Ambient Pressure Diving Ltd

Equipment Inspection following a diving incident.

A step by step guide:

1) Photography:

It is absolutely essential to photograph everything. Sometime later when you are working through scenarios, you will need to know what was connected to what, which side each cylinder was, how close to his body was it mounted, did he have dive reel etc – the possibilities of future questions are endless and the photos taken at this stage could prove invaluable. I would strongly advise that the photographer be a separate person to the equipment examiner and ensure the photographer is briefed on getting a shot of everything both prior and during dis-assembly.

2) Record Keeping:

Again, it is absolutely essential to record everything you do and find. E.g. If you are inspecting the diluent side and find no fault then write "No fault found" – you are going to need this data later.

The equipment inspection is a time for data collection – leave the analysis of the cause of the incident until afterwards, when you have all the data in and you have time to cross-reference with autopsy findings and statements.

3) Autopsy:

All too often a verdict of "death by drowning" is recorded.
A proper autopsy can reveal much: Contact Dr M. Calder – calderpath@hotmail.com
Telephone: 01223 277220 – he's a pathologist specialising in deaths in water.

3) Recovery:
On the bottom:
The divers need to be briefed on what to look for:
Does the diver have his mouthpiece in?
Mask On?
Is he heavy on the bottom or semi-floating?
Is there a beeping noise? If so –where is it coming from?
Are there any bubbles – if so where from?
Ensure they do not touch the cylinder valves.
Ensure they do not touch the handsets – If the diver is using a Classic Inspiration ask them to note whether the switches are towards the screen or towards the hose – on the diver's left hand set and the diver's right hand set – but don't touch the switches.

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Last updated: 19/7/2010

(The reason for asking this is to test for continuity of evidence).

When they find the body, it's likely to be a time of high stress for the rescue diver. Getting him to work to a checklist may help – but something to stress is that they are not to endanger themselves any more than a normal dive to that depth. **I don't think it is reasonable to bring the diver slowly to the surface - Simply attach a lift bag to the top handle of the rebreather, ensuring the diver is still in the harness properly and send him up.**

Get statements from the divers as soon as possible after surfacing. The Police should be involved with this.

At the surface:
Once at the surface it is very common for the Police to take over. The best Police forces recover the body and equipment intact and follow a procedure similar to this, please communicate with them before the recovery if possible to ensure the continuity of evidence is assured. Try to get them to recover the body and equipment by holding the top handle and NOT the rear convoluted breathing hoses, the combined weight of the equipment and diver – they will pull the T piece fittings from the counterlungs!

It will help if the diver can be recovered to the shore with equipment still attached.
If the equipment can be kept on the diver when he is recovered lay him on his back and photo everything. Shots of the complete ensemble, shots of gauges, control valves, 1st stages, 2nd stages, rebreather front, back, side and top shots.

4) Equipment Inspection

Often the equipment inspector has no involvement until this stage. It is necessary to get some assurance from the Police that the equipment is received – as it was recovered from the water. If cylinder valves have been closed then it is necessary to get that information prior to your inspection.

Try and read witness statements prior to doing the equipment inspection – was the diver red faced on recovery or did he have cyanosis?

Try and glean some information regarding the incident:
Did the problem happen at the surface? – in which case High O2 is ruled out.
How soon into the dive did the problem occur? – Try and get a copy of the download from his dive computer.

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Important Notes:
Classic Inspiration: *never switch on both handsets. Each handset has separate information which can be gleaned. Inspect one handset, switch off and then switch on the other handset.*
Vision Inspiration and Evolution: *the dive data must be downloaded before the unit is submerged again. If you switch the unit on and submerge the unit below 1.2m it will start to record over the top of the incident dive data ! The Vision stores in hard memory the dive info for nine hours of diving. It is stored in hard memory so even when the batteries die the information is retained. If the diver is submerged for some time, then it is the first nine hours that is retained in memory.*

The rebreather's job is to control CO2, PO2 and provide a breathing circuit – so those are the areas you need to concentrate on:

1) Is the loop in tact?
2) Did the diver have a CO2 hit? Mouthpiece valves?/CO2 bypassed the scrubber?/Scrubber material?
3) Was the machine switched on? Was it capable of controlling the PO2?
4) From the circumstances - is it possible to determine whether high O2 or low O2 is most likely to be the problem and is there evidence from the equipment examination to support one line of thought rather than another?

