

Scuba Learning Module 18

Scuba cylinder valves

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Scuba regulators

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Instruments

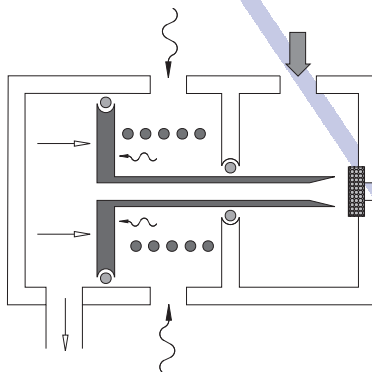
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Function

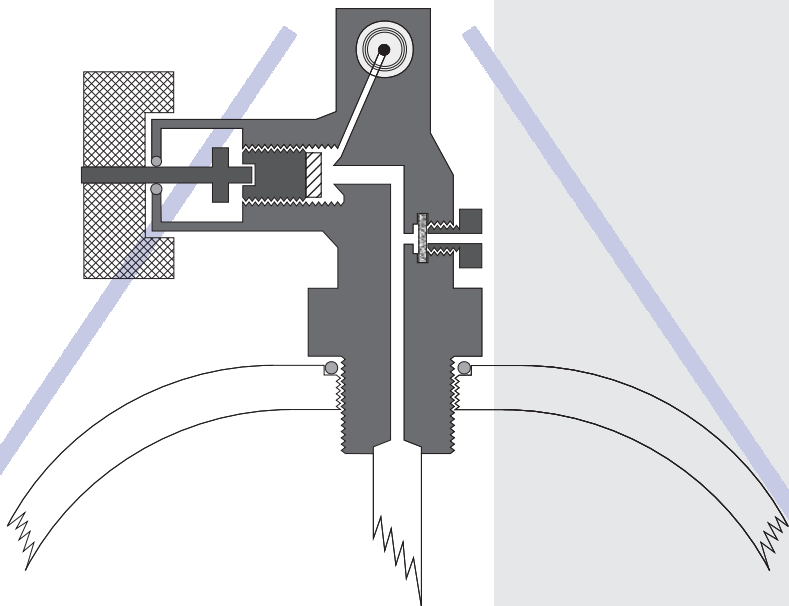
- On/Off tap for cylinder air flow
- Integrated over-pressure relief valve

Types

- Non-reserve (K valve)—most common
- DIN—used for high pressure cylinders > 225 atm (3200 psi)
- Reserve (J valve)—older and unreliable

Valve components

- Teflon seat—damaged by over-tightening valve handle
- Burst disc—over-pressure safety relief valve
- Valve o-ring—seal between valve and regulator
- Cylinder o-ring—seal between valve and cylinder
- Valve stem—helps prevent contaminants entering first stage of regulator when cylinder is inverted



Regulator won't seal

- Valve o-ring may be missing, damaged or wrong size:
 - Check and replace o-ring if necessary
 - Check yoke screw (may be loose)
 - Check hose connections

Cannot fill cylinder

- J-valve closed try other position
- Damaged Teflon seat

See qualified service technician

Gauge reading fluctuates when breathing

- Valve not fully on—check and fix
- J-valve not open try other position
- Damaged Teflon seat

See qualified service technician

Air leak between valve and cylinder

- Cylinder o-ring damaged

See qualified service technician

Air leak from burst disc

- Cylinder has been over pressurised

See qualified service technician

Air leak from handle

- Damaged o-ring, seat or seal

See qualified service technician



Typical dive shop repair facility

Description

- The most common modern regulator is a single hose, two stage regulator which is open circuit (ie exhaust gases are expelled into the external environment)
- High pressure cylinder air is reduced to ambient pressure via two stages of pressure reduction:

First stage (reducing valve)

- Reduces high pressure cylinder air to intermediate (line) pressure 8-10 atm (120-150 psi) above ambient (absolute) pressure

Second stage (demand valve)

