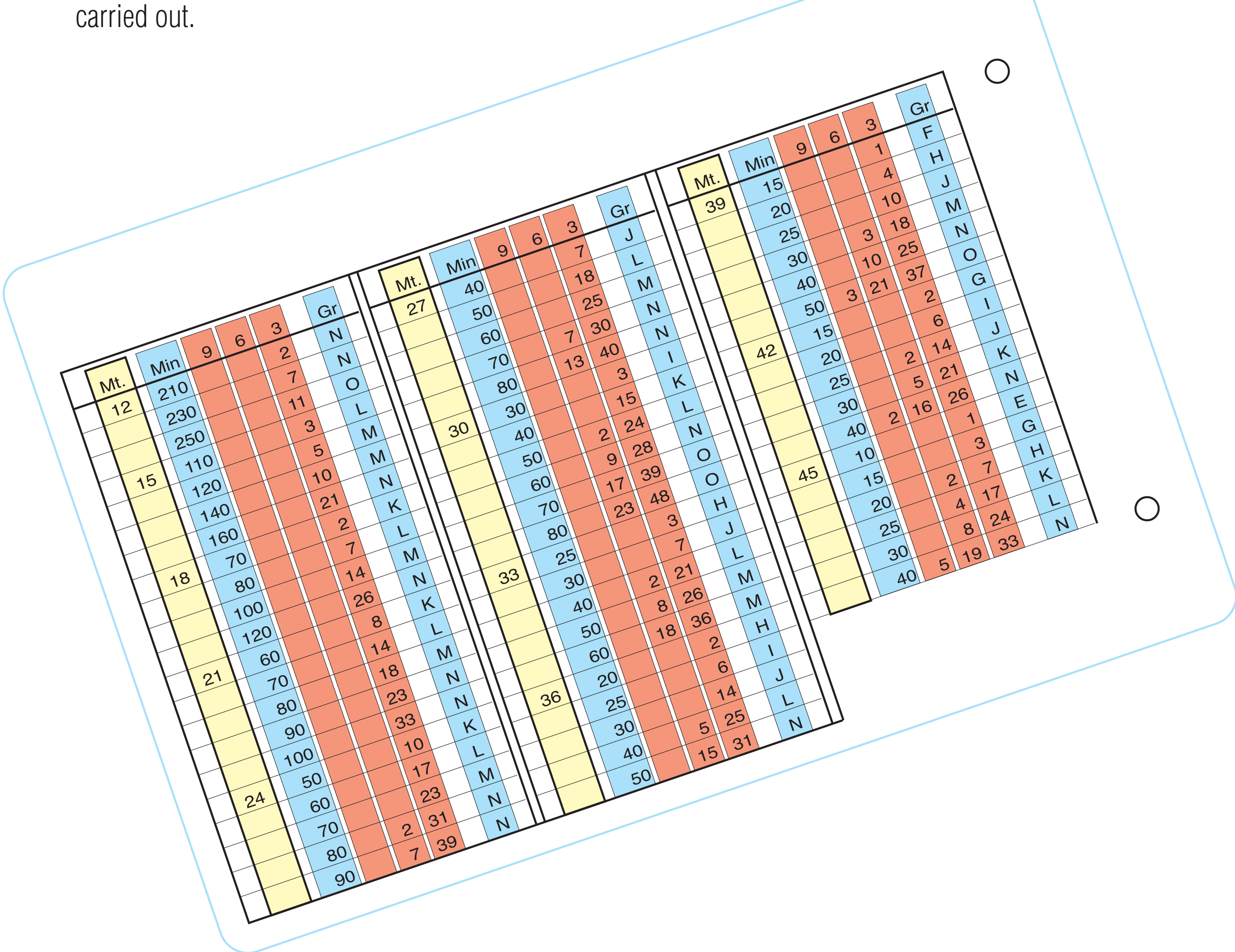
These data have however the disadvantage of supplying indirect information based on statistical principals rather than real figures. If the Doppler device manages to reveal a certain number of bubbles in one area of the body, it is considered that the same will be true for the rest of the body, even if a real count cannot be made.

For this reason the Doppler device can be very useful for developing low risk safety limits, but could be inadequate for an early diagnosis of decompression illness.

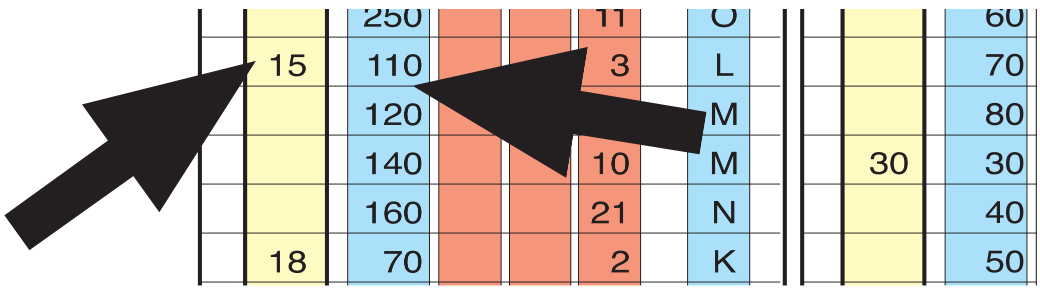


DECOMPRESSION STOPS

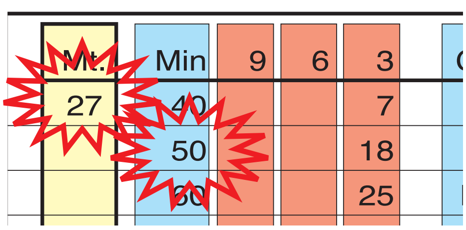
On the rear side of the tables, more time and dive depths are correlated, this time starting however from times beyond the safety limit. These dive times therefore are those where a decompression stop has to be carried out.

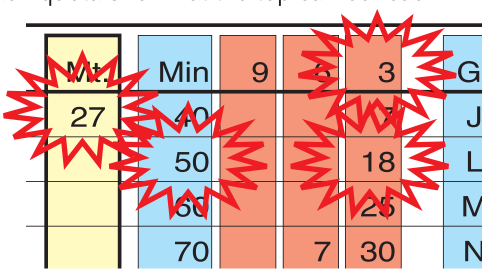


In the first column the maximum depth is shown, starting from 12 metres, in intervals of 3 metres, and also in these cases the higher figure must always be used when planning a dive.



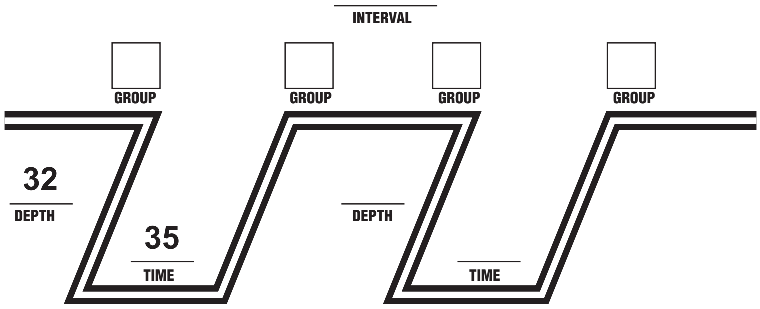
The next column towards the right indicates the dive referral times, shown in minutes. These are correlated with the following columns where the stop times for each quota shown at the top can be read.





EXAMPLES OF CALCULATIONS WITH THE TABLES

To plan a dive, usually one starts with the scheme shown below. The depth one wishes to reach during the dive and the relative time are written down, thus creating a definite dive profile.



Wishing to plan a dive to 32 metres in a time of 35 minutes, the first thing to do is to check on the tables if the time falls within the safety limits. Considering the data in the column under 33 metres, by looking down the column it can be seen that the time limit for this depth is 20 minutes. Hence, this is a dive outside the safety limit and so decompression stops will be necessary.

12	15	18	21	24	27	30	33	36	39	42	45	
5												A
15	10	10	5	5	5	5						B
25	15	15	10	10	10	7	5	5	5	5	5	C
30	25	20	15	15	12	10	10	10	8	7		D
40	30	25	20	20	15	15	13	12	10	10	E	0:10 0:54
50	40	30	30	25	20	20	15	15		F	0:10 0:45	0:46 1:29
70	50	40	35	30	25	22	20		G	0:10 0:40	0:41 1:15	1:16 1:59
80	60	50	40	35	30	25		H	0:10 0:36	0:37 1:06	1:07 1:41	1:42 2:23

As a result, the data given on the other side of the tables must be used.

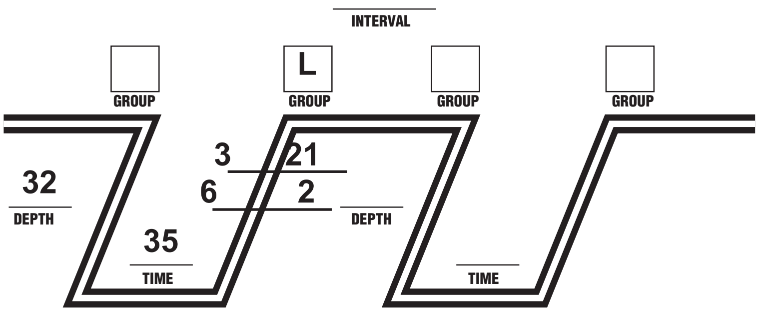
	40
	50
	60
	70
	80
33	25
	30
	40
	50
	60
36	20

Mt.	Min	9	6	3		Gr
27	40			7		J
	50			18		L
	60			25		M
	70		7	30		N
	80		13	40		N
30	30			3		I
	40			15		K
	50		2	24		L
	60		9	28		N
	70		17	39		O
	80		23	48		O
33	25			3		H
	30			7		J
	40		2	21		L

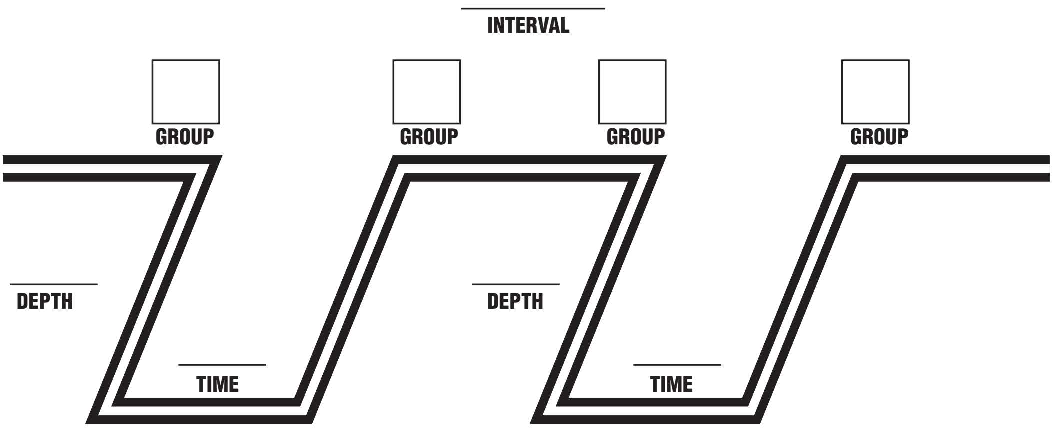
By considering the higher figures as usual, so the line relating to 40 minutes in this case, we can see that to carry out the planned dive, two decompression stops will be necessary, at 6 and 3 metres, of 2 and 21 minutes respectively, emerging under the dive letter group L.

To calculate the total ascent time, the minutes of the decompression must be added to the necessary minutes taken for the ascent at a speed of 10 metres a minute.

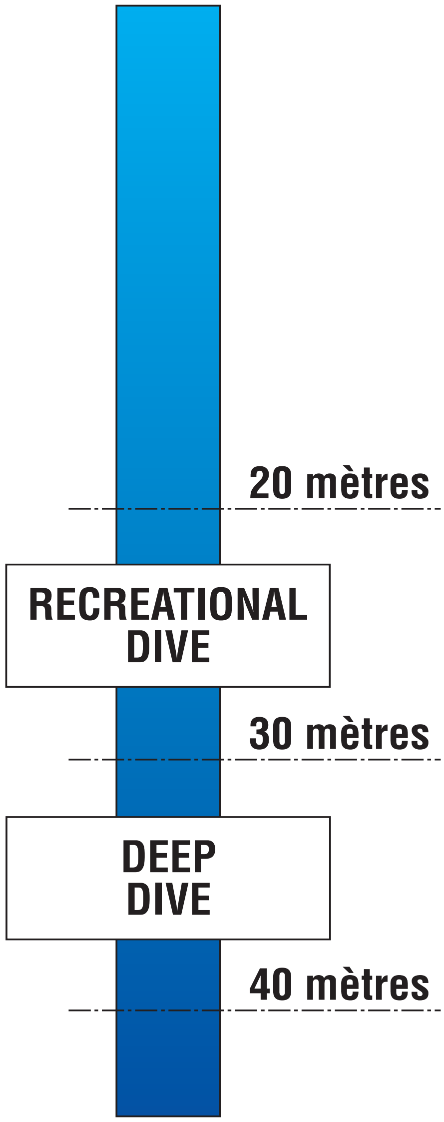
Decompression time	**23**	**+**
Ascent time	**2**	**=**
Total ascent time	**25**	



Planning a successive dive must follow the system shown in the previous course, taking into account that in the case of a first dive outside the safety limits, the second should be within the limit and after a 30 minute surface interval time.



Deep Dives



DEFINITION

The care that a diver must take rises in proportion with the increase in depth. This is because of the greater amount of time it takes to return to the surface, the greater amount of air consumed, greater difficulty in being recovered in the event of an accident, the psychological effects that depth can cause and the narcotic effects caused by nitrogen. Nowadays it is the acknowledged opinion at international level that the limit for a "recreational" dive should not be beyond 40 metres and a "deep dive" is anything over 30 metres. Regardless of the fact that the increase in depth increases the hazards, deep dives are widely practised and so it is important to know the dangers and to adequately organise oneself to be able to face these, reducing the risks to a minimum.

DEEP DIVES

To tackle a deep dive, a number of factors must be taken into consideration. First of all, it must be remembered that despite experience and technical skills acquired while scuba diving, in depths of over 30 metres not everyone reacts in the same way to an increase in the percentage of nitrogen, and its effects. This means that every diver must be cautious when considering a dive of this type, taking great care, given that individual reactions can be very different. It is advisable to carry out a deep dive only after a "training" period, starting with less demanding depths. It is only by doing numerous dives that the body can adapt a little to nitrogen at high pressure and go to greater depths in the best physical condition. When planning a deep dive, the cold must not be forgotten, as well as emotional tension and breathlessness, all factors which can lead to narcosis. The risk of decompression illness increases, as when carrying out dives outside the "safety limit", when more air is consumed due to more breathing effort because of the rise in the pressure, or sometimes, because of the lower water temperature, or to counteract the negative push when one is not used to the B.C.D. In all these cases, the amount of nitrogen absorbed by the tissues in the body increases. The result is that there are less safety guarantees for deep dives than for shallow dives, in that problems could arise that are difficult to predict either from the use of the tables or even from a dive computer

PLANNING A DEEP DIVE

EQUIPMENT

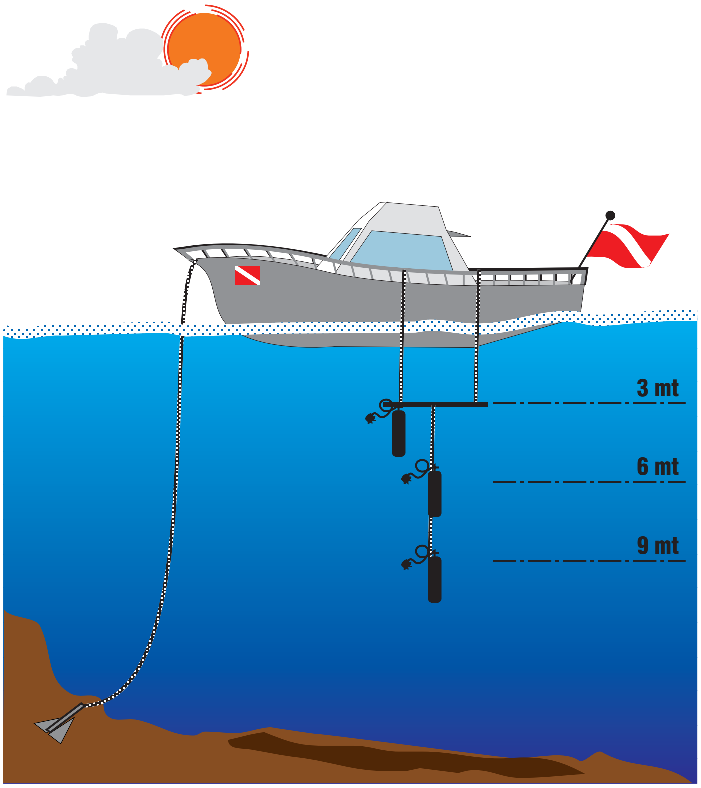
It is extremely important when tackling deep dives to be completely familiar with both your own and your dive buddy's equipment. It is necessary to be able to quickly reach and manoeuvre the valves on the tanks, the regulators or the B.C.D. controls. Equipment about to be used on a dive must always be carefully studied and tested, making sure that maintenance has been thorough.

INSTRUMENTATION

In order to follow the planned parameters , a constant control of the time and depth of the dive is particularly important. It is advisable therefore to be equipped with instruments that can be easily read, even in conditions with little light, and conceived in such a way as not to cause confusion or mistakes in the event of reading difficulties, which could be a result of narcosis. A good torch is extremely useful for deep dives, for reading the instruments, to signal one's position to your dive buddy in situations of low visibility together with acoustic signals, and to be able to appreciate colours which are difficult to distinguish in deep water.

SUPPORT BOAT

To safely tackle a deep dive, a high level of organisation on the surface, particularly if the dive is in open water, needs to be guaranteed. A good sized support boat is ideal, equipped with the necessary equipment for positioning and safety. In this case, once the dive site has been chosen, the anchor line can be used as a guide in descent.



As decompression stops will be necessary, the crew on board should set up a decompression harness at a depth of 3 metres and one or more reserve tanks tied to a line starting from a depth of   6-9 metres.

CONTROLLING THE WEIGHT

As a result of an increase in depth, negative buoyancy also increases. This is compensated for by a knowledgeable use of the   B.C.D. to regain neutral buoyancy and to avoid using a lot of effort to keep at a desired quota. Great care must be taken not to overdo the weights, or on the other hand, to have too light a belt which during the ascent or decompression stops would not compensate for the positive buoyancy given by the empty tank.

CALCULATING AIR CONSUMPTION

Air consumption varies from diver to diver and also depends on the activities that are carried out during the dive. Thus it is difficult to work out the ideal tank capacity for deep dives. It is usual to decide to ascend and finish a dive with at least still 1/3 of the air left for any eventual emergency and the necessary safety stops.

To work out air autonomy, the following parameters have to be considered:

Quantity of air in the cylinder.

Dive time

Depth of the dive

The quantity of air in a cylinder depends on two factors:

The cylinder capacity

Loading pressure

Of which:

VOLUME OF AIR IN THE CYLINDER = CYLINDER CAPACITY X LOADING PRESSURE

It has been established that the quantity of air consumed rises in proportion to the increase in depth. Given that the diver breathes air at ambient pressure, usually consumption for normal activities is 20 litres a minute, so a formula for total consumption during a dive is the following:

CONSUMPTION IN LITRES = 20 X AMBIENT PRESSURE X TIME

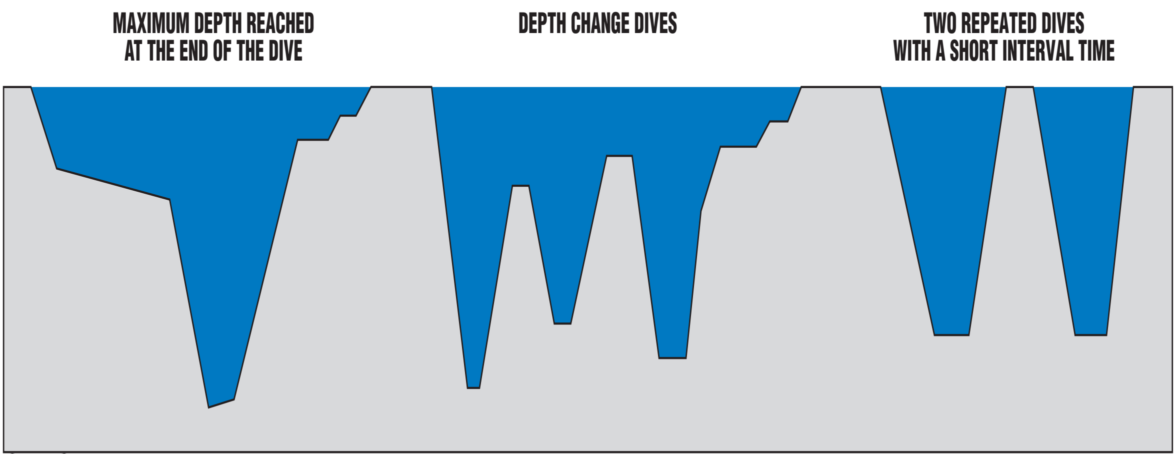
To obtain autonomy time knowing the cylinder capacity at a planned depth:

$$\text{autonomy time in minutes} = \frac{\text{VOLUME OF AIR IN THE CYLINDER}}{\text{20 X AMBIENT PRESSURE}}$$

THE DIVE

Before entering the water, all personal equipment should be checked and very detailed plans made with your dive buddy, carefully following the directives given by the group leader during the briefing.
The descent, if possible, should be made along the anchor line, inflating the B.C.D. at intervals to control the speed. Your dive buddy should always be kept in sight. Once the maximum depth planned has been reached, neutral buoyancy should be achieved as soon as possible. During the dive, the depth, residual air and dive time should all be frequently checked, as well as your own condition and that of your dive buddy. In the event of narcosis symptoms, the procedure to follow is to signal to your buddy and to ascend towards a shallower depth, making sure that you have been followed and then deciding if it is necessary to end the dive. The anchor line is also very useful as a guide for the ascent. Your dive buddy must be again kept in sight and should either be ahead or behind. During a decompression stop or any necessary safety stops, it is better not to all stop in the same point.

