Assistant Life Support Technician

Facts Sheet





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TRAUMA TRAINING

IMCA®
Training Establishment
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TRAUMA TRAINING

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TRAUMA

TRAINING

NORMAL VALUES 1

Conversions 1.1

1 bar	750 mmHg	= 10 msw	= 14.54 psi
1 atmosphere	760 mmHg	= 33 fsw	= 14.7 psi

1 gallon (imp) of salt water	10.3 lb
1 gallon (imp) of fresh water	101b
1 cubic foot of salt water	64.38 lb
1 cubic foot of fresh water	62.5 lb
1 cubic metre of salt water	1.03 tonne
1 cubic metre of fresh water	1.003 tonne
28.32 litres	1 cubic foot
35.32 cubic feet	1 cubic metre
1,000 litres	1 cubic metre
Convert "Fahrenheit to "Celsius	(°F-32) ÷ 1.8= °C
Convert "Celsius to "Fahrenheit	(°Cxl.8) + 32 = °F
Absolute Temperature (Kelvin)	°C + 273
Absolute Temperature (Rankine)	°F + 460
Convert Parts Per Million to %	ppm ÷ 10,000
Convert % to ppm	*%x* 10,000

Diver Gas Consumption Rates 1.2

Chamber BIBS Consumption	20	L/min/bar(A) or 0.75 ft^3/min/Ata
Divers gas consumption (open circuit)	35	L/min/bar(A) or 1.25 ft^3/min/Ata (20-60 industry range)
Divers gas consumption (recovery systems)	5	L/min/bar(A) or 0.18 ft^3 /min/Ata
Divers gas consumption (bailout in emergency)	40	L/min/bar(A) or 1.5ft^3/min/Ata (40-62.5 industry range)
Divers gas consumption (bailout in emergency NORSOK)	62.5	L/min/bar(A) or 2.2ft^3/min/Ata

Metabolic 0_2 Consumption In DDCs (FROM AODC 014) 1.3

30L/hour (0.5 L/min) or 0.72 m³/day (per diver).

0.018 f ft³/min or 25 ft³/day (per diver).

Oxygen Partial (PPO_2) Pressure Limits 1.4

Saturation lockout gas		0.5 to 0.9 bar
Bounce Dive lockout gas		1.2 to 1.6 bar
Bailout		1.2 to 2.8 bar
Saturation Storage		0.35 to 0.45 bar
Saturation Decompression		0.5 to 0.6 bar
Chamber emergency gas	BIBS	0.2 to 0.8 bar
Therapeutic treatment	BIBS	1.5 to 2.8 bar

Carbon Dioxide ($PPCO_2$) Partial Pressure Limits 1.5

Chamber	5 mbar	0.005 bar max	or 0.5% SE
Bell	20 mbar	0.02 bar max	or 2 % SE

Note: These values can vary dependant on company requirements.

PHYSICS 2

Boyle's Law 2.1

$$P_1V_1 = P_2V_2$$

Or

$$PV = \text{Constant}$$

Q. If a wet bell has a floodable volume of 200 ft^3 at what depth is the bell if the gas volume is reduced to 20 ft^3?

A. $P_1V_1 = P_2V_2$

$$\frac{P_1V_1}{V_2} = P_2$$

$$\frac{1 \times 200}{20} = 1\text{ata}$$

Therefore depth of wet bell = (10 ata - 1atm) = 9 atm = 297 feet

OR

(10 bar (A) - ATM) = 9 bar = 90 msw

NOTE: The P_1V_1 formula is not commonly used in practice, but is replaced by the following formula:

CHAMBERS: FREE GAS VOLUME = FLOODABLE VOLUME x PRESSURE

DIVERS: FREE GAS VOLUME = BREATHING RATE x ABSOLUTE PRESSURE x TIME

Free Gas Volume

Is the volume that a quantity of gas will occupy at a pressure of 1 bar.

Note: For chambers / cylinders use GAUGE Pressure, for divers use ABSOLUTE Pressure.

The Floodable Volume

The Floodable Volume of a cylinder or chamber relates to either the volume of water or the volume of gas at a pressure of 1 bar that can be held by that cylinder or chamber.

Applications of the Free Gas Volume formula

1) To find the volume of gas in a quad e.g.,

Q. How much gas in a 45L bottle quad at a pressure of 190 bar?

A. FV of quad = 45 *x* 50 = 2,250L or 2.25 m^3

FGV = FV *x* P = 2.25 x 190 = 427.5 m^3

2) To find diver consumption e.g.,

Q. How much air will a diver breathe in 41 minutes at a depth of 25 msw

A. Consumption rate *x* absolute pressure *x* time in minutes

35L/min x 3.5 bar *x* 41 min = 5,022.5 litres = 5.023 m^3

3) To calculate blowdown gas e.g.,

Q. How much air is required to pressurise an 18 m^3 vessel to 38 msw?

A. FV of chamber *x* relative pressure

$18m^3$ x 3.8bar = $68.4m^3$

Charles' Law 2.2

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

NOTE: temp absolute = °C + 273

NOTE: temp absolute = °F + 460

Q. A bailout bottle when charged to 200 bar reached a temperature of 100°C, after cooling to 60°C what was the pressure in the flask?

A. $P_1 x T_2 = P_2 x T_1$

P_1 = 200

T_1 = 100 + 273 = 373K

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

P_2 = ?

T_2 = 60 + 273 = 333K

$$P_2 = \frac{200 \times 333}{373} = 178.5 \text{ bar}$$

NOTE: Use gauge pressure for pressure cylinders

NOTE: Use absolute pressure for manned chambers

Dalton's Law 2.3

PP *x* 100 = % x AP

Q. A chamber is at 67 msw and contains 4% 0_2, it is then vented back to 23 msw

(a) What is the 0_2 percent at 23 msw?

(b) What is the pO_2 at 23 msw?

A. (a) Percent always remains constant = 4%

(b) $pp = \frac{\% \times AP}{100}$

$pp = \frac{4 \times 3.3}{100}$ =0.132 bar = 132 mbar

Henry's Law 2.4

States the amount of gas that will dissolve in a liquid at a given temperature is almost directly proportional to the Partial Pressure of that gas.

Q. If a body absorbs 1 litre of Nitrogen on the surface, how much will it absorb at 165 ft?

A. 1 *x* 6 ata = 6 litres

Archimedes' Principle 2.5

$$U = V \times D$$

Where: U = Up thrust
V = Volume Displaced
D = Fluid Density

Q. A pontoon 12m *x* 7m *x* 3m floats with 2.5m submerged.

(a) What is the up thrust?

(b) What is the weight of the pontoon?

(c) How much weight could I place on the pontoon without it sinking?

A.

(a) U = V;cD

U = (12 x 1 x 2.5) x 1.03 (Density of seawater = 1.03 te/rn3)

Up thrust = 216.3te (Tonnes)

(b) Pontoon weight is equal to the up thrust

(c) U = V x D (when entire object is submerged)

U = (12 x 7 x 3) x 1.03

U = 259.56 te (Tonnes)

Thus additional weight = 259.56 - 216.3 = 42.26 te

Establishing A PPO_2 In The Chamber 2.6

$$\frac{(pO_2 \text{ required} - pO_2 \text{ initial}) - (\text{msw} \times \% O_2 \text{ low mix})}{(\%O_2 \text{ high mix} - \% O_2 \text{ low mix})}$$

This gives the initial blowdown pressure using the high mix and can be converted to either metric or imperial depths.

Q. Establish a pO_2 of 0.4atm in chamber at 200ft using 5/95 and 2/98

(a) To what depth will be the initial pressurisation on 5/95?

A. $$\frac{(400 - 210) - (75 \times 2)}{(5 - 2)} = \frac{(190 - 150)}{3} = \frac{40}{3} = 13.3 \text{ msw}$$

Initial chamber pressurisation on 5/95 will be 13.3msw then continue to storage using 2/98.

Parts Per Million - (PPM) 2.7

ppm is similar to a percentage but is expressed as parts of 1,000,000 to conveniently deal with the small proportions of gas involved.

To convert:

ppm to %	divide ppm value by 10,000
% to ppm	multiply % value by 10,000
ppm to partial pressure	$\frac{\text{ppm value} \times \text{Pressure Abs}}{1{,}000{,}000}$
partial pressure (bar) to ppm	$\frac{\text{partial pressure} \times 1{,}000{,}000}{\text{Pressure Abs}}$

Q. Surface CO_2 readout is 500ppm. What is the CO_2 percent and pCO_2 in the bell at a depth of 150 metres?

$$pCO_2 = \frac{0.05 \times 16}{100} = \frac{0.1}{100} = 0.008 \text{ bar}$$

A. CO_2 percentage $= \frac{500}{10{,}000} = 0.05\%$

Q. The bell is at 200msw with a pCO_2 of 0.005 bar. What will be the surface read out in ppm?

A. Surface Readout $= \frac{0.48 \times 10{,}000}{19} = \frac{4{,}800}{19} = 253 \text{ ppm}$

GAS MIXING 3

Various formulae are available to assist in the mixing of gas. There is an alternative formulae method available in your manual some may prefer to use.

