IDU · OPEN WATER DIVER

Open Water Diver

IDU training manual · Supervised Diver · Open Water Diver

Authors: Vladimir Polyakov, Tatyana Chernova

International Divers Union · idu-global.com · 2026

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Answer key

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CHAPTER 1

Introduction. IDU. Course Programme

History of diving, the IDU association, certification levels and limits, the course programme, signals.

1.1 The underwater world and the history of diving

The underwater world is a hydrocosmos: weightlessness, extraordinary creatures and an ocean of new experiences. The ocean covers about 70% of the planet's surface, and people have long tried to explore it — first for food, then for shells and pearls, for military purposes, for salvaging cargo from wrecks and for servicing ships and harbour structures. This is how commercial diving developed, but until the mid-20th century all diving was purely utilitarian.



The underwater world — a hydrocosmos

Everything changed in 1943, when Jacques-Yves Cousteau and engineer Émile Gagnan created the **Aqua-Lung** — a self-contained breathing apparatus with a demand regulator. Simple, affordable equipment and Cousteau's educational work gave birth to diving as a leisure activity. Today dozens of certification agencies and tens of thousands of instructors operate worldwide, and equipment rental, dive centres and liveaboard fleets have made diving accessible to everyone.

1.2 The IDU association

International Divers Union (IDU) was founded in 2018. IDU training programmes and standards are based on many years of experience and on international ISO standards; their main principle is safety.

The association's aims: to unite recreational and professional divers who regard safety as the most important principle of diving; to promote diving; to develop and implement training standards; to take part in underwater archaeology, biology and ecosystem-protection research; to search for historically significant wrecks and new dive sites.

IDU principles:

- Quality training is the foundation of safe diving.
- Safety comes with experience.
- Experience comes from regular practice.
- Knowledge and understanding provide the greatest dive safety.

1.3 Certification levels and limits

Certification	Age	Max depth	How they dive
Supervised Diver IDU	from 10 (Junior under 14)	12 m	only under the supervision of an IDU professional
Open Water Diver IDU	18+; from 10 with written parental consent	18 m	independently with a buddy or in a group, no-decompression dives
Junior Open Water Diver IDU	10–14	12 m	as above; at 14 the certification automatically becomes OWD

Dives are made in conditions equal to or better than those in which training took place. If conditions differ significantly (cold water, currents, poor visibility), a briefing from an IDU instructor is mandatory; best practice is an orientation dive with a professional. Dives are made only with adequate surface support: first aid kit, oxygen, a support vessel where needed, and a Divemaster-level professional or higher.

1.4 Course programme

Theory. Without knowledge it is impossible to understand what happens to the diver and the equipment underwater. You will study physics, physiology, equipment, the environment, dive planning and first aid.

Skill development has four stages: on land (the correct sequence of actions) → on the surface → in confined water → in open water. Well-practised skills make dives comfortable, automatic skills save lives in emergencies, and without regular practice skills are lost.

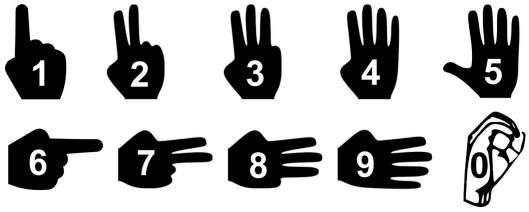
Confined water — a swimming pool of suitable depth or a body of water offering similar conditions of visibility, depth, water movement and access. Here you master your equipment and all basic skills without unnecessary stress (depth up to 5 m).

Open water — a body of water offering conditions typical of natural waters in the region. Open-water training dives are conducted to a maximum of 18 m (Junior — 12 m) and give you the experience needed for independent diving.

1.5 Underwater communication



Basic signals: down, up, OK, stop, hold, problem



Gas pressure numbers with one hand

Divers communicate with hand signals. The safest system is one in which all or nearly all signals are given with one hand, leaving the other free. Basic signals: "down", "up", "OK", "stop", "hold/wait", "problem", "how much gas?" and pressure numbers. Your instructor will show you additional signals and regional variations.

1.6 Psychological preparation

The underwater environment does not forgive mistakes. IDU training is built on gradual adaptation — from simple to complex. Practising skills in calm conditions under an experienced instructor builds self-confidence and psychological resilience in stressful situations.

Knowledge check

1. Maximum depth for an IDU Open Water Diver:

a. 12 m
b. 18 m
c. 20 m
d. 30 m

2. Depth limit for a Junior Open Water Diver IDU (age 10–14):

a. 12 m
b. 14 m
c. 18 m
d. 21 m

3. A Supervised Diver IDU may dive:

a. Independently with a buddy to 18 m
b. Only under the supervision of a professional, to 12 m
c. With a buddy to 12 m
d. Only in a pool

4. The correct order of skill development:

a. Confined water → land → open water
b. Land → surface → confined water → open water
c. Open water → confined water
d. Surface → open water → confined water

5. "Confined water" is:

a. Any freshwater body

b. A pool or a body of water with similar conditions of visibility, depth, water movement and access

c. A current-free body of water deeper than 18 m

d. A fenced sea area

6. You plan a dive in conditions very different from your training. You should:

a. Dive with extra gas

b. Get an instructor briefing, ideally make an orientation dive with a professional

c. Never dive there

d. Dive to only half your maximum depth

7. The Aqua-Lung that launched recreational diving was created in 1943 by:

a. Torricelli and Pascal

b. Jacques-Yves Cousteau and Émile Gagnan

c. Boyle and Mariotte

d. Hans Hass and Cousteau

8. The safest signalling system is one in which:

a. Both hands are used

b. All or nearly all signals are given with one hand

c. Only light signals are used

d. An underwater slate is used

CHAPTER 2

Diving Physics

Atmospheric, hydrostatic and absolute pressure; Boyle's, Dalton's and Archimedes' laws.

2.1 Atmospheric pressure

Atmospheric pressure is created by the weight of the air in the atmosphere. It was first measured by Evangelista Torricelli in **1643**: a metre-long tube sealed at one end and filled with mercury was inverted into a dish of mercury — the column dropped to about 760 mm, leaving the "Torricellian vacuum" above it. Atmospheric pressure balances a liquid column of height

H = P / (ρ·g),

where P is atmospheric pressure, ρ is the density of the liquid and g is gravitational acceleration. For mercury this is 760 mm, for water about 10 m. So a 10 m column of water exerts pressure equal to atmospheric pressure: **1 atm ≈ 1 bar**.

2.2 Hydrostatic pressure

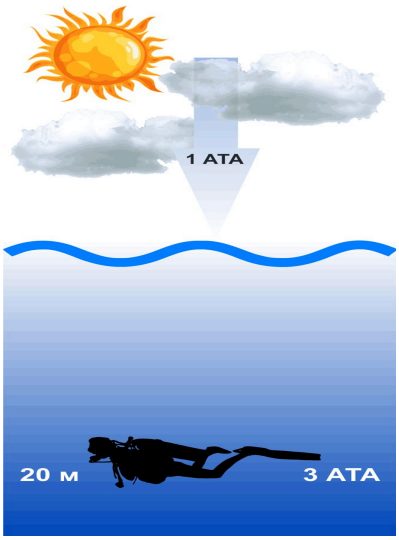
The pressure a liquid exerts on an immersed body is called hydrostatic pressure. According to Pascal's law, pressure is transmitted equally in all directions. Its magnitude is **P = ρ·g·h**. For divers the rule is simple: every 10 m of seawater adds 1 bar — **P = D / 10**. A 10 m column of fresh water gives about 0.97 bar; we ignore this difference in our calculations.

2.3 Absolute pressure

The diver is subjected to the sum of atmospheric and hydrostatic pressure — **absolute pressure**:

P abs = D / 10 + 1 (bar, ata).

At 18 m: 18/10 + 1 = 2.8 bar. A cylinder pressure gauge shows gauge pressure (above atmospheric), but all calculations of effects on the body use absolute pressure. Most diving injuries and illnesses are related to increased pressure and changes in pressure.



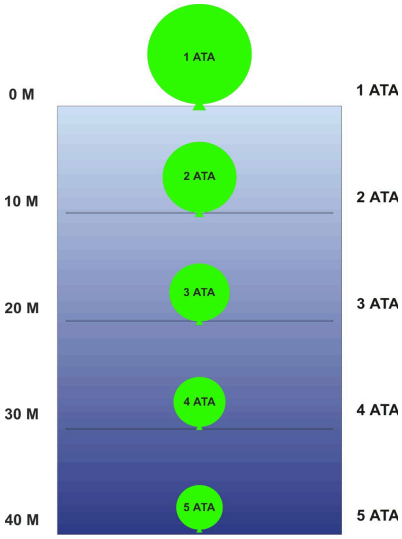
Absolute pressure: 1 ata at the surface, 3 ata at 20 m

2.4 Boyle's law: pressure, volume, density

At constant temperature and mass of gas, $P_1 \cdot V_1 = P_2 \cdot V_2$: as pressure increases, gas volume decreases by the same factor. A 6 L balloon at the surface (1 bar) shrinks to 3 L at 10 m (2 bar) and to 2 L at 20 m (3 bar). On ascent the gas expands in the same way.

Important: **the greatest relative volume change occurs near the surface** — between 0 and 10 m the volume changes by a factor of two, while between 10 and 20 m only by 1.5. That is why buoyancy changes most and the risk of barotrauma is highest in shallow water.

A consequence of the law: **gas density is directly proportional to pressure**. At 20 m (3 bar) every breath contains three times as many molecules as at the surface — so gas is used up faster at depth and breathing takes more effort. The regulator delivers gas at ambient pressure: 1 bar at the surface, 3 bar at 20 m; lung volume stays the same.



Boyle's law: gas volume with depth

2.5 Dalton's law: partial pressure

The total pressure of a gas mixture equals the sum of the partial pressures of its components, and each gas acts on the body as if it alone occupied the whole volume:

pp gas = P abs × fraction of gas in the mix.

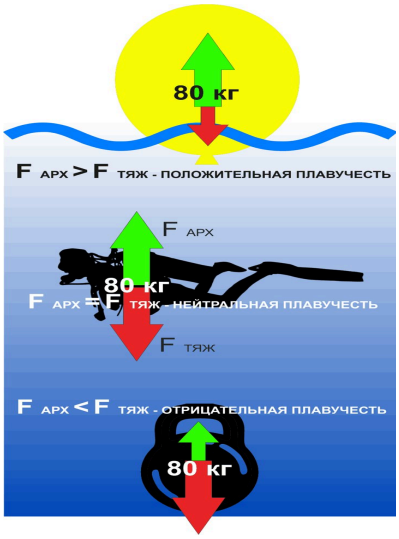
Air is about 21% oxygen and 79% nitrogen. At the surface ppO_2 = 0.21 bar, ppN_2 = 0.79 bar. At 30 m (4 bar): ppO_2 = 0.84 bar, ppN_2 = 3.16 bar. Rising partial pressures explain nitrogen narcosis, tissue nitrogen loading and the increased toxicity of contaminants (e.g. CO) at depth — see the physiology chapters.

2.6 Buoyancy — Archimedes' principle

An immersed body is subject to an upward force equal to the weight of the liquid it displaces: $F = \rho \cdot g \cdot V$.

- Weight less than the buoyant force — **positive buoyancy** (the body floats).
- Weight greater — **negative buoyancy** (it sinks).
- Equal — **neutral buoyancy**: the diver neither sinks nor rises. We aim for it throughout the dive: it saves effort and gas and protects the bottom and its inhabitants.

The human body consists mostly of incompressible water, but wetsuit neoprene and gas in the BCD compress: on descent the volume decreases and buoyancy becomes negative — we add gas to the BCD. On ascent the gas expands and buoyancy increases — gas must be vented from the BCD, otherwise the ascent becomes uncontrolled. Fine buoyancy adjustment is done with breathing (lung volume).



Positive, neutral and negative buoyancy

Knowledge check

1. Absolute pressure at 18 m in the sea:

a. 1.8 bar

b. 2.8 bar

c. 3.8 bar

d. 1.0 bar

2. A 10 m column of seawater exerts a pressure of:

a. 0.5 bar

b. About 1 bar

c. 2 bar

d. 10 bar

3. A 6 L balloon is taken from the surface to 20 m. Its volume:

a. 3 L

b. 2 L

c. 1.5 L

d. 1.2 L

4. The greatest relative change in gas volume occurs between:

a. 0–10 m

b. 10–20 m

c. 20–30 m

d. It is the same at any interval

5. How many times denser is air at 30 m than at the surface:

a. 3 times

b. 4 times

c. 30 times

d. No change

6. Partial pressure of oxygen when breathing air at 30 m:

a. 0.21 bar

b. 0.63 bar

c. 0.84 bar

d. 1.4 bar

7. Neutral buoyancy is when:

a. The BCD is empty

b. The diver's weight equals the buoyant force

c. The diver lies on the bottom

d. The BCD is fully inflated

8. Why does buoyancy decrease on descent:

a. The body compresses

b. Wetsuit neoprene and BCD gas compress — less water is displaced

c. Water density increases

d. The cylinder gets heavier

9. On ascent the volume of gas in the BCD:

a. Decreases — add gas

b. Increases — vent gas

c. Stays the same

d. Decreases — vent gas

10. At what pressure does the regulator deliver air to a diver at 20 m:

a. 1 bar

b. 2 bar

c. 3 bar (ambient pressure)

d. Cylinder pressure

CHAPTER 3

Equipment I: Mask, Snorkel, Fins, Exposure Suits, BCD, Weights

Mask, snorkel, fins, exposure suits, hood, gloves, boots, buoyancy compensator and weights.