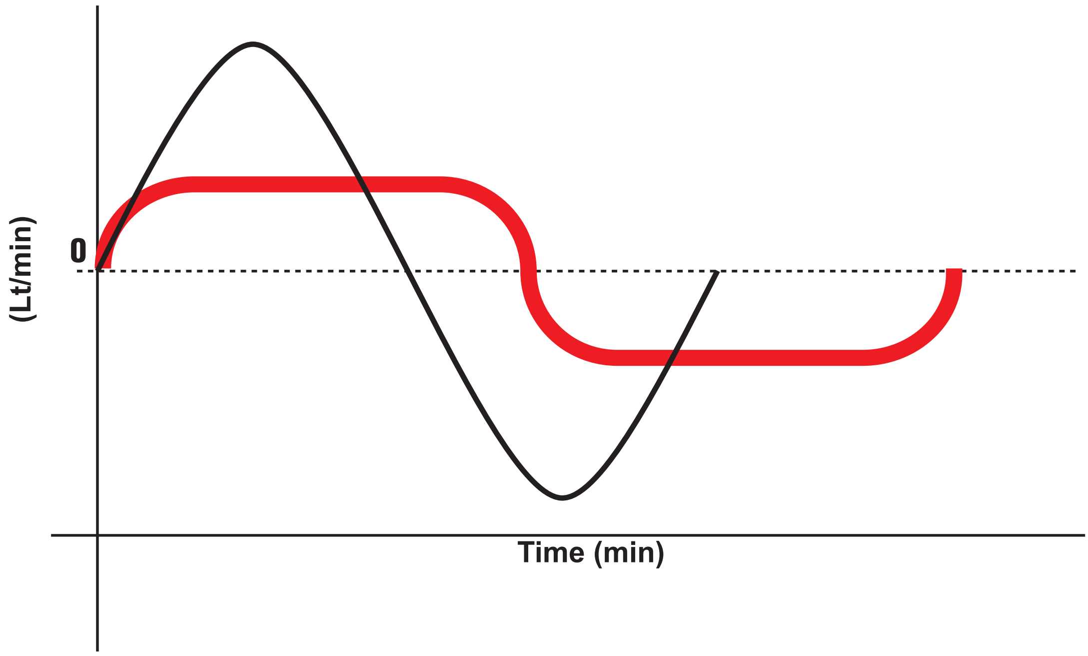
DIVES TO AVOID



BREATHING RHYTHM

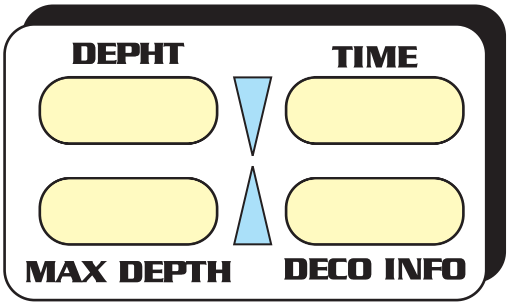
During the dive, a regular breathing rhythm should be kept up, to avoid any extra effort which would lead to breathlessness.

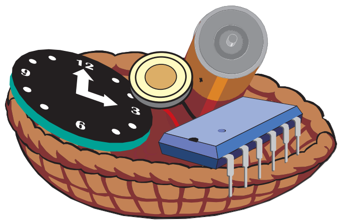
To do this, you must breathe slowly, trying to prolong both the intake as well as breathing out, at a regular speed which reduces respiratory speed and thus also air consumption.



Dive Computers

One of the most important technological innovations of recent years in the scuba diving sector has been the dive computer. This has made many procedures much more simple and can produce much more exact calculations than those made on the basis of consulting diving tables.



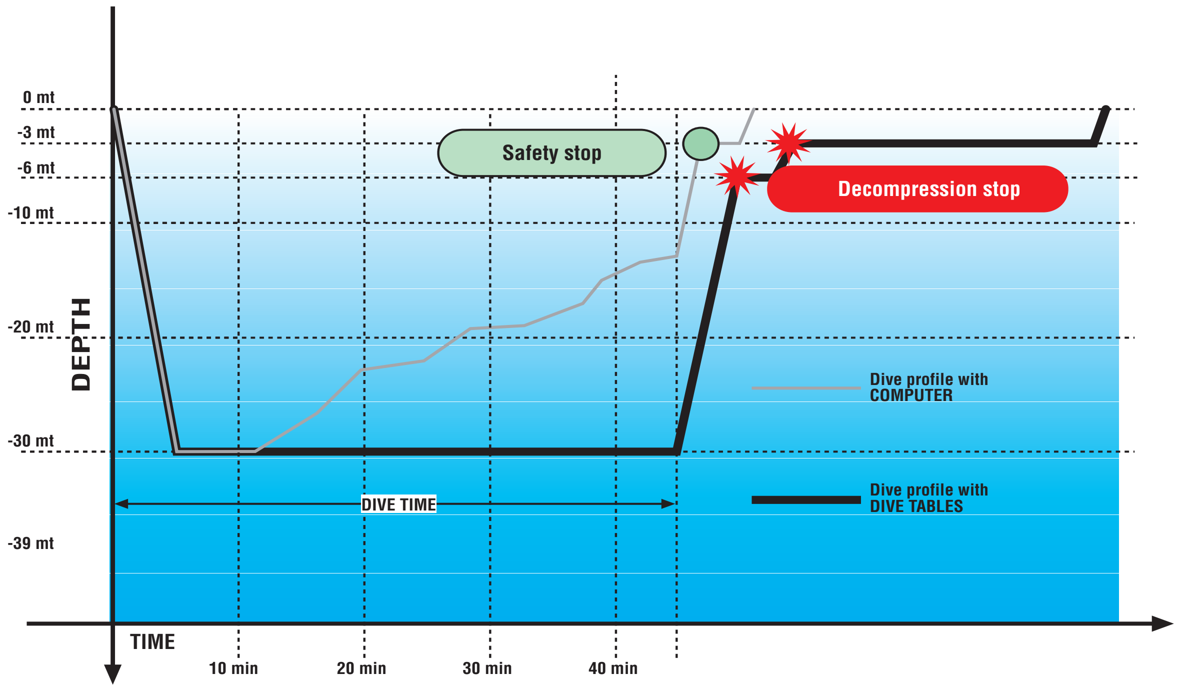


CALCULATING A MULTILEVEL DIVE

The amount of nitrogen that the organism absorbs during a dive depends mainly on the depth reached and the dive time, rising with an increase in these two parameters. The use of standard dive tables cannot calculate a true level of nitrogen absorption according to the dive profile, the diver must base calculations on "maximum depth and the dive time", called "a regular dive ". The dive computers, on the other hand, make a real profile of the dive, reading the depth at variable intervals from 1 to 5 seconds and the time thanks to an internal clock. The sum of each reading calculates nitrogen absorption. Therefore a dive using a dive computer can be defined as a "multilevel dive", in that the computer considers the time taken during the depth changes while ascending from the maximum depth as part of the total dive time.

HOW THE COMPUTER WORKS

As with the US Navy tables, dive computer calculations are based on algorithms (complex mathematical formulae). The different computer manufacturers use similar algorithms, but with different parameters or theoretical compartment numbers. Therefore there can be slight differences in data, for example the residual time in a safety limit at a given depth.



THE THEORETICAL COMPARTMENTS AND THE HALF-SATURATION TIMES

Taking into account that 6 compartments are used for calculating the US Navy tables while the dive computers have up to 12, it can be stated that the higher the number of theoretical compartments, the closer the results to the real situation. While the US Navy consider the slower compartments with a half-saturation time of 120 minutes, the computers can consider compartments with half-saturation times of up to 700 minutes, and anyway over 300 minutes.

DIFFERENCES IN THE TABLES IN MULTILEVEL DIVES

The dive computer, calculating nitrogen absorption on the basis of the actual amount of time spent at each depth, allows the diver during a multilevel dive to have a longer period of time within the safety limits than that indicated on the diving tables. To make the most of this feature, the dive must be planned so as to reach the maximum depth as soon as possible and then to come up slowly, prolonging the dive time with still less nitrogen absorption, given the progressive return to the surface.

CONSIDERATIONS IN USING THE COMPUTER

While recognising that dive computers have brought advantages and increased safety in S.C.U.B.A. dives , it should be kept in mind that, like any machine, they could break down. Therefore, the tables must always be kept available, and naturally one must be able to use them. It is not advisable to rely on your dive buddy's computer data as reading different dive profiles can mean significant differences in nitrogen absorption and consequently mean different decompression stop times.

Moreover, it must be remembered that the dive computer, like the tables, are based on standard data that do not take into consideration differing personal reactions or situations. These include the age of the individual, his physical condition, emotional state, effort made during the dive, food eaten before the dive. Only some models include water temperature in their parameters, while "integrated models", that is connected to the tanks, control the pressure in the tank but supply approximate data on the residual breathing time before reaching the pressure which is considered "reserve". Some models memorise the dive profile, which can be useful in the event of an accident, in that it allows the medics to reconstruct the events of the dive. The multi-medial models can be connected to a personal computer to download the data onto a logbook, which can then be elaborated or printed out.

COMPUTER COMPARISON

Trademark Model	OCEANIC XT - 100	MARES TUTOR	MARES GUARDIAN	Modulo M BRAVO 2	CRESYes SUB EON SUUNTO	UWATEC ALADIN AIR X
Mathematical model	Haldane variations	Haldane variations	Haldane variations	Haldane variations	Haldane variations	Buhlmann
Halftimes	12 5 / 480 min.	9 2,5 / 480 min.	9 2,5 / 480 min.	12	9 2,5 / 480 min.	8 5 / 640 min.
Graphic display of tissue	Yes (One sample)	No	No	Yes (One sample)	No	No
Depth graphic display	No	No	No	No	Yes	No
Variable ascent speed	No	Yes 10-12-18 Mt/'	Yes 10-12-18 Mt/'	No	No	Yes 7-20 mt/'
Measurement ascent speed	Yes - 5 segments Da 0 a 18 mt/'	Yes 20-60-90-120%	Yes 20-60-90-120%	No	Yes 2,5-5-5,5 7,5-10 mt/' Slow	Yes in per cent
Fast ascent alarm	Yes Besides 18 Mt/'	Yes Changeable	Yes Changeable	Yes Besides 12 mt/'	Yes Besides 10 Mt/'	Yes Changeable
Floor	No	No	No	No	Yes	No
Simulator	No	Yes	Yes	Yes	Yes	No
Dive-Log profil	No	No	Yes 10 Dives	No	Yes till 25 ore	No
Watch	Yes	Yes	Yes	No	Yes	No
Nitrox programme	Yes	No	No	No	No	No
Starting up	Manual	Manual Automatic	Manual Automatic	Manual Automatic	Manual Automatic	Automatic
Altitude dive programme	Yes 4 manual>4200	Yes manual >2400	Yes manual >2400	Yes 3 manual	Yes 3 manual>2400	Yes Automatic
Batteries	1 Lithium 3,6V	1 Alkaline 1,5V	3 Alkaline 1,5V	2 Alkaline 3V	1 Lithium 3,6V	1 Lithium 3,6V
Batteries endurance	1 year	3 months	1 year	120 Dives	2 years	5 years
Batteries change	Self-sufficient	Self-sufficient	Self-sufficient	Self-sufficient	Retailer or Self-sufficient	Manufacturer
Safety limit time at 18 metres	58'	48'	48'	52'	52'	50'
Safety limit time at 30 metres	20'	16'	16'	24'	18'	16'
Safety limit time at 39 metres	11'	9'	9'	13'	9'	10'
Notes	Lights Temperature Nitrox Ascent speed	Ascent speed Graphic ascent speed Safety stop Nitrogen self-reset Lights -No max depth	Ascent speed Graphic ascent speed Safety stop Nitrogen self-reset Lights -Dimension	Grafico N All. vel. disc. -No interface	Floor Ascent speed Profile memory -Alternating field display	Errors StandBy Nitrogen function -No simulator

N.B. This table does not cover the entire production of scuba diving computers and should be considered as just an example for comparing data.

FLYING AFTER A DIVE

There is a period of time before the nitrogen partial pressure returns to the normal sea level rates after a dive. In this period an eventual reduction in ambient pressure in a relatively short space of time, can create similar conditions to the ascent during the dive. Ascending in quota, even going over a mountain pass by car, or taking a plane soon after a dive can be enough to cause the formation of bubbles in the body by gas which is still present in the tissues, leading to forms of decompression illness. According to indications from the US Navy, before flying a diver who has carried out one or two dives following the decompression tables must stay at sea level for long enough to enter at least Group "D" of the relative tables. To do this, the following procedure should be used:

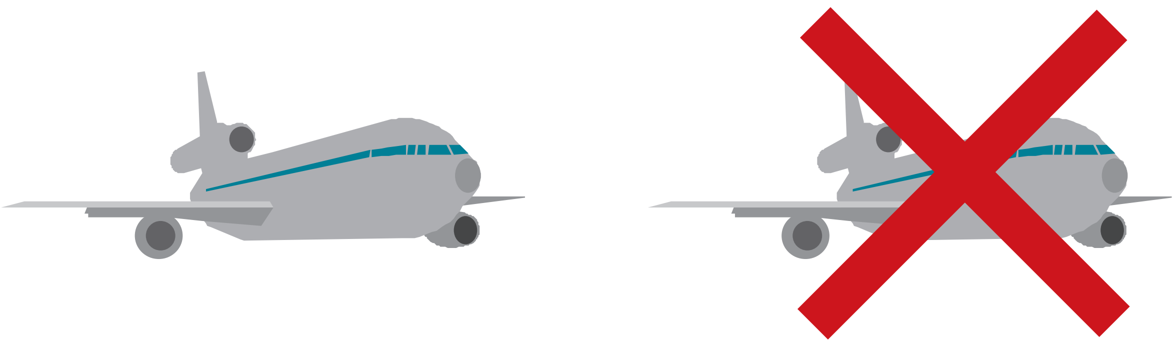
-Wait at least 12 hours if safe dives have been carried out in the last 2 days for a total time of less than 120 minutes;

-Wait at least 24 hours after repeated dives:

-Wait between 24 and 48 hours after dives outside the safety limit.

Although the number of cases of Decompression illness due to fling is fairly low, to be safe it is better to reduce the number of dives before having to fly, avoiding tiring dives, those outside the safety limits and especially repeated dives.

In the modern dive computers, this calculation is made automatically. At the end of each dive, "NO FLY" data is given, that is, how long to wait before flying.



LESSON 3 - BLS/AED

CMAS

WORLD UNDERWATER FEDERATION

Cardiopulmonary resuscitation Course

A.N.M.C.O.
Associazione nazionale medici cardiologi ospedalieri

President: *Franco Chiarella*
Curator of manual: *Maurizio Burattini*

In collaboration with:
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According to current estimates, every year one person in every one thousand inhabitants (varying between 0.6 and 1/1,000/p.a.) Suffers sudden cardiac death (scd) caused by cardiocirculatory arrest (ca): around 50,000 new cases in italy each year, 700,000 in europe, and 330,000 in the usa. In around 40% of cases of sudden cardiac arrest (sca) outside the hospital environment, on the arrival of the emergency medical services a cardiac arrhythmia incompatible with life is recorded: ventricular fibrillation (vf) (or ventricular tachycardia with no pulse (vt)); the electrical signals regulating the heartbeat become chaotic and the heart stops pumping blood.

The brain is thus deprived of oxygen and only a few minutes later (around 10') cerebral damage is so severe that long term survival becomes impossible. It is estimated that if an ecg were recorded during the first few minutes after ca (immediately after collapse) this percentage would rise to 70%-75% of cases. The only valid treatment in these cases is immediate cardiopulmonary resuscitation (cpr) and electrical defibrillation. It has been proven by international studies that less than a third of ca victims receive a cpr from persons present at the event, and even fewer receive high quality cpr. Survival rates could double or triple if high quality cpr was practised by the people present on the scene during collapse. In the majority of north american cases, the average percentage of survival in cases of outside hospital ca is 6.4%. Some programs of immediate defibrillation for non-professional rescuers and operators in the emergency services have brought rates of cardiac arrest survival with vf from 49% to 74% in the presence of witnesses: in airports, casinos and in the case of intervention by police officers. The guidelines recently published by the aha (circulation, december 2005) underline this point and recommend that maximum commitment be given to the teaching of cardiopulmonary resuscitation (cpr) procedures to the greatest possible number of people, so that outside hospital it is possible to perform defibrillation with an aed within 5 minutes (with maximum public access to defibrillation programs) and, in the case of ca within the hospital environment, this should be possible within 3 minutes.

The survival chain

This illustration shows a series of actions to carry out when a person suffers cardiac arrest.

Survival depends largely on the rapidity with which these actions are performed. Since you could be required to use an aed before any other action, your intervention can potentially really make a difference. Cpr performed by the first rescuers and the electrical discharge transmitted by an aed can often make the heartbeat resume. The time factor is crucial following cardiac arrest: every minute of delay in administering the electrical discharge reduces by up to 10% the possibility of resuscitating the heart. Cpr by the emergency rescuers can help gain a few more minutes before the arrival of the aed. Everyone should be able to recognize and report a cardiac arrest. The ability to practise cpr should become common practice, and there should be increasingly large emergency aid groups, both within and outside the health system, able to use automatic external defibrillators safely and effectively in cases of cardiac arrest. However, it is important to remember that, whatever your level of training and however much effort you make, in real emergencies you will not always succeed in saving the assisted victim.
The american heart association uses 4 rings in a chain (the “chain of survival”) to illustrate the actions to be performed in the shortest possible time, essential both for victims of ca and vf (figure 1). These rings are:

- Immediate recognition of the emergency and activation of the emergency medical services (ems) or of the local answering system for emergencies: “call 118” (in italy).
- Immediate cpr from bystanders: immediate cpr can double or triple the possibility of survival for victims of sca due to vf.
- Immediate use of a defibrillator: cpr plus defibrillation within 3-5 minutes of collapse can determine a percentage of survival between 49% and 75%.
- Immediate advanced cardiopulmonary resuscitation, followed by post-resuscitation treatment, performed by the emergency services.

Bystanders can perform 3 of the 4 rings of the survival chain. When bystanders recognize the emergency and activate the emergency system (ems), they ensure that an advanced cardiopulmonary resuscitation team are sent to the site of the emergency. In many communities, the time interval between the ems call and their arrival is 7, 8 minutes or more. This means that, during the first minutes after collapse, the victim’s chances of survival are in the hands of the bystanders.
Victims of cardiac arrest need immediate cpr. Cpr provides a small, but vital haematic flow to the heart and brain. Cpr prolongs the rescue time when vf is present and increases the possibility of a discharge interrupting vf (cardiac defibrillation) and allowing the heart to resume an effective heartbeat and adequate systemic perfusion. Cpr is particularly important if the discharge is not carried out within 4, 5 or more minutes of collapse. Defibrillation does not make the heart “start up” again, but “stuns” it, briefly interrupting vf and every other electric cardiac activity. If the heart is still vital, its natural pacemaker can start emitting impulses again to produce an effective ecg, leading to an effective haematic flow.

Basic Life Support (BLS) in adults

Bls consists in a sequence of coordinated actions. These actions, if undertaken during the first minutes of an emergency, can determine survival.
Cardiac arrest occurs when the heart stops pumping blood. Blood circulation to the brain and the rest of the body is blocked. The victim “collapses”, loses consciousness and stops breathing. The most frequent cause of cardiac arrest (often due to a heart attack) is an arrhythmia called ventricular fibrillation, because of which the heart can no longer exert effective compression, so it stops pumping blood.

SIGNS OF CARDIAC ARREST

1. Loss of consciousness:
   if you call the victim aloud or slightly shake them, there is no reaction
   (call the emergency services and open the airways).

2. No breathing:
   if you look, listen and feel for 10 seconds: the victim doesn’t breathe normally
   (perform two ventilations).

3. No pulse and vital signs:
   if you feel the carotid pulse for 10 seconds, there are no signs of beating and, looking at the victim, there is no sign of movement, coughing or respiratory activity:
   - the victim has neither pulse nor vital signs
   - the victim is in a state of cardiocirculatory arrest (perform an external heart massage).

the phases of bls can be identified and remembered using the first three letters of the alphabet:

A

Airways

Check consciousness, alert the emergency system, check that the airways are open.

B

Breathing (respiration)

Assess spontaneous respiratory activity. Perform two ventilations.

C

Circulation

Assess circulatory activity and perform external cardiac massage.

NEVER PUT YOUR OWN HEALTH AT RISK

PHASE A. - CHECK STATE OF CONSCIOUSNESS

If a person is apparently without life:

- *ask loudly "do you feel well?"*
- *shake the person's shoulders slightly*
- *observe whether there is any sign of response*
- *in absence of response, consider the person Unconscious*
- *call someone in the vicinity to help. Send this person to get an Aed and call the emergency services.*

If the assisted person is conscious, calling them loudly and shaking their shoulders slightly should be enough to arouse them. Observe any possible signs of response (movement, coughing, breathing). If you notice any reaction, this means that the person is conscious. Since they could be injured, be careful when checking consciousness or unconsciousness: avoid excessive shaking so as not to worsen any possible injury to the neck or backbone. If the assisted person is unconscious, note any signs of breathing or of a carotid pulse before carrying out the cpr procedures.

What do i do if the victim shows any sign of response?

A person who at first appears to be lifeless but then responds to stimuli by moving parts of their body, emitting sounds or trying to speak, is obviously not in cardiac arrest and therefore does not need resuscitation. However, they could have a serious injury and be incapable of reacting alone. Their condition could therefore worsen. It is therefore important to stay beside them until they wake up again or until their condition is clear and does not represent any serious threat.
After calling for help and requesting an aed:
Place the victim on a hard surface, position their limbs along their body and bare their chest in order to perform the following phases of cpr correctly.

If the assisted person gives no signs of response they are unconscious

ACTING ON A CONSCIOUS VICTIM, BEFORE CHECKING THEIR STATE OF CONSCIOUSNESS, COULD CAUSE UNNECESSARY INJURY

PHASE B - OPEN THE AIRWAYS TO CHECK RESPIRATION

If an unconscious person is lying face upwards or in a neutral position, their tongue can easily fall back into their throat, obstructing the airways. If the airways are blocked, respiration is not possible. To free the airways, with one hand pressed against their forehead, tilt the head back and, with the other hand, lift the victim's chin. Remove any foreign bodies clearly obstructing the mouth. Since the tongue is connected to the jaw, this manoeuvre of "head back and chin lift" makes the tongue lift up from the back of the throat, opening the airways.

this simple operation is often enough to restore spontaneous respiration.

Tilt the head of the assisted person back, look for and remove any possible foreign body obstructing the mouth. Lift the chin and check the presence of spontaneous respiratory activity by performing l.l.f.

L

Look to see whether the thorax (chest) is rising and falling

L

Listen for any signs of respiration

F

Feel for any flow of expired air with your cheek.

Checking for respiration should last a maximum of

10 seconds

Victims of cardiac arrest, during the first few minutes following the arrest, can produce noises such as gurgles, coughing or moans, as well as muscular movements of the stomach and chest. However, this so-called "agonal respiration" is ineffective, since it cannot make air enter and escape from the lungs. Checking by the look-listen-feel on your cheek method will tell you whether the person is breathing normally or not.

WHAT DO I DO IF THE PERSON IS BREATHING NORMALLY?
If you hear and perceive a flow of air from the mouth and nose, and notice a rising and falling of the chest, this means that the person is breathing normally. In this case, place the person in the safety position on their side, being careful to avoid turning or twisting their neck and head.