- Reduces intermediate (line) pressure to ambient pressure

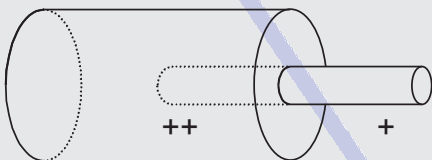
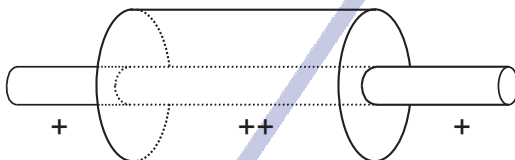


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Types

- Base design is either diaphragm or piston operation
- Both can be either unbalanced or balanced

Principals of balancing



Unbalanced

- Need force to hold rod in
- Larger diameter rod and orifice requires larger force
- Force required to hold rod in is dependent on pressure inside

Unbalanced first stages

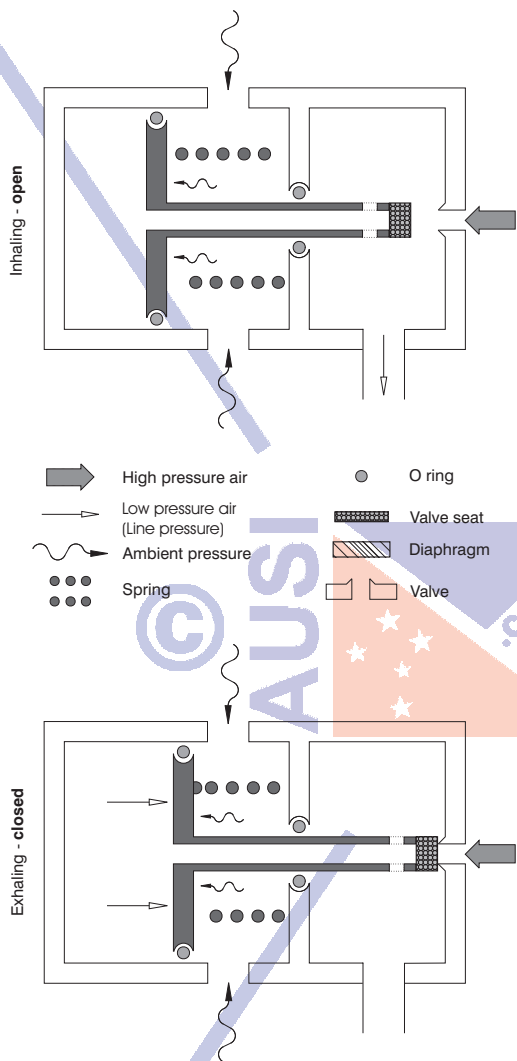
- Cylinder pressure helps determine opening and closing of valve
- Poor airflow characteristics - particularly on deep dives (due to increased air density)
- Line pressure and hence second stage performance is affected by cylinder pressure

Balanced

- No force required to hold rod in
- Can use larger diameter rod and orifice
- Pressure inside does not effect movement of rod

Balanced first stages

- Constant second stage performance because line pressure is constant
- Better air flow characteristics due to larger orifice
- Line pressure is independent of cylinder pressure
- Less wear and tear because valve is independent of high pressure air



Unbalanced piston

Opening forces

- Ambient pressure **constant** (at a given depth)
- Spring tension **constant**, 8-10 atm (120-150 psi)
- High pressure air variable

Closing forces

- Intermediate pressure **variable**

Result

- As cylinder pressure falls intermediate (line) pressure decreases hence regulator becomes harder to breathe
- To keep first stage size manageable, high pressure orifice is small therefore reducing air flow, particularly at depth