3.1 Mask

A mask has two jobs:

- **It keeps an air space in front of the eyes.** The eye can only focus when light reaches the cornea from air; without a mask everything underwater is blurred.
- **It allows equalisation of the mask air space.** That is why the mask has a nose pocket: by exhaling through the nose into the mask, the diver prevents mask squeeze (mask barotrauma). Swimming goggles are therefore unsuitable for diving.



Dive mask

Masks may have a frame or be frameless, one or two lenses, anti-reflective or corrective lenses; the skirt is made of black, coloured or clear silicone. Lenses must be tempered glass. Masks with a wide field of view are preferred.

How to fit a mask: move your hair away from your face (a moustache may prevent a seal and may have to be trimmed), place the mask on your face without the strap, press the frame lightly, hold your breath and do not exhale through your nose. If the mask stays on your face without your hands, even when you tilt your head down, there is no leak through the skirt and the mask fits. Silicone straps degrade from salt and sun and can snap during a dive; neoprene or webbing straps last longer.

3.2 Snorkel

A snorkel saves gas while swimming on the surface — to the descent point and back. For a diver the best choice is a simple flexible snorkel without valves that folds into a BCD pocket. Do not snorkel near boats with running engines — exhaust gases are dangerous.

> Rule: any equipment not in use during the dive must be securely stowed and must not hinder the diver.



Flexible snorkel without valves

3.3 Fins

Fins provide propulsion and directional control. There are:

- **snorkelling fins** — full foot pocket, simple design;
- **freediving and spearfishing fins** — long flexible blades requiring special technique;
- **diving fins** — full-foot or **open-heel** (adjustable straps or spring straps). Open-heel fins are more versatile: they are worn over boots that protect the feet on shore from rocks, coral and sea urchins.



Open-heel fins

Composite fins (made of several materials) are light and convenient for recreational diving but perform less well in strong currents and cold water. Fins made of a single material (rubber, monoprene) are heavier but more powerful and durable; they are used by military, professional and technical divers. Choose fins for the conditions in which you will dive.

3.4 Exposure suits

Wetsuits are made of neoprene — a foam material containing gas bubbles. There are full suits and shorties. Two-piece open-cell suits are designed for freediving and spearfishing: they are inconvenient for scuba and quickly compress and thin out at depth.

Thickness guide (individual sensitivity to cold varies):



Drysuit

Water temperature	Protection
28–30 °C	3 mm
25–27 °C	5 mm
20–24 °C	7 mm (+ hood)
16–20 °C	7 mm semi-dry suit or drysuit
below 16 °C	drysuit

A **semi-dry suit** is a wetsuit with improved seals at wrists, ankles and neck and a waterproof zip: almost no water circulates inside.

Wetsuit drawbacks: limited insulation and **variable buoyancy** — neoprene compresses at depth (the suit becomes thinner, warmer protection and buoyancy decrease) and expands on ascent. Advantages: price and availability. Cut varies a lot between manufacturers, so always try a suit on.

Drysuits are made of neoprene, crushed neoprene or multilayer fabrics (bilaminate and trilaminate). Seals are latex, silicone or neoprene, glued or on quick-change rings. The zip is watertight. Insulation is provided by the **undersuit**, chosen according to temperature. Neoprene drysuits are warmer and cheaper but heavier and more easily damaged; trilaminate suits are tough, light and versatile (from the tropics to the Arctic) but more expensive. A drysuit has inflator and exhaust valves: gas in the suit maintains insulation and prevents suit squeeze. Drysuit diving requires the **Dry Suit Diver IDU** course.

3.5 Hoods, gloves, boots

- A **hood** (3–9 mm) reduces heat loss through the head and neck — an area with an intense blood supply. It must fit snugly without restricting movement.
- **Gloves** protect against cold and injury. Wet gloves are neoprene; dry gloves have seals or attach to a drysuit and are worn with liners. Check local rules: some marine parks prohibit gloves.
- **Boots** with hard soles protect the feet on shore and keep them warm; top pads protect against chafing from the fin pocket.

3.6 Buoyancy control device (BCD)

BCD functions:

- compensating for buoyancy changes at depth;
- providing positive buoyancy at the surface;
- securing the cylinder, weights and all equipment to the body;
- carrying accessories.



Modular BCD: backplate, harness, wing

One-piece designs (jacket or wing with integrated harness) are convenient and have pockets, integrated weights and extra dump valves. Drawbacks: if one component fails the whole unit goes for repair; the size is fixed.

Modular designs (backplate, harness, wing) are a versatile "construction kit" with quick replacement and upgrade of components. IDU recommends modular systems as the most reliable and adaptable to different conditions.

3.7 Weight systems

Weights offset the positive buoyancy of the diver and equipment. Options:

- a weight belt with a quick-release buckle (released with one movement);
- integrated BCD weight pockets — releasable or not;
- weights on cylinder bands, on the backplate (trim pockets).

Dropping weights is an emergency procedure. With correct weighting and safe diving practice you will probably never need it, but every diver must know how to drop both their own and their buddy's weights.

Knowledge check

1. Why can't swimming goggles be used for diving:

a. They leak
b. They cannot be equalised — there is no nose pocket
c. Narrow field of view
d. They fog up

2. How do you check that a mask fits:

a. Put it on with the strap and dive
b. Place it without the strap, press lightly, hold your breath — the mask must stay on even when you tilt your head down
c. Press it hard against your face for a minute
d. Choose by head size

3. The best snorkel for a diver:

a. With two valves and a float
b. A simple flexible snorkel without valves, stowed in a BCD pocket
c. A rigid snorkel with a top valve
d. A snorkel is never needed

4. Advantage of open-heel fins:

a. Lighter
b. Worn over boots that protect the feet on shore
c. No adjustment needed
d. More efficient in a pool

5. Recommended protection at 25–27 °C:

a. 3 mm
b. 5 mm
c. 7 mm
d. Drysuit

6. Below 16 °C the recommended protection is:

a. 7 mm wetsuit
b. 5 mm with hood
c. Drysuit
d. Shorty with undersuit

7. The main drawback of a wetsuit for buoyancy control:

a. It is heavy

b. Neoprene compresses at depth — buoyancy changes

c. It lets water in

d. It is not warm at the surface

8. What provides insulation in a drysuit:

a. The shell material

b. The undersuit and the gas layer inside the suit

c. Latex seals

d. The zip

9. Which BCD type does IDU recommend:

a. Jacket only

b. Modular (backplate, harness, wing)

c. Any

d. Only BCDs with integrated weights

10. A weight system must allow:

a. Maximum weight

b. Quick release with one movement

c. All weights on the belt

d. No release at all

CHAPTER 4

Equipment II: Cylinders, Regulators, Instruments, Accessories

Cylinders and valves, regulator, instruments, dive computer, SMB, spool, lights, knife; assembly and care.

4.1 Cylinders



Cylinders of different sizes

Cylinders are made of **steel** (hemispherical bottom, needs a boot) or **aluminium** (usually flat bottom). Steel cylinders are negatively buoyant, while aluminium cylinders become positively buoyant towards the end of the dive — take this into account when weighting.

Common sizes: steel 10, 12, 15 L; aluminium is marked in cubic feet of gas at working pressure: **S80** (aluminium, 80 cu ft) has an internal volume of about **11.1 L**.

Working pressure: aluminium usually 207 bar (3000 psi), steel 232 bar (≈3365 psi) or 300 bar (≈4350 psi). Filling a cylinder above its working pressure is prohibited: it risks cylinder failure, and an overfilled cylinder is condemned at inspection. **Test pressure** (higher than working pressure) is applied only during the hydrostatic test. Both are stamped near the neck.

Inspection follows the rules of the country of use: **visual inspection** (usually annual — inside and outside, for corrosion and damage) and **hydrostatic test** (usually every 5 years; the date is stamped on the cylinder). A visual inspection sticker is a sign of a conscientious dive centre.

4.2 Valves

There are two connection standards:

- **YOKE (INT)** — the regulator is clamped on; the O-ring sits exposed on the valve face; working pressure up to 232 bar. Common in the Americas and Asia.
- **DIN** — the regulator screws into the valve, the O-ring is captured inside the connection; 5 threads — up to 232 bar, 7 threads — up to 300 bar. Common in Europe. More reliable and compact.



YOKE and DIN valves and first stages

IDU recommends DIN valves and regulators. DIN-to-YOKE adapters and convertible valves are available.

Valves have one or two outlets: two outlets allow two independent regulators — important in cold water, where freezing is possible.

4.3 Regulator

The regulator lets you breathe underwater and has two stages.



Regulator: first stage, primary and alternate second stages, gauge

The **first stage** reduces cylinder pressure to **intermediate pressure** — about 8–10 bar above ambient. Intermediate pressure rises with depth together with ambient pressure. Designs are piston or diaphragm; balanced first stages deliver steadily regardless of cylinder pressure; "overbalanced" ones raise intermediate pressure slightly more than ambient at depth, easing breathing of dense gas. Diaphragm stages with an **environmentally sealed (dry) chamber** are less prone to freezing.

The **second stage** delivers gas **at ambient pressure** on demand: 1 bar at the surface, 3 bar at 20 m.

- **Unbalanced** second stage: the valve is held closed by a spring against intermediate pressure; breathing effort depends on intermediate pressure.
- **Balanced**: part of the intermediate pressure is fed into a balance chamber and offsets the valve — the spring is lighter, breathing is easier and more consistent.

Cold-water regulators (certified for water below 10 °C) are protected against freezing and suit any conditions; "warm-water" regulators must not be used in cold water.

A regulator set includes: primary second stage, **alternate second stage (octopus)** or an independent alternate gas source, BCD inflator hose and pressure gauge. Service follows the manufacturer's schedule, but **at least once a year**, even if unused.

4.4 Instruments

A diver monitors **remaining gas, depth, time and direction**.

- The **pressure gauge (SPG)** connects to the high-pressure (HP) port of the first stage and shows cylinder pressure (bar or psi). The red zone is the reserve: time to end the dive.
- A **transmitter** sends pressure to a wrist computer. Convenient, but the battery may die or the signal drop out, so a transmitter is used only together with a mechanical gauge.
- **Depth gauge and watch** have been almost entirely replaced by the computer but can serve as backups.
- An underwater **compass** has a liquid-filled housing.



Pressure gauge

4.5 Dive computer

A computer continuously tracks the dive profile, calculates no-decompression time, warns of its end, of exceeding depth and ascent rate, and guides the safety stop. IDU places special emphasis on computer training: today it is an essential part of a diver's kit.



Dive computers

Basic functions of a recreational computer:

1. Depth, time, temperature.
2. No-decompression limit calculation.
3. Alarms for exceeding limits (no-deco, depth, ppO_2, ascent rate).
4. Nitrox capability.
5. Residual nitrogen tracking, time to fly.
6. Dive log.

When choosing, consider: display readability and visible alarms, intuitive controls, user-replaceable or rechargeable battery, service availability. Check charge and settings before a trip. Technical diving requires multi-gas computers; a simple recreational computer will later serve as a backup.

4.6 Accessories

A **surface marker buoy (SMB)** marks the ascent point and protects against boats. Closed SMBs or those with a valve are preferred — they don't lose gas on the surface. Length at least 1.5 m, in waves and currents at least 2 m. The standard colour is **orange**; in some regions a **yellow** buoy means "need assistance" — agree on this with the support team before the dive.


Spools and reel



Surface marker buoys

A **spool or reel** is used to deploy the SMB, mark a point or search. A spool is enough for a recreational diver: compact and inexpensive. Line length at least 12 m (preferably 20–30 m — more than the depth from which you will deploy the SMB). For thick gloves choose a spool with a wide finger hole.

Lights — primary and backup. Today almost all dive lights are LED: compact and efficient. Requirements: rated for the planned depth, burn time with a large margin over the dive time. On a night dive carry at least one backup light (batteries are convenient in backups — they fade gradually). A light is also a communication tool.