Gas Mixing Triangle 3.2

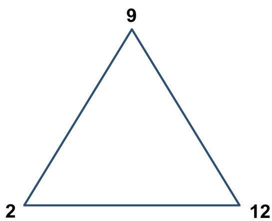
The rules to use in the triangle method are as follows:

- When a pressure is given, whether it is "have", "start", "want" or "require" etc, then that pressure is what goes above the base line of the triangle.
- The Oxygen percentage of the gas with the pressure mentioned goes to the apex of the triangle.
- The other two Oxygen percentages mentioned go at the other two comers of the triangle (it doesn't matter in which order).
- If Helium, He, pure He is one of the gases, the Oxygen percentage is nothing therefore the figure is 0.
- If Oxygen, 0_2, pure 0_2 is one of the gases, the Oxygen percentage is 100% therefore the figure is 100.
- The pressure of the gas you are trying to find is always worked out in the line opposite the triangle corner the % is in.
- Subtract the % from each other and put on the outside lines of the triangle.

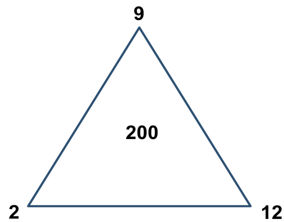
Q. You want to make 200 bar of 9%, using 2% and 12%

A.

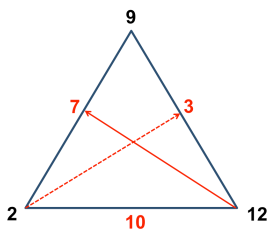
1. Write in The Mixes



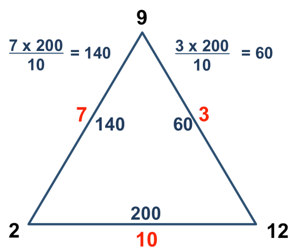
2. Write in The Pressure That You KNOW



3. Subtract The Mixes



4. Do The Calculations

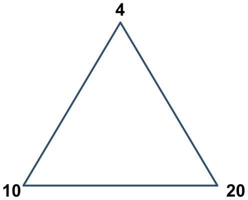


You need 60 bar of 2% and 140 bar of 12%

Q. You have 100 bar of 4%, you want to make 10% by adding 20%

A.

1. Write in The Mixes



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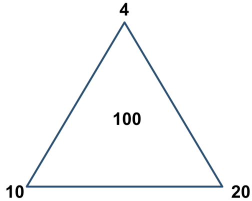

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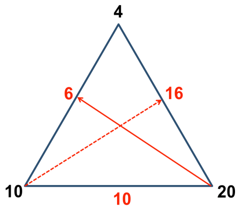

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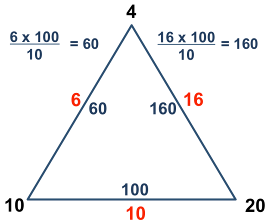


You need to add 60 bar of 20%, giving a final pressure of 160 bar.

Q. We require 200 bar of 4/96 to be made up from the following available gases:

Mix 1 = 185 bar of 10/90

Mix 2 = 165 bar of 3/97

Mix 3 = 175 bar of 2/98

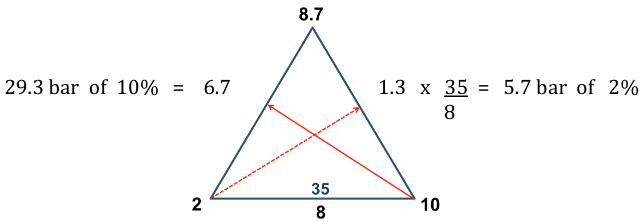
Using Dalton's Law find out the ppO_2 deficit in the base mix, i.e. MIX 2

A. Final mix = 200 bar x 4% = 800 units of pO_2

Mix 2 = -165 bar x 3% = 495 units of pO_2

Mix required = 35 bar x ?% = 305 units of pO_2

Therefore we require 35 bars of 8.7% mix using mix 1 and mix 3



Therefore we require 5.7 bar of 2% and 29.3 bar of 10%.

Gas Mixing Traditional Method 3.3

Pressure of Mix 1 $\frac{\text{Final Pressure x (\% Final Mix - \% Mix 2)}}{\text{(Mix 1 - Mix 2)}}$

Final Pressure = $\frac{\text{Pressure Mix 1 x (\% Mix 1 - \% Mix 2)}}{\text{(Final Mix - \% Mix 2)}}$

If your mixing gasses together:

% of Final Mix = $\frac{\text{(Pressure Mix 1 x \% Mix 1) + (Pressure Mix 2 x \% Mix 2)}}{\text{(Pressure Mix 1 + Pressure Mix 2)}}$

GAS ANALYSIS 4

Paramagnetic (Servomex type analyzer) 4.1

A quartz dumbbell is suspended in a magnetic field. When sample flows, the oxygen being a paramagnetic gas (attracted by magnetism), collects in the strongest part of the magnetic field and deflects the dumbbell. Deflection is measured by a beam of light across a split photocell and gives an accurate measurement of oxygen content in sample.

Polarography (Teledyne type analyzer) 4.2

The fuel cell is a battery made up of two electrode filaments in an electrolytic jelly. When the oxygen in the sample impinges on the jelly it is absorbed (polarography) and causes a current to flow between electrodes which give a measurement of oxygen content in sample.,

Precaution: Electrolytic jelly is corrosive.

Fuel cells: B1 6 months cell life

90% scale readout in 5 seconds response.

B3 18 months cell life.

90% scale readout in 15 seconds response.

NOTE: Cell life is for a $pp0_2$ of 210 mb. Obviously in higher PP's the lifespan is shorter.

Infra Red (luft type $C0_2$ analyzer) 4.3

Principle is that all gases absorb specific lengths of radiation. Two chambers in the analyzer, one filled with helium, which will not absorb CO_2 wavelength and the other containing a sample. A comparison is then taken between chambers of a wavelength passed through them and a measurement of CO_2 content in the sample produced by the difference. Sample must be dry to obtain an accurate reading.

Alarms 4.4

Oxygen analyzers on line to dive must have HI/LO alarm fitted. CO_2 analyzers on line to diver must have HI alarm fitted.

Colorimetric (Draeger Tube Type Analyzing) 4.5

CO_2 in the gas sample passing over crystals in the Draeger tube cause a discolouration of the crystals by chemical reaction. CO_2 content in the sample is then read off against a scale on the side of the Draeger tube. Reading has an 80% accuracy.

Percentage Surface Equivalent 4.6

Normally used to define CO_2 limits when using Draeger tubes in the bell.

Sample taken in the bell and read directly off the tube scale is the Percentage Surface equivalent of 1 atmosphere absolute.

If the true bell percentage is required the Percentage Surface Equivalent must be divided by absolute depth.

Draeger pump and tube are designed to pass 100 ml of sample gas at surface, therefore the volume of gas passing through pump and tube in the bell will be 100 ml x absolute depth. The normal calculation of multiplying a true surface percentage x absolute depth is automatically accomplished so allowing the Draeger tube readout to be used as a direct Surface Percentage Equivalent reading for defining CO_2 limits within the bell.

Parts Per Million (PPM) 4.7

Normally used to express very small percentages of a gas when using a surface analyzer to monitor bell atmosphere.

Sample taken at surface is a true percentage of the bell's atmosphere, however as it is required to know what this represents as a Percentage Surface Equivalent of one atmosphere absolute it must be multiplied by the absolute depth. (See physics section for formula).

NOTE: If it is required to be expressed as a Partial Pressure the Surface Percentage Equivalent must be divided by 100.

AIR AND GAS REQUIREMENTS IMCA D050 5

Air Diving 5.1

- Air to be in containers or come from TWO independent dedicated sources. Rig air is not considered to be a dedicated source.
- 2 emergency dives to full intended working depth.
- 1 twin lock chamber compression to maximum treatment depth (165 ft).
- 3 complete surface decompression cycles (Sur/De/0_2).
- 90 cu. Metres ($3200ft^3$) 0_2.

Bounce Diving 5.2

- Enough gas for planned dive & 1 emergency dive to full intended working depth.
- 2 chamber to transfer depth with enough supplied to carry out any necessary flushing for TWO complete decompressions (if using air it should be container stored or be from TWO independent dedicated sources. Not to be rig air.)
- 1 chamber pressurisation to maximum diving depth and carry out full saturation decompression in the event of a medical emergency.
- Enough O_2 for saturation decompression.

Saturation Diving 5.3

- Enough gas for intended bell run plus same amount in reserve. This does not include bell onboard gas.
- Enough gas to pressurise all required chambers to storage depth plus same amount in reserve. This reserve to be maintained throughout sat.
- 2 full decompressions from storage depth plus that required for daily use in leakage, locks, toilet etc.
- Enough O_2 for metabolic consumption and maintaining $pp0_2$ during the decompression plus same amount in reserve.
- Minimum of 3 weeks of zero & calibration gas.
- Each diver to have a minimum of 4hrs on BIBS at 20L/min.