PLACE VICTIM IN THE LATERAL SAFETY POSITION

The lateral safety position:

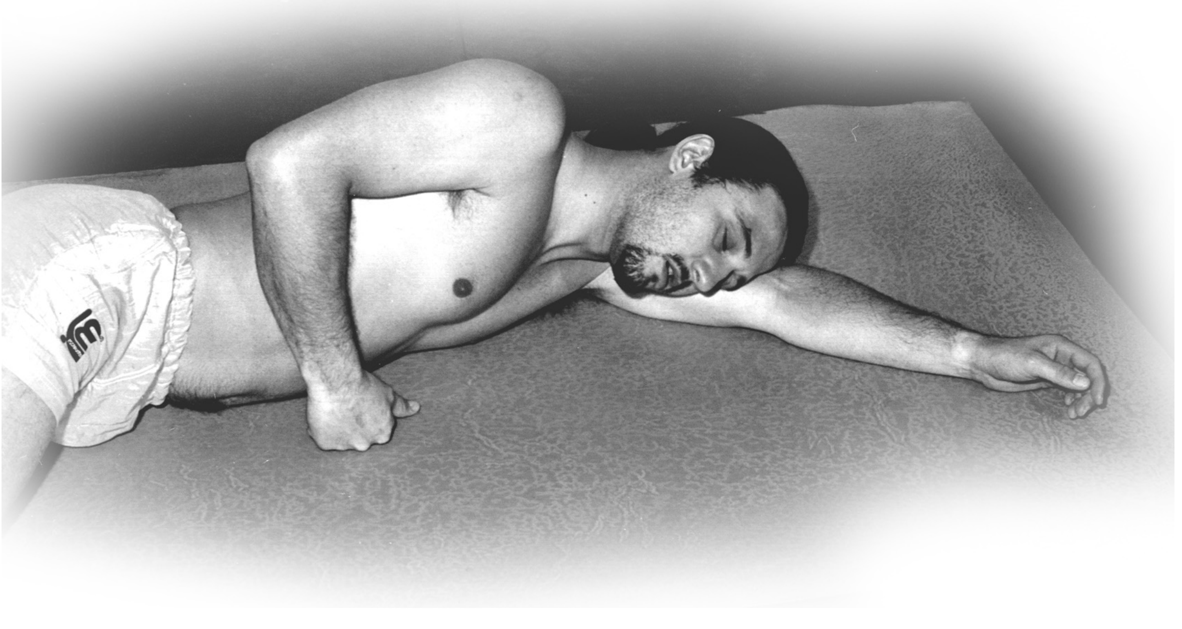
Prevents the tongue from obstructing the airways

Facilitates the emission of any eventual fluids from the mouth

Prevents the victim from turning over onto their back

Allows the victim to breathe easily

To place the person in the lateral safety position:
1. Grab the victim's arm nearest to you and stretch it out perpendicular to their body. Fold the arm at the elbow and position the hand of this arm parallel to their head, with the palm turned upwards.
2. Place the other arm across their chest.
3. Keeping the hand of the other arm on their chin, bend the opposite knee at right angles and use this raised knee as a lever to turn the person on their side with as little effort as possible.
4. Bend the hip and knee of the upper leg at right angles and keep the elbow of their upper arm away from the lower arm. Make sure that their face always stays turned downwards with their mouth open.
If possible, always keep the unconscious person with normal respiration that you have placed in the lateral safety position in view.
Check respiration at brief time intervals.



WHAT DO I DO IF THE PERSON IS NOT BREATHING NORMALLY?

PERFORM TWO EFFECTIVE VENTILATIONS

Emergency respiration enables you to obtain an exchange of air in the lungs of a person who is not managing to breathe autonomously. Even the air "exhaled" from the lungs of the rescuer and insufflated into the lungs of the assisted person contains enough oxygen. Every effective ventilation provokes a visible rise in the chest wall. Inhaled air is then expelled again because of the weight of the chest wall. The air can be inhaled and then exhaled only if the airways are kept open.

in order for emergency respiration to be effective make sure that you:

- keep the airways open at all times so that air can go in and out of the lungs
- close the person's nostrils every time you practise ventilation to avoid air escaping from the nose without entering the lungs
- place your lips around, and not above, those of the victim to seal hermetically and prevent air from escaping
- insufflate slowly and detach your mouth when the person's chest rises.

Every ventilation should last around 1 second. Rapid insufflation of an excessive volume of air can inflate the stomach rather than the lungs. In these cases the victim may vomit and the contents of the stomach could be inhaled or insufflated into the lungs, representing a serious complication.

Make sure that the airways are open by extending their head and lifting their chin.

Close their nostrils by pinching them between two fingers. Insufflate slowly (two seconds) until their chest rises.

Let the person exhale air passively. Check the lowering of the chest wall.

Artificial respiration can be performed in various ways, either with or without special equipment. The use of one or the other method will depend on the situation and the rescuer will decide the most suitable method each time, trying to use the method that produces the greatest volume of air with the smallest amount of effort, which is the safest way for both the rescuer and the victim.

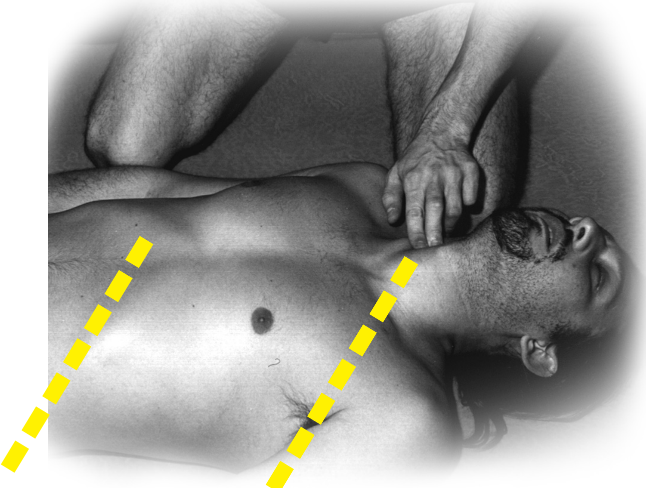
As the rescuer can be exposed to the risk of infectious diseases, use of a special mask is recommended.

After two effective ventilations

PHASE C - CHECK THE CAROTID PULSE AND VITAL SIGNS

For the emergency medical service paramedic

The search for effective circulatory activity must be carried out on the larger arteries in order to facilitate pulse retrieval and because the systolic impulse tends to continue even when arterial pressure is very low. For this reason the paramedic has to verify the presence of the carotid pulse (for the layperson the present guidelines do not require identification of the carotid pulse).



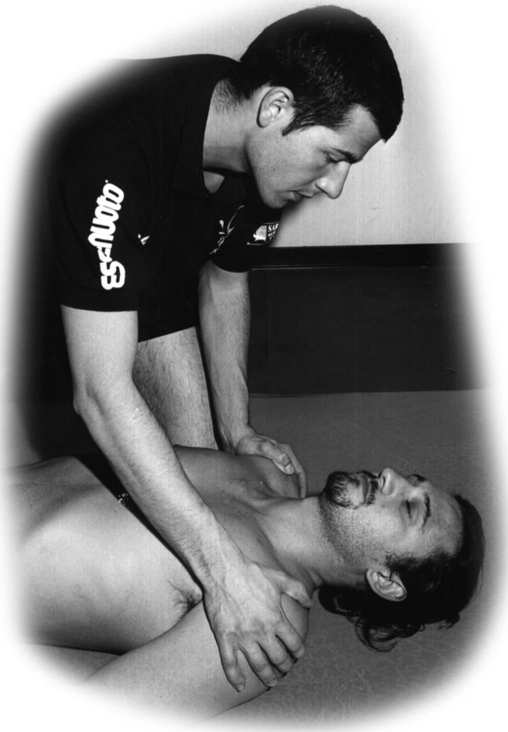
Identification of the carotid occurs while keeping the head extended by placing one hand on the victim's forehead and locating the trachea (the thyroid cartilage) with two or three fingers of the other hand. Then slip two fingers between the trachea and the muscles on the side of the neck (closest to the operator) where the carotid pulse can be identified. In searching for the pulse only a light pressure should be applied, so as not to compress the artery. This search for the pulse should last 10 seconds at the most. During these 10 seconds in which you try to identify the carotid pulse, attentively observe the victim, looking for possible signs of circulation (vital signs): movement, coughing and breathing.

Check for vital signs:

Look, listen and try to identify:
- respiration
- coughing
- movement

Spend no more than 10 seconds checking.
If you are a paramedic, also verify the carotid pulse

10 seconds



If there is no pulse and no evidence of vital signs

PERFORM 30 CHEST COMPRESSIONS

Correctly performing cardiac massage is important in order to maintain sufficient pressure of cerebral and myocardial perfusion. Cardiac massage correctly performed ensures:

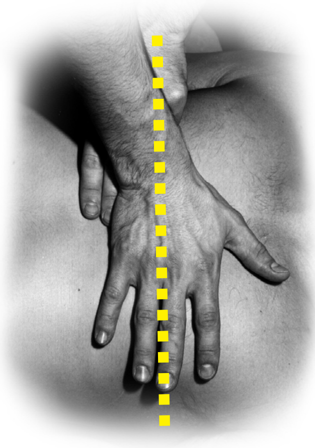
- 10%-20% of the normal flow of perfusion to the heart

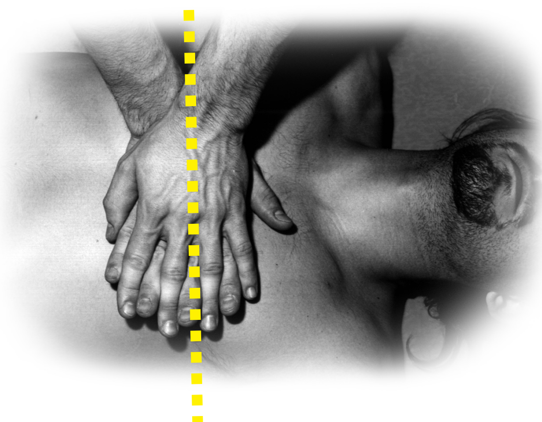
- 20% - 30% of the normal flow of perfusion to the brain

Pressures of efficient cerebral and coronary perfusion can also be obtained after a certain number of external chest compressions correctly performed (to perform compressions lower the sternum by 4-5 cms at a frequency of 100 compressions/minute) and immediately fall to inadequate values as soon as the cardiac massage is interrupted; these are re-established again only after a certain number of compressions and for this reason maximum attention should be given to minimizing interruptions of the cardiac massage.
While performing cardiac massage, you must ensure complete relaxation of the chest after each compression because maintenance of a high inter-thoracic pressure would hinder the venous return to the heart and major arteries, jeopardizing diastolic pressure and therefore the effectiveness of the chest compressions.

Performing a cardiac massage incorrectly drastically reduces these percentages with potentially grave consequences, therefore:

With the chest bared, place your hands in the centre of the chest of the assisted person along the line between the two nipples (the inter-mamillary line) on the lower half of the sternum.



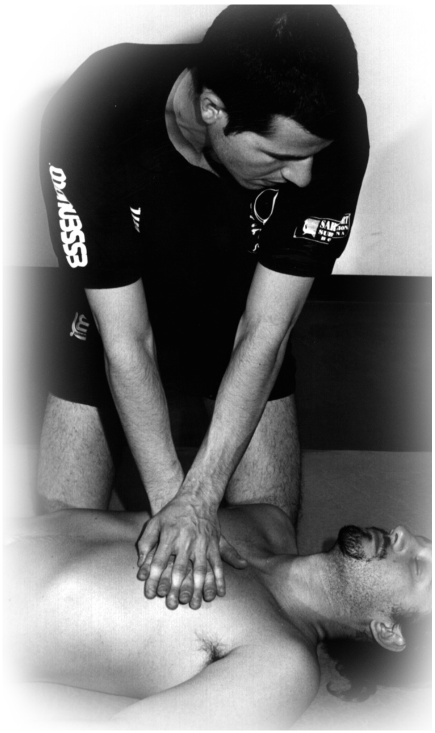


COMPRESSION TECHNIQUE

Chest compressions can make enough blood circulate in order to keep the vital organs alive for some time.

To optimize this pumping effect:

1) "push hard"
Push hard enough.
Keep your arms stretched and push down 4 - 5 cms.
If you push with bent elbows, your arms could act as a spring and the effective depth to which you push down the sternum could be insufficient.



2) "push fast"
Push fast enough.
A rhythm of 100 compressions per minute means doing 30 pushes in around 20 seconds.
Count the compressions aloud.

3) allow the chest to relax completely
Release the pressure between one push and the next, allowing the heart to fill up, but keeping a light skin contact to avoid losing the correct point of compression.

Reduce effort to the minimum

Performing chest compressions is tiring.
You will get tired less easily if you act as follows:
- kneel at the victim's side
- keep your shoulders perpendicular to the position of your hands
- use your body weight to push.

In order that the cardiac massage does not lose its effectiveness (despite using the correct technique) it is strongly recommended that two rescuers perform the compressions, alternating every two minutes.

Reduce risk of injury to the minimum

Compressions too emphatically performed can cause bone fractures in the rib cage, and even serious damage to internal organs.
To reduce this risk to the minimum:
- press in the right point

Place your hands on the middle of the chest of the person being assisted on a line between the two nipples (the inter-mamillary line) in the lower half of the sternum.
Place the palm of one hand on the point identified and put the other hand on top. Lift your fingers off the chest while performing the compressions.

Avoid pushing on the lowest point of the sternum!

- push at a regular speed, without brusque movements.

Avoid pushing too hard.

After 30 compressions stop and perform (or allow your partner to perform) 2 ventilations.

If there is no pulse and no signs of circulation BEGIN CPR Alternate 30 compressions / 2 ventilations

Remember:

A) push hard
B) push fast
C) allow the chest to expand completely
D) reduce interruptions of chest compressions to the minimum

Practice cpr continuously until:

A) someone capable of practising cpr can relieve you, or
B) a doctor tells you to interrupt cpr, or
C) you are replaced by someone able to use an aed, or
D) you are too tired to continue.

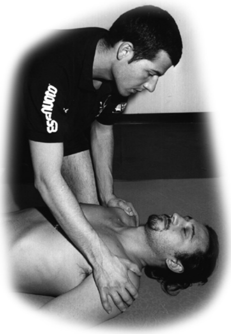
Save energy

Do not insufflate too emphatically or quickly.
Do not push too hard or too fast.

Save time

Take the smallest possible time to go from compression to ventilation and vice versa.

Recapitulating:







The semi-automatic defibrillator (aed)

We have previously noted that ventricular fibrillation and ventricular tachycardia without pulse are the most frequent cardiac arrhythmias (75%) responsible for cardiac arrest. These arrhythmias induce the heart to beat chaotically in the first case and rhythmically but too fast in the second, causing it to lose the ability to pump blood.
These would quickly lead to death if not interrupted. An electric shock (defibrillation) is able to combat for a moment all the electric potential of the myocardium, interrupting the arrhythmia that causes cardiac arrest and enabling the resumption of a regular and effective heartbeat. Electrical defibrillation is the only effective therapy in these cases.
The probability that defibrillation will be effective in interrupting vf or vt decreases rapidly after a few minutes (- 10% for each minute that passes) to arrive near zero at around 10 minutes.
For this reason time is the determining factor in the success of defibrillation, which has to be performed as soon as possible. Defibrillators are required to carry out defibrillation. These are instruments able to supply high “doses” of direct current over a very brief time period (in milliseconds).
The defibrillators used in basic life support-defibrillation (bls-d) are the so-called semi-automatic external defibrillators (aed).
These instruments, once connected to the chest of the subject through the use of adhesive electrodes, are able to analyze the heartbeat completely automatically and, in the presence of ventricular fibrillation or tachycardia, tell the operator when to perform the shock, load their own condensers and are set up ready to provide the shock on command by the operator.

When to use an AED

After checking that the person being assisted:

IS UNCONSCIOUS

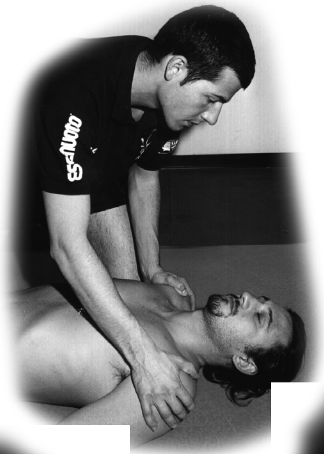
(open the airways and alert the emergency services)

IS NOT BREATHING

(perform two effective ventilations)

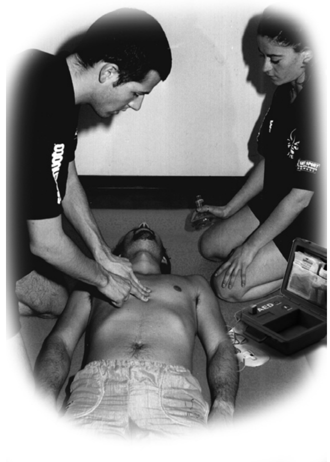
DOES NOT HAVE A PULSE OR VITAL SIGNS

(begin cardiac massage)



If the semiautomatic defibrillator is immediately available and collapse of the victim took place within 4 minutes you can immediately use it (two rescuers perform cpr while preparing the victim and positioning the electrodes). This is because the probabilities of finding a defibrillable heartbeat (vf or vt without pulse) are very high during the first few minutes.

If an aed is available more than 4 minutes after the victim's collapse, it is advisable to first carry out cardiopulmonary resuscitation (cardiac massage and ventilation for 5 cycles of 30:2) for at least two minutes, in order to bring oxygen and substrata that can favour restoration of a defibrillable heartbeat (vf/vt).



POSITIONING OF THE AED
Place the aed to the left of the person.

TURN ON THE AED AND FOLLOW THE ORAL INSTRUCTIONS
Remove the sealed container of electrode pads from the accessories compartment. Open the wrapping and extract the electrode pads.

PLACE THE PADS IN THE CORRECT POINTS ON THE BARE CHEST
Each pad has clear visual instructions for its correct positioning. If the pads are put in the correct points, the electric current will pass from one to the other through the chest and directly through the heart, thus providing effective defibrillation, in line with the assisted person's right shoulder, directly below the clavicle. On the left of the chest, around 10 cm below the armpit, insert the electric cable. (not provided for all brands and models)

MAKE SURE THAT GOOD CONTACT IS MADE BETWEEN THE PADS AND THE SKIN
In the lower section, the pads contain an active central area with a sticky surface to facilitate capturing the electric signals. Along the edges of the whole pads there is an adhesive zone to keep them in position. Normally, to get a good electric contact you need to press the pads onto the skin and rub your fingers along the edges using a circular movement. If the aed tells you to check the pads, or if the pads become loose and fall, first try to fix them by smoothing them with your fingers. If this is not effective, use a new set of electrodes.

IF THE SKIN IS WET
Before applying the pads, dry the skin well with a paper handkerchief or with any other available material to improve contact with the electrode pads. Also dry the skin between the two pads to prevent the current from passing from one to the other on the skin surface rather than through the chest.

IF THE SKIN IS VERY HAIRY
Use a razor to quickly remove excess hair from the application points of the pads.

DISTRIBUTION OF THE WORK BETWEEN TWO RESCUERS
If a colleague is present with your same level of competence, it is important to have a clear and common awareness of how to share the assignments. The rescuer who arrives with the aed will use the instrument, and also acts as the "team leader", telling the other colleague what to do and when, for example:
- to check the state of consciousness, respiration and circulation
- to remove garments from the victim's chest
- to practise cpr
- to make emergency phone calls
- to talk to any other people present.

ONLY ONE RESCUER
If you are alone in assisting a person you will have to do everything yourself. If among the people present there is anybody else capable of carrying out cpr, ask them to help you.

Sequence of actions with the AED

Once the electrodes of the semiautomatic defibrillator have been applied, you will not have to do anything except follow the vocal instructions provided by the instrument itself. At this time your main job will be to keep up safety levels for you and any eventual bystanders. Nobody, for any reason, should be allowed to touch the victim during the phases of analysis and electrical discharge.

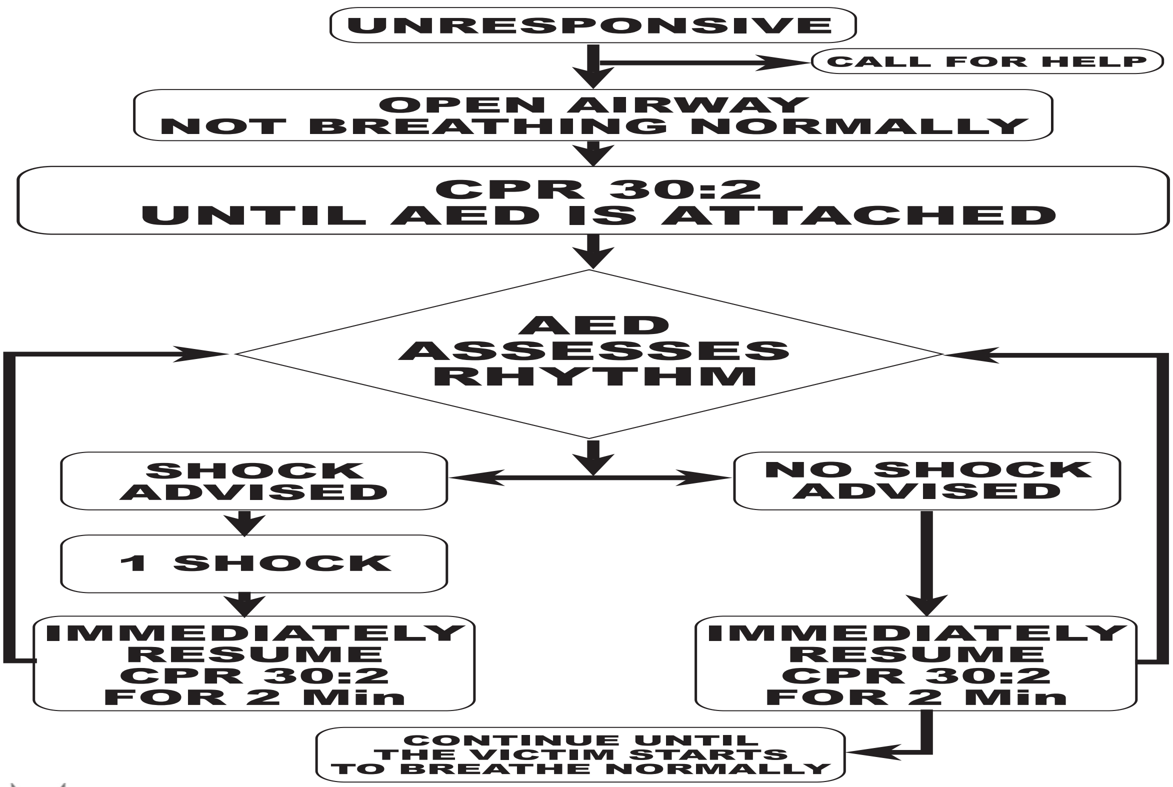
ANALYSIS AND SUGGESTIONS FOR ADMINISTERING THE DISCHARGE
When attached to the assisted person, the aed quickly analyzes the heartbeat and determines whether the defibrillator can be used or not. If it can, the aed automatically sets itself up and is ready for use. If discharge is not recommended, the aed does not load and you cannot transmit an electrical discharge.

It is extremely important that in the analysis of the heartbeat phase
(so as not to delay recognition of the arrhythmia)
And in the phase of electrical discharge
(so as not to cause injury to bystanders)
Nobody comes close to or touches the patient for any reason!