Balanced (flow through) piston

Opening forces

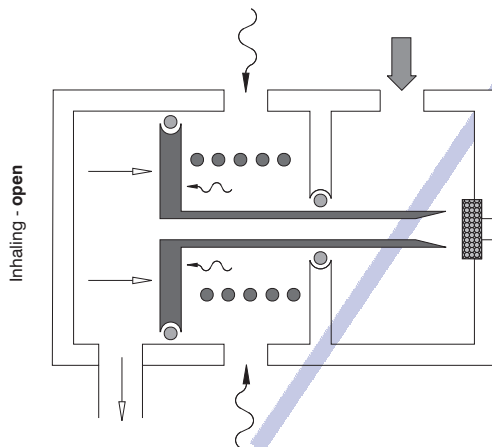
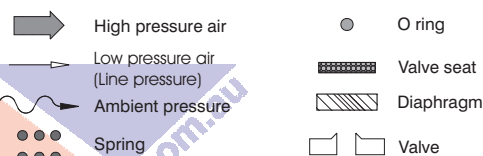
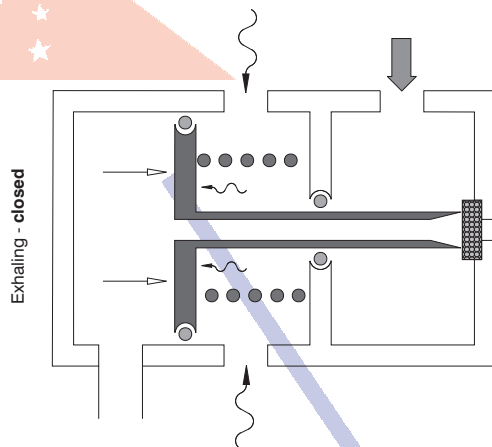
- Ambient pressure **constant** (at a given depth)
- Spring tension **constant**, 8-10 atm (120-150 psi)

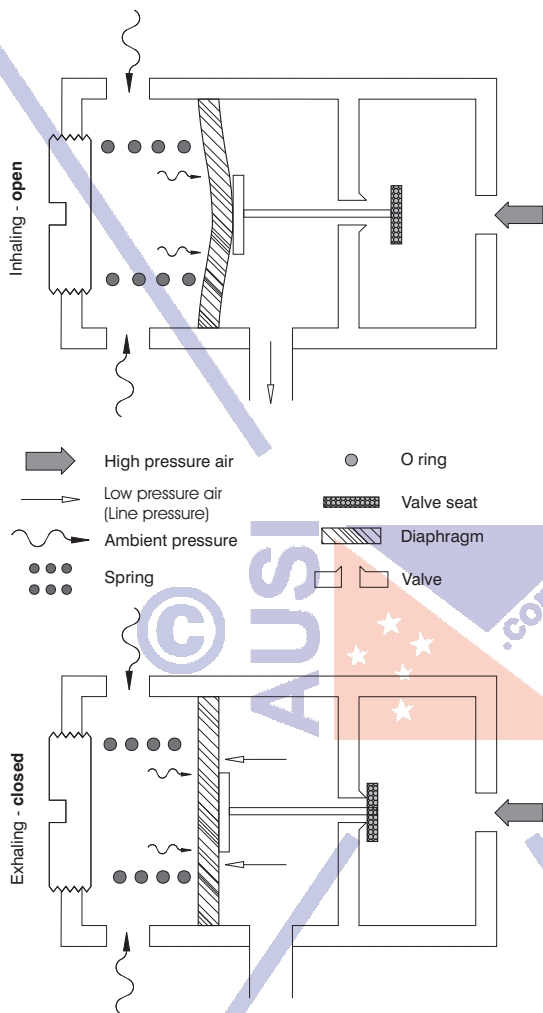
Closing forces

- Intermediate pressure **constant**, 8-10 atm (120-150 psi) above ambient

Result

- Since intermediate (line) pressure is independent of cylinder pressure a larger orifice can be used and hence better air flow characteristics particularly at depth
- Less wear and tear on valve seat means less maintenance
- Ensures constant performance of second stage
- Generally have the best air flow characteristics





Unbalanced diaphragm

Opening forces

- Ambient pressure **constant** (at a given depth)
- Spring tension **constant**, 8-10 atm (120-150 psi)