Cutting tools (knife, line cutter, shears) free you from nets, fishing line and ropes. They must be compact, reachable with either hand; carry two (e.g. knife + line cutter) mounted in different places.

4.7 Equipment assembly

1. Analyse the gas in the cylinder and label the cylinder with the result.
2. Stand the cylinder in front of you, valve outlet facing away.
3. Slide the BCD band over the cylinder and tighten; lift the BCD by the shoulder straps — the cylinder must not slip.
4. Attach the regulator: second-stage hoses on the right.
5. Connect the inflator hose.
6. Check the second stages before opening the valve: you cannot inhale, you can exhale freely — diaphragms and valves are intact.
7. Slowly open the valve fully.
8. Check pressure on the gauge.
9. Breathe from each second stage while watching the gauge: the needle must not move (do not do this check on the surface in freezing conditions).
10. Clip the gauge to the left hip D-ring.
11. Inflate the BCD until the overpressure valve vents — checks inflator and valve; leave for 3 minutes — leak check.
12. Check the dump valves and the inflator deflate button.
13. Fit the weights and make sure they are secure.
14. If the cylinder cannot be secured upright, lay it down with hoses tucked in.

Disassembly — in reverse: close the valve, purge the regulator, disconnect the inflator and the regulator, fit the first-stage dust cap.

4.8 Care and storage

- Rinse all equipment in fresh water after diving. **Keep water out of the first stage** — never immerse it, even with the dust cap on.
- Dry in the shade: sunlight degrades materials.
- Store in a dark, dry, ventilated place.
- Suit on a wide hanger; BCD slightly inflated; regulator without kinked hoses; neoprene laid flat; mask in its box; fins flat or hanging.
- All equipment requires regular servicing.

Knowledge check

1. An S80 cylinder is:

a. An 80 L steel cylinder
b. An 80 cu ft aluminium cylinder with an internal volume of about 11.1 L
c. An 11.1 L steel cylinder
d. An 80 bar cylinder

2. A cylinder with a working pressure of 207 bar is filled to 230 bar. This is:

a. Acceptable if the cylinder is new
b. Prohibited: risk of failure, and the cylinder is condemned at inspection
c. Acceptable in cold water
d. Acceptable for steel

3. A hydrostatic test is usually performed:

a. Annually
b. Every 5 years (per national rules)
c. Before every fill
d. Every 10 years

4. Which connection standard does IDU recommend:

a. YOKE
b. DIN
c. Either
d. Adapters only

5. Why is DIN more reliable than YOKE:

a. It is cheaper
b. The O-ring is captured inside the threaded connection
c. It can be hand-tightened
d. It needs no service

6. First-stage intermediate pressure is:

a. Equal to cylinder pressure
b. Equal to ambient pressure
c. About 8–10 bar above ambient
d. Always 1 bar

7. A balanced second stage:

a. Has two springs
b. Has its valve offset by intermediate pressure — easier, more consistent breathing
c. Works without a first stage
d. Free-flows constantly

8. How often must a regulator be serviced if the manufacturer gives no interval:

a. Every 3 years

b. At least once a year, even if unused

c. Only after failure

d. Every 5 years

9. Why watch the gauge while test-breathing the regulator:

a. To measure consumption

b. The needle must not move — otherwise the valve is not fully open or there is a fault

c. To check the octopus

d. There is no need

10. How must a first stage never be rinsed:

a. Under a shower with the cap on

b. By immersing it in water — even with the cap on

c. With fresh water

d. Any way is fine

CHAPTER 5

The Aquatic Environment: Vision, Light, Sound, Heat

Vision underwater, light and colour, sound, heat loss, hypothermia and overheating.

5.1 Vision underwater

Without a mask everything underwater is blurred: the eye is built for light reaching the cornea from air. Water is optically close to the tissues of the eye, so the cornea almost stops refracting light and the image no longer focuses on the retina. A mask restores an air space in front of the eye and vision becomes sharp.

But at the water–glass–air boundary light is refracted again: **objects appear about one-third larger and one-quarter closer** than they really are. That is why beginners often reach short of an object and fish look bigger. The field of view in a mask is also narrower — turn your head more often.

5.2 Light and colour

The deeper you go, the less light there is. Light levels depend on:

- **the sun's angle** — the lower it is, the more light is reflected from the surface (morning, evening, high latitudes);
- **surface conditions** (waves);
- **suspended particles** — organic and inorganic matter, plankton.

So at 10 m in the Red Sea it is almost as bright as near the surface, while at the same depth in the Barents Sea it may be nearly dark.

Water absorbs light selectively and acts as a blue filter. With depth, **red** disappears first (within the first 5–10 m), then **orange** and **yellow**, then **green**; **blue** penetrates furthest — at depth everything looks blue-grey. A torch restores natural colours — one reason to carry a light even by day in clear water.

5.3 Sound

Sound travels about **4.5 times faster** in water than in air (≈1500 m/s versus ≈340 m/s). On land the brain locates a sound by the difference in arrival time at the right and left ears. Underwater this difference is too small, and sound is also conducted through the skull — so **a diver hears well but cannot tell the direction** of a sound source: an approaching boat or a buddy's signal.

Practical conclusion: if you hear an engine, do not surface at random — ascend slowly, looking around and rotating, with one hand above your head, and use an SMB.

5.4 Thermal conductivity and hypothermia

Water draws heat away about **25 times faster** than air. So even in the tropics (28–30 °C, against a normal body temperature of 36.6 °C) an unprotected diver gradually cools.

Hypothermia is a drop in body temperature below 35 °C. The body defends itself: shivering produces heat, skin vessels constrict to reduce heat loss, and blood is concentrated around the internal organs and brain.

Degree	Body temperature	Signs
Mild	35–32 °C	intense shivering, blue lips and skin, clumsiness, difficulty speaking and thinking
Moderate	32–28 °C	shivering weakens or stops, drowsiness, confusion
Severe	below 28 °C	stupor, unconsciousness, risk of respiratory and cardiac arrest

Prevention: correct thermal protection (suit thickness table — Chapter 3), a hood, and ending the dive at the first signs of shivering. Individual sensitivity to cold varies, and the body cools more on repetitive dives.

First aid for hypothermia:

- move the casualty to a dry, warm place sheltered from the wind;
- remove the wet suit, dry them, dress them in warm dry clothes and cover them (blanket, rescue blanket);
- if conscious — warm (not hot) sweet drinks;
- for moderate and severe hypothermia — keep them lying down, handle gently, call medical help.

Do not:

- give hot showers, saunas or hot packs on the limbs — sudden dilation of peripheral vessels draws blood away from the internal organs;
- give alcohol — it dilates skin vessels and increases heat loss; the feeling of warmth is false;
- rub with alcohol or massage vigorously — for the same reason.

5.5 Overheating

Overheating (hyperthermia) is dangerous mainly because of **dehydration**: heavy sweating thickens the blood and impairs circulation, which is a risk factor for decompression sickness. Do not put on your wetsuit long before the dive in heat and sun; if necessary, wet your suit and head with water and stay in the shade.

If a diver feels unwell from the heat — help them out of the wetsuit, move them to a cool, shaded, ventilated place and give plenty to drink (water or oral rehydration solution; coffee, strong tea and

alcohol increase dehydration). With confusion and a high body temperature (heatstroke) — active cooling and medical help.

Knowledge check

1. How do objects look through a mask underwater:

a. Smaller and farther

b. About one-third larger and one-quarter closer

c. Twice as large

d. The same as on land

2. Why is everything blurred underwater without a mask:

a. Salt irritates the eyes

b. Water is optically close to the eye's tissues — the cornea hardly refracts light

c. There is little light

d. Because of pressure on the eye

3. Which colour disappears first with depth:

a. Red

b. Blue

c. Green

d. Yellow

4. Which colour penetrates deepest:

a. Red

b. Orange

c. Yellow

d. Blue

5. Why can't a diver tell the direction of a sound underwater:

a. Sound does not travel in water

b. Sound travels ~4.5 times faster and the brain cannot detect the arrival-time difference between the ears

c. The mask interferes

d. Water absorbs sound

6. How many times faster does water conduct heat away than air:

a. 2

b. 5

c. About 25

d. 100

7. What must you NOT do for hypothermia:

a. Give warm sweet drinks

b. Remove the wet suit

c. Give alcohol or rub with alcohol

d. Cover with a blanket

8. Why is overheating dangerous for a diver:

a. It increases gas consumption

b. Dehydration, which increases DCS risk

c. It reduces buoyancy

d. It isn't

CHAPTER 6

Air Spaces and Barotrauma

Equalisation; ear, sinus, mask, dental and lung barotrauma; first aid.

6.1 Air spaces in the body

Body fluids and tissues are practically incompressible, but gas in air spaces obeys Boyle's law. Spaces that matter to divers:

- the **middle ear** — connected to the throat by the **Eustachian tube**;
- the **paranasal sinuses** — frontal, maxillary, sphenoid, ethmoid;
- the **lungs**;
- the **mask air space** and, in a drysuit, the **suit air space**;
- cavities in teeth under poor fillings, gas in the intestines.

The greatest change in gas volume occurs near the surface (Chapter 2) — which is why ear problems usually occur in the first metres of descent.

6.2 Equalisation

On descent water presses on the eardrum from outside. The regulator supplies gas at ambient pressure, but the Eustachian tube is normally closed — gas does not enter the middle ear by itself. It has to be opened:

- **Valsalva manoeuvre** — pinch the nose and gently blow into it;
- **Frenzel manoeuvre** — pinch the nose and push with the tongue/throat, as when saying "k";
- **swallowing** with the nose pinched (Toynbee), moving the jaw.

Equalisation rules:

- start at the surface and equalise **early and often** — about every metre in the first metres of descent, **before** you feel discomfort;
- descend feet first, controlling your speed (a descent line helps);
- if your ears won't clear — **ascend 1–2 m** and try again; **never force equalisation**;
- if it still fails — abort the dive.

Healthy sinuses equalise by themselves. The mask air space is equalised by **exhaling through the nose into the mask** during descent; otherwise — mask squeeze: marks, bruising, burst blood vessels in the eyes.

6.3 What barotrauma is

Barotrauma is tissue damage caused by a pressure difference between an air space and the surroundings. On descent gas in a space is compressed ("squeeze"); on ascent it expands.

Middle-ear barotrauma

Occurs on descent if the diver did not equalise in time or could not (cold, allergy). Pressure stretches the eardrum inwards; bleeding, swelling or rupture may follow. Signs: fullness, pain, reduced hearing, pain when pressing the tragus; with a ruptured eardrum — sudden vertigo as cold water enters. Help: stop diving, put nothing in the ear yourself, see an **ENT doctor**.

Reverse block

Occurs **on ascent**: because of a swollen Eustachian tube (cold, allergy, decongestant wearing off) expanding gas cannot escape from the **middle ear** or sinuses. The eardrum bulges outwards with severe pain. Action: stop the ascent, descend 1–2 m, ascend slowly to let gas escape; do not perform a Valsalva. The only prevention is not diving with a cold or allergy.

Inner-ear barotrauma

The most dangerous ear barotrauma. Most often caused by an **overly forceful Valsalva**: a sudden pressure spike can damage the round or oval window of the inner ear. Signs: severe vertigo, nausea, vomiting, ringing in the ears, hearing loss, loss of balance, pallor, sweating. Help: stop diving, rest with the head raised, no equalising or straining, **see a doctor urgently**. The same symptoms occur in inner-ear decompression sickness — if they appear after a dive, give **oxygen** and act as for DCS (Chapter 7). If vomiting — recovery (lateral) position.

> **Never dive with cold or allergy symptoms.** Decongestant drops and tablets work only temporarily; their effect may wear off underwater and cause a reverse block.

Sinus barotrauma

Swollen mucosa blocks the sinus openings — on descent or ascent there is sharp pain in the forehead, upper jaw or behind the eyes, sometimes a bloody nasal discharge. Prevention is the same — no diving with a cold or allergy.

Mask squeeze

Occurs if you don't exhale through the nose into the mask on descent. Signs: red marks, swelling, haemorrhages in the whites of the eyes. Usually resolves by itself; with severe haemorrhages or impaired vision — see a doctor.

Dental barotrauma

Gas under a poor filling or in a cavity may cause pain on descent or ascent, even a cracked tooth. See your dentist regularly.

Drysuit squeeze

If no gas is added to a drysuit on descent, the fabric pinches the body in folds — bruises and welts. Drysuit use is taught on the Dry Suit Diver IDU course.

6.4 Lung overexpansion injury

The most dangerous barotrauma. Cause — **holding your breath during ascent**: expanding gas ruptures the alveoli. Bronchitis, asthma and mucus in the airways are also dangerous — gas becomes "trapped" in part of the lung. The risk exists even when ascending from shallow depths — from 2–3 m in a pool.

