Anatomy of a Technical Diver

A good SCUBA equipment configuration needs to support all of your diving whether that be an open water dive or a penetration dive inside a wreck or a multi-stage cave dive. The configuration must be able to adapt in such a fashion that the addition of items necessary for each dive does not in any way interfere with or change the core aspects. Diving with the same basic configuration allows the same response to emergency at all times while reducing task-loading due to familiarity.
In other words, a good gear configuration not only helps solve problems, it prevents them.

By achieving a configuration which is streamlined and comfortable to dive with, you will experience diving with reduction in stress and task-loading thus increasing your enjoyment.

Strive to achieve a attitude where you **NEVER** accept any equipment situation where your own standards are compromised. Correct any equipment configuration problems immediately as opposed to waiting until the next dive.

If you are searching for advice on a specific aspect of equipment configuration, please use the following index to quickly move to it. If we have not yet touched on the subject or we don't answer your question in the detail you require, please don't hesitate to contact us.

Anatomy of a Technical Diver

Configuration

When building any system, the best place to start is at the foundation. The foundation for us is the back-mounted tanks. These will be either used in a single tank or dual tank configuration. When the diving allows the use of a single cylinder, this cylinder should be fitted with a dual take-off valve. Many divers try to unsafely extend the dives they do with single cylinders by the addition of pony bottles. Pony bottles do have a place in diving, however they should never be misused by counting them as part of the diver's intended or redundant gas supply. Those dives which require true gas redundancy should be completed with back-mounted double tanks. When using back-mounted doubles, these should be fitted with a manifold. Our last consideration for the back-mounted tanks is the valve knobs themselves.

Now that we have our tank assembly we need some way of attaching this to ourselves. The backplate and harness provides this function as well as providing the attachment points for all our dive lights, stages and other essential dive equipment.

To provide the necessary buoyancy control we primarily use a wing, which is mounted between the backplate and tanks.

Regulator choice, configuration and hose routing is possibly one of the most emotive subjects in diving.

The choice of a wet suit or dry suit will mainly be driven by the water temperature and dive exposure time. Divers diving in cold conditions and divers utilizing trimix as a main dive gas, may consider the use of Argon as a suit inflation gas. For the male dry suit diver, dive comfort can be improved on long dives with the installation of a Pee valve in their dry suit.

The experienced diver will also consider the finer points of their dive equipment and will ensure that the detail and careful thought process that went into building the core components of their dive system is also carried through to the little things, which are, unfortunately, often overlooked.

Anatomy of a Technical Diver

Tanks

While many open water divers are still comfortable with the common aluminum 80ft^3 (approx. 10 Litres) other divers have opted for larger and heavier cylinders, increasing available air and reducing the need for additional weight on a belt. Most technical divers prefer larger volume low pressure steel cylinders made by manufacturers like Pressed Steel and Faber. In the USA these tanks generally have a working pressure of 2,640psi (180 bar). The lower pressure tanks do not mandate high pressure to achieve a reasonable air supply but allow for higher volumes when necessary. The steel 95ft^3 cylinder is very popular due to its wide availability and reasonable cost. For many divers it may be sufficient. For many years cave divers have favoured the Pressed Steel 104ft^3 cylinder for its high volume and favourable buoyancy characteristics. Most divers need little, if any, weight with the steel 104, but it is often unnecessarily heavy, especially when ocean diving.

In Europe the norm has become 232bar (3,400psi) tanks with cylinder sizes ranging from 10 litres (approx. 98ft^3) to 15 litres (approx. 122 ft^3). The 300 bar cylinders which are available are not recommended for a number of reasons

1. Stress on manifolds, first stages, HP hoses etc.
2. Sub-optimal buoyancy characteristics.
3. Gas mixing problems as the gas laws become "real" as opposed to "ideal".

Some tanks are fairly heavy when full yet will become neutral or even positive when empty. The diver should ensure that he has ample weight to remain submerged at 20 feet (6m) with empty cylinders. One may offset this problem with a conventional weight belt, with weight placed behind the backplate or with a heavier stainless steel plate.