Closing forces

- Intermediate pressure **variable**
- High pressure air **variable**

Result

- As cylinder pressure falls intermediate (line) pressure increases and second stage becomes easier to breathe from and may free flow
- To keep first stage size manageable, high pressure orifice is small therefore reducing air flow, particularly at depth

Balanced diaphragm

Opening forces

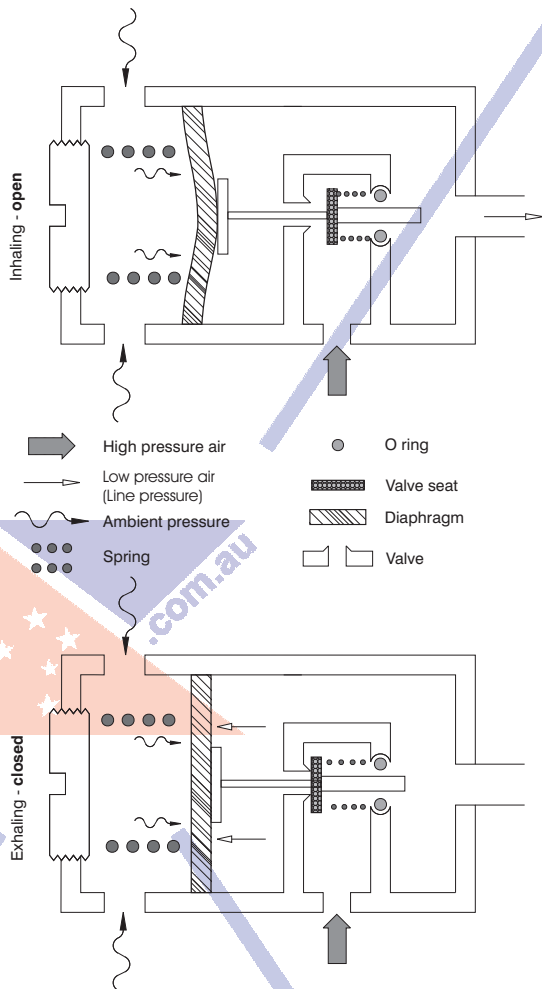
- Ambient pressure **constant** (at a given depth)
- Spring tension **constant**, 8-10 atm (120-150 psi)

Closing forces

- Intermediate pressure **constant**, 8-10 atm (120-150 psi) above ambient

Result

- Since intermediate (line) pressure is independent of cylinder pressure a larger orifice can be used and hence better air flow characteristics particularly at depth
- Less wear and tear on valve seat means less maintenance
- Ensures constant performance of second stage



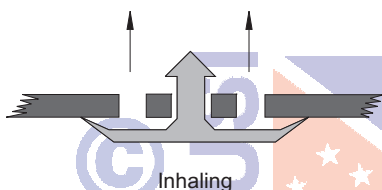
Basic operation

In static position

- Internal air pressure (mouthpiece side) equals external ambient pressure, main diaphragm straight

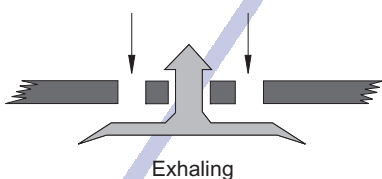
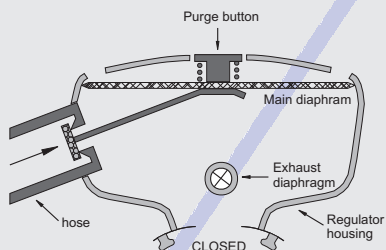
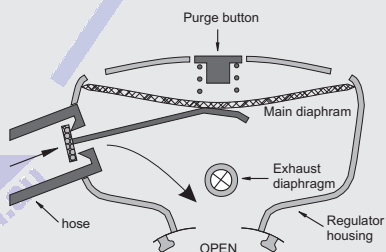
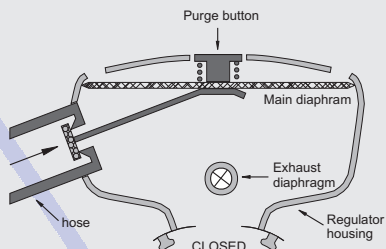
On inhalation