> **The golden rule of diving: breathe continuously, never hold your breath.** In an out-of-gas emergency ascent, exhale continuously, making an "aaah" sound.

Gas from damaged alveoli may enter:

- **the blood — arterial gas embolism (AGE)**: bubbles travel to the arteries of the brain and heart. Signs appear quickly — during ascent or within minutes of surfacing: confusion or unconsciousness, convulsions, paralysis, numbness, speech and vision disturbances, chest pain, bloody froth from the mouth. Life-threatening;
- **the pleural cavity — pneumothorax**: sharp chest pain radiating to the shoulder, increasing shortness of breath, rapid shallow breathing, cyanosis; the casualty is more comfortable half-sitting;
- **the mediastinum and under the skin — emphysema**: pain behind the breastbone, voice change, difficulty swallowing, swollen neck, crackling when pressing the skin.

First aid:

- check consciousness and breathing; if absent — CPR;
- lay the casualty **flat** (with pneumothorax, half-sitting is acceptable if breathing is easier); if vomiting or with impaired consciousness — recovery position;
- give **100% oxygen** as early as possible and without interruption;
- call an ambulance and say the casualty is a diver; contact the nearest hyperbaric chamber;
- monitor until help arrives; do not let the casualty go back underwater.

Knowledge check

1. Which space is connected to the throat by the Eustachian tube:

a. Inner ear
b. Middle ear
c. Outer ear canal
d. Frontal sinuses

2. When should you start equalising your ears:

a. When pain appears

b. At 5 m

c. At the surface and then often, before discomfort

d. Only below 10 m

3. Your ears won't clear on descent. You should:

a. Equalise forcefully

b. Keep descending — it will equalise by itself

c. Ascend 1–2 m and gently try again; if it fails — abort the dive

d. Remove your mask

4. A reverse block occurs:

a. On descent

b. On ascent, when expanding gas cannot escape from the middle ear or sinuses

c. On the surface

d. Only in a pool

5. The most common cause of inner-ear barotrauma:

a. Mask squeeze

b. An overly forceful Valsalva

c. Fast ascent

d. Cold water

6. How do you prevent mask squeeze:

a. Tighten the strap

b. Exhale through the nose into the mask on descent

c. Descend head first

d. Use a frameless mask

7. Why must you not dive after using decongestant drops:

a. They reduce buoyancy

b. They may wear off underwater and cause a reverse block

c. They cause narcosis

d. You may — it solves the problem

8. The main cause of lung overexpansion injury:

a. Fast descent

b. Holding your breath during ascent

c. Rapid breathing

d. Great depth

9. Signs of arterial gas embolism appear:

a. After a day

b. Quickly — during ascent or within minutes of surfacing

c. Only at depth

d. After a week

10. First aid for lung overexpansion injury:

a. Sit them up and give water

b. Send them back down for recompression

c. Lay flat, 100% oxygen, call an ambulance, contact a hyperbaric chamber

d. Give aspirin and let them rest

CHAPTER 7

Breathing and Gases: CO_2, Stress, Saturation, DCS, Nitrogen Narcosis, Carbon Monoxide

Breathing and CO_2, hyperventilation, stress, saturation, DCS, nitrogen narcosis, carbon monoxide, cramps.

7.1 Breathing underwater

At the surface we don't think about breathing. Underwater, in an unfamiliar environment, instinct raises the alarm — breathing becomes fast and shallow. With experience anxiety fades and breathing returns towards normal.

The main trigger to breathe is the **level of carbon dioxide (CO_2)** in the blood, and CO_2 is produced by the muscles: the more work, the faster the breathing and the higher the gas consumption. That is why an experienced diver with good buoyancy and efficient finning uses noticeably less gas than a beginner — the Perfect Buoyancy Control IDU course is devoted to this.

Underwater, breathing is made harder by:

- **gas density**, which increases with depth — breathing takes more effort, and the breathing muscles themselves produce CO_2;
- **regulator resistance** — a good balanced regulator makes inhalation easier;
- **dead space** — the second-stage housing is added to the larynx and trachea, and exhaled gas lingers there.

Rapid shallow breathing ventilates the lungs poorly: fresh gas does not reach the alveoli, CO_2 builds up, causing breathlessness, air hunger, headache, panic and, in severe cases, unconsciousness.

> **Breathe slowly, deeply and rhythmically.** If your breathing gets out of control — stop, hold on to something, take a few slow deep breaths with full exhalations; continue when your breathing has settled.

Holding your breath "to save gas" (skip breathing) is doubly dangerous: it causes CO_2 build-up (and ultimately higher gas consumption) and **lung overexpansion injury** if your depth decreases at that moment.

> **Golden rule: never hold your breath underwater.**

7.2 Hyperventilation

Hyperventilation is rapid deep breathing beyond the body's needs, which lowers blood CO_2. Its dangers:

- **before breath-hold diving** (snorkelling, freediving) it suppresses the urge to breathe — oxygen runs out before the desire to breathe appears, and the person loses consciousness without warning, often just below the surface (**blackout**). Never hyperventilate before a breath-hold dive;
- at the surface under stress it causes dizziness, tingling fingers and air hunger — this can escalate into panic.

If your breathing gets out of control — slow it down with full slow exhalations.

7.3 Stress

Stress is a natural reaction to an unusual or threatening situation: cold, poor visibility, current, fatigue, equipment failure, peer pressure, lack of experience. Signs: rapid breathing, wide eyes, jerky movements, fixation on one object, ignoring the buddy's signals, a vertical position in the water. Uncontrolled stress leads to **panic** — the main cause of accidents.

Managing stress:

- **Stop — Breathe — Think — Act**: stop, regain control of your breathing, assess the situation, perform a practised procedure;
- plan dives within your training; don't give in to "everyone's going, so I'll go too";
- maintain your skills through regular practice;
- watch your buddy and intervene early — before stress turns into panic.

7.4 Gas solubility. Saturation and desaturation



William Henry (1774–1836)

According to **Henry's law** (William Henry, 1803), the amount of gas dissolved in a liquid is proportional to the partial pressure of that gas above the liquid. A diver breathes gas at increased pressure — nitrogen dissolves into the blood and tissues (**saturation**) until partial pressures equalise. On ascent the pressure drops and nitrogen leaves the tissues into the blood and is exhaled through the lungs (**desaturation**).

Think of a bottle of fizzy water: open it slowly and the gas escapes quietly; open it abruptly and the liquid foams with bubbles. A diver ascending at the correct rate "opens the bottle slowly".

Tissues saturate at different rates: there are **fast** tissues (blood, brain) and **slow** ones (joints, bone, fat). The longer and deeper the dive, the more nitrogen is absorbed. Recreational diving is based on **no-decompression dives**: saturation must not exceed the level at which mandatory decompression stops are needed for a safe ascent.

7.5 Decompression sickness (DCS)

DCS was first encountered on a large scale in the second half of the 19th century in caisson work — for example, building the Brooklyn Bridge (1870–1883) — hence its other name, **caisson disease**. In 1908 John Haldane proposed the first model of tissue saturation and staged decompression; his work was later developed by Robert Workman and Albert Bühlmann — their models underpin modern tables and computers.

DCS is a complex of injuries caused by inert-gas bubbles forming in tissues and blood when pressure drops too quickly: impaired circulation, damage to the nervous system and tissues.

Signs (usually within the first hour after the dive, but possible up to 24 hours):

- extreme fatigue, malaise;
- skin itching, rash, "marbled" skin (patches from red to blue-purple);
- joint and muscle pain;
- numbness, tingling, weakness, paralysis;
- dizziness, balance, hearing and vision disturbances;
- breathing difficulty, cough, chest pain;
- confusion, convulsions, unconsciousness.

Denial ("it's just a bruise, I'll sleep it off") is a common and dangerous mistake: give first aid whenever DCS is suspected.

How to avoid DCS:

- do not exceed the no-decompression limit; plan with a margin;
- observe the ascent rate (no faster than 9–10 m/min) and make a safety stop;
- make the deepest dive first in a series and the deepest part first in a dive;
- observe surface intervals and time to fly (per your computer; the generally accepted minimum is 12 hours after a single dive and 18 hours after a series, preferably 24 hours);
- after diving avoid heavy exertion, hot baths and saunas.

Risk factors (almost all impair the circulation that removes nitrogen):

- **dehydration** — sweating in the heat, dry cylinder air, alcohol, coffee; drink water before and after dives;
- **hypothermia** — peripheral vasoconstriction slows desaturation;
- **heavy exertion** during and immediately after the dive;
- **alcohol** before and after diving;
- **age, excess weight, poor fitness**;
- **fatigue, lack of sleep, illness**;
- **fast ascents**, repeated ascents and descents ("saw-tooth" profiles), multi-day dive series.

First aid for suspected DCS:

- remove the casualty's equipment and keep them at rest;

- lay them **flat on their back**; if vomiting or with impaired consciousness — **recovery (lateral) position**; if not breathing — CPR;
- give **100% oxygen** as early as possible and continuously;
- if conscious and able to swallow — **still water** (no caffeine or alcohol);
- call an ambulance, say the casualty is a diver; arrange transport to a **hyperbaric chamber**;
- record the dive profile (send the computer with the casualty), the time symptoms appeared and how they developed; watch the buddy too — they dived the same profile.

Never try to treat DCS by going back underwater ("in-water recompression").

7.6 Nitrogen narcosis

As the partial pressure of nitrogen rises (Chapter 2), it begins to act on the nervous system like an anaesthetic. When breathing air, many divers can notice the first effects at 20–30 m, and the effect increases with depth. The sensations are individual and vary from day to day.

Signs:

- reduced concentration, slow thinking, errors in simple calculations;
- impaired fine motor skills;
- euphoria, overconfidence, "drunkenness";
- or, conversely, anxiety, depression, apathy, tunnel vision.

Narcosis is dangerous because the diver notices problems more slowly and makes worse decisions. It is increased by: fast descent, darkness and poor visibility, cold, heavy work and CO_2 build-up, fatigue, anxiety, alcohol and medication.

Action: stop, signal your buddy, **ascend a few metres** together. The symptoms quickly disappear with decreasing depth, without after-effects. For an OWD (to 18 m) narcosis is usually mild, but you must know its signs.

7.7 Carbon monoxide (CO) poisoning

Carbon monoxide binds to haemoglobin about **200–250 times more strongly** than oxygen and blocks oxygen delivery to the tissues — above all to the brain. By Dalton's law its effect increases many times at depth: a concentration harmless at the surface becomes dangerous at depth.

The source of CO in cylinders is exhaust gas drawn into the compressor air intake: from the compressor's own engine or a generator, from a nearby car or boat, and also from an overheated or faulty compressor and filters.

CO has no colour and no smell. But its source — petrol or diesel exhaust — does smell. Therefore:

- before the dive, smell the gas from the cylinder by cracking the valve slightly: **any smell of exhaust, oil or burning, or an odd taste — do not use the cylinder**;
- no smell does not guarantee no CO — the reliable check is a **CO analyser**;
- fill only at reputable dive centres.

Signs of poisoning: headache, dizziness, nausea, weakness, confusion, unconsciousness; bright red lips are a late and unreliable sign. Help: **100% oxygen**, rest, medical help.

7.8 Cramps

Muscle cramps (most often in the calf and foot) are triggered by fatigue, cold, unsuitable or overly stiff fins, poor finning technique and dehydration.

To relieve a calf cramp: stop, straighten your leg, grasp the fin tip and pull it towards you, massage the muscle gently. Then change your kick, reduce the effort; if it recurs — end the dive. Let your buddy know about the problem.

Knowledge check

1. Why does breathing become harder with depth:

a. The oxygen fraction decreases
b. Gas density increases — more work of breathing and CO_2 build-up
c. The partial pressure of CO_2 in the inhaled air increases
d. It doesn't

2. How should you breathe underwater:

a. Fast and shallow
b. With pauses to save gas
c. Slowly, deeply and rhythmically
d. Through the nose only

3. Why is hyperventilation before a breath-hold dive dangerous:

a. It causes DCS
b. It suppresses the urge to breathe — sudden unconsciousness is possible
c. It increases buoyancy
d. It isn't — it safely extends the breath-hold

4. The first thing to do under severe stress underwater:

a. Ascend quickly
b. Stop and regain control of your breathing, then assess and act
c. Drop your weights
d. Remove your mask

5. Henry's law: the amount of gas dissolved in a liquid is proportional to:

a. Temperature
b. The partial pressure of the gas above the liquid
c. The volume of liquid
d. Depth in feet

6. When do DCS signs usually appear:

a. Only underwater

b. Most often within the first hour after the dive, but possibly up to 24 hours

c. After a week

d. Only after 48 hours

7. Which factor does NOT increase DCS risk:

a. Dehydration

b. Hypothermia

c. Alcohol

d. A slow ascent with a safety stop

8. First aid for suspected DCS:

a. A repeat dive for recompression

b. A hot shower and coffee

c. Lay flat, 100% oxygen, still water, call for help and transport to a hyperbaric chamber

d. Sit them up and observe for a day

9. What to do if you notice signs of nitrogen narcosis:

a. Continue the dive

b. Surface immediately

c. Stop, signal your buddy, ascend a few metres

d. Hold your breath

10. How do you check cylinder air for carbon monoxide contamination:

a. CO smells — sniffing is enough

b. CO is odourless: an exhaust smell indicates contamination, but only a CO analyser is reliable

c. Look at the gas colour

d. Check with the pressure gauge

CHAPTER 8

The Environment: Water, Currents, Waves, Marine Life

Fresh and salt water, currents, tides, surf, hazardous and venomous marine life.