Sequence of operations with the AED

While the old guidelines recommended performing a series of three consecutive shocks and then continuing with cpr procedures and checking the carotid pulse, the ilcor 2005 guidelines advise performing sequences of only one shock (if recommended), and immediately continuing with cpr procedures, beginning with a cardiac massage, continuing the cpr for two minutes and then starting a new phase of analysis using the aed and so on.

AED ALGORITHM



Airway obstruction (ao)

Complete airway obstruction is a rare, but preventable, cause of cardiac arrest, which, if not treated, leads to death in a few minutes.
Airway obstruction can derive from intrinsic causes (for instance, one of the most frequent is the tongue during loss of consciousness) or from extrinsic causes (foreign bodies, blood from brain traumas, vomit).
Airway obstruction is not the cause of death among diving and/or drowning victims. Water, being liquid, does not behave as a solid foreign body, which can obstruct the airways. In this type of emergency the first thing to do is to correct the asphyxia by performing lifesaving resuscitation and the procedures of cpr. Procedures for freeing the airways are not suitable because they could cause complications and they would necessarily delay the performance of cpr, which remains the most suitable treatment for diving victims.
The most frequent cause of airway obstruction in adults is food (large and not sufficiently chewed pieces of food, usually meat). Associated factors can be a high alcohol content in the blood and dental prostheses.
Therefore, it is important to:

- ***Cut food into small pieces and chew it as much as possible before swallowing, especially if you have dental prostheses***
- ***Avoid laughing and speaking during mastication and swallowing***
- ***Avoid excessive consumption of alcohol***
- ***Prevent children from excessive movement, running or laughing when they have food in their mouths***
- ***Prevent children from putting objects into their mouths, especially of a large size***
- ***Avoid giving even small bits of stringy food or food that is difficult to chew to children (e.g. Ham fat).***

RECOGNITION OF AIRWAY OBSTRUCTION
Recognizing cases of airway obstruction and, above all, managing to distinguish this emergency from others, such as stroke, heart attack, or an overdose of drugs, which can also lead to respiratory arrest, is fundamental in order to intervene correctly.
Airway obstruction can be:

A) partial

B) complete

In the case of partial obstruction, the flow could be sufficient or insufficient for adequate pulmonary ventilation.
Coughing, respiratory difficulty, cyanosis, or placing one's hands on one's throat are all signs that suggest airway obstruction. The presence of some signs of reaction, such as speaking or violent coughing, suggest a partial obstruction with sufficient respiratory flow. In this case the rescuer encourages the patient to cough and activates the emergency procedure only if the obstruction persists, even though partial.
On the other hand, increasing respiratory difficulty, weak coughing, a desperate attempt to put one's hands on one's neck, and possible cyanosis suggests an obstruction with an insufficient respiratory flow. In this case you need to act immediately, as if confronted with a complete obstruction.

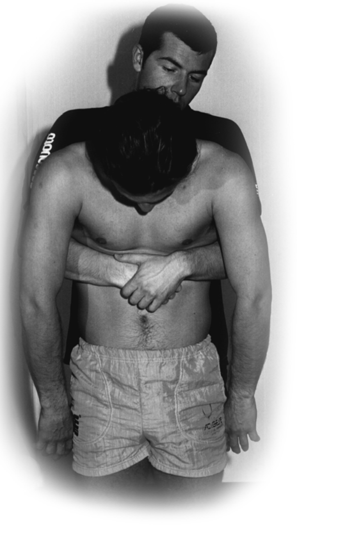
If the patient is unable to speak, breathe, cough, or is cyanotic there is probably a complete obstruction with no flow.

ACT IMMEDIATELY!

If the flow of air through the airways and reaching the lungs continues to be insufficient, the patient's oxygen saturation falls rapidly, and if the obstruction is not removed quickly, the patient becomes unconscious and rapidly dies.

THE HEIMLICH MANOEUVRE

The recommended procedure for professional rescuers to resolve airway obstruction in conscious adult victims (> 8 years old) is called the heimlich manoeuvre (also known as abdominal below diaphragm thrusts or abdominal thrusts). The purpose of abdominal thrusts is to raise the diaphragm, to increase pressure on the airways by pushing air out of the lungs, and to provoke artificial coughing.



Abdominal thrusts, however, can cause complications (broken or lacerated abdominal or thoracic organs), so they should only be performed if strictly necessary and the patients that have received them should always go for a medical check-up after the event. A suggestion to reduce the possibility of complications is not to place your hands on the xiphoid process of the sternum or the lowest part of the ribcage. However, even when the manoeuvre is correctly performed there can be complications. Sometimes a regurgitation could accompany aspiration.

THE HEIMLICH MANOEUVRE TECHNIQUE WITH A STANDING OR SITTING CONSCIOUS VICTIM

The rescuer positions himself/herself behind the victim, embracing their chest completely at waist height. Place a fisted hand with the thumb placed against the patient's stomach at a point situated along a horizontal line halfway between the xiphoid process and the navel. Grab your fist with the other hand and with this press against the patient's abdomen with a rapid thrust directed inwards and upwards. Repeat until the foreign body has been expelled or until the patient loses consciousness. In this case begin cpr.

SELF-ADMINISTERED HEIMLICH MANOEUVRE

The heimlich manoeuvre can also be self-administered; in this case the victim punches himself, using the same technique as previously described. In case of failure, you should quickly and repeatedly thrust the upper part of the abdomen against a hard, strong and stable surface, such as the back of a chair, the side of a table or a handrail, to produce the same effect as abdominal thrusts.

THORACIC THRUSTS FOR OBESE VICTIMS OR PREGNANT WOMEN

In cases when the victim is either in the last months of pregnancy or particularly obese, thoracic thrusts could be used as an alternative to the heimlich manoeuvre.

Place yourself behind the patient, with your arms immediately under the armpits of the patient and encircle the patient's chest. Place a fist on the thumb side in the middle of the patient's sternum, taking care to avoid the xiphoid process and the edge of the ribcage. With the other hand, grab your fist and perform thrusts backwards and upwards until the foreign body is expelled or the patient loses consciousness.

If you can't put your arms around the pregnant woman or extremely obese person, you can perform thoracic thrusts with the patient lying down. Lay the patient down (with their shoulders to the floor) and kneel down at the patient's side. The position of the hands and technique of thoracic thrusts are the same as for the external chest compressions during cpr. In adults, for instance, the palm of the hand is at the level of the lower half of the sternum. Every thrust should be given with the intention of removing the obstruction.

ACTIONS FOR THE LAY RESCUER IN THE CASE OF UNCONSCIOUS VICTIMS

The teaching of complex techniques (manoeuvres) for the resolution of ao in unconscious victims by a lay rescuer is no longer to be recommended. If, during attempts to resolve ao, the victim of suffocation becomes unconscious, the lay rescuer, if alone, should contact the emergency medical services (or send someone to contact them) and begin cpr. In fact, chest compressions can be effective in removing an ao in a non-responsive patient. The lay rescuer should carry out cpr with a single addition. Every time the airways are open, look inside to see if there are foreign bodies at the back of the throat. If an object is visible, remove it.

This recommendation is made to simplify cpr training for a layperson and to ensure acquisition of the essential manoeuvres of ventilation, lifesaving and compression, while continuing to provide treatment for victims of ao.

The cleaning manoeuvre with the fingers should be performed in unconscious subjects with complete ao. It should not be performed if the patient responds or is losing consciousness.

With the patient's face upwards, open their mouth while grabbing both the tongue and the lower part of the jaw between thumb and fingers, lifting the mandible (tongue – chin lift). This lifts the tongue away from the back of the throat and from any possible foreign body that could be blocking the throat.

This manoeuvre alone could be effective in resolving an obstruction. Insert the index finger of the other hand along the inside of the cheek and deep into the throat of the patient until the base of the tongue. Then, with a hooking movement, try to move the foreign body and bring it into the mouth to be removed easily. Sometimes you need to use the index finger to push the foreign body against the opposite side of the throat in order to move it and remove it. Be careful to avoid pushing the object deeper into the airways.

SEQUENCE FOR THE RESOLUTION OF AO IN UNRESPONSIVE PATIENTS

Victims of ao could initially be conscious and subsequently lose consciousness. In this case the rescuer will know that ao is the cause of the patient's symptoms.

Victims of ao might not be conscious from the beginning. In this case the rescuer will probably be unaware that the patient has ao until repeated attempts of lifesaving respiration are shown to be ineffective.

Resolution of ao in a victim who is initially conscious.

If you have witnessed the victim's collapse and know that this has been caused by ao, the following sequence of actions is recommended:

- Contact the emergency medical services within the time foreseen by the cpr sequence. If a second rescuer is present, ask the second rescuer to contact the emergency services while you stay with the patient. Make sure that the patient is lying down.
- Perform a tongue-chin lift followed by cleaning with the fingers to remove the object.
- Open the airways and try to ventilate. If you are unable to make the patient's chest expand, move their head and try to ventilate again.
- If you are unable to provide effective ventilations (their chest doesn't expand) even after attempts to reposition the airways, place yourself astride the patient's thighs and carry out the heimlich manoeuvre for a maximum of 5 times.
- Repeat the tongue-chin lift sequence, cleaning with the fingers, (repeated) attempts to ventilate, and the heimlich manoeuvre (from points 2 to 4) until the obstruction disappears and the chest expands with ventilations or advanced procedures are available (e.g. Kelly pliers, magill forceps,) to restore clearance of the airways.

- If the ao has been removed and the airways are clear, check respiration. If the patient isn't breathing, perform slow lifesaving respirations. Then check for signs of circulation (check for pulse and signs of respiration, coughing or movement). If there are no signs of circulation, begin chest compressions. To perform abdominal thrusts to an unresponsive or unconscious patient, place yourself astride the patient's thighs and place the lower part of one hand on the patient's abdomen, on a line going across the body slightly above the navel and well below the xiphoid process. Place your other hand directly on top of the first. Press on the abdomen with both hands, making rapid thrusts upwards. If you are in the correct position, above the central part of the abdomen, the thrusts will be most unlikely to go to the right or left. Use your body weight to carry out the manoeuvre.

RESOLUTION OF AO IN A VICTIM WHO IS INITIALLY UNCONSCIOUS.

- The sequence of actions and observations is exactly the same as the one previously described.

If the foreign body is removed and the airways are clear, check for breathing. If the victim isn't breathing, perform 2 lifesaving respirations. Subsequently check for signs of circulation (check for pulse and signs of respiration, coughing or movement). If there are no signs of circulation, begin chest compressions.

First aid principles

GENERAL INFORMATION ABOUT TRAUMAS

Damage provoked on an organism by a mechanical action is defined as trauma.

The trauma can affect the:

- skin only (burns, bruises, excoriations, wounds),

- muscles (tearing, stretching, bruising),

- articulations (sprains and dislocation),

- bones (fractures),

- blood vessels (arterial or venous haemorrhage).

These effects can be combined in various ways.

A person who has suffered a trauma leading to any of the lesions described above feels pain, increasing in relation to the gravity of the situation. In the case of fracture, the limb is deformed and often the victim is unable to move it. If articulated bone structures have been affected, there could also be considerable swelling of the joint.

Burns

Burns represent a serious problem involving around 20,000 victims a year.
Unfortunately, despite modern techniques of first aid and rapid hospitalisation, around 3,000 of these victims die in the days following the trauma.
Survivors can experience serious permanent injury.
A burn affects the skin and soft tissues (muscles, blood vessels, etc.) And represents a local or more wide-spread loss of substances, with shock as a possible consequence of the trauma.

To classify how serious burns are, in clinical emergencies the criteria adopted is based on the extension, depth and location of the burns.
Regarding the criterion of the depth of the lesion, 3 degrees are identified:

- FIRST DEGREE
very superficial lesion, erythema (like sunburn), which recovers in a few days;

- SECOND DEGREE
these are more serious and deeper lesions which form blisters and ulcerations. They require particular care to avoid infection and recover the functions in the affected zone;

- THIRD DEGREE
these are the most serious lesions with loss of substance from the skin tissue and from subcutaneous tissue. They appear as a deep red eschar, hard and with black edges, not painful.

The position of the burn is also very important, since burns affecting areas of the body with particularly delicate tissue, such as the face, neck and abdomen, can provoke spreading of the lesion, with serious complications and risk of death in the patient.
It is also important to remember that burns to the face complicate first aid if the burn affects the upper airways.

RESCUER'S INTERVENTION

- in assisting the burned victim it is important not to remove clothing, even when burnt. While waiting for medical personnel to arrive, check the extension of the lesion and the areas affected.

- in cases when vital signs are not present (heartbeat and respiration) resuscitation by the insufflated air method remains the most important form of assistance that the rescuer can perform.

- it is important to avoid, if possible, that the burnt parts (no longer protected by the skin) become infected on contact with the surrounding environment (smog, dust, etc.). Therefore, the rescuer should try to cover the patient with a blanket or sheet, considering that major treatment will be carried out in a medical and absolutely sterile environment.

To sum up, the rescuer can help by checking the presence of the vital functions (heartbeat and respiration) and in the first aid of any eventual associated traumas, such as injuries with haemorrhaging, fractures, etc..

Haemorrhages

Haemorrhage can be defined as loss of blood from a blood vessel, whose walls have been injured by some kind of trauma. You can intervene immediately only on haemorrhages of superficial blood vessels with blood escaping from the skin, while for internal haemorrhages, which can be suspected from symptoms in the patient, surgical intervention is often required.
In the case of external haemorrhaging we can try to establish whether an artery or a vein has been affected:

A) IF THE HEMORRHAGE IS COMING FROM AN ARTERY:
1 – the blood will be bright red in colour
2 – the blood will flow under pressure and in spurts, still with the rhythmic pulsing (systole and diastole) induced by the heart.

B) IF THE HEMORRHAGE ORIGINATES FROM A VEIN:
1 – the blood that escapes will be dark red in colour, brownish
2 – the blood will flow slowly and continuously.

FIRST AID FOR HAEMORRHAGES
Haemorrhage is an emergency that immediately requires first aid intervention, consisting of covering the wound in order to reduce the quantity of blood lost as much as possible.
This intervention is called haemostasis.

COMPLICATIONS OF HAEMORRHAGES
If there is excessive loss of blood, the victim experiences an abrupt drop in blood pressure. In these cases the patient will complain of intense thirst, blurring of sight, increased respiratory frequency, agitated heartbeat, and will have a barely noticeable radial pulse, frequent dehydration of the skin, which will appear inelastic and pale or white in colour, and a dry tongue. If the blood pressure drops excessively, since the brain will not be receiving enough blood, the patient passes out and can die of hemorrhagic shock.

HAEMOSTASIS BY TAMPONADE
Haemostasis by tamponade is operable on any part of the body: the limbs, trunk, abdomen, head and neck. This manoeuvre consists in direct compression, with the hand or fist, on the injured vessel, by squeezing it against the underlying bone structure.

HAEMOSTASIS BY CONSTRICTION

Constriction is a manoeuvre of haemostasis that can be practised in the case of haemorrhage to a limb, where it is possible to constrict the damaged blood vessel above the lesion. This constriction is best carried out with a belt, a tie or any other wide-banded object, so as not to excessively injure the blood vessels and the underlying nerves at the point of application (if the band is too tight).

Avoid constriction with haemostatic ties or rope

The constriction must not be excessively tight and should not be kept on for too long (maximum 10-15 minutes). In fact, the tissues below the constriction could suffer excessively from lack of blood and suffer very serious alterations.
It is therefore preferable to effect a haemostasis by direct tamponade, even if a limb is affected, since constriction also compresses blood vessels not affected by the haemorrhage.

If the subject shows an excessive drop in blood pressure, they should be placed in the antishock position:

1) lie the patient stretched out;
2) lift their legs so that they are higher than the head;
3) loosen any article of clothing (tie, collar, shirt or belt) that could constrict the subject, making it difficult for them to breathe
4) cover the patient so that they don’t catch cold.

N.b.
- never administer alcoholic drinks which, by dilating the vessels, could reduce the blood pressure even further.
- these measures apply to all situations in which a lowering of arterial pressure occurs.
- the volume of circulating blood is around 5 litres. There is risk to life if more than a litre of blood is lost through haemorrhaging.

Fractures, sprains and dislocations

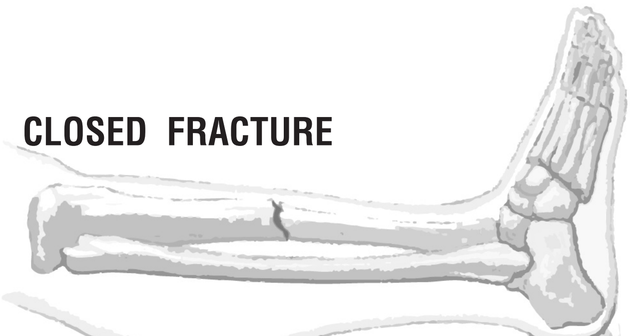
***Fracture** is a simple or complex breakage of the bone. Traumas are the most frequent cause of fractures: an external force overcomes the mechanical resistance of the bone and determines a fracture.*

***Sprain** is a traumatic capsular-ligament lesion of an articulation without displacement of the joints, caused by a sudden or forced movement.*

***Dislocation** is a permanent displacement of the joints with respect to each other. Complete dislocation is when the change of position between the two surfaces is complete; when a partial contact remains, it is called incomplete dislocation or subluxation.*

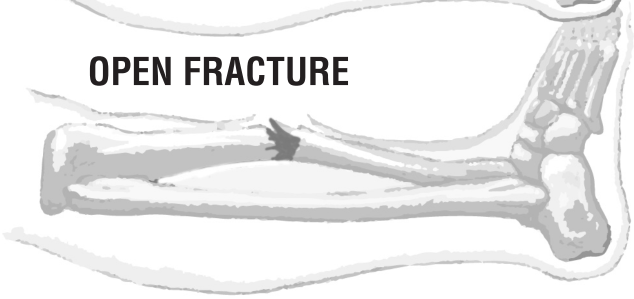
The rescuer should always suspect that a bone fracture could result from a trauma. It is important to avoid brusque movements to the injured or fractured limb, also because any eventual bone fragments could cause serious damage to the surrounding nerves and blood vessels.
In the case of fracture or dislocation of a limb, observation of the subject can provide useful information:

CLOSED FRACTURE



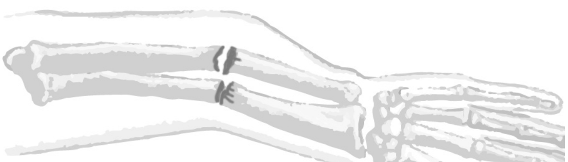
closed fractures
- the subject will place the damaged limb in a position of defence and rest,

OPEN FRACTURE



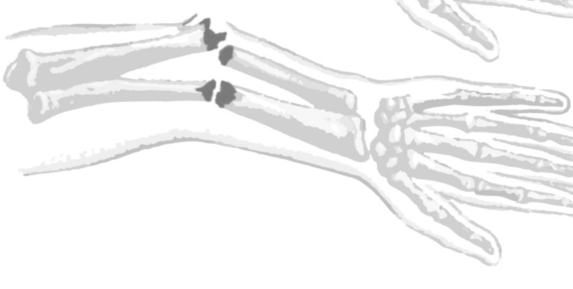
open (compound) fractures
- in compound fractures or dislocations there will be a clearly visible deformity of the limb,

CLOSED FRACTURE



closed fractures
- there is clear functional impotence of the stricken limb.

OPEN FRACTURE



open (compound) fractures
- in open fractures (i.e. With laceration of the muscles and tissues) the bone stump will appear through the skin,

COMPLICATIONS OF FRACTURES, SPRAINS AND DISLOCATIONS

These include:

1) general complications

A) the most significant is traumatic shock

2) local complications including

A) exposure of the wound to infection;

B) visceral lesions: damage to the pleura and/or the lungs is typical in displaced vertebral fractures;

C) vascular lesions, such as: lesion of the humeral artery in the fracture of the humerus and the popliteal artery in fractures involving the articulation of the knee;

D) nerve injury: medullary lesions, which can complicate fractures or vertebral sprains are very dangerous and may cause various states of paralysis.

It is certainly essential in first aid treatment of a traumatized subject to avoid causing any of the complications described above by arranging suitable transport of the traumatized patient.

FIRST AID OF FRACTURES, SPRAINS AND DISLOCATIONS

The limbs that have suffered this kind of trauma must be immobilized to avoid complications due to brusque movements.

HOW TO BE EQUIPPED TO CARRY OUT FIRST AID FOR TRAUMAS

The rescuer will have to procure pieces of wood (or of other hard material) in sufficient number and length to use to immobilize the fractured limb.

To immobilize a leg, for example, bear in mind that:

A) you need at least three pieces of wood;

B) they must be long enough to block the articulation both above and below the fracture;

C) they must be attached solidly to the injured limb through the use of sanitary bandages or, if not available, ties that are easy to cut.

For all fractures the fundamental intervention is immobilization. If the lesion affects the chest, abdomen or spinal column, the patient will need to be transported with extreme caution on a hard surface to maintain the position of the head and lower limbs: it is absolutely essential to avoid untoward movements during transport that could move the spine, determining damage to the spinal cord.

To do this, you can use, according to availability and the location of the accident: stretchers, house doors or any hard, flat wooden board.

These must be slowly and carefully positioned below the patient without moving them at all.

Muscular lesions and tendons

According to the type of trauma and cause of injury affecting the muscle, different types of muscular strain can occur: bruised, strained or pulled, lacerated, broken, torn and crushed muscles.
First aid treatment should include immobilization of the whole limb containing the damaged muscle, in the same way as for a fracture, and rapid hospitalisation of the patient. The same procedure should be followed for suspected injury to tendons.

GENERAL INFORMATION ABOUT SPINAL INJURY

The spinal cord is contained in the spinal column, which protects it. A fall or accident can cause a fracture to the bone structure protecting the spinal cord. The consequences of a fracture to the spine can be:

1) fracture of the bone itself

2) injury to the spinal cord by fragments of fractured bone.

The rescuer should bear in mind that injury to the spinal column can be associated with neurological damage, the gravity of which will depend on the duration, intensity, type of trauma and, obviously, the position of the injury.
Nerve injury frequently occurs after the initial trauma when, through untoward movements made during transportation of the injured person, fractured bone fragments injure the spinal cord.
In the aquatic environment the cervical rachis is the most likely nerve injury. The frequency of injury to this part of the body explains the high percentage of patients with very serious paralysis (quadriplegia: all four limbs paralyzed) in accidents occurring during aquatic sports. When an accident happens in water, rescue of the injured persons can be particularly difficult. Those who have experienced this kind of rescue know how complex it is to ensure that the victim is floating in a correct position, if unconscious, and transported without risk of damaging manoeuvres to the injured rachis. It is certainly necessary to get help from several people in order to carry out this type of rescue and take the injured person out of the water.