- Air pressure < ambient pressure
- Main diaphragm bows inwards
- Valve opens and air flows through mouthpiece
- Exhaust valve closes



On exhalation

- Main diaphragm returns to normal position
- Valve closes and air flow stops
- Exhaust valve opens



Inlet valve types

Tilt (upstream) valve

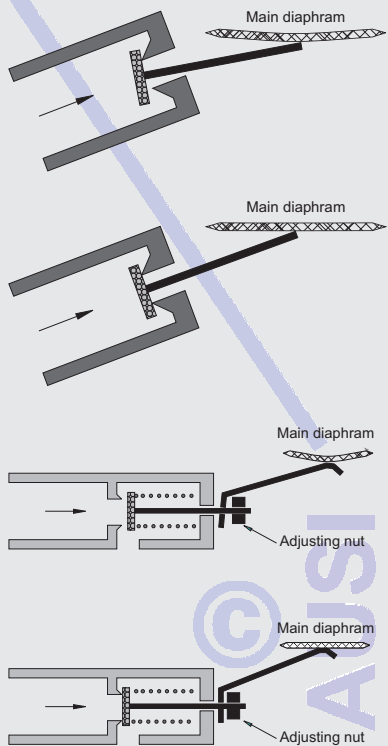
- Can handle variable line pressure (good for hookah)
- Need pressure relief valve (in case of high line pressure)
- Need non-return valve within one metre (3') of mouthpiece when used on hookah to prevent fatal lung damage if hose bursts
- Rarely used with scuba

Lever (downstream) valve

- Need constant line pressure (ie used in conjunction with balanced first stage)
- Harder to breathe with increased depth
- All downstream valves are "fail-safe" (ie will open when over-pressurised)

Adjustable lever valve

- Spring tension is manually adjusted externally to overcome increased breathing resistance at depth
- Can be screwed in on safety regulator to prevent free flow



Servo-assisted

Function

- Balanced main valve opens aided by a smaller "pilot" valve
- Automatically compensates for increased breathing resistance at depth

Static

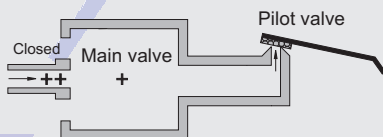
- Air pressure on hose side of diaphragm equals air pressure in chamber

Inhalation—two steps

- Inhalation triggers lever of pilot valve and air escapes out of chamber faster than air can be replaced through hole in diaphragm—creating a pressure difference across the diaphragm
- Pressure difference causes diaphragm to flex allowing air to enter second stage
- Pressure difference causes diaphragm to flex allowing air to enter second stage

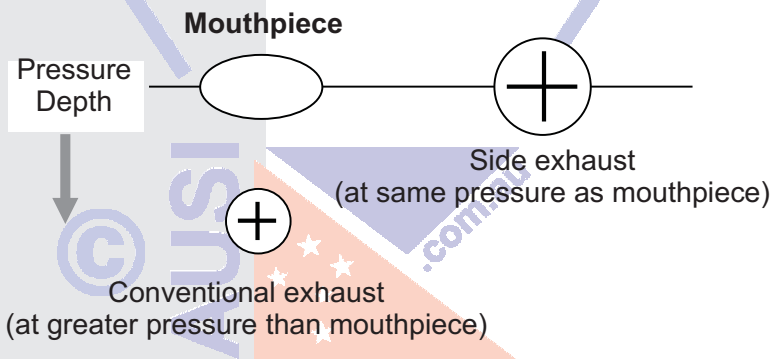
Exhalation

- On exhalation, air pressure in chamber increases returning diaphragm and pilot lever back to **static** position



Exhaust systems

- Most commonly located below mouthpiece
- Side exhaust offers less resistance to exhalation therefore less carbon dioxide retention because it is at same level (therefore pressure) as the mouth
- Side exhaust valves can also be larger (ie more efficient) since exhalation is not against a higher water pressure