8.1 Fresh and salt water

Fresh water has a density of about **1.00 kg/L**, seawater **1.02–1.03 kg/L**. The difference is small, but by Archimedes' principle salt water pushes the diver up more strongly: you need more weight in the sea than in fresh water (with the same equipment — usually 2–3 kg more for an adult diver). When switching between fresh and salt water, re-check your weighting.

Salinity varies between seas. The Red Sea is one of the saltiest (hot, almost no rainfall and no inflowing rivers), so more weight is needed there than, for example, in the Mediterranean or the Baltic.

Seawater is aggressive to equipment: salt crystallises as it dries and damages materials, and metal corrodes. After sea dives always rinse your equipment in fresh water before drying it.

8.2 Currents

Permanent currents are caused by the movement of large water masses driven by wind, differences in temperature and salinity, the Earth's rotation and the seabed topography. **Variable currents** are caused by tides.

Currents carry plankton — small fish follow, and large predators follow them. That is why current-swept sites are often the richest and most interesting.

Rules for diving in currents:

- **entry and exit at the same point** — start your route **into the current** and return with it, while you still have plenty of gas and energy;
- **entry and exit at different points** — drift with the current but don't miss the exit point; the boat follows the group's SMB;
- descend quickly using a line, stay close to the reef and bottom — the current is weaker there;
- don't fight a strong current — move shallower or into the shelter of the terrain; if you are being swept away — surface with an SMB;
- **down- and up-currents** near walls and headlands can pull you deeper or shallower — watch your depth and computer; if necessary move away from the wall and add gas to your BCD.

Strong ebbing currents that can carry a diver far from the exit point are dangerous. Beginners should plan such dives only with an experienced guide. More on this in the **Drift Diver IDU** course.

8.3 Tides

Tides are caused by the gravitational pull of the Moon and Sun. In most areas there are two high and two low tides a day (roughly every 6 hours). At the turn of the tide there is **"slack water"** — a period of weak current, convenient for diving in straits, lagoons and bay entrances. Before diving in tidal areas, study the tide tables: visibility often worsens on the ebb, and the current at a lagoon mouth can be very strong.

8.4 Waves, surf, rip currents

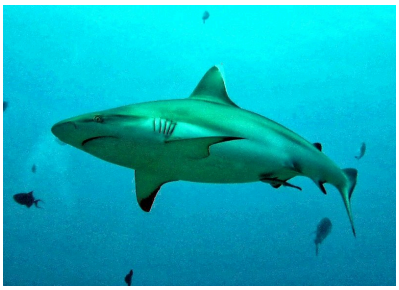
Waves make entries and exits, regrouping on the surface and boarding the boat more difficult, and cause seasickness and fatigue. In rough seas it is better to cancel the dive.

Surf — waves breaking near the shore. Rules:

- watch the surf for a few minutes — waves come in sets; choose a lull;
- enter fully equipped, regulator in your mouth and mask on; do not stop in the surf zone;
- pass through the surf line quickly, under the waves — diving under them or turning sideways;
- exit between sets of waves; do not stand up in the surf zone — crawl or swim to the shallows.

A rip current is a narrow flow running away from the shore through the surf line (through a gap in a reef or sandbar). Signs: a strip of dark, calm, murky water with foam where waves do not break. If caught in one, **do not swim against it** towards the shore: swim **parallel to the shore** until you are out of the flow, then return.

8.5 Behaviour underwater and hazardous marine life



Shark



Moray eel



Titan triggerfish

Underwater we are guests. Most creatures show no aggression unless touched, cornered or fed.

> **Rule: underwater we are only spectators. Touch nothing — and nothing will touch you.**



Stingray

The same rule protects the reef: corals grow very slowly, and one fin kick can destroy years of growth. Good buoyancy is the best protection for both diver and reef.

Territorial fish. The best known is the **titan triggerfish (*Balistoides viridescens*)**. During breeding it guards a nest on the sand; its territory is shaped like a **cone widening towards the surface** and can extend several metres. An attacking triggerfish bites painfully. If attacked, **swim horizontally away from the nest, not upwards** (going up keeps you in its "cone"), shielding yourself with your fins. Even the little **clownfish** bravely defends its anemone.

Moray eels are timid and hide in crevices. Don't put your hands into cracks and **don't feed** morays: smelling food, they may bite the feeding hand.

Sharks. Shark attacks are extremely rare: worldwide a few dozen unprovoked attacks are recorded each year, only a handful of them fatal, while humans kill tens of millions of sharks every year. Most attacks are a shark's mistake at the surface, where a swimmer resembles prey. Large species are considered potentially dangerous: the **great white** (*Carcharodon carcharias*), **mako**, **tiger**, **bull**, **oceanic whitetip** (*Carcharhinus longimanus*), **hammerheads** and **Galapagos** shark. Sharks have an excellent sense of smell and "ampullae of Lorenzini" — organs that detect the weak electric fields of a prey's muscles.

When meeting a potentially dangerous shark:

- stay together as a group, close to the bottom or the reef wall;
- move calmly without sudden movements; don't chase or corner the shark;
- keep watching the shark; don't turn your back on it;
- minimise time on the surface: board the boat quickly; never swim alone on the surface;
- if the shark shows interest (circling, approaching, arching its back) — calmly end the dive along the reef.

The largest fish, the **whale shark** (up to 18 m), is harmless and feeds on plankton.

Stingrays are dangerous only because of the barb on the tail used in self-defence. Don't hover directly above a ray or block its path. When entering the water from a sandy shore, **shuffle your feet** — rays buried in the sand will swim away.

8.6 Venomous marine life and first aid



Lionfish



Sea snake



Fire coral

Venomous marine creatures can be roughly grouped as **stinging** (fire coral, jellyfish, anemones), **spiny** (scorpionfish, sea urchins), **sea snakes** and others.

Fire coral (*Millepora*) is actually a hydroid, not a true coral. Its stinging cells cause burning pain, redness and blisters. Help: rinse with seawater (not fresh water!), remove fragments, apply vinegar, cold compress, anti-itch and antihistamine products. Healing takes from a week to a month.



Box jellyfish



Portuguese man o' war



Stonefish

Sea urchins — long spines break off in the skin. Remove large visible fragments (don't dig deep), immerse the area in hot water (~45 °C), apply antiseptic; for deep punctures near joints — see a doctor.

Scorpionfish — lionfish, scorpionfish, stonefish. Usually mentioned with them is the **crocodilefish** — from the related flathead family (same order, Scorpaeniformes); its spines have not been shown to be venomous, but the spines on its head inflict painful wounds — treat it with the same caution, first aid is the same. The venom on the spines is a protein mixture causing excruciating pain, swelling and sometimes heart problems. The pain can be so severe that the diver loses control — a drowning risk. **Never leave the casualty alone**; help them ascend and get out of the water. No deaths have been recorded among reported lionfish stings; stonefish venom is the most dangerous, and an antivenom exists.

First aid:

- remove visible spine fragments;
- **protein venom is destroyed by heat**: immerse the affected part in hot water **about 45 °C** (as hot as tolerable without scalding) for 30–90 minutes;
- clean the wound and see a doctor; if not vaccinated — **tetanus** prophylaxis; for a stonefish sting — to hospital urgently (antivenom).

Sea snakes are highly venomous but not aggressive and do not attack divers; bites happen when someone tries to catch a snake. Help: rest, pressure bandage along the whole limb, immobilisation, urgent medical care.

Jellyfish. Stinging cells "fire" venom on contact; the effect ranges from mild irritation to death. General rules:

- get out of the water, don't rub the area, **don't rinse with fresh water** (it triggers remaining stinging cells);
- carefully remove tentacles with tweezers or a plastic card, not with bare hands;
- pain relief — hot water about 45 °C or a cold compress; with severe symptoms — see a doctor.

Specifics:

- **box jellyfish** and **Irukandji** — **pour vinegar over the sting for at least 30 seconds**, be ready for CPR, call for help urgently; antivenom is given by medics;
- **Portuguese man o' war** — **no vinegar**; rinse with seawater, hot water 45 °C;
- **sea nettle, lion's mane** — rinse with seawater, remove tentacles, hot water; tentacles of jellyfish washed up on the beach still sting.

Knowledge check

1. How does your weighting change moving from fresh water to the sea (same equipment):

a. Less weight
b. More weight
c. No change
d. Depends only on depth

2. Entry and exit at the same point, there is a current. How do you plan the route:

a. Into the current first, back with it
b. With the current first
c. Across the current
d. Ignore the current

3. What is "slack water":

a. Water in a lake
b. A period of weak current at the turn of the tide
c. A zone without waves
d. Fresh water in the sea

4. A rip current is carrying you away from the shore. You should:

a. Swim against it towards the shore
b. Swim parallel to the shore until out of the flow
c. Dive to the bottom
d. Remove your equipment

5. How do you escape an attacking triggerfish:

a. Upwards to the surface
b. Horizontally away from the nest, shielding yourself with your fins
c. Towards the nest
d. Freeze

6. The main rule of behaviour with marine life:

a. Feed them so they don't attack
b. Touch nothing — we are only spectators
c. Keep your hands on the bottom
d. Scare them with sudden movements

7. How should you behave when meeting a potentially dangerous shark:

a. Surface quickly
b. Stay together near the reef, move calmly, keep watching the shark
c. Swim towards it to scare it
d. Turn your back and freeze

8. Why shuffle your feet entering the water from a sandy shore:

a. To warm up

b. To scare away rays buried in the sand

c. To check the depth

d. To avoid stirring up silt

9. First aid for a scorpionfish sting:

a. Cold compress

b. Vinegar

c. Remove spines and immerse in hot water about 45 °C

d. Cold fresh water

10. Box jellyfish sting. First aid:

a. Rinse with fresh water

b. Rub with sand

c. Pour vinegar for at least 30 seconds, be ready for CPR, call for help urgently

d. Coca-Cola

CHAPTER 9

Dive Planning: Gas Consumption and Minimum Gas Reserve

Planning principles, surface air consumption (SAC), minimum gas reserve (MGR), the dive plan.

9.1 Planning principles

The Open Water Diver IDU course prepares you for independent diving — which means a diver must not only be able to swim underwater but also plan and organise a dive. A plan rests on four principles:

1. **Do not exceed the no-decompression limit** — the maximum time at the planned depth that requires no mandatory decompression stops.
2. **Enough gas** to complete the dive, including the minimum gas reserve (MGR) and consumption — your own and your buddy's.
3. **Training** — yours and your buddy's — matches the difficulty of the dive and the conditions: temperature, current, visibility, waves and wind.
4. **Comfort** — the risk of the dive does not exceed the diver's comfort level and is justified by its purpose.

A well-trained diver understands the risks of a dive and plans it according to their own experience and their buddy's abilities.

9.2 Surface air consumption (SAC)

SAC (Surface Air Consumption) is a diver's gas consumption in litres per minute **converted to the surface** (1 bar). Knowing SAC, you get consumption at any depth by multiplying by absolute pressure:

Consumption at depth (L/min) = SAC × P abs

Consumption depends on workload, so SAC is measured in three modes:

- **low workload** — drifting, slow swimming;
- **medium** — swimming without current at a normal pace;
- **high** — swimming against a current, fast pace.

How to measure. At a pre-selected constant depth, record time (T), cylinder pressure (P) and depth (D) every 3–10 minutes. Example (12 L cylinder):

T, min	P, bar	D, m
3	190	15.3
8	170	15.7
13	150	15.1
18	130	14.9
23	110	15.2
28	90	15.0

1. Measuring time: 28 − 3 = **25 min**.
2. Gas used: 190 − 90 = **100 bar** → 100 / 25 = **4 bar/min**.
3. In litres: 4 × 12 = **48 L/min** (at depth).
4. Average depth: (15.3 + 15.7 + 15.1 + 14.9 + 15.2 + 15.0) / 6 = **15.2 m** → P = 15.2/10 + 1 = **2.52 bar**.
5. **SAC = 48 / 2.52 ≈ 19 L/min.**

Repeat the measurement in all three modes to get three SAC values for planning in different conditions.