GAS LABELING 6

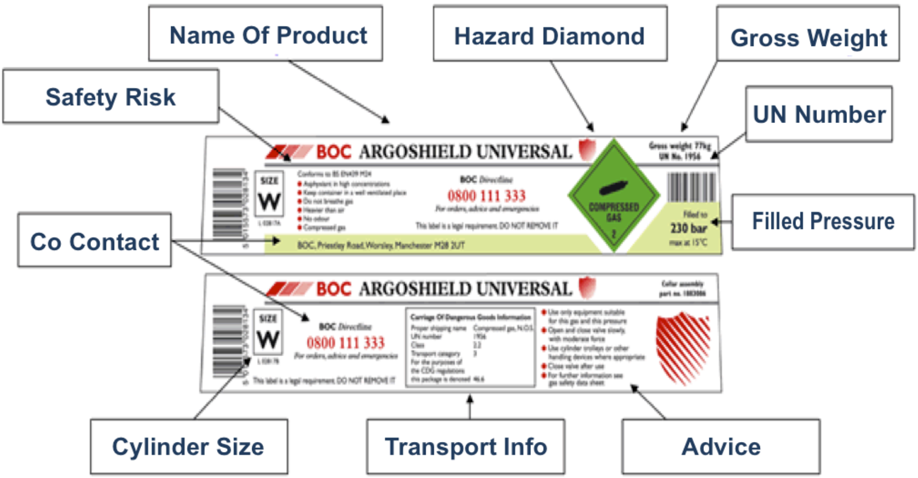
The dangers of accidentally mixing the wrong gas in the offshore setting cannot be over emphasized, and it is for this reason that numerous regulations are adhered to including:

- BS4001 - Standard for air Purity
- BS 1319C - Colour Coding of Gas Cylinders

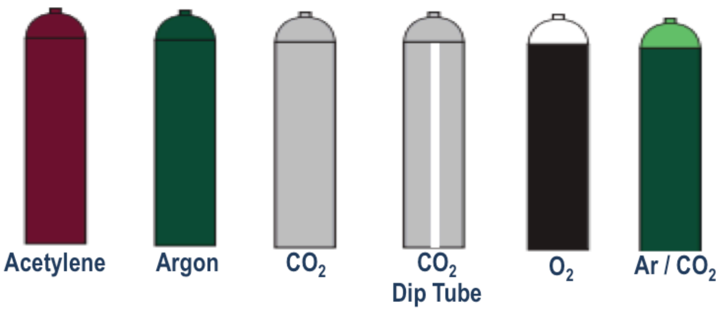
Cylinders should be clearly marked with the chemical formula and the gas content (percentages).

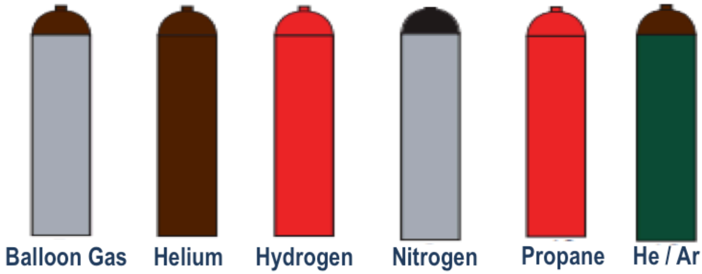
Cylinder Information 6.1

Gas providers (such as B.O.C. & Dominion) provide a huge amount of useful information on the neck of the cylinders:

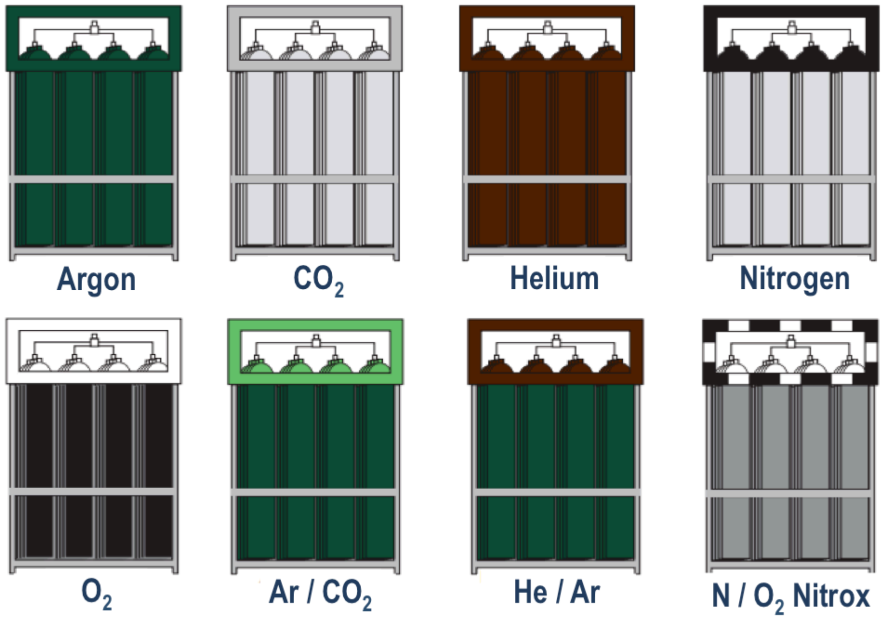


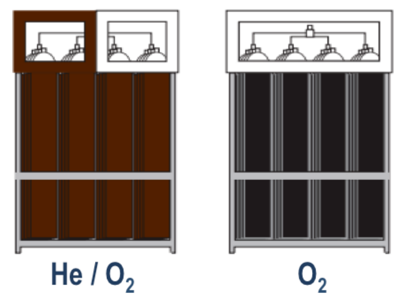
Cylinder Colour Coding 6.2



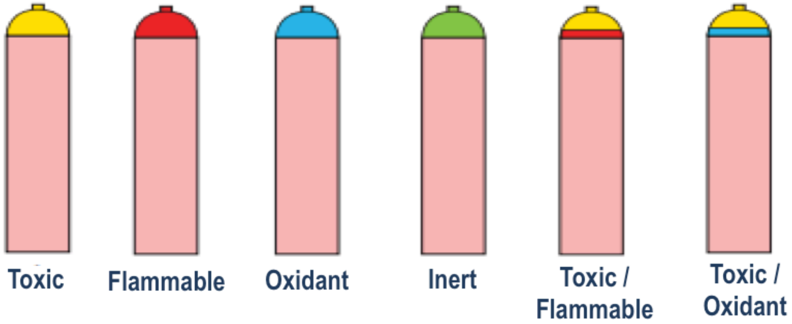


QUAD Colour Coding 6.3

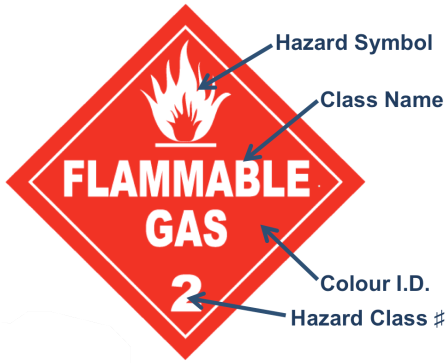




Cautionary Colour Coding 6.4



Cautionary Colour Symbols 6.5



- Diving operations should be carried out in a 'safe & suitable place".
- Diving operations are deemed to have commenced when:
  - The diver enters the water / liquid / chamber, that has a pressure exceeding 100mb.
- Max planned duration of saturation- 28 days (U.K.).
- Decompression chamber required on site on all offshore / pipeline diving operations.
  - DDC's must be twin lock with enough room for 2 divers to lie down.
  - DDC's must have a '24 hour' Emergency Capability.
- Dives deeper than 50 m - H/W suit required.
- Dives deeper than 50 m - Closed bell required.
- Dives deeper than 150 m - divers gas heater requires (Norway also).
- Minimum Divers qualification to work offshore - Part 1.
- Maximum depth for surface orientated diving - 50 m.
- Oxygen reduced at source to 40 bar (AODC D 012).
- If Air dive is conducted through the moon pool, the dive depth must not be shallower than the Vessel Draft + 10 m (e.g. 5 + 10 = 15m). "Wet bell or closed bell diving only".
- SCUBA is unsuitable for operations covered by the ACOP "Commercial Diving Projects Offshore" under the Diving at Work Regulations 1997.

Accidents:

- All accidents which result in the loss of 3 days or more work must be reported as soon as practical and within 10 days in writing.
- DCI - Is classed under Schedule 3 as a reportable disease (The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (RIDDOR) do not specify a time limit for reporting the diseases).
- UNLESS: It's a fatality or a dangerous occurrence in which case it must be reported to the HSE immediately.

LEGISLATION 8

Health And Safety At Work Act 1974 - (HASAWA) 8.1

Statutory Instruments:

- SI - 1997 - 2776 Diving at Work Regulations
- ACOP (Approved Code of Practice) "Commercial Diving Projects Offshore"

I.M.C.A. International Marine Contractors Association (Formerly AODC) 8.2

IMCA publish numerous Codes Of Practice, which are followed internationally in commercial diving operations.

The specific code of practice related to Life Support Technicians is:

- IMCA D013 (Rev 4) IMCA offshore diving supervisor and life support.

D.M.A.C. Diving Medical Advisory Council 8.3

D.M.A.C. publish Medical Codes Of Practice, which are followed internationally in commercial diving operations. They are adopted by I.M.C.A. and therefore are universally applied when a diving operation is operating under I.M.C.A. guidelines.