Care & maintenance

- Always wash in fresh water after use (make sure dust cap is in place)
- Fix minor problems immediately
- Don't store in non-ventilated regulator bags
- Don't store with kinked hoses
- Use hose protectors
- Annual service by qualified service technician

Never service your own regulator, servicing requires specialist tools and training

Free flowing

- In water turn mouthpiece down
- Block mouthpiece with hand
- If adjustable, de-tune regulator
- Turn cylinder off, purge regulator then turn back on
- Check purge button—it may be stuck
- First stage may be frozen—allow to thaw

If unable to stop see a qualified service technician

Breathing wet

- Check mouthpiece for holes, torn lugs or missing cable tie
- Check exhaust diaphragm (can be inverted, torn or have debris caught under it)
- Check for hole in main diaphragm
- Check for cracked or loose housing
- Check breathing technique and mouth seal

If unable to control see a qualified service technician

Hard to breathe

- If adjustable, adjust properly
- Check cylinder valve is turned on fully
- Cylinder valve may need service

If unable to control see a qualified service technician

Air leaking from 1st stage

- Check hose connections and o-rings
- Check cylinder valve o-ring
- Check yoke screw isn't loose

If unable to control see a qualified service technician



Line pressure, used to determine whether the free flow is a first or second stage problem

A small leak is normal for some regulators (Sherwood Brut or Magnum)

Air leaking from 2nd stage hose joint

- Check hose connections and o-rings

If unable to control see a qualified service technician

Squealing in 1st stage

- Not dangerous just annoying

See qualified service technician

Vibration in 2nd stage when breathing

- If adjustable readjust
- Not dangerous just annoying

If unable to control see a qualified service technician

Hose bulging, leaking, cracked or damaged

- Replace hose

Rattle in 2nd stage

See a qualified service technician

Little or no air flow when purge button depressed

See a qualified service technician

Adjustment knob hard to turn

See a qualified service technician

Discoloured sintered bronze filter

- Turquoise, black, reddish brown or white coating indicates contamination

See a qualified service technician

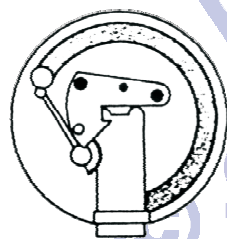
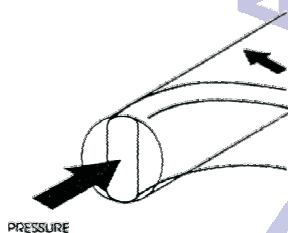


Typical dive shop repair facility

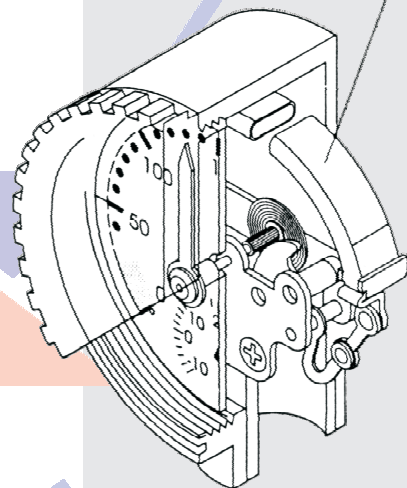
Types

Bourdon Tube

- The Bourdon Tube is a curved pipe that straightens when air pressure inside the tube is increased
- The movement of the tube is transmitted to the pointer needle which indicates pressure on the dial