9.3 Minimum gas reserve (MGR)

The signal to begin the ascent is **the end of the no-decompression limit** or a remaining pressure equal to the **minimum gas reserve (MGR)** — whichever comes first.

MGR is the amount of gas **two divers** need to ascend safely from the maximum depth of the dive on one cylinder (if the buddy has run out of gas): at an ascent rate of no more than 9–10 m/min and with a 3-minute safety stop. Under stress consumption rises, so we assume **SAC = 30 L/min** for both.

Example: maximum depth 18 m, 12 L cylinders.

Stage	Time	Depth (pressure)	Consumption per diver
Reaction: assess, give gas to buddy	1 min	18 m (2.8 bar)	1 × 2.8 × 30 = **84 L**
Ascent 18 → 5 m (13 m)	2 min	average 11.5 → 12 m (2.2 bar)	2 × 2.2 × 30 = **132 L**
Safety stop	3 min	5 m (1.5 bar)	3 × 1.5 × 30 = **135 L**
Ascent 5 m → surface	1 min	taken as 1 bar	1 × 1 × 30 = **30 L**
Total	7 min		**381 L**

For two: 381 × 2 = **762 L**. In a 12 L cylinder that is 762 / 12 = 63.5 bar. Round up to 65 bar and add **15 bar** so that the cylinders are not completely empty at the surface:

MGR = 65 + 15 = 80 bar.

So on a dive to 18 m with a 12 L cylinder, the divers **begin the ascent no later than when either diver's pressure reaches 80 bar**. For a different depth, cylinder size or SAC, repeat the calculation the same way. On a multilevel dive MGR is calculated for each depth level: it is smaller at shallower depths.

Gas remaining at the surface. On a normal dive the MGR is not used up completely: the diver surfaces with a noticeable reserve. It is desirable to surface with **35–50 bar**. Note: many dive centres require cylinders to be returned with **at least 50 bar** and impose penalties for less — take this into account when planning.

9.4 Gas planning for a dive

Example: **12 L cylinder, 200 bar**, depth **18 m**, no current, entry and exit at the same point. It takes 5 minutes to reach the reef and the same to return. SAC = 19 L/min.

1. **Gas available for the dive** (excluding MGR): (200 − 80) × 12 = **1440 L**.
2. **Gas for the swim out and back**: 10 min × 19 × 2.8 ≈ **533 L**.
3. **Left for the reef**: 1440 − 533 = **907 L**.
4. **Time at the reef**: 907 / (2.8 × 19) ≈ **17 min**.

At 5 + 17 = **22 minutes** into the dive the diver turns back to the exit point and arrives there with at least the MGR (80 bar). Also check the no-decompression limit for 18 m in the table or on the computer: dive time must not exceed it.

A multilevel dive is calculated the same way — split into segments by depth and time.

9.5 Making a plan

The dive plan is agreed with the buddy at the briefing and includes:

- objective and route, entry and exit points, landmarks;
- maximum depth and time, no-decompression limit;
- gas: starting pressure, MGR, turn pressure, gas signals;
- descent and ascent procedure, safety stop;
- signals and actions if separated from the buddy and in emergencies;
- conditions: current, visibility, temperature, surface support.

> **Plan your dive — and dive your plan.** If conditions change, change the plan or cancel the dive.

Knowledge check

1. SAC is:

a. Gas consumption at maximum depth

b. Gas consumption in litres per minute converted to the surface

c. Cylinder volume

d. Gas reserve

2. In 20 minutes at a constant depth a diver used 80 bar from a 12 L cylinder. Consumption at depth:

a. 4 L/min

b. 48 L/min

c. 960 L/min

d. 16 L/min

3. Consumption at depth 48 L/min, average depth 14 m. SAC:

a. 20 L/min

b. 48 L/min

c. 34 L/min

d. 12 L/min

4. A diver's SAC is 20 L/min. Consumption at 18 m:

a. 20 L/min

b. 36 L/min

c. 56 L/min

d. 76 L/min

5. The minimum gas reserve (MGR) is the gas needed:

a. By one diver for the safety stop

b. By two divers to ascend safely from maximum depth on one cylinder

c. To swim to the dive site

d. To inflate an SMB

6. Why is SAC taken as 30 L/min when calculating MGR:

a. It is the average SAC

b. In an emergency both divers' consumption rises due to stress

c. The regulator manufacturer requires it

d. To allow for leaks

7. According to the calculation in this chapter, MGR for 18 m with a 12 L cylinder is:

a. 50 bar

b. 80 bar

c. 110 bar

d. 150 bar

8. When must a diver begin the ascent:

a. Only at the end of the no-decompression limit

b. At 50 bar

c. At the end of the no-decompression limit or on reaching MGR — whichever comes first

d. When tired

9. 12 L cylinder, 200 bar, MGR 80 bar. How many litres are available for the dive:

a. 2400 L

b. 1440 L

c. 960 L

d. 1200 L

10. What pressure is it desirable to surface with after a normal dive:

a. 0–10 bar

b. 35–50 bar — many dive centres require at least 50 bar

c. 100 bar

d. It doesn't matter

CHAPTER 10

IDU No-Decompression Dive Tables and Dive Computers

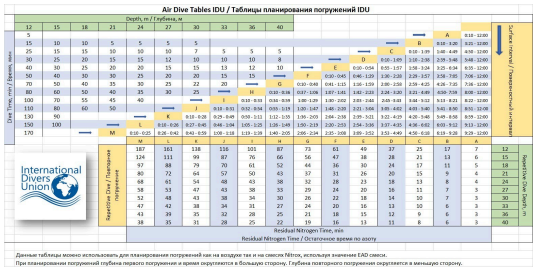
Using the IDU tables, repetitive dives, the dive computer and its planner mode.

10.1 The no-decompression principle

All recreational dives are based on the principle of **not exceeding the no-decompression limit**: at any moment the diver can end the dive and ascend to the surface at a safe rate without mandatory decompression stops. A safety stop is nevertheless always recommended.

Planning tools are the **IDU tables** (the simplest and most accessible) and the **dive computer** (the most accurate). The IDU tables are for air; for Nitrox mixes they are used with the equivalent air depth (EAD) — this is taught on the Nitrox Diver IDU course.

10.2 How the IDU table works



IDU no-decompression dive tables

The table has three sections.

1. Dive data. Columns are depth (12, 15, 18 … 40 m), rows are time. **The bottom value in each column is the no-decompression limit** for that depth (for example, 170 minutes for 12 m). If the exact depth or time is not listed, **round up to the next greater value**. Moving right from the cell to the diagonal gives the **pressure group** (A … M) after the dive.

2. Surface interval. From the group after the dive, move right along the same row to the interval that contains your time on the surface, then down — this gives the **new pressure group** after the surface interval.

3. Residual nitrogen (RNT — residual nitrogen time). For the new group and the depth of the repetitive dive, the table gives a notional time "already used" before entering the water. It is subtracted from the no-decompression limit. **When finding RNT, round the repetitive dive depth down** — this gives a more conservative value.

> The maximum depth for an IDU Open Water Diver is 18 m. Columns deeper than 18 m are used only after further training.

10.3 Worked example

First dive: 10 m, 45 minutes. Round up: column 12 m, row 50 minutes → group **F**.

Surface interval 90 minutes (1:30). In row F find the interval 1:30–2:28 → new group **D**.

Second dive to 12 m. For group D and 12 m, RNT = **37 minutes**. The no-decompression limit for 12 m is 170 minutes:

170 − 37 = 133 minutes — the maximum time for the second dive.

If the second dive lasts **40 minutes**, add RNT to find the group after it: 40 + 37 = **77 minutes** → row 80 in the 12 m column → group **H**. Further dives are calculated the same way.

10.4 Table rules

- Round the depth and time of the first dive **up**.
- When finding RNT, round the repetitive dive depth **down**; take the repetitive dive's no-decompression limit from the column of its actual (rounded-up) depth.
- In groups **K, L, M**, extend the safety stop **to 5 minutes**.
- After a surface interval of **12 hours or more**, the next dive counts as the first in a series.
- **In cold water (≤ 18 °C)** and with heavy exertion, use **the next greater depth**: for 13 m, the 18 m column instead of 15 m.
- Tables are accurate only for a **simple square profile**; for multilevel dives they give only a rough estimate.

10.5 Dive computer

A computer continuously measures depth and time and calculates tissue saturation from the actual dive profile — so it is more accurate than tables, especially on multilevel dives. It shows the remaining no-decompression time, warns of excessive ascent rate and depth, guides the safety stop, tracks residual nitrogen and shows time to fly.



Computer planner mode

Planner mode. Before a repetitive dive, enter the planned depth — the computer shows the available no-decompression time taking residual nitrogen into account. If it is not enough — extend the surface interval or reduce the depth.

Rules for computer use:

- each diver has their own computer; don't swap or share computers during a series of dives — it "remembers" your saturation;
- if buddies use different computers, follow the **more conservative** one;
- check charge and settings (air/Nitrox, fresh/salt water) before the dive;
- if your computer fails underwater — **begin the ascent** with your buddy, make a safety stop, and don't dive again that day (or follow the manufacturer's recommendations);
- if the no-decompression limit is accidentally exceeded — follow the computer's decompression stop instructions and do not dive for at least 24 hours afterwards.

Knowledge check

1. What does the bottom value in each depth column of the IDU table mean:

a. Minimum dive time

b. The no-decompression limit for that depth

c. Pressure group

d. Surface interval

2. A dive to 10 m for 45 minutes. Which column and row do you use:

a. 10 m and 40 min

b. 12 m and 50 min

c. 12 m and 40 min

d. 15 m and 45 min

3. How is the repetitive dive depth rounded when finding RNT:

a. Up

b. Down

c. To the nearest value

d. Not rounded

4. Group F after the first dive, surface interval 90 minutes. New group:

a. F

b. E

c. D

d. C

5. Group D, repetitive dive to 12 m: RNT 37 min, limit for 12 m — 170 min. Maximum time for the second dive:

a. 170 min

b. 133 min

c. 207 min

d. 37 min

6. The second dive lasted 40 minutes, RNT 37 minutes. Which time is used to find the group:

a. 40 min

b. 37 min

c. 77 min

d. 3 min

7. In groups K, L, M the safety stop is:

a. Skipped

b. Made at 10 m

c. Extended to 5 minutes

d. Made twice

8. After what surface interval does a dive count as the first in a series:

a. 6 hours

b. 12 hours or more

c. 24 hours

d. 2 hours

9. A dive in 16 °C water to 13 m. Which column do you use:

a. 12 m

b. 15 m

c. 18 m

d. 21 m

10. Your computer fails underwater. You should:

a. Continue using your buddy's computer

b. Continue using tables

c. Begin the ascent with your buddy, make a safety stop, don't dive again that day

d. Take your buddy's computer

CHAPTER 11

Dive Procedures: Buddy System, Checks, Descent and Ascent, Buoyancy, Navigation, Emergencies

Buddy system, equipment checks, entries, descent and ascent, buoyancy, navigation, emergencies.

11.1 The buddy system



Correct buddy position

Underwater a diver relies on three principles: **only I can think for myself, only I can breathe for myself, only I can swim for myself.** A well-trained diver can handle problems alone, but a buddy makes it safer: extra hands, support, an alternate gas source.

- Every dive is made **with a buddy**.
- The distance between buddies allows **immediate assistance** — within a few metres, closer in poor visibility.
- Buddies **see each other without effort**. The best position is side by side at the same depth, the leader half a body length ahead and to the side. The worst is one above the other: the upper diver sees the lower one, but the lower diver has difficulty finding the buddy.
- Check your buddy's position **at least once a minute**.
- Signal your buddy before any action not agreed beforehand.
- Buddy diving also means **mutual monitoring** and **joint equipment checks** before the dive.

Buddy separation

Silt, terrain or current can cause loss of visual contact. Procedure:

1. **Stop.** Look around, up and down; check your instruments; switch on your light — it is visible from afar even in murky water.
2. **Search for no more than one minute** on the spot, turning slowly. Don't swim away — you will most likely move further from your buddy.
3. **Begin the ascent** at a normal rate, deploy your SMB, make a safety stop.

4. **Wait for your buddy on the surface for 5–6 minutes**, looking around and underwater (your buddy has also searched for a minute and is ascending).
5. If not found — **signal** and report the missing buddy to the surface support. Do not organise a search yourself: coordinated action with the support team is more effective and allows help to be called in time.

The buddy-separation procedure must be discussed at the briefing.