The specific code of practice's related to Life Support Technicians are:

- DMAC 05 Recommendations on minimum level of O_2 in helium supplied offshore.
- DMAC 11 (3) Provision of first aid and the training of divers, supervisors and dive teams.
- DMAC 13 (3) Medical equipment to be held at the site of an offshore diving operation.
- DMAC 21 (2) Guidance on the duration of sat exposures and surface intervals.
- DMAC 26 Saturation Chamber Hygiene.
- DMAC 28 Provision of emergency medical care for divers in saturation.
- DMAC 31 Accelerated emergency decompression (AED) from saturation.
- DMAC 32 Guidance on dealing with the body of a deceased diver in saturation.

Classification Societies / Bodies 8.4

Organizations that certify the worthiness of pressure vessels:

- Lloyds.
- DNV (Det Norske Veritas)
- ABS (American Bureau Of Shipping).

IMO International Maritime Organisation 8.5

Provides specific Code for Diving Systems used offshore.

Hyperbaric Rescue Systems H.R.S. 8.6

- Must be coloured 'International Orange'.
- Must be clearly marked with signs (Three must be visible at all times).
- 24 hour onboard Life Support (Ref section 67 in ACOP).

NORWEIGAN REGULATIONS 9

Norsok Standard (U100) 9.1

- Developed by NTS
- Governing body for Norwegian Regulations - NPD
- Everything 'In Water' is termed a dive.
- Oxygen in chamber must not exceed 25%.
- Oxygen reduced at source to 40 bar.
- All gases over 25% O_2 are treated as 100% 0_2.
- 50m Max depth of Surface Orientated dive under Normal Operations.
- Dives deeper than 20 msw should use a wet bell.
- If diver is tended from a point 5m or more above sea level, a basket or Wet Bell must be used to gain access to water (**not a ladder**).
  - A secondary means of retrieval from the water must be supplied.
- Max Umbilical Lengths:
  - Diver = 45 metres
  - Bellman = 48 metres (At least 5msw away from nearest hazard).
- Bell Handling wires design load at least twice maximum static load.
  - Main lifting wire and alternative at least 4 times maximum design load.
- DDC must have min of 24 hours life support facility
  - Habitat minimum 48 hours - Life support facilities
- Maximum Normal Saturation = 14 days + decompression
  - Diving Deeper than 250 msw = 10 days + decompression
- Bell Run Times - 8 hours clamp off to clamp on.
- Bell run communication recordings to be kept to a minimum of 12hrs.
- Bailout Gas Carried must be sufficient to give 10 minutes regardless of depth. (Taken as the Diver using 62.5 1/min).
- Bell onboard gas carried must be sufficient to give 20 minutes regardless of depth. (62.5 1/min breathing rate).

Chamber sizes:

Saturation chambers:

- 2m over deck plates at mid chamber (min).
- 4m^3/man Useable volume (min).

Air Chambers:

Surface Orientated:

- 1.8m I.D. (min) Length 2.0m (min)

Closed Bell (2 man)

- 4.5m^3 (min)

Closed Bell (3 man)

- $6.0m^3$ (min)

Closed Bell trunk

- 0.8m I.D. (min)

Hyperbaric Life Boats:

- Hyperbaric Diver Evacuation Unit: Must be able to maintain an acceptable environment for minimum of 72 hours.
- The HLB must have its own propulsion facility and be capable of functioning for a minimum of 72 hours.

Accidents:

- It is the responsibility of the employer to report occupational accidents and disease to the Labour Directorate by the quickest possible means and confirm by writing within 2 hours.

Plant And Equipment 9.2

IMCA DO 18. Is referred to in Norsok Standard U-100 as an "informative reference". It is thus "A recommendation or an example of an acceptable standard"

SAFETY 10

Electrical Equipment 10.1

- DC current 5 times safer than same current AC.
- 24v DC max voltage u/w without safety trips. (DSM 1985/2).
- 110v AC max voltage u/w with safety trips.
- 110v max voltage in deck and in workshops.
- Welding / Burning underwater:
  - DC Supply
  - NEGATIVE torch
  - POSITIVE earth
  - TWIN POLE knife switch
  - When working in enclosed spaces precautions should be taken to avoid explosive gas build up from the welding/burning process.
- Insulation is the primary passive defense against electric shock.

Water Jetting 10.2

- Never tie back the trigger in ON position.
- 4000 - 8000 psi working pressure for grit entrainment.
- 8000 - max psi working pressure for water jetting.
- Difficult to treat subcutaneous infections if injury occurs.
  - Casualties often requiring surgical intervention / intravenous antibiotics.

Fire Hazard 10.3

- Bad housekeeping is the most common cause leading to fires.
  - O_2% above restricted limits.
  - Allowing flammable materials in the Sat environment.
  - Unregulated use of electronic devices (particularly with lithium ion batteries).

Radiography 10.4

Ultimate Responsibility Onboard
- Radio supervisor with letter of appointment.

Emergency Contact Ashore
- Duty Radiology Officer.

Radiation Source
- IRADIUM (Ir) 192.
- Measured In Curies Or Sieverts.

Safe Distance Off U/W During Exposure
- 8 Metres

Alarm Badges
- To be worn by divers (Light to illuminate at 25 microspheres).

PLANT AND EQUIPMENT 11

"All" plant and equipment used in a Diving Operation must be tested and examined '6 Monthly by a Competent Person and a Certificate Issued - (This includes pipework, panels etc.). It should also be inspected immediately before use (e.g. bell checks)

Exceptions:

Diving Chambers and DDC's

- 2½ Years Pressure Leak Test at FWP.
- 5 Years Hydrostatic Test.

Umbilicals

- 6 Monthly Function and Visual
- 2 Years Pressure Leak Test at max. W.P.

Wires/Winching (Man Riding)

- 6 Monthly Function and Load Test to SWL x 1.
- 1 Year Annual Load Test SWL x 1.5
- 1 Year on Wire Terminations.
- Main DDC wire should be rated 8 times DDC weight (i.e. a factor of 8 to 1).
- Guide weight wire/x haul tugger etc. should be treated likewise.

Compressors

- 6 Monthly test and Air/Gas Purity Sample (BS EN 12021).

Gauges (depth and last inline to divers breathing)

- Re-Calibrate 6 Monthly

B.O.B.'s

- 6 Monthly Internal and External Examination

B.O.B.'s and OBG Cylinders

- 2 Yearly Internal and External Examination and Maximum WP Leak Test

B.O.B.'s and OBG Cylinders.

- 4 Yearly Internal and External Examination 1.5 x Hydrostatic W.P. Test

Cylinders containing moist gas (for example a gas reclaim receiver)

- 15 monthly internal and external examination and gas leak test to max W.P.
- 5 yearly hydraulic test to 1.5 x W.P.

DYNAMIC POSITIONING 12

Reg 5:2 (A) Diving Operations are to be carried out from a "suitable and safe" place.

Forces affecting ships station keeping: Wind - Current - Tide.

Reference Systems: Taut wire - Artemis - Acoustic

Taut Wire:

- Lateral movement detected by sensor head on boom.
- The deeper the water the greater the operating range of the Vessel.

Potential Problems:

- If the wire is not kept in a straight line, i.e. around ships hull, fouled on structure.
- All equipment to be kept clear of wires, i.e. Tugger / Basket.

Artemis:

- The "Mobile Antenna" is on the vessel.
- The "Fixed Antenna" is on the Jacket, Shore.

Potential Problems;

- Blockage of signal.

Acoustic:

- Transducer on ship.
- Transponder on Seabed.

Potential Problems:

- The deeper the water, the longer time it takes to react.

Minimal Acceptable Reference Systems 12.1

Alert Levels

Green Light	Normal Operation Status.
Yellow Light	(Flashing) Degraded Operational Status Any change in weather (Deteriorating), Reference Systems, Vessel Propulsion Systems.
Red Light	Flashing/Accompanied by Audible Alarm – EMERGENCY STATUS.

Collision Levels

Green Light	No risk of collision exits.
Yellow Light	(Flashing) Possible risk of collision exits.
Red Light	(Flashing) Accompanied by Audible Alarm – EMERGENCY STATUS - IMMINENT COLLISION.

Thruster Power

- Must not exceed 80% of power capability for more than "Brief or Isolated Periods".

Dynamic Positioning 12.2

Vessel Movements (With Diver Out of the DDC)

- Maximum Sideways, Forward or Backward movement - 10 metres
- Maximum Heading Change = 15°.

Diving Through Moon pool

- No diving permitted through a moon pool within the depth range 10 metres below the ships keel.

Most Common Cause of DP Incidents

- OPERATOR ERROR

Visibility

- No surface orientated diving when visibility under 0.5 nautical miles.

MISCELLANEOUS USEFUL FACTS 13

- Frequency of Diver Hand Held Locator = 37.5 KHz. (Norway also).
- Chambers should be cleaned every 24 hours.
- No vigorous exercise during the last stages of Decompression.
- OBG - SDC must have sufficient OBG to last 20 mins for each diver (breathing rate 62.5L/min) at the MAX EXCURSION DEPTH of the dive (Norway only).
- SDC - Emergency Diver Recovery - 1st Action of Bellman "OBG ON" Last thing before leaving SDC - Flood trunk.

Platform Status/Zones:

ZONE 0 - No risk of gas

ZONE 1 - An area in which an Air/Gas mixture is likely to occur.

ZONE 2 - High risk area - Air/Gas mixture present, most of the time.

Ear Infections:

- Stop diving.
- Take swab and send it ashore for analysis to determine treatment required.
- Treat on receipt of results.