At the end – you may be simply required to state what you think is the most likely cause of the incident – but you will need to state whether there was anything in the equipment inspection to support that. I strongly suggest an opinion isn't given until all the facts are gleaned.

The order of equipment test may vary with the state the equipment is in. If the mouthpiece is closed and the product is in good condition, it may be appropriate to place on a breathing simulator for a CO2 challenge. Qinetiq at Alverstoke is the centre for such testing in the UK.
Here at APD we can do rebreather inspections but have only got involved in the past, when there has been an in water witness to events and at the request of the Coroner or family.

Work slowly and methodically:

a) Examine the loop for air tightness (positive pressure test)
    i) is the mouthpiece open or closed?
    ii) What is the pressure relief valve setting, fully open (counter-clockwise), half open or fully closed (clockwise)?
    iii) note if and where the loop is leaking

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b) If a strip down is necessary, start with the gas cylinders, one by one:

i) identify which gauge is with which cylinder
ii) note the pressure and photograph the gauge
iii) identify which cylinder is connected to the ADV and manual inflators)
iv) check the cylinder valves – are they open or closed ? (some get confused with inverted cylinders – looking on the knob, clockwise is closed, anti-clockwise is open – sorry to state the obvious but this has been messed up on two separate equipment inspections that I know of – it seems the inverted cylinders may have caused confusion.)
v) if gas leaks from a fitting – close the cylinder valve immediately – and identify where the gas is leaking from:
    a. is the 1st stage attached to the cylinder valve properly?
    b. Are all the hoses connected properly?
    c. Are any hoses damaged?
    d. Is the gas leaking from the 2nd stage?
    e. Is the 2nd stage intact?
    f. Basically identify and record what you find.
vi) analyse the gas for oxygen content and if appropriate for helium content
vii) consider checking gas for oil and Carbon monoxide contamination with relevant Draeger tubes
viii) if the cylinder is empty – check for water – de-valve and empty into a measuring jug, note the volume of water.

c) Examine the loop for constrictions, components inserted in the loop such as mouthpiece with small orifice, VR3 4th cell holder – is the convoluted hose kinked?, are any of the convoluted hoses kinked?

d) Remove the mouthpiece and hoses at the T pieces,

i. tip any liquids into a receptacle (extreme caution required – in the event of a pulmonary baratrauma (burst lung) there is potential for blood and body fluids to be in the exhale hose.)
ii. The non-return valves need to be tested for back leaks – consider very carefully how this is to be achieved – ideally it needs to be done prior to cleaning so connectors may need to be employed.

e) Check the counterlungs for water and empty into a measuring jug.

f) Remove the canister from the loop by disconnecting at the T pieces.

i. remove the lid
ii. note if there is any liquid on top of the scrubber cartridge (if there is a volume of water then this would imply there has been no CO2 bypassing the Sofnolime. Tip the liquid out, measuring and noting the volume.

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iii. Check to see whether the scrubber spacer ring and O ring are in place and located correctly
iv. Push down on the scrubber cartridge – does it travel up and down freely?
v. Remove Spacer, O ring and Sofnolime cartridge
vi. Measure the position of the bottom "spider" – it should be only just inside the scrubber cartridge.
vii. Insert the complete scrubber cartridge in a strong polythene bag and seal it with a polythene bag sealer. (Even if soaked, it is possible to have the scrubber material analysed – contact Gavin Anthony – Qinetiq, Alverstoke: www.qinetiq.com .
viii. At this stage it is quite okay to remove the bottom spider and take a look at the material – what brand and grade is it? But, then simply screw the bottom spider back in place – under NO circumstances should the scrubber material be emptied.
ix. Try and impound the container with any unused scrubber material from the diver's home. (This will be required by QinetiQ (pronounced Kinetic)).
x. Try and glean some information from witnesses regarding the renewal of the Sofnolime.
xi. Tip the moisture from the scrubber base into a measuring jug and note the volume.