11.2 Equipment checks

Checks are mandatory. They have three parts: the **Pre-Dive Check** (on land/boat), the **Bubble Check** (at the surface or at the start of the dive) and the **S-Drill** (at the start of the dive).

Pre-Dive Check

Done with your buddy once equipment is on. Each diver checks their own equipment and **says it out loud** while the buddy watches. Order — top to bottom:

1. Mask (primary and spare, if carried).
2. Cylinder valve — open.
3. Pressure — state the gauge reading.
4. Primary second stage — works; while breathing from it, watch the gauge: the needle does not move. Clip the gauge in place *(do not breathe on the surface in freezing conditions)*.
5. Primary second-stage hose — free and accessible.
6. Alternate second stage — works, in place *(do not breathe in freezing conditions)*.
7. Inflator — works.
8. BCD dump valves — work.
9. All buckles and straps — fastened.
10. Weights — in place, release accessible.
11. Computer and compass — on, working, which wrist.
12. Lights (if needed) — working, where attached.
13. Cutting tool — where it is.
14. SMB and spool — where they are.
15. Fins.

Bubble Check

At the surface: the diver signals "bubbles"; the buddy inspects the valve, first stage, second stages, inflator (and drysuit valve) by putting them under water. No leaks — "OK" signal, then swap roles.

Underwater (at the start of the dive, at 3–5 m): buddies hover facing each other; the checker signals "bubbles" and "turn around"; the buddy turns slowly through 360°; the checker inspects possible leak points and signals "OK". Then swap roles.

S-Drill

Performed after the Bubble Check at 3–5 m to confirm that the diver can quickly hand the primary second stage on the long hose to the buddy:

1. The checker signals "S-Drill".
2. The buddy switches from the primary to the alternate second stage.
3. Frees and deploys the primary hose, showing that it is accessible.
4. After the "OK" signal, restows the hose and switches back to the primary.
5. Buddies swap roles.

11.3 Entries and exits

From a boat:

- **giant stride** — from a high deck or platform: holding mask and regulator, step forward, BCD partly inflated;
- **back roll** — from the low side of a boat (inflatable): sitting with your back to the water, holding mask and regulator, roll backwards;
- **seated entry** — from a low platform or pool edge: sit, turn and slide gently into the water.

Before entering make sure the area below is clear (no divers, boats or obstacles); afterwards signal "OK" and move away from the entry point.

From shore: assess waves and surf (Chapter 8) and enter fully equipped; put fins on in waist- or chest-deep water holding on to your buddy, or lying down in the shallows. On sandy bottoms shuffle your feet.

Exiting onto a boat: approach the ladder one at a time, never stay under the ladder or behind the stern near the propellers; remove your fins and climb up with regulator in your mouth and mask on until you are out of the water. **Exiting onto shore** — in reverse, taking the surf into account.

11.4 Descent

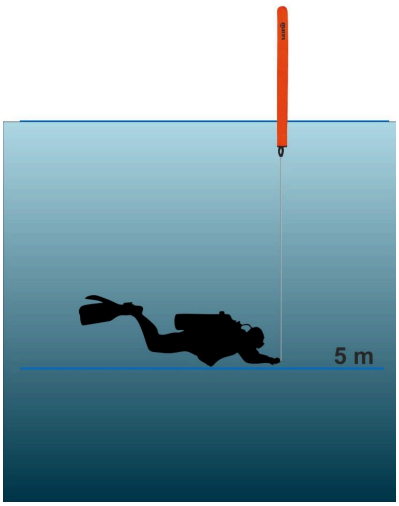
1. On the surface adopt a **vertical position**: it is easier to look around and to vent the BCD.
2. Agree the descent with your buddy ("down" signal), note the time, switch from snorkel to regulator.
3. Fully deflate the BCD, exhale — begin descending **feet first** without finning.
4. Equalise early and often (Chapter 6).
5. As you descend, move to a horizontal position and add gas to the BCD to stop **above the bottom** without touching it.

Control your descent rate: movement underwater has inertia, and a fast descent increases narcosis and hinders equalisation. The recommended maximum descent rate is **no more than 20 m/min**.

11.5 Ascent and safety stop

During ascent pressure drops and nitrogen leaves the tissues. Too fast an ascent — like a fizzy bottle opened abruptly — leads to DCS, and holding your breath leads to lung overexpansion injury.

- Ascent rate — **no more than 9–10 m/min** (watch your computer), slower near the surface.
- Begin the ascent together with your buddy on the "up" signal; stay horizontal, vent the BCD, breathe continuously.
- **Safety stop — at 3–6 m for at least 3 minutes** (5 minutes in groups K, L, M of the table). It is a recommended procedure that reduces DCS risk — always make it. Computers automatically start safety-stop mode after ascending above 6 m.
- After the stop, adopt a vertical position, raise a hand above your head, ascend slowly looking around and rotating; use an SMB. At the surface inflate the BCD and signal "OK".



Safety stop with an SMB

11.6 Buoyancy control

Neutral buoyancy is the diver's core skill. It saves effort and gas, prevents injury and protects the reef.

- **Don't overweight** — excess weight has to be compensated with gas in the BCD.
- Keep **minimal gas** in the BCD — the more there is, the more buoyancy changes with depth.
- **Breathe steadily**: full lungs lift you, empty lungs lower you; use breathing for fine adjustment.
- Stay **horizontal**: gas doesn't collect in one part of the BCD or drysuit.
- Add and vent gas **in small amounts** and wait for the effect.
- **Weighting check:** at the surface with an empty BCD and a normal breath you float at eye level and begin to sink as you exhale; at the end of the dive with a nearly empty cylinder you must be able to hold the safety stop comfortably.
- Practise regularly — without practice the skill fades.

11.7 Basic underwater navigation

Navigation is needed to reach an objective out of sight, return to the exit point and follow a planned route.

- **Natural navigation:** bottom topography, rocks, coral pinnacles, sand ripples, slope direction, current, the sun's position. Move from one landmark to the next and remember them for the return.
- **Compass:** a scaled card in a liquid-filled housing, a "lubber line" and a side window. A **heading** is the angle between north and the direction of travel. Hold the compass level, lubber line along your body's axis.
- **Reciprocal heading:** heading ± 180° (e.g. out 60° — back 240°).

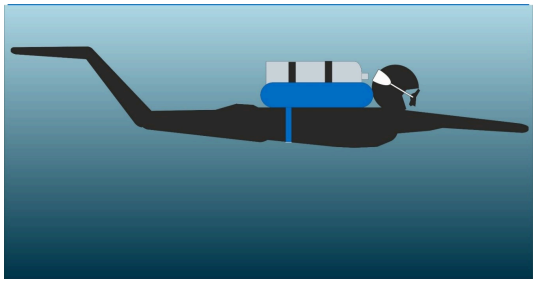
- **Distance:** estimate by time or by kick cycles measured in advance.

More in the **Underwater Navigation IDU** course.



Compass: lubber line and side window

11.8 Body position and finning techniques



Horizontal trim

The smaller the body area across the direction of travel, the lower the drag. The correct position is **horizontal**, parallel to the surface (or bottom), knees bent, fins raised.

- **Frog kick** — the main, most efficient kick; the water is pushed back and up — the bottom is not disturbed.
- **Modified frog** — small amplitude, mainly the feet work: slow, careful movement close to the bottom and objects.
- **Flutter kick** (legs work from the hip) — for a short burst, e.g. against a current; tiring and can stir up silt.
- **Modified flutter** — knees bent, only the feet work: for tight spaces and near the bottom.
- **Back kick** — to move away from an object without turning; one of the hardest skills.
- **Helicopter turn** — turning on the spot with minimal fin movement.

Finning techniques are learned with an instructor — they cannot be learned from a book or video. The **Perfect Buoyancy Control IDU** course will help you perfect them.

11.9 Underwater emergencies

- **Free-flow** second stage: don't let go of the regulator — keep it in your mouth with lips slightly open and breathe, letting excess gas escape; switch to the alternate or to your buddy and end the dive.
- **Out of gas:** signal "out of gas" to your buddy, take gas from them (primary on the long hose or alternate), hold on to each other and begin a joint ascent with a safety stop.

- **Controlled emergency swimming ascent** (if no buddy is nearby and depth is shallow): ascend with the regulator in your mouth, **exhaling continuously** ("aaah"), no faster than **18 m/min**, controlling buoyancy.
- **Entanglement:** stop, don't spin, call your buddy, free yourself slowly, use a cutting tool if needed.
- **Dropping weights** — a last resort when buoyancy cannot be established any other way (at the surface — to stay afloat).

Knowledge check

1. How often should you check your buddy's position:

a. Every 5 minutes

b. At least once a minute

c. Only during the safety stop

d. As needed

2. You have lost your buddy. How long do you search underwater before ascending:

a. 5 minutes

b. About one minute

c. Until reaching MGR

d. Don't search

3. How long do you wait for your buddy on the surface:

a. 1 minute

b. 5–6 minutes, then inform the support team

c. 20 minutes

d. Don't wait

4. Why breathe from the second stage while watching the gauge during the Pre-Dive Check:

a. To measure SAC

b. The needle must not move — the valve is fully open and supply is normal

c. To warm up the regulator

d. No need

5. The purpose of the S-Drill:

a. To check for leaks

b. To make sure the primary hose is free and gas can be handed to the buddy quickly

c. To check the computer

d. To practise descent

6. Which entry is used from the low side of a boat:

a. Giant stride

b. Back roll

c. Head-first dive

d. Seated entry facing the water

7. Recommended maximum ascent rate:

a. 18 m/min

b. 20 m/min

c. 9–10 m/min

d. 5 m/min

8. The safety stop is made:

a. At 10 m for 1 minute

b. At 3–6 m for at least 3 minutes

c. On the surface

d. Only after dives deeper than 18 m

9. The most efficient kick that doesn't stir up silt:

a. Flutter

b. Frog

c. Back kick

d. Modified flutter

10. The reciprocal of heading 60°:

a. 120°

b. 240°

c. 300°

d. 0°

CHAPTER 12

First Aid, Insurance, Travel, Logbook and Further Training

First aid, insurance, travel, first aid kit, logbook and further IDU training.

12.1 First aid on dives

Every dive is backed by **surface support**: a first aid kit, an **oxygen kit** (100% O_2), communications to call for help, a boat or shore access, and a Divemaster-level professional or higher. Know in advance where the nearest hospital and **hyperbaric chamber** are and how to contact them.

General procedure in an accident:

1. **Assess safety** — don't become a second casualty.
2. Get the casualty out of the water and remove their equipment.
3. Check **consciousness and breathing**; if absent — call for help and start **CPR**.
4. With any suspicion of DCS or lung overexpansion injury — **lay flat and give 100% oxygen** (Chapters 6, 7).
5. Call for help and say the casualty is a diver.
6. Record the dive profile, the time and development of symptoms; hand them to the medics together with the casualty's computer.

First aid and CPR are taught on the **Emergency First Aid IDU** course — we recommend it to every diver.

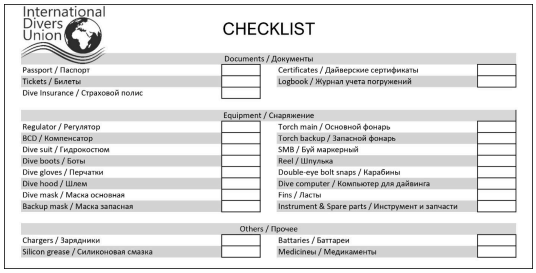
12.2 Diver insurance

Diving involves risks, and treatment — especially in a hyperbaric chamber — is expensive. Diving insurance helps you deal with this at minimal cost.

- **Travel insurance with a "diving" option** — suits occasional trips. Read the contract carefully: is the **hyperbaric chamber** covered and to what extent, is there a **depth limit** (often 18–30 m), is a certification required, which countries and types of dives are excluded.
- **Annual diver insurance** — convenient for those who dive often and travel a lot.

Before a trip, ask your insurer **how exactly the policy works in the destination country**: which clinics and chambers they have agreements with, who pays for treatment on the spot, the emergency phone number. Make sure the insurance actually works where you will dive — in practice this varies from country to country.

12.3 Diving and travel



International Divers Union

CHECKLIST

Documents / Документы			
Passport / Паспорт		Certificates / Дайверские сертификаты	
Tickets / Билеты		Logbook / Журнал учета погружений	
Dive Insurance / Страховой полис			
Equipment / Снаряжение			
Regulator / Регулятор		Torch main / Основной фонарь	
BCD / Компенсатор		Torch backup / Запасной фонарь	
Dive suit / Гидрокостюм		SMB / Буй маркерный	
Dive boots / Боты		Reel / Шпулька	
Dive gloves / Перчатки		Double-eye bolt snaps / Карабины	
Dive hood / Шлем		Dive computer / Компьютер для дайвинга	
Dive mask / Маска основная		Fins / Ласты	
Backup mask / Маска запасная		Instrument & Spare parts / Инструмент и запчасти	
Others / Прочее			
Chargers / Зарядники		Batteries / Баттареи	
Silicon grease / Силиконовая смазка		Medicineu / Медикаменты	

Packing checklist

Diving opens up the planet's most pristine places. There are two main types of trip:

- **daily diving** — a day of diving with a return to shore; easy to combine with a hotel holiday;
- **liveaboard safari** — a trip on a specially equipped boat-hotel for 3 days or more: remote sites and more marine life.