Divers arriving on a job must have:

- LOG BOOK, MEDICAL, CERTIFICATE of TRAINING
- If supervising for a 2 year period prior to 1981 - there was no need to have been a qualified diver.

Umbilical Length

- The maximum umbilical length must not exceed the distance to the nearest thruster minus 5 metres.

DECOMPRESSION ILLNESS D.C.I. 14

D.C.I. is a disorder that comprises of both micro bubble aggregation in slow tissue compartments (notoriously nervous tissue and collagenous tissue) and macro bubble entanglement in sensitive arterial systems (very often the pulmonary and the cerebral circulatory system). These two conditions are known separately as Decompression Sickness (D.C.S.) and Arterial Gas Embolisms (Pulmonary & Cerebral).

It is always related to inadequate / or too fast decompression in relation to the divers individual risk factors.

D.C.I. Individual Risk Factors 14.1

The management of D.C.I. is best approached with the attitude 'prevention is better than cure'. It is for this reason that eliminating (or reducing) the associated risks, will dramatically decrease the chance of a D.C.I. episode.

These risks include:

Dive Profiles:
- Sawtooth pattern.
- Shallow to deep dives.
- Rapid ascent.
- Multiple daily dives.
- Omitted decompression.
- New dive (no adaptation).
- Exercise at depth / during or after decompression.

Obviously the type & style of diving is a key area. This is why the commercial Diving industry has adopted Saturation Diving so heavily.

Individual diver:
- Age / fitness / weight of diver.
- Dehydration. **A key area in D.C.I. prevention is a well hydrated diver.**
- Patent Foramen Ovale (PFO). A shunt in the heart, present in 20% of population. Reduces off gassing.
- Limb tourniquetion.

Temperature:
- Too Hot. Will lead to dehydration, which decreases off gassing.
- Too Cold. Cause vasoconstriction and reduce off-gassing to sensitive surface fat areas.

Post Dive Regime:
The diver will continue to off-gas for 24 hrs after a dive. It is for this reason that a strict post dive regime is adhered to:

- Altitude Exposure. Avoid flying or mountaineering for 24 hrs.
- Exercise. Avoid strenuous exercise during off-gassing period.
- Hydration. Avoid dehydration in off-gassing period.

D.C.I. Classification / Diagnosis 14.2

A doctor is ultimately responsible for the diagnosis of a DCI episode. However delayed treatment of DCI (particularly A.G.E.'s and severe neurological DCI's) may have very serious consequences, it is for this reason that Diving Supervisors & Life Support staff have taken on the role treatment initiators in suspected DCI cases whilst medical help is sought. In the saturation environment Diver Medical Technicians are taught how to conduct a physical / neurological assessment of the suspected DCI diver in conjunction with surface support.

All treatment is initiated within the guidelines of specific companies Standard Operating Procedures and treatment algorithms.

DCI Terminology

It is important to understand some of the medical terminology used in the diagnosis / classification of DCI.

One of the main obstacles is the adherence to outmoded classification systems. This namely being the Type 1 & Type 2 system. Within hyperbaric medicine this classification system was abandoned in the late 1990's due to it production of a massive variations in diagnosis.

The approach to diagnosis of DCI is three-fold, the examiner must consider:

- Time of symptoms onset.
- Evolution of the symptoms.
- Manifestation of the symptoms.

Time of Symptoms Onset

When the symptoms manifest is a key first step. The onset of symptoms is classified as:

- Acute. Within 24hrs of the diving.
- Chronic. It is more than 24hrs after the diving.

The rapidity of symptom manifestation is very much related to the severity of the D.C.I., a pulmonary or cerebral arterial gas embolism (PAGE / CAGE) with present rapidly (8% on ascent 83% within 5 minute 9% within 10minutes). The mean average of symptom manifestation after diving is 3hrs (60% of cases), 83% of cases will present within 8hrs of diving. Physiologically 100% of DCI's will present within 24hrs of diving (It is for this reason that this is the 'bend watch' time limit). However diving physicians will very often take 'new' cases on within 48hrs of diving due to diver denial (when a diver refuses to admit new symptoms) this is a particular problem with recreational divers.

If a diver complains of chronic symptoms, it may be questioned whether the cause is gas burden related. The longer a diver 'sits on' symptoms, the more difficult recompression therapy becomes, early treatment is always preferable.

Evolution Of The Symptoms

How the manifested symptoms evolve is a key are in denoting the severity of the possible condition. We can describe the evolution as:

- Progressive. Symptoms changing / worsening.
- Static. Symptoms unchanged once notices.
- Relapsing. Symptoms improved, then worsening.
- Spontaneously improving. Symptoms improving with no medical intervention.
- Resolved. Symptoms resolved with no medical intervention. Classic with skin bends, it must be remembered that some DCI's have intermittent symptoms.

Manifestation Of The Symptoms

It is important that the examiner understands the process of bubble aggregation, unevolved / micro bubble aggregation is more common in slow compartments (nervous or cartilage tissue) and arterial gas embolisms tend to present more in lungs or the brain (pulmonary / cerebral) with a rapid onset.

Neurological (C.A.G.E.) Cerebral Arterial Gas Embolism presents with rapid stroke symptoms.

- F.A.S.T. Facial weakness, Arm strength reduction, Symmetry (one side of the body affected).
- Rapid onset (within 10 minutes).
- Gross reduction in conscious level.

Neurological. Both the central and peripheral nervous systems may be involved and the manifestations can be broken down into the loss of certain functions:

- Aberration of thought processes, loss of memory, speech disorders, alteration to conscious level, seizures, loss of co-ordination; loss of strength or sensation.
- Cranial nerve abnormalities including Nystagmus (rapid flicking / rotating eyes).

Neurological (Spinal). It may appear to be involved alone or with other parts of the nervous system.

- Deep dives with a rapid ascent to the surface are commonly involved.
- Symptoms commonly occurs shortly after dive (about half of cases are symptomatic within 10 minutes).
- In severe cases, the condition is presents with **girdle pain**.
- The patient may notice pins and needles, numbness / weakness in the legs.
- Motor and other sensory deficits.
- Generally symptoms will occur on both sides of the body below the point of bubble formation.
- Neurogenic (spinal) shock may complicate the clinical picture.
- The bladder is frequently involved (difficulty to void or full retention).

Neurological (Audio-Vestibular). There are two mechanisms whereby the audio-vestibular system may be involved: barotrauma (perilymph fistula / oval round window rupture) and tissue injury resulting from the formation of bubbles from dissolved gas.

- Micro-bubbles involving the cochlea / the eighth cranial nerve.
- It is very difficult to distinguish between a DCI & inner ear barotrauma.
- The syndrome includes: vertigo (a sense of rotation), tinnitus, nystagmus or loss of hearing after a dive.
- Nausea and vomiting may accompany these symptoms.

Neurological (Constitutional). There are a number of non-specific symptoms that occur after diving and which, if severe or accompanied by other manifestations, may be considered part of the decompression illness syndrome.

- Symptoms include headache, fatigue, malaise (may include nausea and vomiting) and anorexia (loss of appetite).

Pulmonary. (The Chokes) Related to the lungs: massive Pulmonary Arterial Gas Embolism (P.A.G.E.).

- Chest pain, cough, haemoptysis, shortness of breath, cyanosis and, cardiogenic shock.
- Progressive & rapid (presentation within 10 mins).

Limb Pain. Often Junctional musculoskeletal, affecting cartilage tissue.

- Deep aching pain in or around one or more joints.
- Following 'bounce' dives, the upper limbs and the shoulder often involved.
- In saturation divers, it is the lower limbs and the knees, most commonly affected.
- The pain is usually poorly localised; it may resolve spontaneously and is then known as a ‘niggle'. Niggles may flit from joint to joint.
- The pain may be: dull, boring ache, similar to tooth ache. If the joint is held in a particular position that is least painful, it is not made worse by movement.
- If the pain is in a lower limb, weight bearing may be poorly tolerated.
- The 'classical' signs of inflammation: redness, swelling, warmth to the touch and tenderness are **missing.**
- Bilateral or girdle pains normally denote a neurological cause.

Cutaneous. The skin may be affected in two manifestations of decompression:

- Cutaneous DCI generally presents with severe itching around the shoulders or over the trunk.
- This develops into an erythematous rash, which may progress to cyanotic mottling or marbling of the skin.

Lymphatic.

- Lymph nodes become enlarged and tender and this is associated with oedema.
- The skin feels thickened and may have the ‘pitted' appearance of orange peel.
- If pressure is applied to the skin, a visible indentation remains.

Technician D.C.I. Diagnosis 14.3

As previously mentioned, the diagnosis of a medical condition should be undertaken by a medical physician. However the speed of treatment of an acute case of D.C.I. is very important in ensuring a positive outcome. As a general rule the approach of: ‘symptoms after a dive that cannot be attributed to anything other than the dive must be assumed to be caused BY the dive’.

It is for this reason that an aggressive neurological assessment is taught to D.M.T.’s and is present in all company SOP’s. This is the cornerstone of DCI diagnosis (notice the sheer number of neurological manifestations in the previous section).

The neurological assessment should be systematic and a very useful Neuro Exam video is available from IMCA (IMCA D036) :http://www.imca-int.com/diving-division/diving-videos/d036.aspx.