Anatomy of a Technical Diver

Additional Considerations:

1. The wide range of tanks available allows one to choose an appropriate size. Tanks much larger than 104's are usually too much for all but a lengthy exposure. Tanks in the 100ft^3 range are most universally appropriate.
2. High pressure tanks such as the Genesis line are generally unwise choices as they have unfavourable buoyancy characteristics and have a poor pressure-to-volume relationship.
3. Hot-dip galvanized tanks appear far more rust resistant but environmental considerations and cost seem to be reducing their availability.
4. The diver should be able to remain submerged with empty tanks at 20 feet (6m) and must adjust weighting accordingly.

Faber 95 and 120 ft^3 tanks.

Proper style of threaded bolt to be

used to secure doubles.

Anatomy of a Technical Diver

How to Rig a Stage Bottle

Stages

Stages can be of a variety of sizes depending upon their function within the dive. The largest bottle which should ever be considered for use as a stage is the aluminum 80 (approx 10 L). A dive requiring more staged gas than can be provided by an 80 should be planned with multiple stages NOT larger stages.

The aluminium 80 swings equally from negative to positive with air, less negative with gas, by the amount of the air or gas carried. Steel cylinders should never be considered as stage tanks.

Stages are rigged with stainless steel bolt snaps, the size of which is determined by whether or not the water temperature will require the use of gloves. The bolt snaps are attached by knotting them into a piece of 1/4" line which is run through rubber hose or brake line, looped around the neck of the tank and run under a hose clamp which is placed approximately halfway down the tank. The upper clip should be tight to the break of the neck of the tank, the lower clip should have plenty of tail as shown in the photo on the left. This allows the stage bottle to ride in the slipstream while scootering. The clip can be run under the hose once to bring the stage closer to the body for swimming, if desired.

The stage tank needs to be held close at the neck and loose in back to prevent drag. There should **NEVER** be any metal-to-metal connections on any part of the rig. In Europe, the practice has been to put a brass ring around the stage neck, with a double-ended piston bolt used to attach the neck to the diver's harness - the stage bottom is similarly held with a double-ended piston bolt to a D-ring held in place on the tank with a hose clamp. This means that the stage is held with metal-to-metal connection to the diver. This is a very dangerous practice as these piston bolts may freeze (due to debris or damage) resulting in the stage being permanently attached to the diver; in the event of an entrapment the diver cannot remove the stage.

Stages need to be permanently marked with the maximum operating depth (MOD) of the gas they are to contain. The MOD, in three-inch high letters, is placed horizontally in the orientation of the tank on both sides so the diver and his buddy can identify the MOD at all times.

The stage regulator is rigged with a pressure gauge on a six-inch hose which is bent back on itself to face the diver and tied in place by cave line at the first stage. The stage hose must be of octopus length. The stage regulators are always "parked" on the bottle and the bottle turned off unless in use. Stages are generally worn on the left side, leaving the diver's right hand free to drive the scooter and manipulate other gear. The primary light, worn on the right, balances out the stage bottles. When carrying more than two stages, nitrox bottles are customarily carried close to the body and the lighter trimix bottles are clipped to the hip D-ring.

To deploy a stage regulator, first look on the stage bottle for the correct depth marking. Put the corresponding regulator around your neck, open the valve and put the regulator in your mouth. If you can breathe, you are breathing the correct gas.