Lid and Handset examination:

It is difficult to give a step by step guide for the lid and handset because much will depend on the condition of the components in the lid. If the lid was flooded for some time, then the batteries and battery contacts may be destroyed. The oxygen cells may not be functioning properly or even be functioning at all. The difficult part is trying to determine what damage was there at the time of the incident and what is a result of what happened after the incident.

Just how much you re-build the power supply and oxygen cells depends on what you are trying to achieve. If the components need re-building by replacing components – are you really going to be able to prove anything ? e.g. on the Classic - if the handsets are badly flooded the electronic modules might be affected depended on how long they've been flooded – so you can rebuild the lid components to find the handsets don't work – but where has that got you?

With the Vision electronics – the priority is to power up the system so you can download the dive data. Using the LogViewer program a lot of information regarding the incident will be gleaned – so with the Vision it would be appropriate to re-build the entire power

supply if necessary (if an external (6 volt DC power source is used it is essential to guarantee the correct polarity – incorrect polarity will damage the electronics.)

With the Classic there is very little data to be gleaned from the handsets. Slip the front covers off and inspect for water. If water is present it will have to be emptied and dried before any testing. The switch is unlikely to survive a flood. Are the handsets flooded due to a broken handset or has water passed down from the lid?

Oxygen cells might recover if allowed to dry. Simply measure the voltage of the cell by using a digital voltmeter across the outside two pins. On the Co-axial style connectors it is essential to use a spare connector – push it onto the cell and place the DVM probes on the connector. Under no circumstances should the DVM probes be inserted down the centre of the cell's co-xial connector – you will destroy the +ve contact.

Measure the voltage of the batteries - noting which battery comes from which slot (Controller One's battery is closest to the junction box on the Classic), Measure the voltage at rest and if live, under load – operating the solenoid. (I would use another solenoid for this test – simply bend the terminals on the solenoid out slightly so the terminals can bridge the battery contacts).

Classic Handset examination:
Note the position of the on/off switch on each handset.
Try switching on one handset (and ONE handset ONLY!!). Make a note whether it fires up or not. DO NOT calibrate! Make a note of what the handset says – at this stage it is simply going through a diagnostic check and will advise which oxygen cells are out of range. Make a note of the Elapsed on Time. Switch off.
Do the same with the 2nd handset.

Assuming everything is in reasonable condition:
Connect on some oxygen (from one of your cylinders) and see if the solenoid operates and adds oxygen, measure the O2 % - place the lid in a polythene bag, place an oxygen sensor inside the bag and feed out to your DVM.

Note the handset readings compared to your DVM.

The best testing is done at a specialised test laboratory where the scrubber can be challenged with CO2 and the oxygen control can be tested under the same conditions as the diver experienced.

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Test Laboratories:

The following test laboratories are equipped with calibrated test facilities for testing rebreathers under hyperbaric conditions:

U.K.

Ambient Pressure Diving Ltd
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Water ma Trout Industrial Estate,
Helston, Cornwall,
TR13 0LW , U.K.
Tel: +44 (0)1326 563834.
Contact: Martin Parker - martinparker@apdiving.com

Health & Safety Laboratory
http://www.hsl.gov.uk/
Harpur Hill
Buxton
Derbyshire SK17 9JN
UK

Contact: Nicholas Bailey
PPE
VPN 524 8334
Tel 01298 218334
Fax 01298 218393
nicholas.bailey@hsl.gov.uk

QinetiQ
Haslar Marine Technology Park
Haslar Road, Gosport
Hampshire, PO12 2AG

Contact: Gavin Anthony
Principal Consultant Diving and Life Support

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Contact Ian Himmens on:

Ian@ansti.com

U.S.A

Navy Experimental Diving Unit
http://www.supsalv.org/nedu/nedu.htm

Buffalo University
CRESE
Centre for Research in Special Environments
Contact Prof. Lundgren, Tel: +1 (716) 829-2310

Sweden

Department of Defence Medicine, Swedish Defence Reasearch Agency, Stockhom, Sweden.
http://www.foi.se