If a diver is given the provisional diagnosis of DCI, how this is described is very important, the medic would typically collect the speed, progression & manifestation of the symptoms to arrive at a diagnosis such as:

"Acute, progressive, neurological DCI"

Obviously this is dependent upon the observable symptoms, which is very important, because the diagnosis of DCI is entirely a clinical diagnosis (there are no blood tests or CT scans).

Management Of D.C.I. 14.4

All suspected D.C.I.'s should be reported to medical and diving supervisors.

The key treatment of D.C.I. is recompression therapy with the addition of therapeutic O_2 via BIBS (at 2 – 2.8bar dependant on company SOP's).

The timing of recompression therapy is dictated by the severity of the symptoms, a gross A.G.E. (PAGE / CAGE) or a severe neurological DCI should be compressed as a mater of haste whilst under the care of D.M.T.'s, the DMAC 13 medical kit should be provided to the D.M.T.

It is for this reason that Dive Supervisors / L.S.S.'s may initiate recompression therapy whilst calling for medical review.

How the D.C.I. is treated (what recompression tables are utilised), is dictated by company S.0.P.'s and the type of diving that has been undertaken.

However typically for Saturation Diving this approach may be typical:

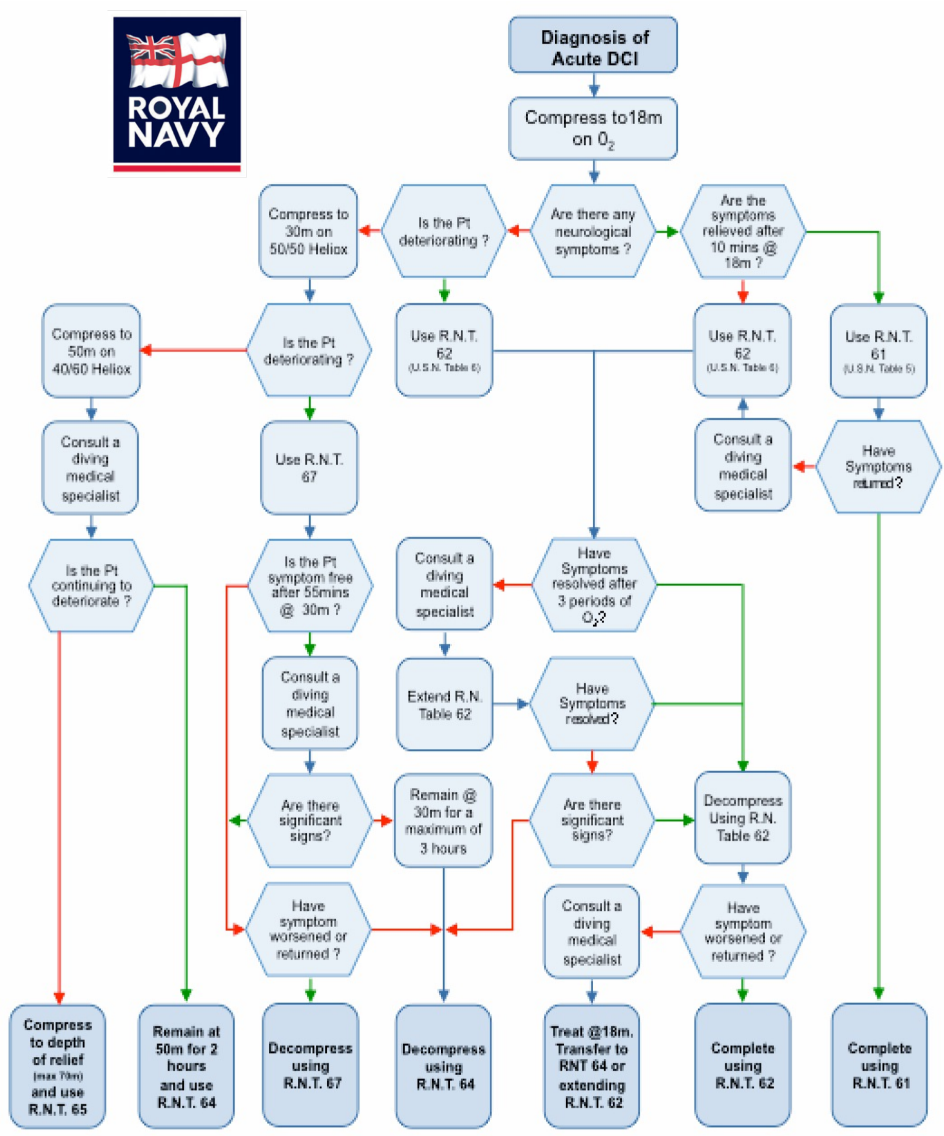
- Limb pain DCI:
  - Recompress to depth of relief.
  - Therapeutic gas via BIBS: PO_2 2.0 - 2.8 bar 3-6 cycles.
  - Hold at depth for 6-12 hours.
- A.G.E. / Neurological DCI:
  - Recompress additional 30m.
  - Therapeutic gas via BIBS: 6-12 cycles.
  - Hold at depth for 12-24 hours.
- Post surfacing: may need saturation facility.

During the entire time of a treatment the patient should be 'tended' to by a D.M.T. who should monitor & report on the patients condition to the duty medic.

It is very important that the patient should wear straps on his BIBS, this avoids O_2 leaks in the chamber & prolonged holding of a mask causes limb tourniquetion. The D.M.T. should vigilantly observe for O_2 Toxicity.

Management of D.C.I.'s whilst surface diving is very often don with the use of specific algorithm treatment tables. These tend to be heavily modified by individual companies.

Royal Navy's Treatment Algorithm 14.5



As can be observed, the actual table used is dependent upon the divers response to the treatment.

BAROTRAUMA 15

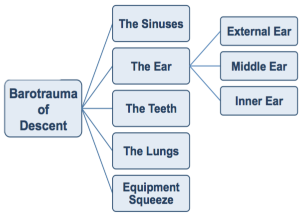
Barotrauma is physical damage to body tissues caused by a difference in pressure between an air space inside or beside the body and surrounding fluid.

Barotrauma Squeeze's 15.2

A *squeeze* occurs whenever fixed volume gas spaces within the body or diving gear are not pressure counterbalanced to surrounding depth.

Types of squeeze that may occur include:

- Sinus Squeeze.
- Ear squeeze.
- Thoracic Squeeze.
- Face or Body Squeeze.
- Tooth Cavities Squeeze.



Sinus Squeeze

Presentation of Sinus Squeeze:

- Sensation of fullness or pain over the involved sinus or in the upper teeth.
- Numbness of the front of the face.
- Bleeding from the nose.

Management of Sinus squeeze:

- Appropriate equalization technique.
- Cessation of compression / ascending.
- Nasal vasoconstrictors / oral antihistamines (To promote nasal mucosal shrinkage of the sinus.)
- Divers who have symptoms for longer than 5-10 days should see a specialist.
- If severe pain and nasal bleeding are present or if there is a yellow or greenish nasal discharge, with or without fever, a specialist should be seen promptly.
- Divers with a history of nasal-sinus disease should have an E.N.T. evaluation before beginning to dive.

External Ear Squeeze

Presentation Of External Ear Squeeze:

- Fullness or pressure in region of the external ear canals.
- Pain.
- Blood or fluid from external ear.
- Rupture of ear-drum (entrance of cold water into the middle ear).
  - Extreme dizziness (vertigo).
  - Nausea, and possible vomiting.

Management of External Ear Squeeze:

- Appropriate equalization technique.
- Cessation of compression / ascending.
- Ear-drum rupture should be treated according to the procedures for treating middle ear barotraumas.

Middle Ear Squeeze

Presentation Of A Middle Ear Squeeze:

- The symptoms of middle ear squeeze consist are similar to an ear blockage.
- Conductive hearing loss (may not be the primary complaint because of the intense ear pain).
- Mild tinnitus and vertigo.
- Blood in middle ear / eardrum.
- If the ear drum ruptures;
  - The pain is usually relived.
  - Cold water may enter the middle ear causing:
    - Dizziness.
    - Nausea.
    - Ringing in ears.
    - Acute or chronic infection with resultant temporary or permanent deafness.
- Excessive Valsalva manoeuvre may cause damage to the oval window.

Management of Middle Ear Squeeze:

- Divers should attempt to re-establish pressure balance as quickly as possible.
- If unable to resolve this difficulty quickly, the diver should ascend to the surface.
- Often, returning to the surface is all that is necessary to relieve the symptoms of mild ear squeeze, (it may take a few days for the fluid / blood to be absorbed from the middle ear cavity).
- A nasal decongestant spray, nose drops, a mild vasoconstrictor medication, or an antihistamine taken by mouth may help.
- Chewing gum, yawning, or swallowing may also help.
- If examination reveals that the diver has a rupture of the ear drum:
  - The diver should seen by a physician.
  - Cease Diving until the tear has healed, which usually occurs quickly (unless infected).
  - Monitor the healing process and take steps to control infection in the damaged ear.

Barodontalgia (Tooth Cavities Squeeze)

Presentation of Tooth Squeeze:

- Pain in affected tooth.
- Maxillary sinus pain.
- Tooth may implode.

Management of Tooth Squeeze:

- Stop descent - return to surface.
- Analgesic management as required.
- Dental review.