TRANSPORT OF SPINAL INJURIES IN WATER

First aid to a person with suspected spinal injuries must fulfil certain requirements:

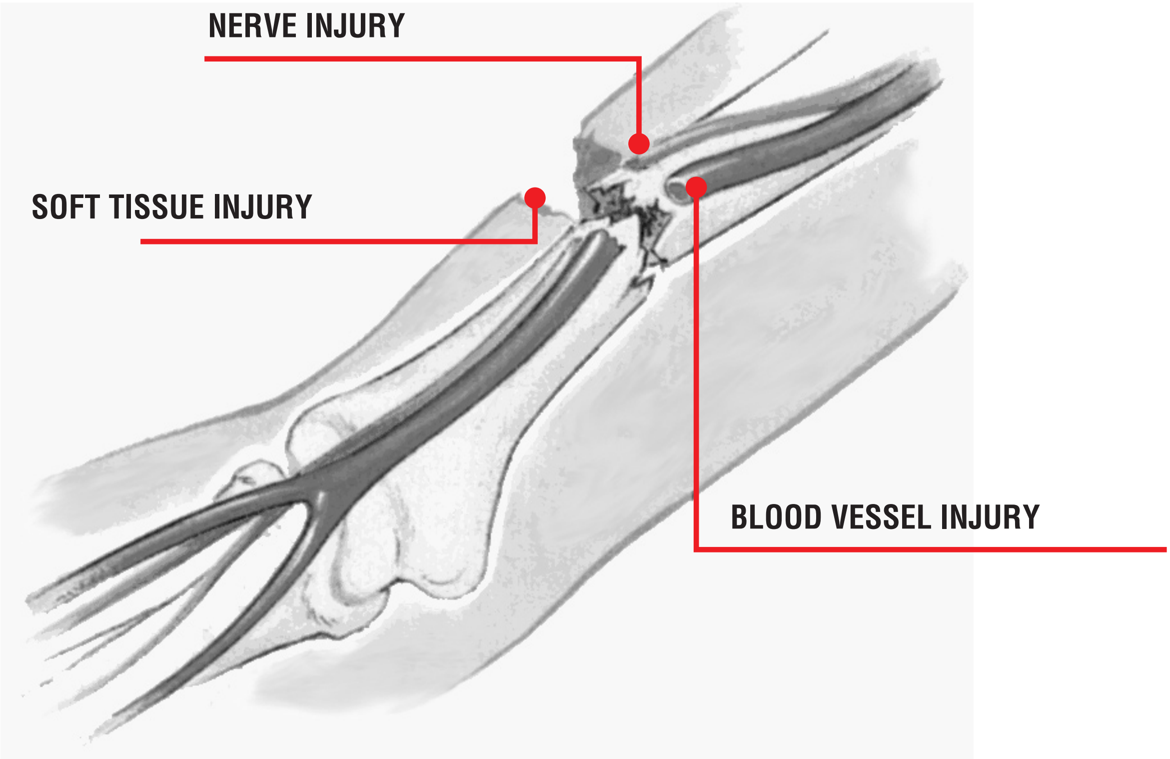
1) the patient must be removed from the position in which they have been found, avoiding any possible pressure on the rachis;

2) they must be transported in supine decubitus, a position allowing for better respiration and greater control of the injured person by the rescuer.

Emergency rescuers must be provided with a suitable means of transport, fulfilling the following requirements:
A) easy to manoeuvre, and usable also by non-paramedic personnel;
B) enabling rescue by a single person (sufficiently trained in the rescuing procedure);
C) easily transportable on boats, ambulances, helicopters, etc.;
D) consisting of shockproof, buoyant material, resistant to mechanical movement.

Concluding remarks

It is difficult to imagine that, following a serious bone trauma, there will not be complications to the muscles, blood vessels, tendons and joints.
All the traumas described could happen together.
It is therefore always worth following the procedure of immobilizing the injured part of the body, protecting it from other external agents, immediately alerting the emergency medical services and, finally, constant monitoring of the patient until hospitalization.



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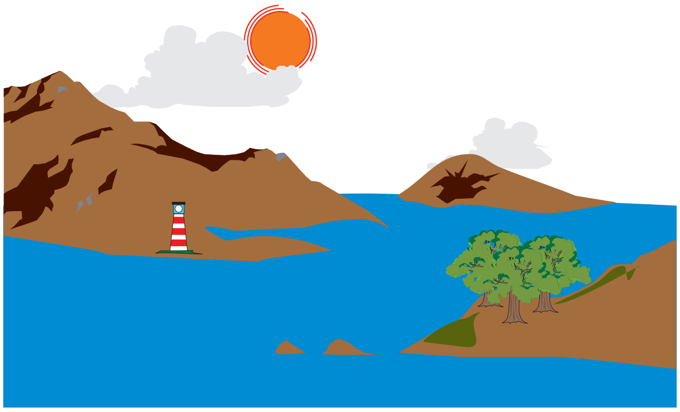
LESSON 4

CMAS

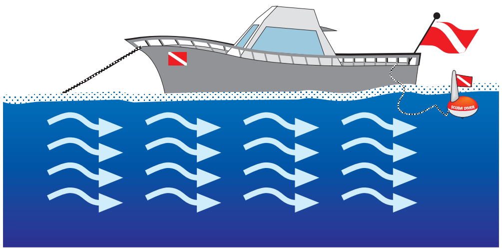
WORLD UNDERWATER FEDERATION

Natural orientation

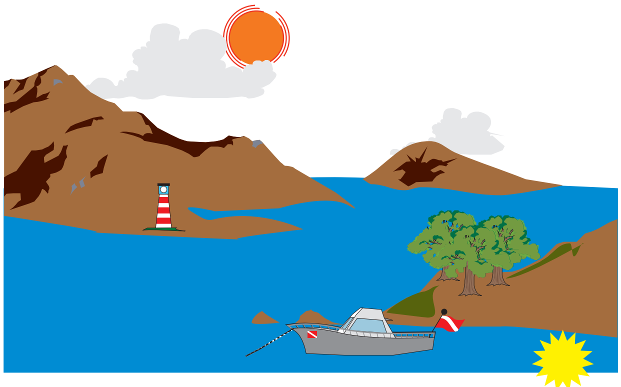
SITE OF ORIENTATION



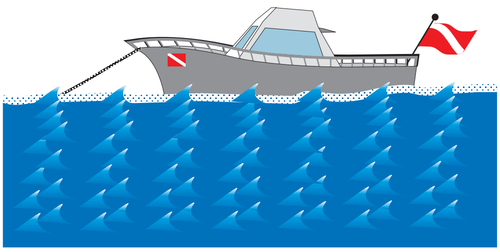
Pay attention to main features and memorize them



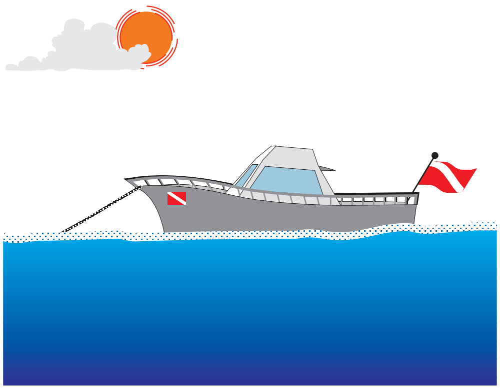
Current direction



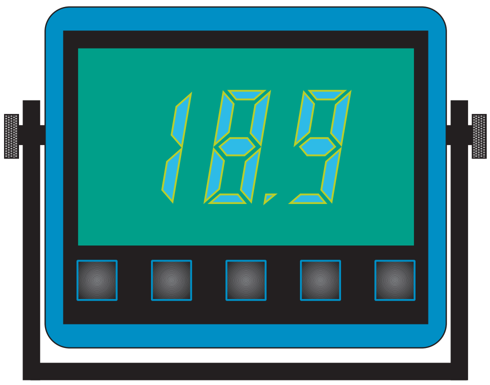
Location of the boat, of the entry point
and of other features



Waves direction

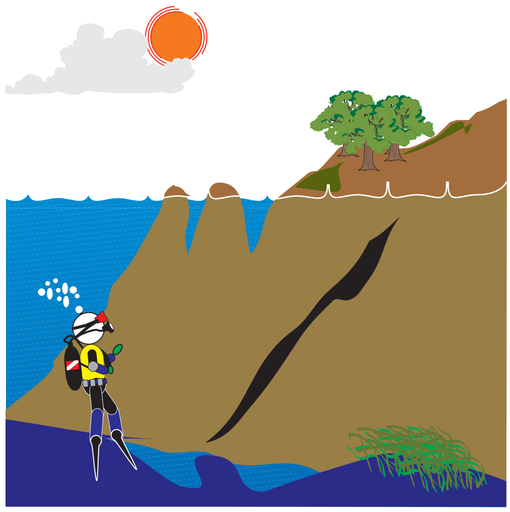


Location of the boat, of the entry point
referring to the sun

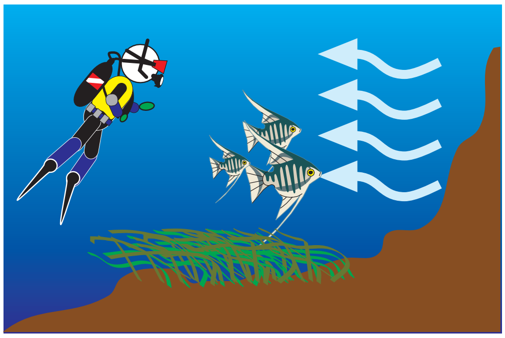


Depth shown by the boat's econometer
or indicated by the chart

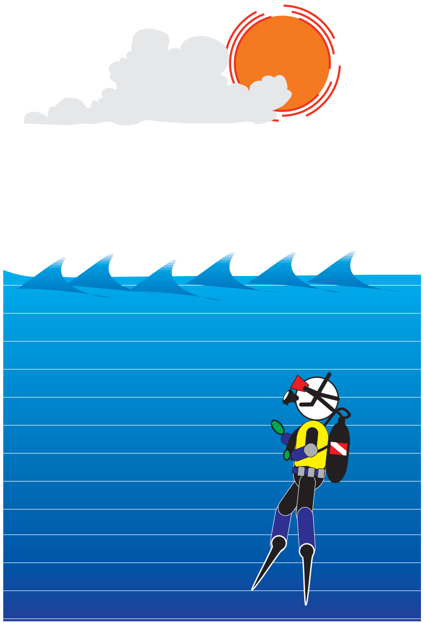
EFFECTIVE USE OF ENVIRONMENTAL FEATURES



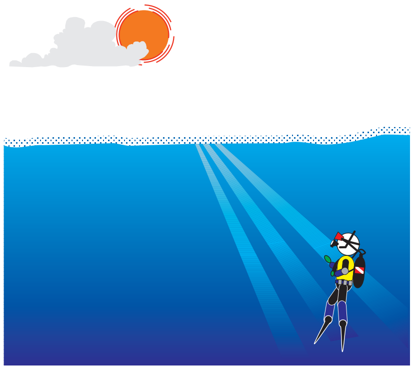
Main features of a dive



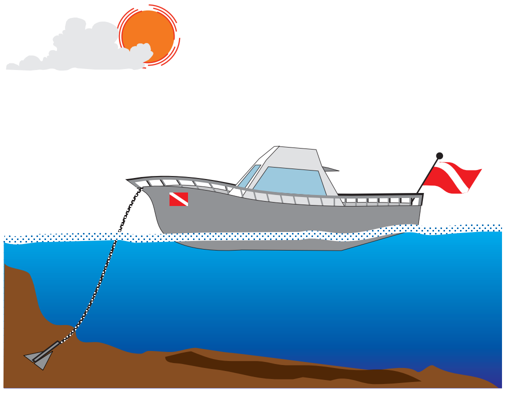
Current direction



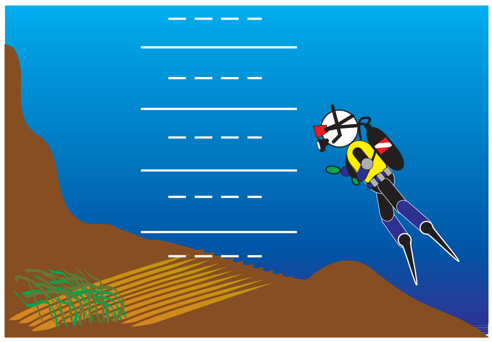
Orientation referring to the surface waves



Orientation referring to the sun



Shadow of the boat



Depth

Sand ripples

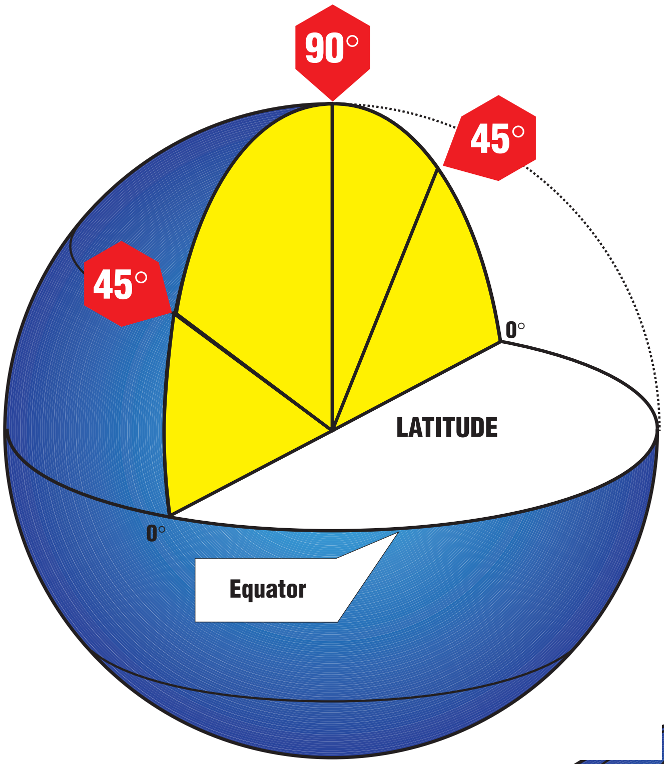
The compass

THE GLOBE

The earth is an ellipsoid of rotation, which revolves on its own axis. The two points where this axis passes through the surface are known as poles. The North pole is the one, if we look on it from above would rotate the earth counterclockwise; the South pole is the opposite.

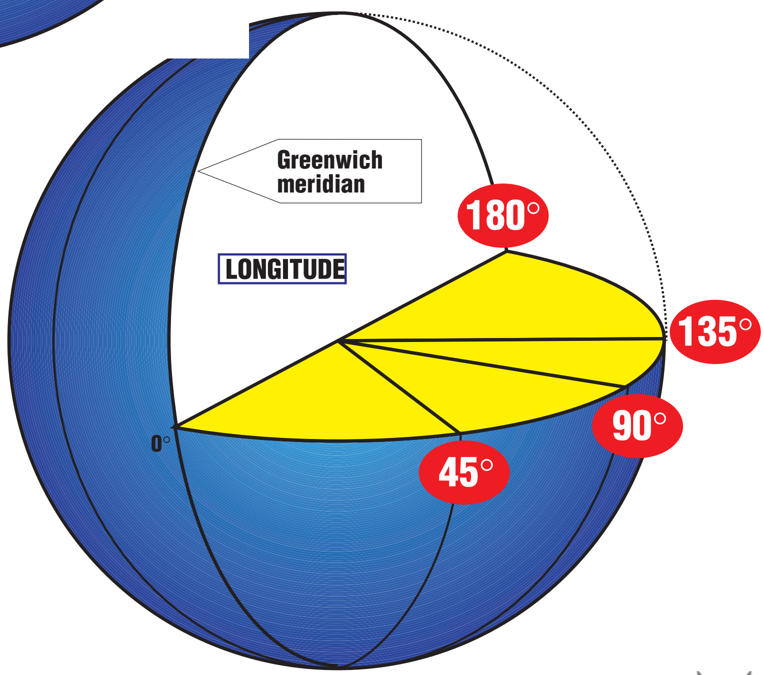
POSITION

The system employed to define an exact position on the earth is given by a series of lines called orthogonal spherical co-ordinates. When these lines have a direction east west are called parallels of latitude and meridian of longitude if they have a direction north to south. Any point on the earth can be defined by its longitude and latitude. These lines are expressed in degrees and minute of an arc.



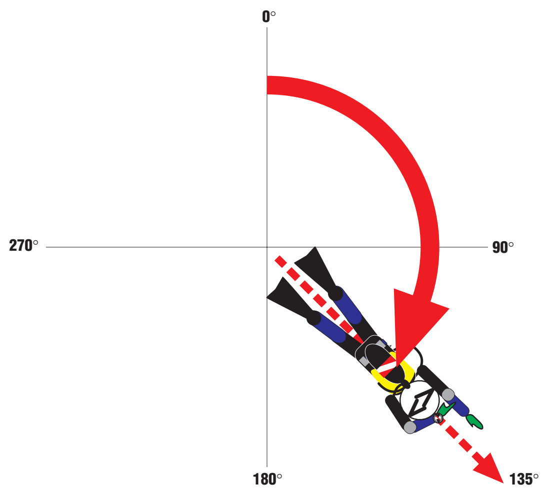
LATITUDE
The latitude is the angular distance on a meridian North or South from the equator. It is measured from 0° to 90° N if from the equator we move to the North Pole and from 0° to 90° S, if we move to the South Pole. Any point along the equator has 0° latitude whereas at the South Pole and North Pole the latitude is 90°N and 90° S.

LONGITUDE
It is the distance East or West on the earth's surface measured by the angle which the meridian of a particular place makes with some standard meridian as, in England that of Greenwich. It is reckoned to 180°east or west and is expressed either in degrees, minutes and seconds, or in time.



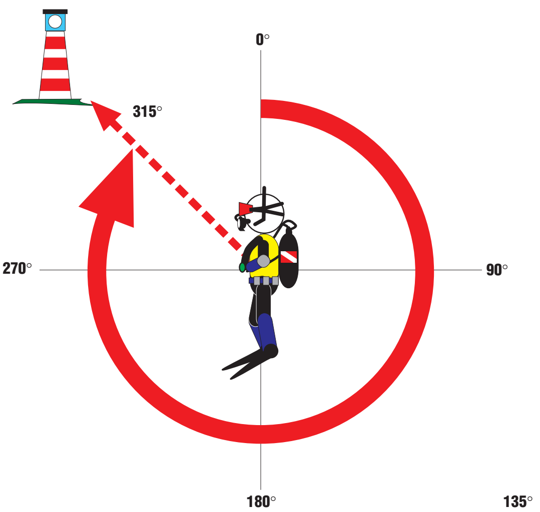
DIRECTION

In navigation a direction is given by the angle of the direction itself and the north direction. When the direction corresponds to the boat or diver's direction itself it is called route. When it concerns the direction from the observator to the another object or between two objects is called bearing. They are both expressed in degrees and measured clockwise starting from the north.



NAUTICAL MILE KNOT

Nautical mile is used to express distances at sea; it corresponds to 1,852 Mts. For the English who calculate a nautical mile along different latitude the nautical mile equals about 1,853. Nautical mile is the unit for the distance whereas the knot is for the speed and it corresponds to the distance of one nautical mile travelled in an hour. For example we can say that a ship has a speed of 8 knots or that it sails a distance of 8 miles an hour. As a knot corresponds to 0.5 Mt/sec, we can transform with a certain approximation the speed expressed in MT/sec dividing by 2 the number of knots. For example wind blowing at the speed of 20 knots, is a wind of 10 Mt/sec.

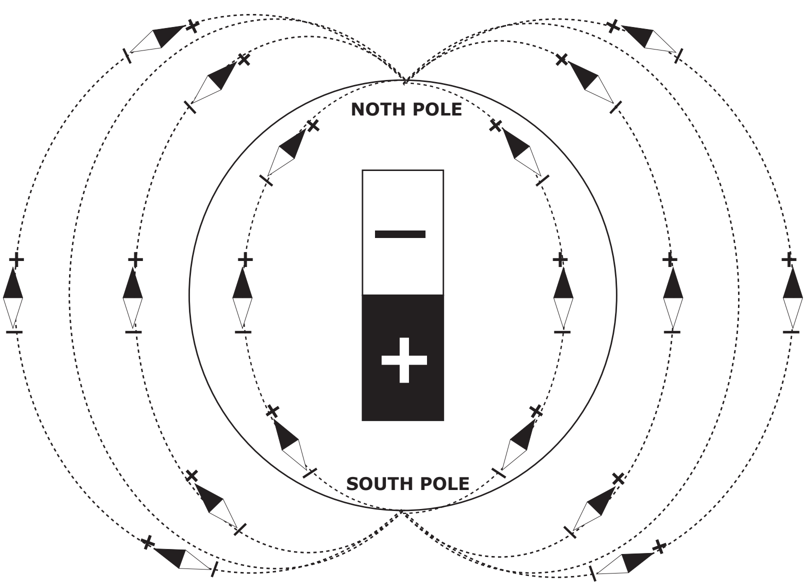


NAUTICAL CHART

The nautical chart is a graphic representation on a plane surface of a section of the earth's sea surface constructed to include known dangers and aids to navigation such as seas, coasts etc. As regards diving the most useful charts are those employed for fishing as they indicate depth, anchorage etc.

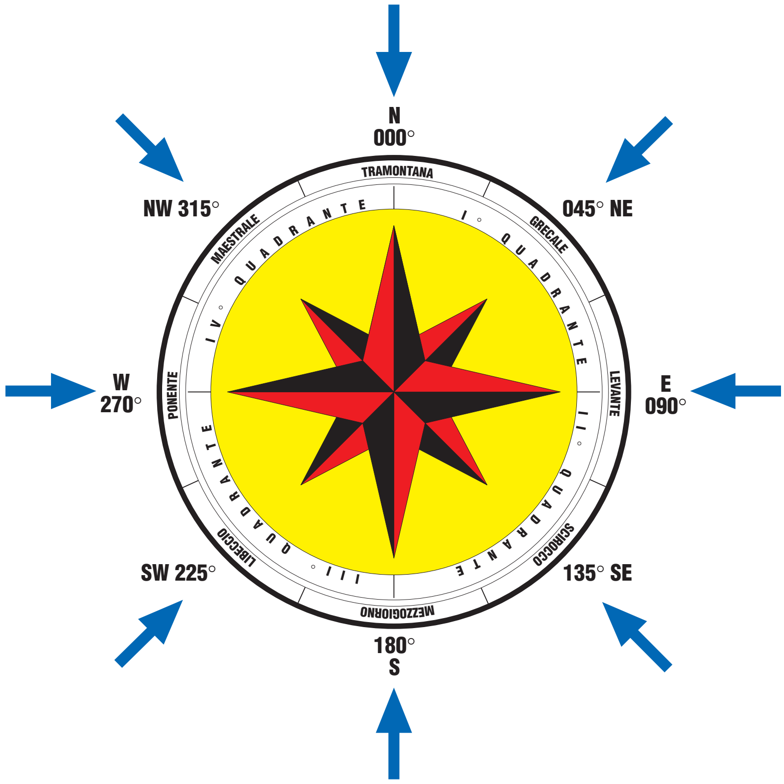
GEOMAGNETISM

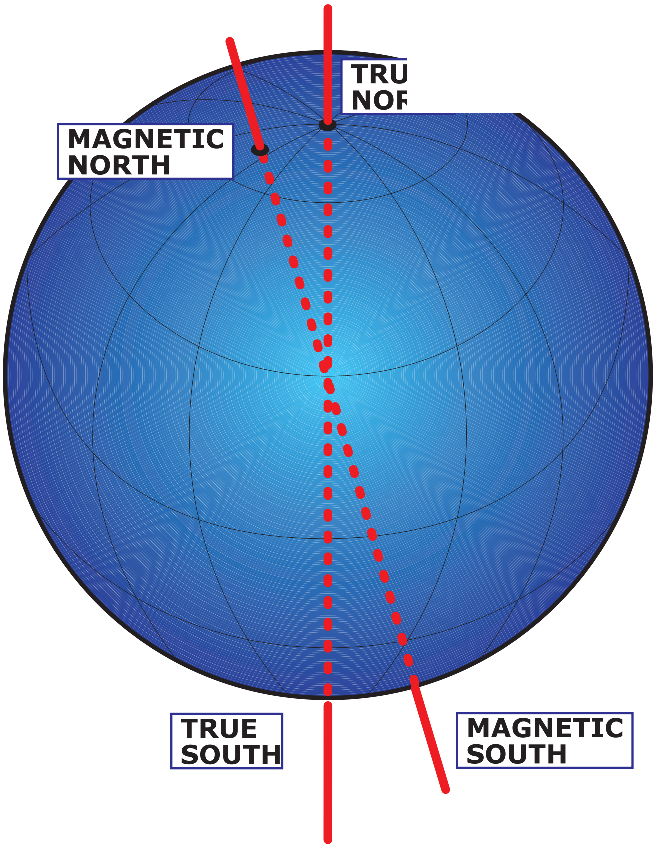
The iron masses within the earth cause it to be a place of permanent magnetism. As result the earth acts as an enormous magnet with its own poles, positive and negative, like any other magnet. From these poles radiate lines of magnetic force; from the positive pole located in the South they travel to the North thus creating around the planet a permanent magnetic field known as earth's magnetic field. If at any point of this magnetic field a magnetic needle is suspended, free to orientate itself, it follows the tangent to the force prevalent at that point. As we know that opposite poles attract each other, whereas those of the same nature repel each other, we have that the positive pole of the needle will be attracted by the magnetic north pole, whereas the negative will be attracted by the magnetic south pole.