C-Shaped Bourdon Tube



Electronic

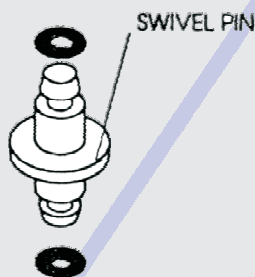
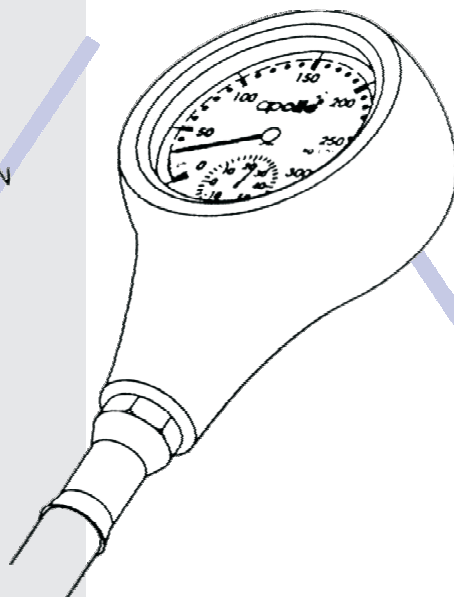
- Pressure is applied to a transducer which converts it to an electrical signal
- Electrical signal is converted to digits on the display

Usage

- Never surface with less than 50 atm (750 psi)
- Always consult the manual before using an electronic gauge for the first time
- Lubricate swivel o-rings every three months or if leakage occurs at gauge/hose junction
- Ensure gauge reads zero when air is turned off and purged
- Replace hose if bubbling, bulging or splitting occurs
- Have serviced annually by a qualified service technician

Safety features

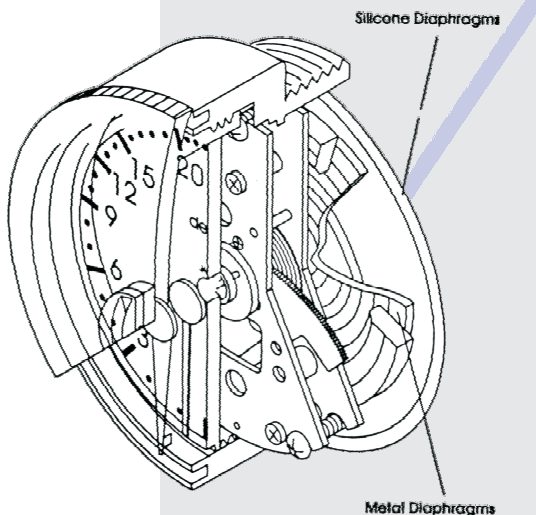
- Restrictors in regulator 1st stage and regulator end of high pressure hose to stop rapid air loss
- Over-pressure plug in back of gauge prevents lens blowing out
- High pressure hose impregnated with many tiny holes to prevent de-lamination



Types

Diaphragm

- Water pressure acts directly on metal diaphragm which then activates mechanism attached to needle
- Re-zero maximum depth indicator (MDI), where appropriate



Electronic

- Pressure is applied to a transducer which converts it to an electrical signal
- Electrical signal is converted to digits on the display
- Electronic gauges are very accurate
- Don't forget to turn-on before diving (if necessary)

Gauges should be serviced and calibrated annually by a qualified technician

Types

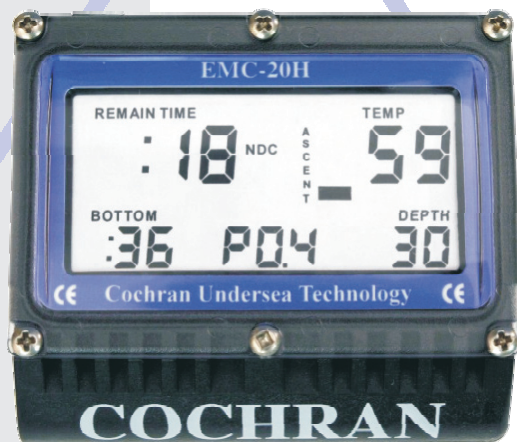
- Standard
- Air integrated
- Hoseless air integrated

Standard features

- Dive time
- Current depth
- Maximum depth
- Remaining no decompression time
- Planning mode
- Ascent rate