Face / Body Squeeze

Caused by malfunction or inappropriate used equipment.

Presentation of Face / Body Squeeze:

- Pain at the site of the squeeze.
- Blood-shot eyes.
- Bleeding into skin, around eyes, or from nose may occur.
- Puffed-swollen cheeks.

Management of Face / Body Squeeze:

- Severe - stop diving until clear.
- Analgesia medication as necessary.

Thoracic Squeeze

Caused by compression of lungs to less than their residual volume resulting from an extremely deep free dive (breath holding) or pronounced body squeeze.

May produce significant lung damage due to blood and tissue fluids being forced into the alveoli and air passages.

Presentation Of Thoracic Squeeze:

- Feeling of chest compression during descent.
- Pain in the chest.
- Difficulty in breathing on return to the surface.
- Bloody sputum.

Management of Thoracic Squeeze:

- In severe cases, the diver requires assistance to the surface.
- Implement reduced consciousness care.
- Implement airway / breathing interventions.
- Medically assess & evaluate.

G.I.T. Squeeze

Presentation of Gastrointestinal Expansion

- Abdominal discomfort.
- Abdominal pain (sharp in nature).

Management of Gastrointestinal Expansion

- Usually self-curing by belching or passing wind.
- If severe, slow down rate of ascent.
- If occurring in chamber, chew peppermints.

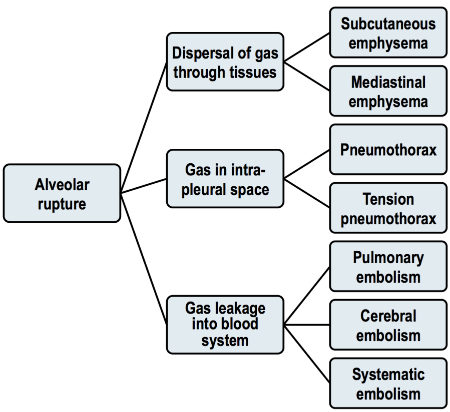
Pulmonary Barotrauma's 15.3

The lungs are a particular 'choke point' when it comes to air filled spaces within the body. Alveolar rupture may cause several conditions:

- Pneumothorax
- Tension Pneumothorax
- Mediastinal / Subcutaneous Emphysema

Air may also be pressurized into the arterial bed causing D.C.I.:

- Pulmonary Arterial Gas Embolisms (P.A.G.E.)
- Cerebral Arterial Gas Embolism (C.A.G.E.)



Pneumothorax

Presentation of a Pneumothorax (severe)

- Commonly the pneumothorax is small and there are few signs.
- Abnormal airway signs: **Distress / wheeze.**
- Neck Signs: **Trachea deviation** (late sign) / **distended neck Veins / Emphysema present / L**arynx intact.
- Breathing (RISE – FALL): **rapid Rate** / **aSymmetrical movement** / **gross Effort & accessory muscle use** / **Feel emphysema / hyper-resonant on affected side** / breath sounds: **absent on affected side.**
- Difficulty speaking (will need to take a breath in the middle of a sentence).
- Painful breathing / complain of chest pain.
- Rapid pulse rate (tachycardia).
- Non-palpable radial pulse (Reduced blood pressure).
- Reduced conscious level (cerebral hypoxia).
- Pale, clammy skin / Grey or blue lips and skin (cyanosis).

Management of a Pneumothorax

A Small Pneumothorax Can Be Treated Conservatively:

- Contact duty medic / supervisor.
- Conduct primary / secondary survey & record observations.
- Administer high flow O_2 on the surface.

All Tension Pneumothoraces Require Draining.

- Conduct primary / secondary survey & record observations.
- Implement compromised airway / breathing management.
- Alert Medical personnel / supervisor & prepare to evacuate.
- Observe for & treat A.G.E.'s.
- Assess for tension pneumothorax & implement treatment.
- Treat Shock. (Always Insert an I.V. cannula, give I.V. fluid as instructed).
- Continually assess casualty.

Tension Pneumothorax

Often an over expansion event. The presence of a diving over expansion tension pneumothorax is related an increased incidence of A.G.E's and D.C.I. in the victim.

Presentation of Tension Pneumothorax

- Standard Tension Pneumothorax presentation.
- Possible P.A.G.E. / C.A.G.E.
- Possible Neurological / musco-skeletal D.C.I.
- Mediastinal and subcutaneous emphysema in neck / shoulders.

Management of Tension Pneumothorax

- Contact duty medic / supervisor.
- Conduct primary / secondary survey & record observations.
- Administer high flow O_2 on the surface.
- A trained medic should needle decompress the chest on the affected side as soon as possible.
- Implement shock management. (O_2 , I.V.I. etc).
- Implement A.G.E. / D.C.I. / subcutaneous emphysema management.
- Continually assess casualty & record observations.
- Prepare to evacuate (as per company S.O.P's).

- A trained medic should place a chest drain on the affected side as soon as possible.

Mediastinal and Subcutaneous Emphysemia

If gas escapes into the interstitial tissue space, it may track along the outside of the airways and blood vessels to the hila of the lungs and from there into the mediastinum.

Presentation of Mediastinal and Subcutaneous Emphysemia.

- Often symptomless.
- A change in the tone of the voice or hoarseness.
- Swelling or crepitation (the skin “crackles') in the neck & face.
- A sensation of fullness in the chest or throat.
- Mild to moderate retrosternal pain.

Management Of Mediastinal And Subcutaneous Emphysemia.

- Usually resolves gradually without specific treatment.
- If there are troublesome symptoms:
  - Giving 100% O_2 on the surface.
  - Recompression as per company S.O.P. (very rare where there are serious symptoms).

GAS TOXICITY 16

Gas toxicity is defined as ill health caused by absorbing airborne gas via the:

- Respiratory system.
- Skin.
- Mucous membrane.

The Factors That Influence The Casualty's Response To The Agent Are:

- The specific gas (some gases are far more toxic than others).
- Exposure time.
- Concentration / partial pressure of the gas.
- Workload (the higher the workload, the higher the respiratory rate, the higher the absorption of gas).
- General fitness.

Pulmonary Oxygen Toxicity (Chronic O_2 Toxicity) 16.1

If O_2 is breathed at a p.p. greater 0.6 bar for long periods it becomes toxic, particularly to the lungs.

Unit Pulmonary Toxic Dose

Where prolonged exposure to high ppO_2 is necessary (such as during recompression therapy), an estimate of the reduction in vital capacity (VC) can be calculated from the following equation: Where kp is a factor derived from the pO_2 using the table below, and "t" the duration of exposure (in minutes).

The "Kp" Table For UPTD Calculation Is: UPTD = kp X t

The appropriate kp value is multiplied by the period of time (in minutes) spent at each oxygen partial pressure. These values are then summed to generate the total UPTD value (Unit of Pulmonary Toxicity Dose) for the exposure.

It should be recognised that individuals may vary considerably in their response to high ppO_2 and the UPTD value is useful only as a guide. Generally, a dose of 1425 UPTD is considered to be the upper limit of acceptable exposure. These limits are never approached in normal conditions (400mb O_2 it the normal storage in sat which has a kp factor of 0).

$p0_2$(BA)	kp	$p0_2$(BA)	kp	$p0_2$(BA)	kp
0.5	0.00	1.3	1.48	2.1	2.64
0.6	0.26	1.4	1.63	2.2	2.77
0.7	0.47	1.5	1.78	2.3	2.91
0.8	0.65	1.6	1.93	2.4	3.04
0.9	0.83	1.7	2.07	2.5	3.17
1.0	1.00	1.8	2.21	2.6	3.31
1.1	1.16	1.9	2.36	2.7	3.44
1.2	1.32	2.0	2.49	2.8	3.57

Presentation of Pulmonary Oxygen Toxicity

- Tickling sensation in the throat, which is worse on inspiration.
- Irritating cough.
- A sensation of substernal burning.
- Coughing becomes uncontrollable.
- Shortness of breath eventually prevents even mild exertion.
- Acute Respiratory Distress Syndrome will present in severe cases.

Management of Pulmonary Oxygen Toxicity

- Reduce the concentration of O_2 in the mix, (preferably to 0.2 BAR. *IPO_2).*
- If substernal burning is present; discontinue oxygen.
- If significant neurological deficit remains and improvement is continuing (or if deterioration occurs when oxygen breathing is interrupted), oxygen breathing should be continued as long as considered beneficial or until pain limits inspiration.
- If oxygen breathing must be continued beyond the period of substernal burning, or if the 4 hour air breaks on long air tables cannot be used because of deterioration upon the discontinuance of oxygen, the O_2 breathing periods should be changed to 20 min on O_2, followed by 10 min breathing chamber air.

C.N.S. Oxygen Toxicity (Acute O_2 Toxicity) 16.2

There is no fixed O_2 exposure at which toxicity becomes apparent. Instead, susceptibility varies both between individuals and within the same person from day to day. As a consequence, there is no cerebral equivalent of the UPTD.

The onset of C.N.S. Oxygen Toxicity is unlikely in resting individuals at depths of 15m or shallower, and very unlikely at 10m or shallower no matter what the level of activity.

However, patients with severe cerebral decompression illness may be abnormally sensitive to oxygen.