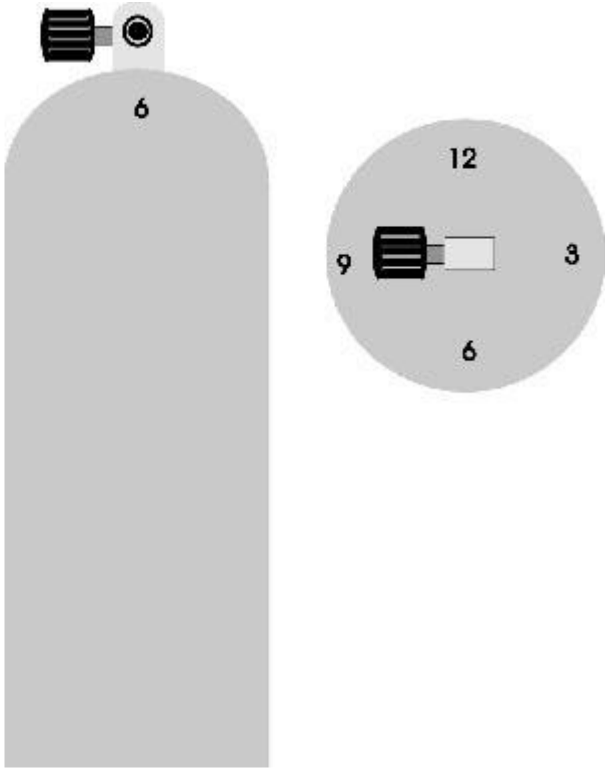
Anatomy of a Technical Diver

Proper Stage Bottle Marking

Use the illustration on the right as the "key" for the following stage tank marking explanation. The numbers represent the positions on the tank where various markings are placed and are merely shown as a reference.

Tank colour is NOT used for content information.

Regulator or hose colour is NOT used for content information.



The illustrations on the left show how to mark the 20' Oxygen bottle. Notice that the word "OXYGEN" is printed along with the depth in 3 inch tall letters. The numeric value (20) represents the Maximum Operating Depth (MOD) for the gas in the bottle.

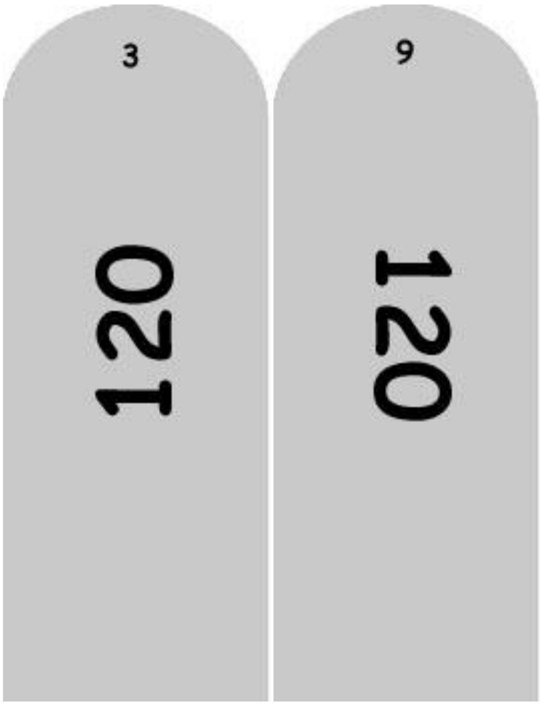
The orientation of the printing allows any other diver in the water to read the tank contents from either side of the stage user.

Anatomy of a Technical Diver

The illustrations to the right show how to mark all other stage bottles for depth.

The MOD is clearly painted on the side with 3 inch tall letters.

Note the orientation again.



Anatomy of a Technical Diver

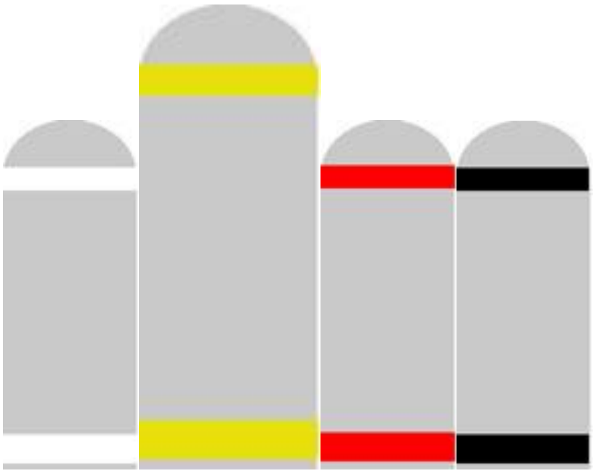
All tanks should have the owners name painted on them.

Note the position of the name at 6 and 12.