Additional features

- Altitude modes
- Remaining air time or no-decompression time (whichever is the least)
- Decompression stop depths and times
- Decompression ceilings
- Nitrogen tissue loading bar graph
- Audible warnings for such things as:
 - Low air
 - Low battery
 - Rapid ascent rate
 - Low remaining no-decompression time



Usage

- Consult manual before using for first time
- Manually switched computers must be turned on before descent
- Always use conservatively
- In case of failure, have a backup dive plan and system:
 - Ascend slowly ($< 9\text{m/min}$, $< 30'/\text{min}$) to between 6m (20') and 3m (10')
 - Stop for as long as air supply will safely allow at 3–5m (10'–15')
- Never share a computer between two divers
- Use safe dive profiles (eg. don't plan decompression dives)
- Avoid multiple ascents
- Always plan for and conduct safety stops, where possible
- If diving at altitude, set the correct altitude mode
- Do not use with any gas mixture other than air

Care & maintenance

- Wash thoroughly in fresh water after use
- Have serviced annually by a qualified service technician
- Replace battery as soon as low battery warning appears or if going on dive holiday and near limit
- Carry spare batteries, where appropriate

Usage

The buoyancy compensator (BC) is also known as a buoyancy control device (BCD):

- Must fit correctly and comfortably
- Must have adequate lift
- Should have independent dump valve
- Check for leaks before dive
- Check inflation mechanism - should operate freely and not stay on
- Check dump mechanism—should operate freely and not stay open
- After use, wash outside and inside with fresh water, drain and store partially inflated



Non-integrated weight system BC/BCD



Integrated weight system BC/BCD

BC deflates

- Check dump valve—clean if necessary
- Check remote exhaust valve—clean if necessary
- Check over inflation valve—clean if necessary
- Check for holes

If cannot repair see a qualified service technician

BC auto inflates

- Check scuba feed valve—lubricate o-rings

If cannot repair see a qualified service technician

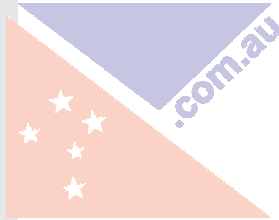
BC won't inflate

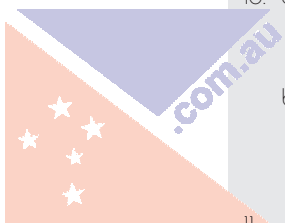
- Check BC hose is connected properly and the correct size
- Check cylinder is turned on and not empty
- Check source of problem by plugging into buddy's hose (if BC inflates—problem is hose, if not—problem is inflation valve)

If cannot repair see a qualified service technician



1.
 - a) What is a DIN valve used for?
 - b) What is the function of a burst disc?
 - c) What can a fluctuating pressure gauge reading indicate?
2. What is the function of:
 - a) Regulator first stage?
 - b) Regulator second stage?
3. List four advantages of a balanced first stage.
4. What effect does falling cylinder pressure have on the following first stages:
 - a) Unbalanced diaphragm?
 - b) Balanced diaphragm?
 - c) Unbalanced piston?
 - d) Balanced piston?
5.
 - a) What two safety items need to be incorporated when using a tilt valve operated second stage?
 - b) What does downstream refer to?
 - c) List the main advantages of a servo assisted second stage.
6. Why is a side exhaust better than a conventional exhaust?
7. Why should you never service your own regulator?





8. List your action for the following:
 - a) Free flowing second stage.
 - b) Wet breathing second stage.
 - c) Hard to breathe second stage.
 - d) Little or no air flow when purge button is depressed.
9. Describe a Bourdon Tube.
10.
 - a) When should swivel o-rings be lubricated?
 - b) List three inherent safety features in a high pressure gauge.
11. What is the most common type of depth gauge?
12.
 - a) List six standard features of a computer.
 - b) What precaution should you take when using a hoseless computer?
 - c) List six important points to consider when using a computer.
13.
 - a) List the pre-dive checks for a buoyancy compensator.
 - b) List your checks if your buoyancy compensator will not hold air.