Presentation of C.N.S. Oxygen Toxicity

The classic presentation of CNS Oxygen Toxicity is: V.E.N.T.I.D.C.:

- **V**ision (Tunnel vision) which may include any abnormality, such as tunnel vision (a contraction of the normal field of vision, as if looking through a tube) .
- **E**ars (Ringing/Tinnitus), which may include any abnormality of hearing.
- **N**ausea may be intermittent.
- **T**witching appears first in the lips or other facial muscles but may affect any muscle. (This is the most frequent and clearest warning of oxygen poisoning).
- **I**rritability, which includes any change in behaviour, such as anxiety, confusion, and unusual fatigue.
- **D**izziness, an apparent increase in breathing resistance, noticeable clumsiness or lack of co-ordination.
- **C**onvulsions such as generalized clonic tonic seizure.

Management of C.N.S. Oxygen Toxicity:

- Reduce the concentration of O_2 in the breathing mixture, (preferably to 0.2 BAR. *IPO_2)*
- Implement Seizure Management.
- Stop decompression. (Refer to company SOP's).
- Contact duty medic / supervisor.

- Prepare to evacuate (as per company S.O.P's).

Convulsions While In Water Diving:

- The diver's depth should be kept as constant as possible until at least the tonic phase of the convulsion ends.
- He should then be returned to the surface / bell.
- Implement airway / breathing management.
  - Observe for pulmonary barotrauma / A.G.E. / D.C.I.
- Treat for possible near drowning.

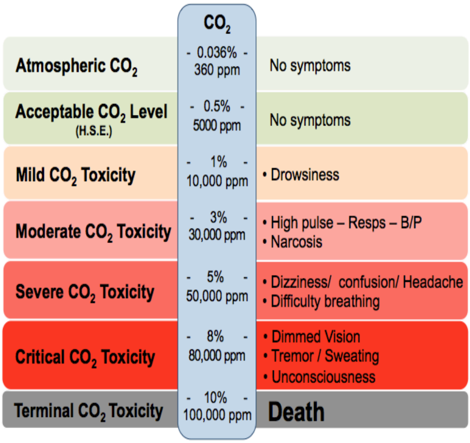
Note. The symptoms of c.n.s. O_2 toxicity may be made transiently worse when the inspired PO_2 falls. This is the so-called 'Off Phenomenon'. Consequently the onset of symptoms or signs may be delayed by up to 5 minutes after leaving the water, coming off O_2, or during a decompression stop where the partial pressure of O_2 is reduced.

Hypercapnia (CO_2 Poisoning) 16.3

Also known as hypercarbia, is a condition where there is too much carbon dioxide (CO_2) in the blood. Acceptable levels of CO_2 (As set by H.S.E.) is 5000 ppm or 0.5% in a breathing mix for 8hrs maximum.

Causes of Hypercapnia;

- Increased workload.
- Pre-existing medical condition.
- Failure of CO_2 absorption (closed / semi closed).
  - Channelling.
  - Soda lime canister exhausted.
- Large dead space.
- CO_2 in gas mix.



Presentation of Hypercapnia

- Increase in respiration & pulse rate.
- Headache.
- Sweating.
- Dizziness.
- Nausea.
- Anxiety.
- Unconsciousness.

Management of Hypercapnia

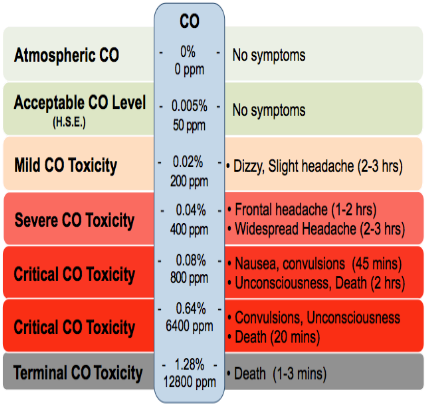
- Manage unconsciousness / reduced consciousness as per Immediate Care.
- Ventilate environment / breathing mix.
- Change soda lime.
- Flush chamber.
- Equalize chamber with entry lock.

Carbon Monoxide Poisoning 16.4

CO is a product of incomplete combustion of organic matter. CO has affinity to Haemoglobin 200 times greater than O_2

Presentation of CO Poisoning

- Breathlessness on exertion.
- Lassitude.
- Dizziness / headache.
- Tinnitus.
- Confusion Loss of consciousness.
- Cherry red complexion (unreliable, rare and fatal).



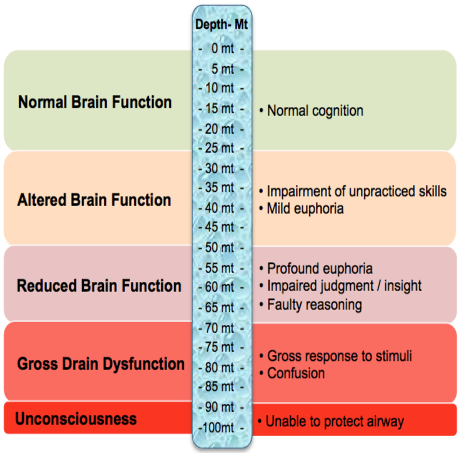
Management of CO Poisoning

- Change gas supply.
- Jump standby to assist divers ascent.
- Recompression (As per company SOP usually RNT 60 / 61).
- Administrating pure O_2 by BIBS (flushes out CO).
- Instigate reduced consciousness management.

Nitrogen Narcosis 16.5

Narcosis while diving (also known as narced, inert gas narcosis or "the raptures of the deep"), is a reversible alteration in consciousness that occurs while diving at depth.

Narcosis produces a state similar to alcohol intoxication or nitrous oxide inhalation, usually it become noticeable beyond 30 metres.



Presentation of Nitrogen Narcosis

- Responses significantly slow down.
- Loosing short-term memory.
- Lack of insight / faulty reasoning.
- Calculation errors.
- Idea fixations.
- Increased anxiety, anger or euphoria.
- Narrowing of a divers mental focus.

Management of Nitrogen Narcosis

- Decrease depth.
- Change mix (Nitrox?).

Hydrogen Sulfide Poisoning 16.6

H_2S is an extremely hazardous, toxic compound. It is a colourless, flammable gas that can be identified in relatively low concentrations, by a characteristic *rotten egg* odor. The gas occurs sulfur springs, gas wells, and as a product of decaying sulfur-containing organic matter, particularly under low oxygen conditions. It is therefore commonly encountered in places such as sewers, sewage treatment plants (H_2S is often called *sewer gas*), mines, and the holds of fishing ships.

H_2S is heavier than air and initially leaves a sulfurous (rotten egg) odour before permanently destroying the sense of smell and therefore becoming tasteless and odourless. Due to the fact the gas is heavier than air / HeO_2 it forces the air or gas mix above it leaving any unsuspecting diver to asphyxiate due to lack of oxygen.

When a diver is working on this site they can accumulate this mud on their equipment, bringing it back to the bell/chamber/deck upon their return. This allows the gas to escape into its surrounding environment.

Presentation of H_2S Poisoning

- Initial smell of rotten eggs.
- Headaches.
- Loss of smell.
- Cough / Haemoptysis.
- Vertigo.
- Confusion.
- Nausea and vomiting.
- Asphyxiation.
- Possible loss of consciousness.
- Seizure.
- Death.

	H_2S	
Atmospheric H_2S	0% 0 ppm	No symptoms
Mild H_2S Toxicity	0.001% 10 ppm	• Irritation eyes, nose & throat
Moderate H_2S Toxicity	0.005% 50 ppm	• Dizzy, headache, nausea • Coughing & breathing difficulty
Critical H_2S Toxicity	0.02% 200 ppm	•Severe breathing difficulty, shock •Convulsions, Unconsciousness
Terminal H_2S Toxicity	>0.02% >200 ppm	• Death

Management of H_2S Poisoning

- If presence of H_2S is suspected then evacuate to a high point until the area is confirmed clear.
- Administer pure O_2 (flushes out H_2S).
- Instigate reduced consciousness management.

Hydrocarbon Poisoning 16.7

Hydrocarbon vapour is a common by product in the oil / gas industry.
There is likelihood for contamination of the bell atmosphere from vapourised contaminants carried on dive suits and umbilical's.
Potentially fatal, levels of hydrocarbons can accumulate in the enclosed environment of a diving bell.
Hydrocarbon vapour has a profoundly sedative quality, so even if fatal levels are not reached immediately, divers may be incapacitated before they can initiate environmental flushing measures.

Presentation of Hydrocarbon Toxicity

- Headaches.
- Confusion.
- Nausea and vomiting.
- Reduction in consciousness.

  - Even before unconsciousness, the ability to react normally becomes impaired:
  - 52% of the anaesthetic level of cyclo-hexane causes convulsions.
  - 44% of the anaesthetic level of benzene causes uncontrolled jerking of limbs.
  - 33% of the anaesthetic level of toluene leads to hyperactivity.
  - 13% of the anaesthetic level of xylene causes tremors, which could impair actions.
- Seizure.
- Death.

Management of Hydrocarbon Poisoning

- Ensure hydrocarbon analysis equipment is functioning & divers are trained in its use.
- Immidiatly don BIBS & flush compartment on contamination.
- Closley observe & manage casualtys who have sucomed to the effects of hydrocarbon exposure.
- Decontaminate bell (as per company SOP's).

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