Tank color is **NOT** used for content information. Divers are **EXPECTED** to verify the **MOD** of a tank by the numbering on the side.

The old WKPP tank color scheme is shown to the right for historical reference only.

- White - Oxygen (20')
- Yellow - Nitrox (70' and 120')
- Red - 190'
- Black - 300'



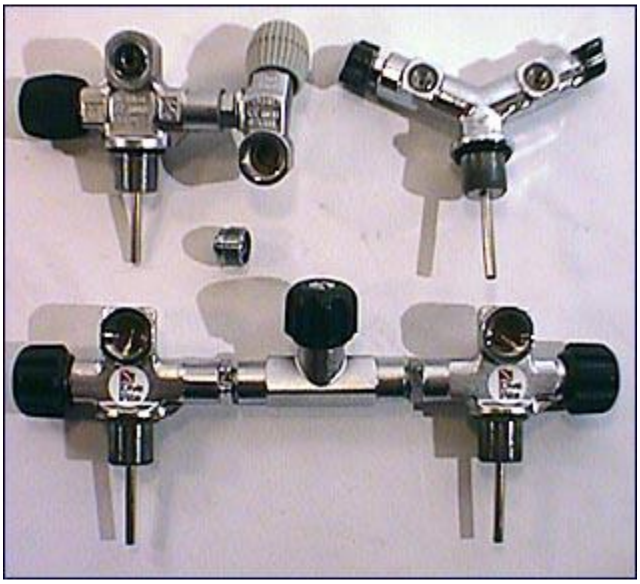
Anatomy of a Technical Diver

Anatomy of a Technical Diver

Valves

K, DIN, H and Y-Valves

Valve types include the antique J-valve, the still relatively popular K-valve, the newer DIN valve and dual first stage designs such as the Y- and H-valves. K-valves and single-orifice DIN valves are common in the open water community but scarce in more advanced diving such as deeper excursions and overhead penetrations where a reserve first stage is necessary to combat potential regulator failure. The Y-valve and newer, more popular H-valve allow a diver to place two first stages on a single tank where one regulator may be shut down still allowing access to the air supply via the second regulator. Y-valves allow only the use of yoke style regulators while the newer H-valve can be used as either DIN or yoke. DIN valves have become far more common in the technical diving community and allow for a more secure fitting and reduced risk of o-ring failure.



H valve (upper left), Y valve (upper right), and manifold (bottom)

Anatomy of a Technical Diver

Manifolds

A manifold is a device that combines the supply of two, usually back-mounted, cylinders. The manifold allows one to breathe from two cylinders at the same time. Diving with independent cylinders requires great care and superior gas management capabilities to effectively monitor the total gas supply, which experience has shown many divers are not capable of. Currently popular manifolds allow the diver to place two first stage regulators on their twin tanks, providing access to both tanks from either regulator. In the event of a first stage failure, the diver may shut down one regulator without losing access to the either tank. Divers may also choose a manifold with an isolator valve between the tanks allowing a diver to interrupt the flow of air between the cylinders. In the rare event that either a burst disk or a tank's neck o-ring were to fail, one could interrupt the flow between cylinders protecting at least half the air supply.

Because this type of failure is highly unlikely, the use of an isolator has sparked some debate. The use of an isolator does require divers to guard against accidentally diving with a closed valve and is another potential failure point. However, when used with care and properly managed it allows for another potentially valuable line of defence, making it very common in technical diving.

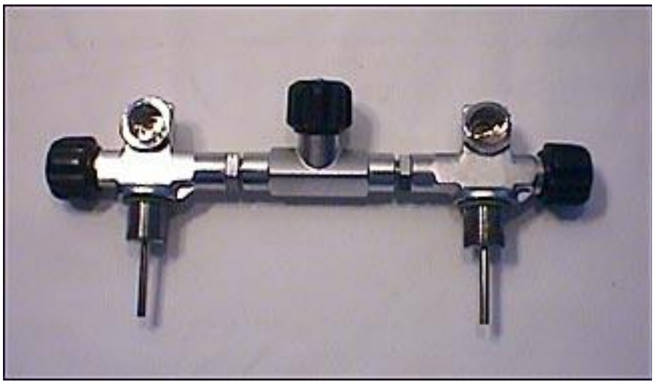
The centre isolator does NOT give the diver the option of closing the centre valve and diving with different mixes in the two cylinders, this being an extremely dangerous practice.