WIND ROSE

The wind rose is a diagram which gives information about the direction and speed of the wind at a location; it is a very old division of the compass that indicates the eight main winds.





COMPASS

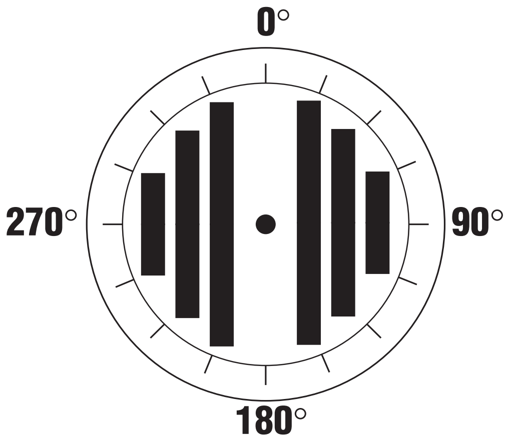
If a magnetic needle or a series of needles-to increase the magnetic force- were fixed under a plate showing the Wind Rose a compass would be obtained. The direction shown by the compass refers to the magnetic north; the angle of variation between the true north and the magnetic north is known as compass variation error. It can be negative if the magnetic north is to the right of the person looking at it, positive if the magnetic north is to the left. This angle varies according to the point on the earth's surface from which the measurement is taken and also because of the movement of the melted masses within the earth centre. However as regards diving activity, this variation is minimal because are taken in consideration only short distances, which are not influenced by the inclination of the earth.

COMPASS PARTS

The magnetic compass for diving activity is usually made up of the following parts:

COMPASS ROSE

It is a disc of nonmagnetic material marked from 0°to 360° clockwise under which are placed a series of magnetic needles.These needles are placed in such a way that the magnetic poles lay between 0°and 180°, in other words on the axis north south.



JEWEL CAP

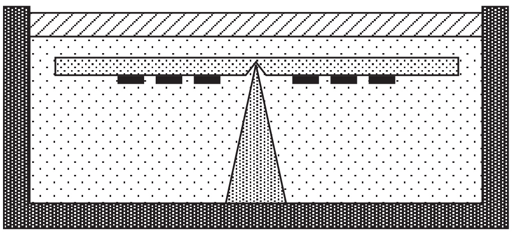
The central rose is balanced on a needle which allows the compass rose to move freely towards north, in this case the Magnetic North.

BOWL

The pivot that holds up the compass rose is contained in a case called bowl, which protects the mechanism. This case is usually filled with liquid for the rose to float in.

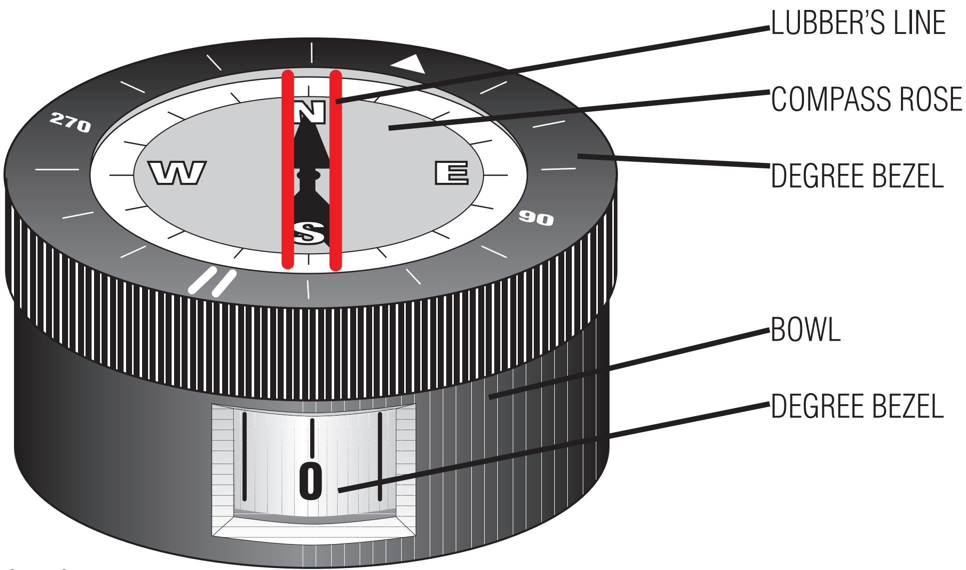
LUBBER'S LINE

Generally on the top of the case an arrow or a line is painted, known as lubber's line, it shows the course to hold during a dive.



DEGREE BEZEL

A degree bezel is fixed onto the outside of the case and is used to indicate the degrees of the route in order to assist during the return course.

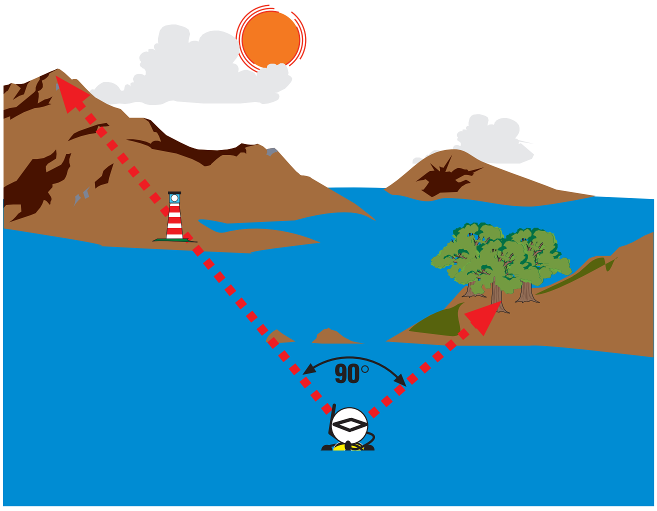


Navigation

POSITION FIX

The compass is not the only element to rely on, when we have points of reference with the right triangulation it is possible to find out one's exact position. If you don't know the dive site very well, remember, before diving, to take into account the most important features around you. This helps after the ascent to evaluate one'exact position as regards the boat or the entry point.

HOW TO CALCULATE DISTANCES



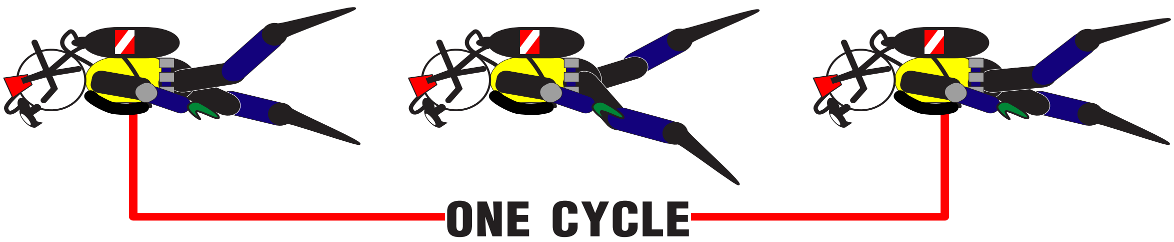
When diving to estimate the route held you can follow these two methods:

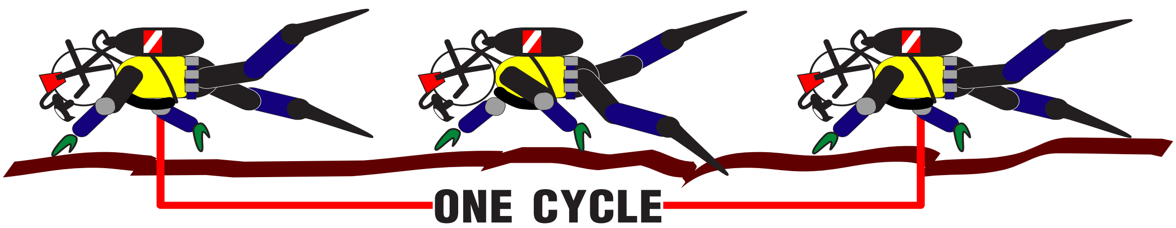
TIME RELATED

Calculating the route hold by bearing in mind the distance covered over a certain lapse of time.

FIN CYCLE

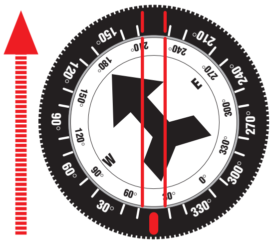
ARMS MOVEMENTS





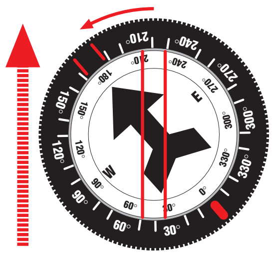
Use of the compass

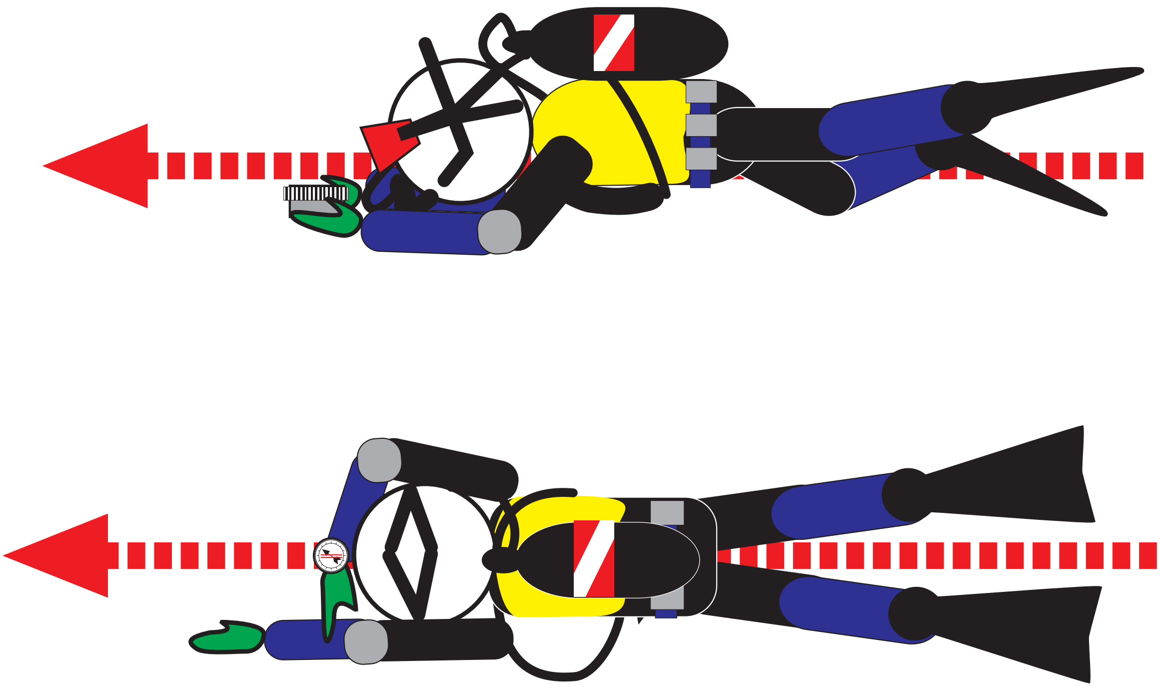
HOW TO PLOT THE COURSE
To plot a course in degrees in order to reach a certain point, the compass must point the lubber's line in the direction of the point itself, on the ring nut or on the lateral opening the corresponding degrees can be read.



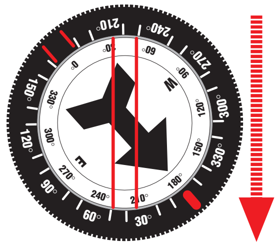
HOW TO HOLD COURSE
In order to hold the course one must:

-rotate the nut ring to match the compass rose with the north
-position correctly the arms
-hold the direction and checking that the north of the compass rose matches the indications on the ring nut





RECIPROCAL COURSE
To get back to the point of departure all one needs to do is to add or take away 180° from the previous course. Or keep the compass needle on the point of the degree bezel opposite from the outbound course.



Limited visibility dive

EQUIPMENT

MAIN LIGHT

The main light must be powerful 10/20 watts at least, and must be equipped with allogen light so as to have a white light. It is worth buying a torch with a rechargeable battery if much use is made of it. These batteries guarantee a more steady light if not as long as the other. This should be kept in mind if the following dive is performed within the following 12 hours.

BACK UP LIGHT

A second light must be carried in case the main light fails. It needn't be as strong but it must be reliable and easy to use.

PERSONAL LIGHT

To indicate divers in limited visibility small lights can be used, usually fixed to the connections of the regulator.
These lights can be chemical, usually a small stick in different colours, which has the disadvantage of not being reusable.

ELECTRIC SIGNALS

Small torches which a light similar to the chemical ones. They can be used several times as they have rechargeable batteries. Stroboscopic light: powerful flashing light usually used to mark the ascent line, the anchor or a landmark. Remember that both unused sticks and dead batteries should be thrown in special containers.

HOW TO CHOOSE A DIVE SITE

Choose your dive site carefully, dive the site in daylight first, thus avoiding or reducing the dangers caused by diving in a new place. The first night dive should be carried out in a full moon night as it helps to orientate.

PLANNING OF THE DIVE

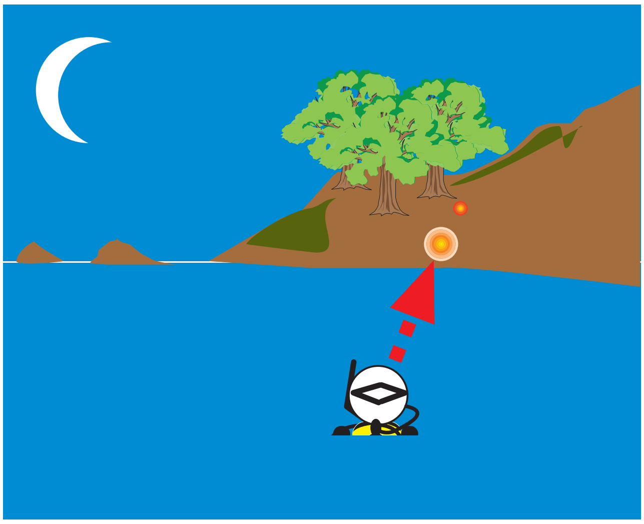
Diving in limited visibility must be carried out with no decompression limit. The standard plan for this type of dive consists in a dive of 40 minutes with a maximum depth of 15 metres. Someone must always remain on the boat or on the dive site to assist the return or help in case of emergency.

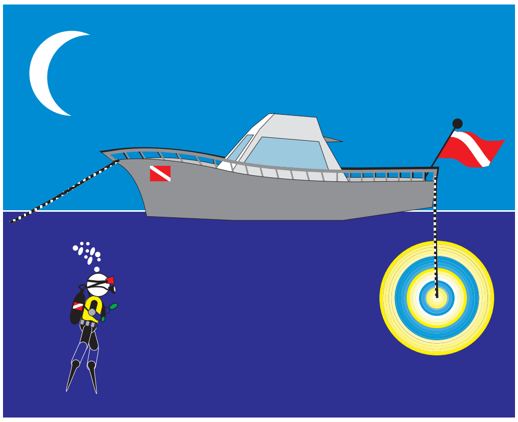
HOW TO PREPARE YOUR EQUIPMENT

Equipment must be prepared and assembled well in advance and possibly in good light.
The torches must be checked and kept at the off position to avoid accidental switching.
Checking with a buddy must be carried out after the assembly and must be repeated a little before diving.

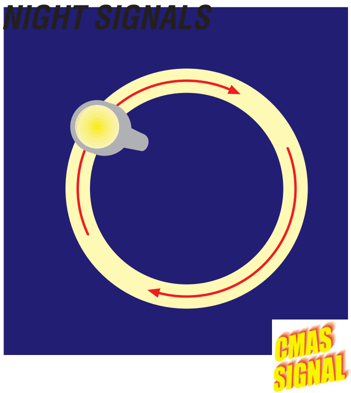
SAFETY PROCEDURES

Safety procedures for this dive don't differ much from the standard ones and are agreed on during the predive briefing by the dive leader or by his assistant. In this occasion it must be also indicated the location of the first aid kit and of the oxygen supplying kit, the way of entry and exit from the water and the buddy system. On the boat or the shore a series of lights will be placed, they help the diver to find the exit point. In case you loose sight of your buddy you must try to locate his light turning off your own. If after a minute this proves impossible you must ascend and wait for your buddy to do the same. At this point you can decide whether to continue the dive. The most common problem that you can face during a dive with limited visibility is the failure of the torch, for this reason it is always advisable to be equipped with a back up torch. If by any chance this torch fails the second torch of your buddy can be used although at this stage it is better to give up the dive. If the dive is carried out from the shore two lights must be fixed, placed at different heights to give a reference for returning and to avoid possible obstacles. When diving from a boat a stroboscopic light is fixed to the ascent line in the water at a depth where can be easily visible.

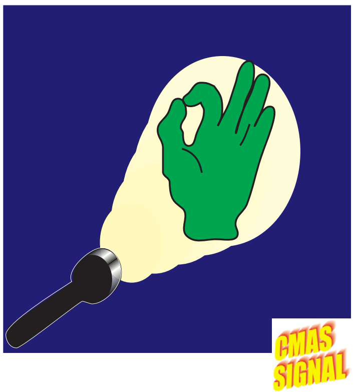




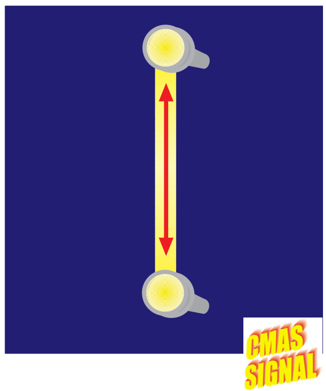
NIGHT SIGNALS



IN THE DISTANCE
Ok it's all right.- Ok is it all right?



NEARBY
Ok it is all-right. Ok is it all right?



Something is wrong. Problems ?

EQUIPMENT MAINTENANCE

This equipment needs a proper maintenance, all the torches must be cleaned carefully so that the watertight rings will not be damaged. They must be dried and greased with silicon, bearing in mind that it is not the quantity of silicon which improves the seal but the even distribution around the seal.
After use the torch should be stored away open without the batteries to avoid dampness; when replacing the bulb care must be taken not to touch it because contact with the fingers can cause damage.

Dry suits

A dry suit keeps the diver's body dry and is recommended for prolonged dives or when diving in cold water throughout the year.

The dry suit on its own can provide hardly any insulation, to keep warm in most diving conditions an undersuit must be put on. As well as protection a dry suit provides buoyancy by letting air in and out through its valves. Dry suit that is normally on the market have certain characteristics in common which are:

-water tight seal, wrists and neck seals in neoprene or latex.

-bronze dry zipper, rubber boots, outlet valve, inlet valve, neoprene hood.

MATERIAL

A dry suit can be made in a different variety of material, but all of them must be waterproof.

Let now consider the different fabrics used in the make of a dry suit.

NEOPRENE

Neoprene employed for dry suits has a thickness of 7 to 9 mm so that it can offer a good thermal insulation, it is the one generally used for ordinary dry suits. The outside is lined with thick nylon in order to help this material to acquire a certain amount of flexibility. This type of suit provides good thermal insulation but it is bulky and difficult to deal with as regards buoyancy. In fact on the surface it requires a considerable weight to compensate the positive push that neoprene causes. In depth it needs a considerable quantity of air to balance this extra weight, as the pressure has reduced the volume of neoprene very much. These suits are manufactured with rubber tape, cold vulcanised and made watertight by the wrists and neck seals in neoprene or latex.

CRASHED NEOPRENE

This type of neoprene is very similar to the previous one but as is treated differently it results in a greater thickness. Dry suits made of crashed neoprene, which stands up better to pressure, are more comfortable to use even if they have a lower degree of thermal insulation.the manufacturing is similar to the suits made in foam neoprene, in this case too the insulation is provided by wrist and neck seals in neoprene or latex.

VULCANIZED RUBBER ON FABRIC

The suits made in this material use a fabric made waterproof by a solution of latex or rubber, it is then vulcanised in autoclave thus creating one piece. This type of suit is very strong and resistant against chemicals and pollution, but it is particularly heavy.

TRILAMINATE

Trilaminate is a material made up of layers of nylon fabric alternate with layers of synthetic rubber. The use of this material makes suits particularly comfortable to wear despite a certain lack of flexibility.

The seams are made waterproof after being made up by a special banding or sealing. Wrists and neck collar seals in latex provide the watertight.

POLYURETHANE

Suits in polyurethane are made up in a fabric coated with layer of thermoplastic polyurethane, this creates a material, which is strong, flexible and resists well to pollution. The different parts are sewn and made waterproof by sealing tape or weld at radio frequency. The wrists and neck collar are manufactured in a traditional way. Dry suit in polyurethane is strong and flexible as well as soft and comfortable, it is also less heavy than those in trilaminate.

SEALS

WRISTS AND NECK IN NEOPRENE OR LATEX

These are generally in neoprene if the suit is in neoprene and in rubber or latex for the other types. Both are reliable, even if the finishing in neoprene are probably softer then those in good quality latex. Great care must be taken when is necessary to alter the tightness of latex. It should be remembered that this operation must be carried out in a qualified centre.

WATER TIGHT BRONZE ZIP

The bronze zip has been designed to protect you in the most critical situations.