Use a packing checklist and bring your certification card, logbook and insurance policy.

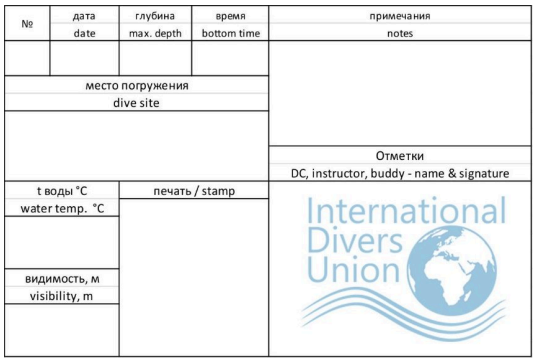
Travelling diver's first aid kit:

- oral rehydration salts;
- ear drops (only as prescribed by a doctor);
- seasickness medication (without marked sedative effect — test your tolerance in advance, not before your first dive);
- painkiller and anti-inflammatory;
- antihistamine tablets and cream — for stings;
- household vinegar — for jellyfish stings (Chapter 8);
- antiseptic, plasters, bandage, sterile wipes;
- sunscreen.

Repair kit: spare mouthpiece, O-ring kit and O-ring pick, cable ties, a multi-purpose dive tool (hex keys, valve and inflator keys, screwdriver), adjustable spanner, spare mask and fin straps.

Flying after diving. Observe the time to fly shown by your computer (Chapter 7); don't plan dives on the day of departure.

12.4 Logbook



№	дата date	глубина max. depth	время bottom time	примечания notes
место погружения dive site				
				Отметки DC, instructor, buddy - name & signature
t воды °C water temp. °C		печать / stamp		International Divers Union
видимость, м visibility, m				

Logbook page

A logbook records your dives and experience. A dive centre uses it to assess your training and choose suitable dives, and an instructor uses it to decide whether you can join the next course.

Record: date, site, depth and time, gas and start/end pressure, weights and suit, conditions (temperature, visibility, current), buddy, observations. Your logbook will remind you how much weight you used with that suit and which sites you liked. A computer's electronic log is convenient but does not replace notes on weights, equipment and conditions.

12.5 Further IDU training



Further training opens new horizons

The Open Water Diver IDU course gives you basic knowledge and skills. The underwater world is diverse, and many conditions require special training.

Recreational programmes:

- **Advanced Adventure Open Water Diver IDU** — an introduction to specialties: Perfect Buoyancy Control, Deep, Underwater Navigation and one of your choice; depth up to 30 m.
- **Advanced Open Water Diver IDU** — five full specialty courses: **Perfect Buoyancy Control, Deep Diver, Underwater Navigation, Nitrox Diver** and one of your choice (Dry Suit, Night and Low Visibility, Wreck, Drift, Ice, Sidemount or TECH Fundamental); depth up to 40 m.
- **Emergency First Aid IDU** — first aid and CPR, also for non-divers.
- **Rescue Diver IDU** — preventing and handling emergencies, rescue in the water and on shore.

Specialties: Nitrox Diver (recommended together with OWD), Dry Suit Diver, Ice Diver, Night Dive and Low Visibility, Underwater Navigation, Perfect Buoyancy Control, Boat Diver, Drift Dive, Deep Diver, Sidemount Diver, Recreational Wreck Diver, DPV Diver, Self-Reliant Diver, Gas Blender, Trimix Gas Blender.

Technical diving: TECH Fundamental → TECH-1 / TECH-1 Trimix → TECH-2 → TECH-3; rebreathers — TECH CCR-1, CCR-2, CCR-3.

Cave diving: Cavern → CAVE-1 → CAVE-2 → TECH CAVE.

Professional programmes: Divemaster IDU — the first professional level (guide, instructor's assistant), followed by IDU instructor courses.

Knowledge check

1. What must surface support for a dive include:

a. Just a boat
b. A first aid kit and oxygen kit, communications to call for help
c. A spare computer
d. A scooter

2. The first action in an accident:

a. Assess your own safety
b. Start CPR in the water immediately
c. Give the casualty water
d. Call relatives

3. What should you check in a diving insurance policy:

a. Only the price
b. Hyperbaric chamber cover, depth limits and how the policy actually works in the country where you dive
c. The colour of the policy
d. Equipment discounts

4. What is a liveaboard safari:

a. A shore dive
b. A multi-day trip on a boat-hotel
c. A night dive
d. A drift dive

5. Why is household vinegar useful in a diver's first aid kit:

a. To rinse ears
b. For first aid for box jellyfish stings
c. For seasickness
d. To clean the mask

6. Why keep a logbook:

a. It is only needed for insurance
b. It proves experience, helps choose dives and courses, and records weights and conditions
c. Airlines require it
d. It is unnecessary with a computer

7. Which specialties are mandatory for Advanced Open Water Diver IDU:

a. Night, Wreck, Drift, Ice

b. Perfect Buoyancy Control, Deep Diver, Underwater Navigation, Nitrox Diver + one of choice

c. Only Deep and Nitrox

d. Rescue and Emergency First Aid

8. Maximum depth for Advanced Open Water Diver IDU:

a. 18 m

b. 30 m

c. 40 m

d. 50 m

Answer key

Chapter 1. Introduction. IDU. Course Programme

1. **b)** 18 m
2. **a)** 12 m
3. **b)** Only under the supervision of a professional, to 12 m
4. **b)** Land → surface → confined water → open water
5. **b)** A pool or a body of water with similar conditions of visibility, depth, water movement and access
6. **b)** Get an instructor briefing, ideally make an orientation dive with a professional
7. **b)** Jacques-Yves Cousteau and Émile Gagnan
8. **b)** All or nearly all signals are given with one hand

Chapter 2. Diving Physics

1. **b)** 2.8 bar
2. **b)** About 1 bar
3. **b)** 2 L
4. **a)** 0–10 m
5. **b)** 4 times
6. **c)** 0.84 bar
7. **b)** The diver's weight equals the buoyant force
8. **b)** Wetsuit neoprene and BCD gas compress — less water is displaced
9. **b)** Increases — vent gas
10. **c)** 3 bar (ambient pressure)

Chapter 3. Equipment I: Mask, Snorkel, Fins, Exposure Suits, BCD, Weights

1. **b)** They cannot be equalised — there is no nose pocket
2. **b)** Place it without the strap, press lightly, hold your breath — the mask must stay on even when you tilt your head down
3. **b)** A simple flexible snorkel without valves, stowed in a BCD pocket
4. **b)** Worn over boots that protect the feet on shore
5. **b)** 5 mm
6. **c)** Drysuit
7. **b)** Neoprene compresses at depth — buoyancy changes
8. **b)** The undersuit and the gas layer inside the suit
9. **b)** Modular (backplate, harness, wing)
10. **b)** Quick release with one movement

Chapter 4. Equipment II: Cylinders, Regulators, Instruments, Accessories

1. **b)** An 80 cu ft aluminium cylinder with an internal volume of about 11.1 L
2. **b)** Prohibited: risk of failure, and the cylinder is condemned at inspection
3. **b)** Every 5 years (per national rules)
4. **b)** DIN
5. **b)** The O-ring is captured inside the threaded connection
6. **c)** About 8–10 bar above ambient
7. **b)** Has its valve offset by intermediate pressure — easier, more consistent breathing
8. **b)** At least once a year, even if unused
9. **b)** The needle must not move — otherwise the valve is not fully open or there is a fault
10. **b)** By immersing it in water — even with the cap on

Chapter 5. The Aquatic Environment: Vision, Light, Sound, Heat

1. **b)** About one-third larger and one-quarter closer
2. **b)** Water is optically close to the eye's tissues — the cornea hardly refracts light
3. **a)** Red
4. **d)** Blue

5. **b)** Sound travels ~4.5 times faster and the brain cannot detect the arrival-time difference between the ears
6. **c)** About 25
7. **c)** Give alcohol or rub with alcohol
8. **b)** Dehydration, which increases DCS risk

Chapter 6. Air Spaces and Barotrauma

1. **b)** Middle ear
2. **c)** At the surface and then often, before discomfort
3. **c)** Ascend 1–2 m and gently try again; if it fails — abort the dive
4. **b)** On ascent, when expanding gas cannot escape from the middle ear or sinuses
5. **b)** An overly forceful Valsalva
6. **b)** Exhale through the nose into the mask on descent
7. **b)** They may wear off underwater and cause a reverse block
8. **b)** Holding your breath during ascent
9. **b)** Quickly — during ascent or within minutes of surfacing
10. **c)** Lay flat, 100% oxygen, call an ambulance, contact a hyperbaric chamber

Chapter 7. Breathing and Gases: CO_2, Stress, Saturation, DCS, Nitrogen Narcosis, Carbon Monoxide

1. **b)** Gas density increases — more work of breathing and CO_2 build-up
2. **c)** Slowly, deeply and rhythmically
3. **b)** It suppresses the urge to breathe — sudden unconsciousness is possible
4. **b)** Stop and regain control of your breathing, then assess and act
5. **b)** The partial pressure of the gas above the liquid
6. **b)** Most often within the first hour after the dive, but possibly up to 24 hours
7. **d)** A slow ascent with a safety stop
8. **c)** Lay flat, 100% oxygen, still water, call for help and transport to a hyperbaric chamber
9. **c)** Stop, signal your buddy, ascend a few metres
10. **b)** CO is odourless: an exhaust smell indicates contamination, but only a CO analyser is reliable

Chapter 8. The Environment: Water, Currents, Waves, Marine Life

1. **b)** More weight
2. **a)** Into the current first, back with it
3. **b)** A period of weak current at the turn of the tide
4. **b)** Swim parallel to the shore until out of the flow
5. **b)** Horizontally away from the nest, shielding yourself with your fins
6. **b)** Touch nothing — we are only spectators
7. **b)** Stay together near the reef, move calmly, keep watching the shark
8. **b)** To scare away rays buried in the sand
9. **c)** Remove spines and immerse in hot water about 45 °C
10. **c)** Pour vinegar for at least 30 seconds, be ready for CPR, call for help urgently

Chapter 9. Dive Planning: Gas Consumption and Minimum Gas Reserve

1. **b)** Gas consumption in litres per minute converted to the surface
2. **b)** 48 L/min
3. **a)** 20 L/min
4. **c)** 56 L/min
5. **b)** By two divers to ascend safely from maximum depth on one cylinder
6. **b)** In an emergency both divers' consumption rises due to stress
7. **b)** 80 bar
8. **c)** At the end of the no-decompression limit or on reaching MGR — whichever comes first
9. **b)** 1440 L
10. **b)** 35–50 bar — many dive centres require at least 50 bar

Chapter 10. IDU No-Decompression Dive Tables and Dive Computers

1. **b)** The no-decompression limit for that depth
2. **b)** 12 m and 50 min
3. **b)** Down
4. **c)** D
5. **b)** 133 min
6. **c)** 77 min
7. **c)** Extended to 5 minutes
8. **b)** 12 hours or more
9. **c)** 18 m
10. **c)** Begin the ascent with your buddy, make a safety stop, don't dive again that day

Chapter 11. Dive Procedures: Buddy System, Checks, Descent and Ascent, Buoyancy, Navigation, Emergencies

1. **b)** At least once a minute
2. **b)** About one minute
3. **b)** 5–6 minutes, then inform the support team
4. **b)** The needle must not move — the valve is fully open and supply is normal
5. **b)** To make sure the primary hose is free and gas can be handed to the buddy quickly
6. **b)** Back roll
7. **c)** 9–10 m/min
8. **b)** At 3–6 m for at least 3 minutes
9. **b)** Frog
10. **b)** 240°

Chapter 12. First Aid, Insurance, Travel, Logbook and Further Training

1. **b)** A first aid kit and oxygen kit, communications to call for help
2. **a)** Assess your own safety
3. **b)** Hyperbaric chamber cover, depth limits and how the policy actually works in the country where you dive
4. **b)** A multi-day trip on a boat-hotel
5. **b)** For first aid for box jellyfish stings
6. **b)** It proves experience, helps choose dives and courses, and records weights and conditions
7. **b)** Perfect Buoyancy Control, Deep Diver, Underwater Navigation, Nitrox Diver + one of choice
8. **c)** 40 m

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