This type of zip has bronze teeth and close hermetically by a pressure on the rubber. It is generally placed along the shoulders or diagonally on the chest, long enough to make putting on easy. Care must be taken not to get anything in between the teeth of the zip, if something does block the zip, it should be opened, cleared and then slowly closed again.

RUBBER BOOTS

dry suit's boots are generally made in soft rubber or in semirigid material with antislippery sole. They guarantee good thermal protection and are easy to put on. To avoid any infiltration of water they are attached to the suit.

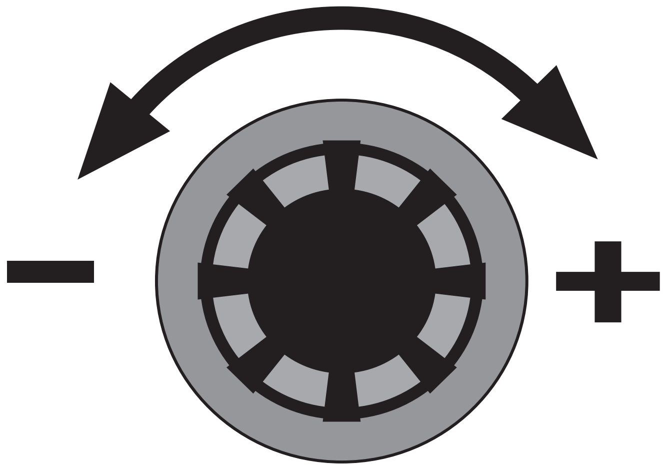
HOOD

Two are the main types of hood: wet, it is made in neoprene, often it has tiny holes in the top to allow any accumulated air to escape, and usually it is separate from the suit.

-dry, made in latex or rubber, it provides a good seal, it is attached to the suit

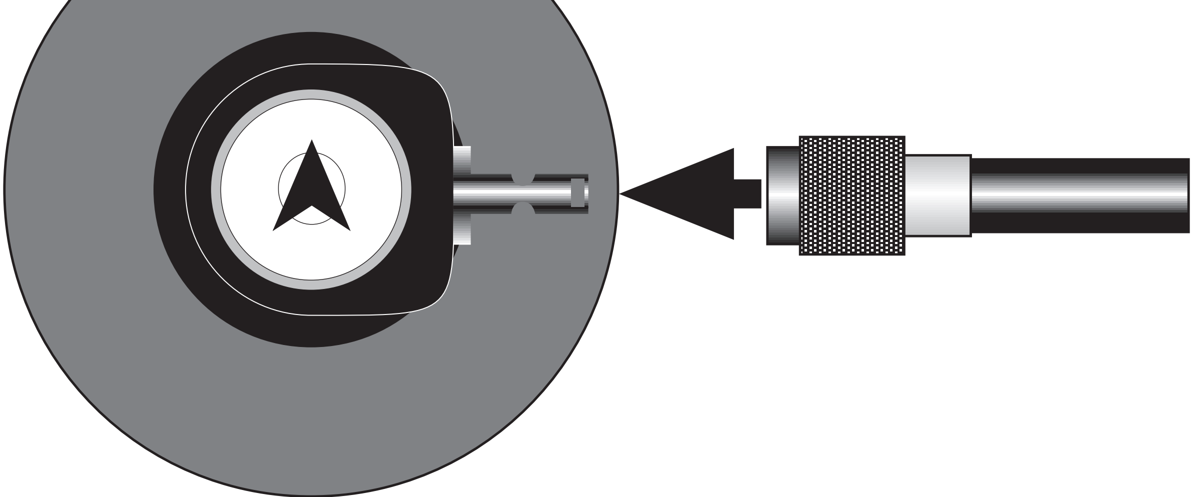
VALVES
This is a very important part of the dry suit, which helps to regulate the airflow.

OUTLET VALVE
This is normally placed high up on the left arm. Two are the types of valve:
-manual, it allows an outlet while the valve is closed internally by a spring
-automatic, it provides constant volume of air inside the suit while ascending. It can also work manually by pressing on the case, which causes a faster outlet mainly at the beginning of the descent.
Both the outlet valves must always let out more air than the amount that an accidental block of the inlet valve would let in.



INLET VALVE
This valve is usually located on the centre of the front chest of the suit; it is equipped with a male socket, which provides the connection of the quick-disconnect low-pressure hose.
Some inlet valves need a special plug for the connection as can cause infiltration of water if they are not connected to a low pressure hose.

QUICK -DISCONNECT HOSE
The quick-disconnect low-pressure hose provides connection to one of the first stage ports. In case of freezing or blocking of the inlet valve, causing a continual flow of air into the suit, the hose must be quickly disconnected.



UNDERSUIT

In order to have proper thermal protection an undersuit is necessary. Different are the undersuits on the market, the main ones are the following:

1) synthetic undersuit in polar ,it gives a certain degree of thermal protection but it is not waterproof.

2) synthetic undersuit in polar combined with a traspirant fabric, it has the same feature as above but also it allows a good transpiration of the body and provides a higher level of thermal insulation.

3) double lined thermal undersuit in special pvc foam. Made in synthetic material, it combines good thermal properties. However it doesn't offer any protection against water or wind.

4) thermal undersuit in thinsulate : as regards thermal insulation it is probably the best undersuit available; waterproof and with a good design. Thinsulate which is a transpirant material has a waterproof lining on the outside and a soft warm lining on the inside.

WHAT TO DO BEFORE DIVING

Before putting on a suit it is advisable to lubricate the cuffs and the neck seals with talcum powder. Never use perfumed talc as the oil in the perfume could cause damage. If talcum is not available use liquid soap, shampoo or hair conditioner. Before each dive the followings must always be checked:

-the zip of the suit:

If the zip is stiff it should be greased with beeswax or paraffin wax, grease or silicon spays. Never begin a dive if the teeth of the zip are damaged or not interlocking.

-the correct functioning of the low pressure inflator hose:

Connect the regulator to the cylinder and the low pressure hose to the suit valve press then the button of the inflator hose, the valve should allow the passage of air only when the button is pressed down. On old type regulators the number of low pressure ports may not be sufficient for connecting the inflator hose to the suit when other accessories are connected to the first stage. In this case is possible to use adapters, which allow connecting several low pressure hoses to a single port.

PUTTING ON A DRY SUIT

PUTTING ON A DRY SUIT UNDERSUIT

If the weather is mild it is advisable to get all the equipment ready for diving before putting on the undersuit and the dry suit to avoid overheating the body.

PUTTING ON A DRY SUIT

Some zip along the shoulder and others are zipped down the front. Each one must be put on differently. Jewels and watches must be taken off as sharp edges could damage the suit.

PUTTING ON A DRY SUIT THAT OPEN ALONG THE SHOULDER

Open the dry suit zip completely, fold the top of the suit inside out down over the outside of the suit to the waist. Sit down and put your feet into the legs of the suit. Stand up and put the suit up to your waist. Put the right arm in the right sleeve of the suit; put two fingers from your left hand into the right wrist seal. Push the seal over your right hand; cup your finger together while you push them through the seal. If your suit has latex wrist seals, adjust the seals so that they lie flat against your wrists. If your suit has neoprene wrists seals, these must be turned down and in. No undersuit must get trapped beneath the wrists seals that could create a channel for water to enter the suit. If the diver has prominent tendons on the inside of the wrists, this can create a channel for water to enter the dry suit. In this case the dry suit wrist seal must be pulled as far up as possible to avoid any water entering. The same procedure must be carried out for the left wrist seal.

The neck seal must be grabbed by putting both hands through the outside opening and spread the neck seal by pulling against it with the palms of the hands. Spread the neck seal and turn your head slightly to the side. Pull the neck seal over your head as you hold it open, pull down on the seal while pushing up with your head.

DRY SUITS OPENING DOWN THE FRONT
Open the zip completely, remember that if it is not open completely the suit can be easily damaged, and put it on as described above.

GETTING RID OF EXCESSIVE AIR
After zipping up a certain amount of air gets caught in the suit and makes movements difficult. Fold the arms over the chest press the outlet valve to expel the air manually or staying in the same position, open carefully the neck band.

PUTTING ON CYLINDERS
To avoid damaging the cuffs and neck of the suit it is advisable to ask a friend to help in putting on the cylinders. Those must be equipped with a b.c., which allows floating on surface and helps to achieve the right buoyancy during a dive.
Low pressure hose of the inlet valve must pass under the arm without causing difficulties to the movements.
Make sure that it is not twisted. After connecting it check it's functioning by pressing the button, air should then flow freely through the valve. A small valve next to the connector prevents air escaping when the valve is not connected to the suit.

ENTERING THE WATER

Before diving vent any air trapped in the suit. Entering the water from the boat or from the shore with no waves, b.c. should contain enough air to allow positive buoyancy at surface level. Entering water through waves it is advisable not to have air in your b.c. thus allowing a dive through the waves easier. Diving from a large boat make sure that the outlet valve is completely open.

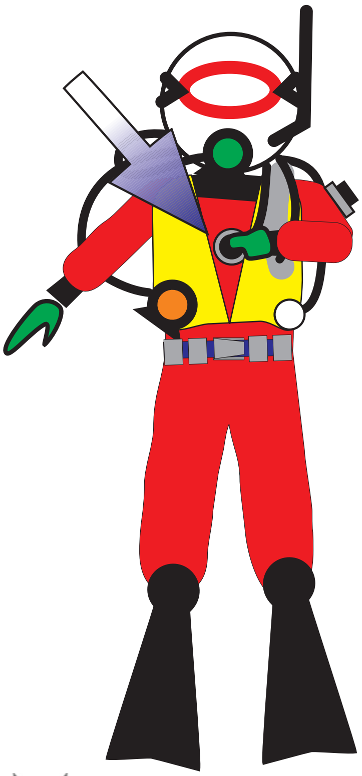
BUOYANCY CONTROL

Before entering the water it is advisable to regulate the weight bearing in mind that fresh water and sea water require different weights. In order to choose the right weight and to verify the right buoyancy it is advisable to dive in sheltered water wearing all the equipment.
The weights are chosen according to the build of the diver, the type of dry suit, the undersuit worn and the size of the cylinder. After diving with all the equipment one must get rid of air in the b.c. if the diver begins to sink when there is still air in the b.c. and in the dry suit, the weights are too heavy and therefore they must be lightened.
If the diver doesn't sink after having let the air out from the b.c. he can take the following step that is to get rid of all the air in the dry suit. Check that the valve in the suit is turned completely counterclockwise "-" then lift the left elbow above the shoulder level. Water pressure in the lower part of the suit will force air upward through the suit causing it to be forced out the valve. With the lungs full of air the diver floats with the eyes at water level breathing out completely, he should begin to sink slowly.
If this doesn't happen weight should be added or taken away.

In any case to carry out a decompression stop at the end of the dive other weights should be added in order to compensate any possible change in the buoyancy due to the of cylinder used. Sometimes 0.300 to 1 kg weight can be added at the ankle in order to help the diver to keep the right buoyancy during a dive. It should be remembered that any change in equipment or cylinder will cause a change in buoyancy and therefore must always be checked before each dive.

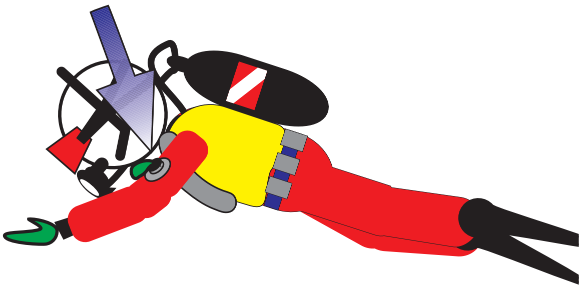
HOW TO BEGIN A DIVE
Before diving make sure that the outlet valve is completely opened by turning it in full counterclockwise
"-". To begin the dive free the air from the bc and lift the left elbow to allow the valve to empty the suit. Even if it is difficult to see the outlet valve, the diver should begin to feel the bubbles of air passing through the valve.

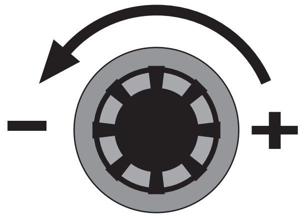
HOW TO DESCEND
To check the speed of descent, with the left arm along his side, the diver must open the valve a little clockwise ***"+"*** paying attention not to close it completely because with this valve closed it would not be possible to get rid of air from the suit in case of emergency. When diving in ice water add air to the dry suit by pressing on the button of the inlet valve placed on the chest with short bursts of pressure rather than long or continuous ones. This will help to avoid the freezing up of the valve and also helps to control the buoyancy. The volume of air must be sufficient to stop the compression in the suit causing pain. To get the air to the feet the diver must stay in horizontal position, parallel to the surface bearing in mind that a vertical position will cause the air to move up to the chest again. Once reached the depth
And re-established neutral buoyancy using the valves of the suit, the dive can be carried on.



BUOYANCY CONTROL

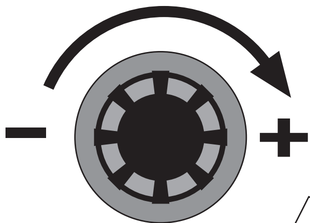
At any variation of depth in order to achieve neutral buoyancy the inlet valve must be used to let air in or out by lifting the left arm. If the suit is equipped with a manual valve this must be worked manually. When carrying out difficult dives to avoid collecting too much air inside the suit, buoyancy can be controlled by using the B.C.. This procedure must be carried out with great care because the buoyancy is obtained by letting air into the suit and the b.c. which work independently, and therefore are more difficult to control especially during the ascent.





HOW TO ASCEND

Before beginning the ascent, turn completely the outlet valve counterclockwise ***"-",*** then begin to ascend slowly and carefully. At this point the air inside the suit will begin to expand, to help get rid of the air lift the left elbow above the shoulder so that the valve is well up. Lifting the arm up and down the speed of the ascent can be controlled. This must never be faster than the speed indicated on the dive computer or on the decompression tables.



ON THE SURFACE

As soon as the surface is reached inflate the bc in order to swim and reach the boat; the outlet valve has to be turned clockwise ***"+"***.

EMERGENCY PROCEDURES

HOW TO RECOVER FROM AN INVERTED POSITION

Whenever you turn upside down in your dry suit, the air inside the suit gets to your feet. To recover to up-right draw the knees up to the chest and flip over into a normal position. In case of rapid descent the diver must swim strongly towards the bottom to help reduce the positive force of expanding air. Once reached the required depth the diver must raise the legs to the chest and get into a vertical position. After this maneuver the outlet valve must be used to set the neutral buoyancy again.

WHAT TO DO WHEN THE INLET VALVE JAMS

If the dry suit is not well maintained the inflator valve could jam in the open position thus filling the suit with air, in this case immediately disconnect the inflator hose from the suit and vent the air in the suit through the outlet valve.

WHAT TO DO WHEN THE INLET VALVE DOESN'T OPERATE

If during the descent the air does not fill in the suit and the hose is connected to the valve the dive must be ended and the diver must return to the surface using the b.c. to check buoyancy and speed of ascent.

WHAT TO DO WHEN THE OULET VALVE LEAKS

End the dive and return to the surface controlling buoyancy and speed with the help of b.c. if the outlet valve leaks the dry suit is unable to hold air. There is also a risk of water infiltrating into the suit through the valve.

WHAT TO DO WHEN THE OUTLET VALVE DOESN'T VENT

If the outlet valve jams in a closed position it cannot vent air from the suit and there is risk of a diver having an uncontrolled ascent. To avoid this cuffs or the neck collar must be opened to let out the air until the right buoyancy is achieved. Remember that this operation lets water into the suit and wets the undersuit.

WHAT TO DO WHEN THE DRY SUIT FLOODS

If the zip breaks or any other part is seriously damaged the dry suit can flood. In this case use the b.c. to correct the buoyancy, end the dive and begin a controlled ascent, trying to keep the part with the leak as low as possible to avoid more loss of air. If there is a considerable amount of water in the suit it could be difficult to obtain neutral buoyancy with only the help of b.c.; in this case you can get rid of weights.
Remember that in this particular case great care must be taken over the speed of ascent.

DRY SUIT MAINTENANCE

Proper maintenance of your dry suit is very important. Without this the suit may not work properly. After each day of diving the suit must be rinsed with clean fresh water together with the zip and valves. Any evaporation inside the suit must be dried out. After this operation the suit must be hung up by the boots out of the sun. Before storage talcum powder must be applied to the latex seals and watertight zip must be greased with a special product.

Diving at altitude

Physic and Physiology

A dive performed at an altitude higher than 700 metres above sea level is known as altitude diving. If we intend to carry it out a particular planning is required, as ambient pressure as well as the gases partial pressures composing the air are different. Given that atmospheric pressure decreases of about 100 millibar every 1,000 metres within the first 5,000 metres, the human body undergoes a condition of hypersaturation.

To acclimate to a different pressure at a certain level our body requires at least 48 hours. By doing this all the tissues of the body become hypersaturated slow as well as fast ones which are those involved in recreational diving.

The main theoretical principals we refer to for calculation of times and decompression in altitude diving are the same than those employed for diving at sea level. As are the same saturation and desaturation curve as well as tissue periods. What makes the difference between altitude diving and diving performed at sea level is that in the former atmospheric pressure is always less than 1 atmosphere thus causing the formation of bubbles.

In order to plan an altitude diving we must refer to standard tables, bearing in mind the ratio between diving pressure and the pressure at the end of a dive. This can be achieved by considering the followings:

-Time spent at the altitude of the dive site before diving

-Diving site altitude

-Planned diving depth

-Planned diving duration

S.L. mt	P Bar	Coeff.
0	1,000	1,0
100	0,988	1,0
200	0,976	1,0
300	0,964	1,0
400	0,952	1,0
500	0,940	1,0
600	0,928	1,0
700	0,918	1,1
800	0,907	1,1
900	0,897	1,1
1000	0,886	1,1
1100	0,877	1,1
1200	0,865	1,1
1300	0,855	1,1
1400	0,844	1,2
1500	0,834	1,2
1600	0,823	1,2
1700	0,813	1,2
1800	0,802	1,2
1900	0,792	1,3
2000	0,782	1,3
2100	0,773	1,3
2200	0,764	1,3
2300	0,755	1,3
2400	0,746	1,3
2500	0,736	1,3
2600	0,727	1,4
2700	0,718	1,4
2800	0,709	1,4
2900	0,700	1,4
3000	0,690	1,4
3100	0,681	1,5
3200	0,672	1,5
3300	0,664	1,5
3400	0,656	1,5
3500	0,648	1,5
3600	0,640	1,6
3700	0,632	1,6
3800	0,625	1,6
3900	0,617	1,6
4000	0,609	1,7

Planning an altitude dive

AFTER A 48-HOUR STOP

If we want to plan a dive at 2,000 metres after a stop of 48 hours at a certain altitude we have to consider:

Altitude	*2,000*	*metres*
Planned depth (Pp)	*30*	*metres*
Planned time	*25*	*minutes*

Referring to the tables atmosphere pressure at 2,000 metres is 0.782 atm ***(H)***.

Now is possible to calculate the ratio between the pressure at sea level ***(H_0)*** and the barometric pressure of the diving site ***(H)***, called Pressure Drop Coefficient ***PDC*** and its opposite called Theoretical Depth Coefficient ***TDC***

$$TDC = \frac{H}{H_0} \qquad PDC = \frac{H_0}{H}$$

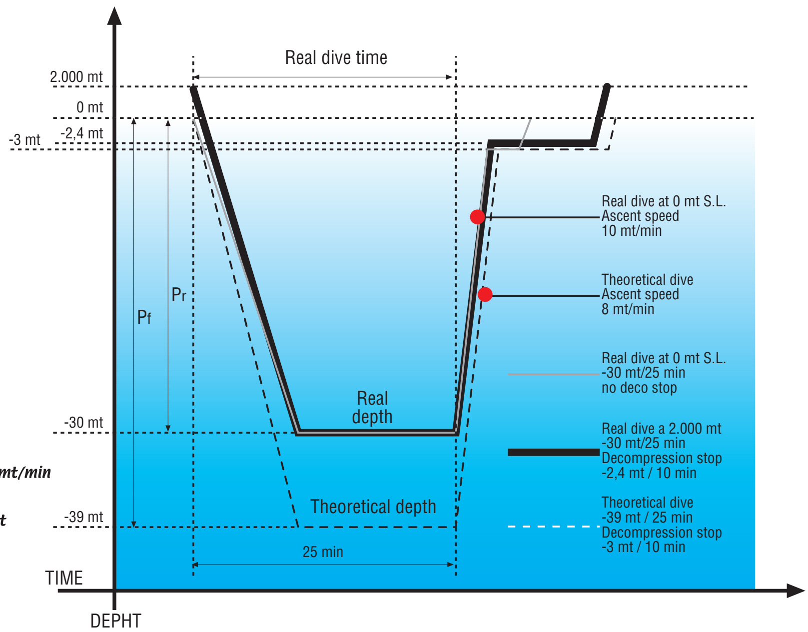
This calculation adjusts the data of the planned altitude dive into a dive carried out at sea level using the standard tables.
To do this the depth known as Theoretical Depth ***(T_d)*** must be calculated, it must have the same ratio as the pressure that a diver undergoes during a dive and the ambient pressure of the dive site.

$$T_d = P_d \times PDC = 30 \times 1{,}27 = 38{,}1$$

Therefore to calculate the decompression data of a dive planned at 30 metres of depth ***(P_d)*** in a site located at a high of 2,000, on the table we must refer to the figure of a dive performed at 38.1 metres rounding it off to 39 for the same duration.
This results in a dive at 39 metres for 25 minutes which means as indicated on the table a decompression stop at 3 metres for 10 minutes. Both the ascent speed and the depth of the decompression must be adjusted using the Theoretical Depth Coefficient. After having ascended at a speed not above 8 metres a minute, a 10 minutes stop must be carried out.

$$\text{Asc. Speed} = 10_{mt/min} \times TDC = 7{,}82_{mt/min}$$

$$1^{\circ}\ \text{stop} = 3_{mt} \times TDC = 2{,}34_{mt}$$



ARRIVAL AT ALTITUDE

Usually altitude dives are performed after moving up to a higher level in a short length of time, therefore as the human body is already hypersaturated the dive can be considered a subsequent dive where PDC is the dive letter of a diving performed at sea level.

With the use of the table ***PDC*** indicates the figure to which round up the actual duration of the dive, referring to the actual planned depth, known as Corresponding Depth ***(C_a)***. The latter must not be confused with the theoretical one, which is generally less than the real depth of a dive.

Therefore if we want to plan a dive at 2,000 after a short stop the procedure is as follows:

Altitude	*2,000*	*metres*
Planned depth (Pp)	*30*	*metres*
Planned time	*25*	*minutes*

$$PDC = \frac{H_o}{H} = \frac{1}{0{,}782} = 1{,}27$$

The real pressure ***(H_a)*** which the diver undergoes at this altitude when is at 30 metres of depth, is given by this formula:

$$H_a = H_i + H = 3\,Atm + 0{,}782\,Atm = 3.7\,Atm$$

In which the pressure we have at 30 metres ***(H_i)***, is added to the atmosphere pressure of the dive site ***(H)***. The Corresponding Depth ***(C_d)*** is the depth where the absolute pressure is 3.7 atm.

$$C_d = 3.7\,Atm = 27\,mt.$$

Now we must correlate on the table ***PDC*** and the Corresponding Depth ***(C_d)***, this will result in 20 minutes of penalisation.

Therefore we should carry out a 45 minute diving, 25 are actual, 20 due to the penalisation consequent to the theoretical depth of 39 metres.

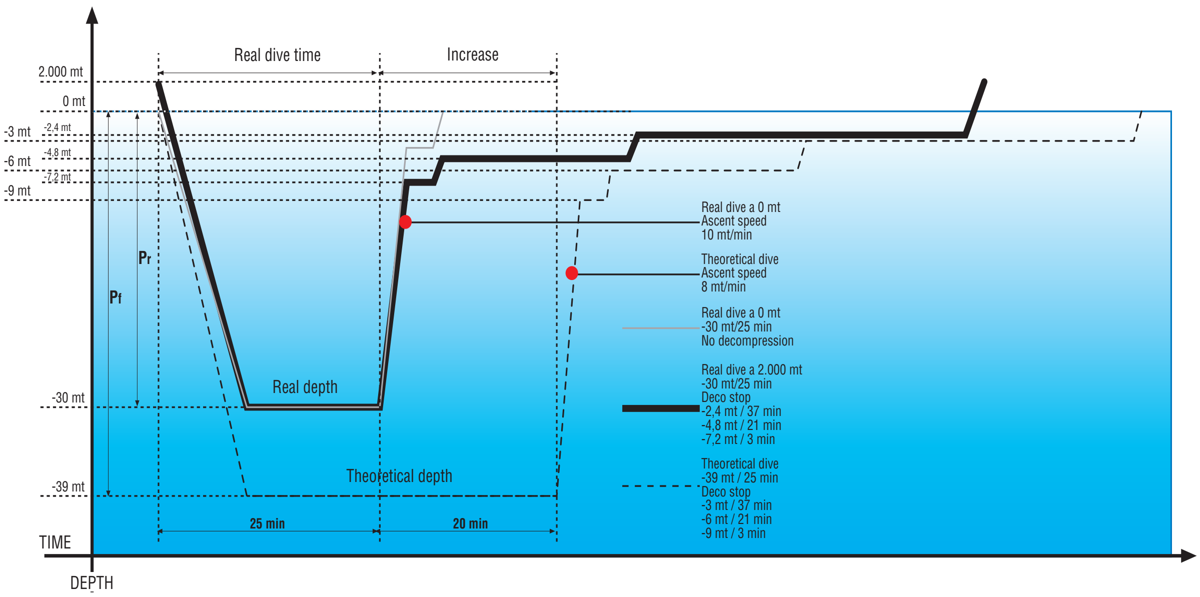
MT	ADJUSTEMENT COEFFICIENT								
	1,9	1,8	1,7	1,6	1,5	1,4	1,3	1,2	1,1
12	213	161	138	101	87	61	49	25	17
15	142	111	99	76	66	47	[illegible]	21	13
18	107	88	79	61	52	36	[illegible]	17	11
21	87	72	64	50	43	31	26	15	9
24	73	61	54	43	38	28	[illegible]	13	8
27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20	11	7
30	57	48	43	34	30	22	18	10	7
33	51	42	38	31	27	20	16	10	6
36	46	39	35	28	25	18	15	9	6
39	40	35	31	25	22	16	13	8	6
	MINUTES OF PENALIZATION								

If we refer to decompression tables decompression stops can be calculated as follows:

3 minutes at 9 metres
21 minutes at 6 metres
37 minutes at 3 metres

Applying the Theoretical Depth Coefficient we have:

3 minutes at 7.2 metres
21 minutes at-4.8 metres
37 minutes at 2.4 metres



ALTITUDE DIVING EQUIPMENT

Besides the diagphram depth gauge, a water column depth gauge is also useful. Even though not very precise, when diving in altitude it helps to indicate the theoretical depth, thus avoiding to calculate both the speed of ascent and the depth at which must be carried out the decompression stop. It is sufficient to follow the indications of the water column depth gauge, stopping at the usual level (-9,-6,-3). This is made possible by the air contained in the Bourdon gauge which at the beginning of the dive is at ambient pressure therefore the depth gauge record the difference between ambient and absolute pressure. When you carry out this type of dive, dive computers can be very useful as are now equipped with programs for altitude diving.
They are reliable and eliminate unnecessary calculation; nonetheless one should never underestimate the potential risks of performing an altitude dive.

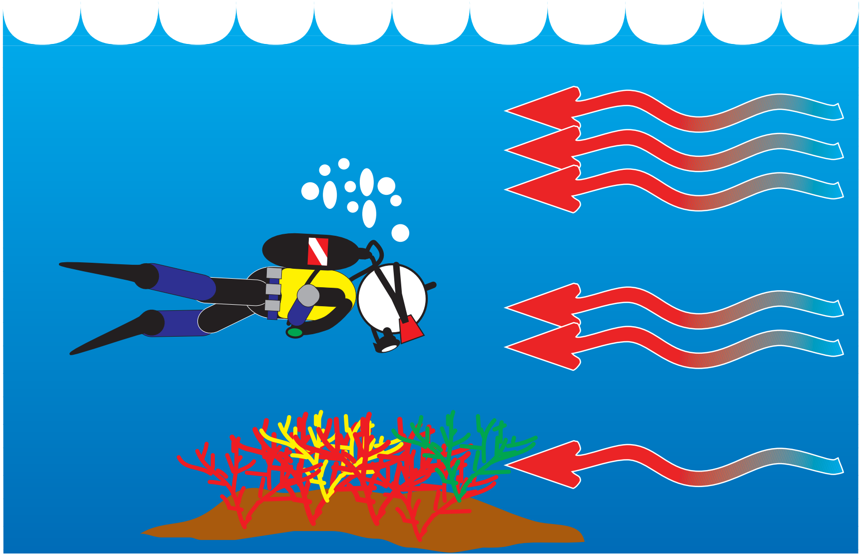
MT	ADJUSTEMENT COEFFICIENT								
	1,9	1,8	1,7	1,6	1,5	1,4	1,3	1,2	1,1
12	213	161	138	101	87	61	49	25	17
15	142	111	99	76	66	47	38	21	13
18	107	88	79	61	52	36	30	17	11
21	87	72	64	50	43	31	26	15	9
24	73	61	54	43	38	28	23	13	8
27	64	53	47	38	33	24	20	11	7
30	57	48	43	34	30	22	18	10	7
33	51	42	38	31	27	20	16	10	6
36	46	39	35	28	25	18	15	9	6
39	40	35	31	25	22	16	13	8	6
	MINUTES OF PENALIZATION								

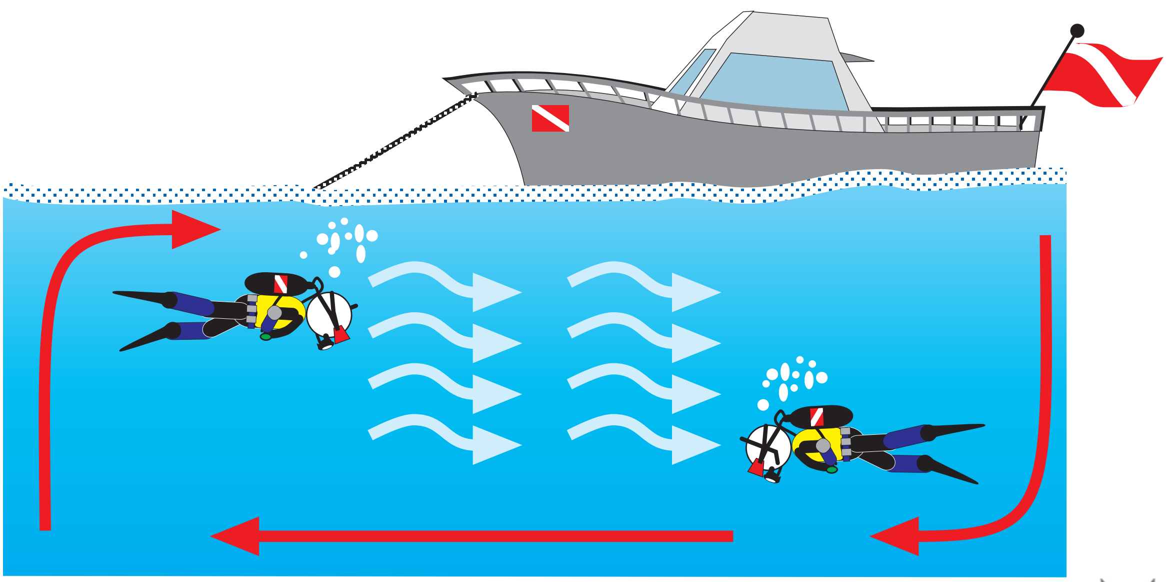
Diving in current

Dives in current is particularly interesting because currents carry out with them an enormous quantity of microscopic living creatures. This type of dive even though it doesn't require specific equipment, needs a careful planning.

HOW TO DIVE IN CURRENT

Diving in current can be either dives starting and returning to the same point or dives starting and returning to a different point. In the first case the problem of having to face part of a dive against the current must be considered, with consequent increase in the effort needed and a major consumption of air .Correct planning must consider the first part of the dive against the current in such a way when the first diver of the group signal that he has reached 100 atm, the return will begin and the ascent in a favourable current will take place with a greater safety.The second type take place when the dive is carried out from a boat which during the dive can be positioned for the ascent, thus avoiding the problem of air consumption. In this case it is useful to have at hand a signalling buoy that can be placed in position before the dive to signal the exact exit point. If by any chance the buoy is not visible from the boat the crew can be alerted by using a whistle. Remember that with the current, swimming near a shelf or near the bottom means that the current is not so strong. In case of taking advantage of current, care must be taken to avoid hitting obstacles thus avoiding personal damage and harm to marine environment.

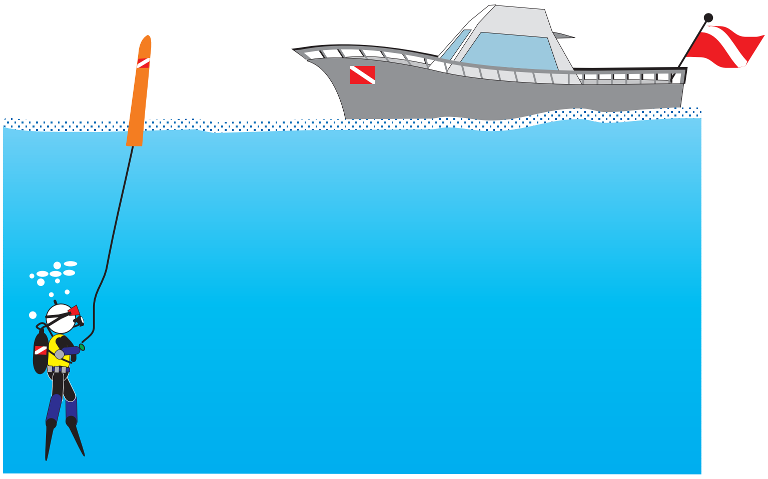


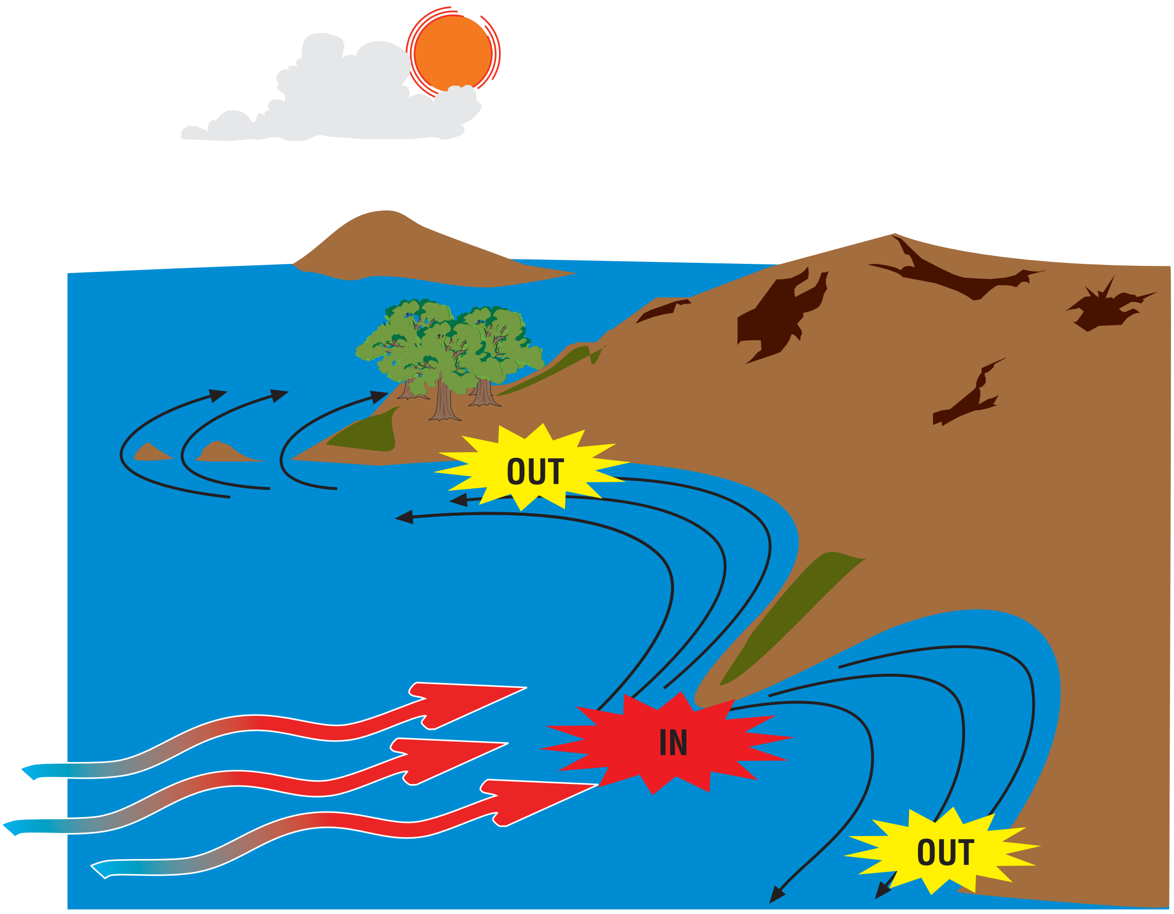


SAFETY PROCEDURES

Before starting a dive it is very important to verify the same procedure for all participants. In case of loosing contact with the dive leader or dive buddy the dive must end.

The ascent begins in the respect of eventual decompression stops and maximum speed of 10 mt/min. On the surface after inflating the B.C. the divers regroups and according to the briefing instruction either go back to the starting point using the favourable current or call the boat crew concluding
the dive.





Dives in fresh water and /or very cold water

LAKE AND RIVER

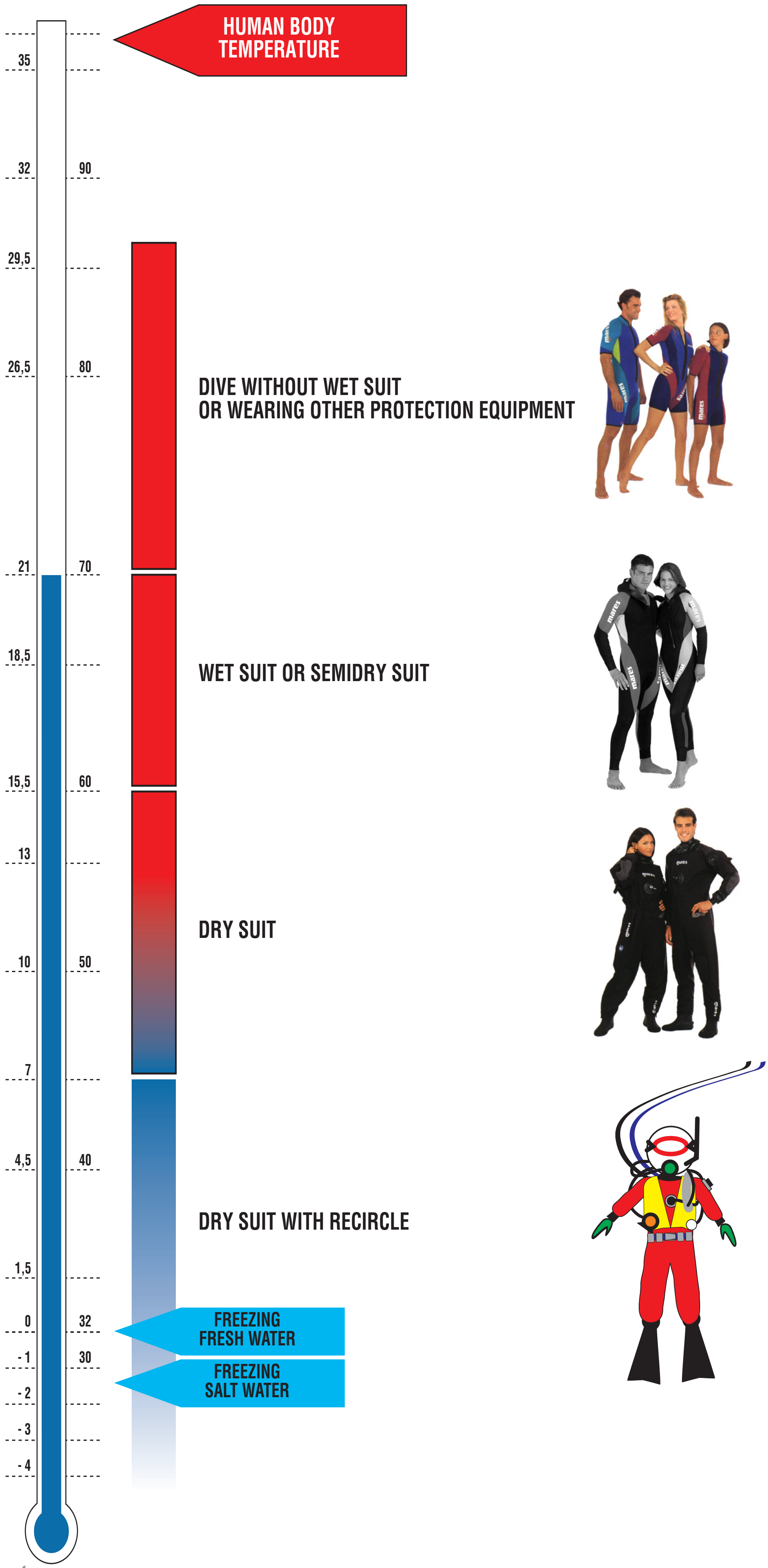
The technique to use for diving in fresh water doesn't differ very much from the one used for diving in sea-water. However in natural and artificial lakes, rivers and alpine lakes, where the difficulties are due to cold temperature, low visibility, and several other factors require a specific planning.
In lakes and rivers it is easy to meet rising and falling currents of great force. For these reasons the planning, buddy system and the use of special equipment, are essential parts to assure a correct and safe dive. The equipment is not any different from those normally used. Care must be taken when fixing the hoses and other parts so that they avoid getting trapped during the dive.

DIVING IN WINTER

The difference that one finds in a winter dive compared with those performed in summer is the temperature both of water and air. The water changes its temperature according to the depth but at 30 metres and below it remains constant. Leaving the water, low air temperature tends to increase the hypothermia already worsen by the temperature of the water. For this reason it is advisable to dive close to a sheltered place preferably heated so that wet cold diving suits can be changed for dry warm clothes. A proper alimentation, helps to protect the body against the cold, food should be taken some hours before a dive in cold water giving the body time to metabolise. Particular care must be taken with equipment which has to be the right one and perfectly maintained. A good quality dry suit in neoprene or other material complete with hood and gloves and a proper undersuit give protection in water over short or medium periods. Winter dives in extreme cold water need the use of a regulator in perfect condition, with an ant-ice protection of the first stage. If a regulator without this protection is used, certain problems could occur. Air getting frozen in the first stage causes ice inside the mechanism thus creating difficulties for the passage of air. If the regulator gets wet and covered with ice, care must be taken not to break away this ice because this action can damage the rubber parts of the regulator. At the end of the dive all the equipment should always be carefully dried and stored away.

SAFETY PROCEDURES

During the briefing the instructor or his assistant as well as discussing safety procedures must be certain that every diver is able to recognize symptom of hypothermia. In any case it is advisable not to exceed time and depth as low temperature brings about higher air consumption thus causing an increase in the nitrogen absorption and a higher level of tiredness.


HUMAN BODY TEMPERATURE
35
32
90
29,5
26,5
80
DIVE WITHOUT WET SUIT
OR WEARING OTHER PROTECTION EQUIPMENT
21
70
18,5
WET SUIT OR SEMIDRY SUIT
15,5
60
13
DRY SUIT
10
50
7
4,5
40
DRY SUIT WITH RECIRCLE
1,5
0
32
FREEZING FRESH WATER
- 1
30
FREEZING SALT WATER
- 2
- 3
- 4

REGISTRATION FORM

CMAS

WORLD UNDERWATER FEDERATION

Student

Name - Surname

Born date

Address

State Zip

Note

Instructor

Name - Surname Certification N°

2 STARS CMAS PROGRAM

SKILL UPDATE

CMAS
WORLD UNDERWATER FEDERATION

Student

Name - Surname

Born date

Address

State Zip

Note

Instructor

Name - Surname Certification N°

CMAS

SKILL UPDATE PROGRAM

	STUDENT			INSTRUCTOR		
	☹	😐	☺	☹	😐	☺
Preparation and assembly of scuba diving equipment						
TANK						
B.C.D.						
REGULATOR						
Putting on the scuba equipment						
DRESSING ORDER						
PUTTING ON EQUIPMENT WHILE STANDING						
PUTTING ON EQUIPMENT WHILE SITTING						
PUTTING ON THE EQUIPMENT IN WATER						
Entering and coming out of the water						
FROM A SHORE						
FROM AN INFLATABLE						
FROM A BOAT						
In water						
CONTROL OF THE BUOYANCY						
BREATHING WITH THE REGULATOR						
EMPTYING THE MASK						
STARTING THE DIVE						
FINNING UNDERWATER						
REGULATOR RECOVER						
BUOYANCY CONTROL						
SIGNALS						
ASCENDING						
Safety procedures						
ASCENDING						
BUDDY BREATHING						
ALTERNATIVE AIR SOURCE ASCENT						
EMERGENCY ASCENT USING THE FINS AND B.C.D.						
IN WATER WEIGHT BELT DRESSING						
Procedure di risalita						
RISALITA CON RESPIRAZIONE IN COPPIA ALTERNATA						
RISALITA IN COPPIA CON FONTE D'ARIA ALTERNATIVA						
RISALITA IN EMERGENZA PINNEGGIANDO						
RISALITA IN EMERGENZA IN ASSETTO POSITIVO						
MANOVRE CON LA CINTURA DI ZAVORRA IN ACQUA						
In water						
IN WATER DRESSING						
EQUIPMENT CHANGE						
GETTING OUT OF WATER						
MAINTENANCE OF THE EQUIPMENT						

Summary P1

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