Additional Considerations:

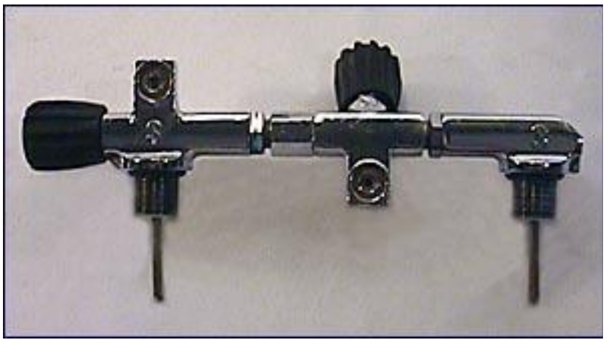
1. Consider using manifolds that allow a diver to adjust the distance between tanks. Popular favourites include the ScubaPro, DiveRite, and Diver's Supply manifolds.
2. Most current production manifolds allow one to place an insert into the DIN orifice, providing for the use of a yoke regulator. Avoid diving this manifold with yoke regulators where possible as o-ring failure is far too common.
3. H-valves are a better option as compared to Y-valves, as they allow for the use of DIN, have easier-to-operate valves and may be upgraded to manifolds for later use.
4. The centre section of a manifold should be of the barrel-style o-ring construction, not the face-seal type. The barrel-style system allows the manifold's centre section to move in the event of it becoming loose without twisting and possibly extruding the o-ring, thus causing a gas leak.

Anatomy of a Technical Diver

Note that the valves are not angled up in a way that exposes the 1st stages to damage.



Older model manifold with yoke valve on the isolator.



Disassembled knob on a manifold.

Anatomy of a Technical Diver

Knobs

Rubber knobs tend to be the best choice for use on tank valves. They are durable, shock-absorbent, shatter-proof, and easy to turn. Their major weakness is that they can roll easily upon contact, allowing for accidental shutdown. Alert divers should find this point irrelevant and will always check their knobs following any contact with the overhead. Plastic knobs do turn less easily but some are relatively fragile and can shatter and fall off, leaving the diver unable to turn the valve off or on. Metal knobs attempt to solve this and the accidental roll problem yet fall a little short because they can bend upon impact and be rendered useless

Collection of broken or mashed knobs from a manifold.

The rubber knob (top) is in good shape after much service, while the hard plastic knobs display various degrees of destruction.

Anatomy of a Technical Diver

Secondary Tanks

Pony Bottles

A pony bottle is designed as a separate air supply to be used in an emergency. These units add unnecessarily to the bulk of a diver's equipment. Most divers exploring deeper water or overhead areas opt for the more sound principal of a back-mounted tank or tanks that allow for two first stages to be used. The single tank would have a Y or H valve while the doubles should be configured with a manifold connecting the tanks. In both situations, bulky equipment is reduced while allowing the diver proper management over his air supply in the event of a regulator failure.

Argon Bottles

Argon bottles are used to introduce argon into a drysuit for added warmth. Argon has favourable insulative qualities and is used when diving in cold water or when using a gas with high thermal conductivity, such as a helium mix, in one's back tanks. Inflating one's suit with a helium-based mixture can produce a large degree of body cooling due to helium's high thermal conductivity. A dangerous reduction of body temperature can easily result from the use of helium-based mixtures for drysuit inflation and divers should avoid this practice. Additionally there is a limited risk of counter-diffusion when immersed in a gas of lower density than one's breathing medium. Argon bottles generally range from about $6ft^3$ to $14ft^3$ and are most efficient with rated pressures close to 2000psi, as argon is typically supplied at a lower pressure. Divers generally secure the argon bottle to the side of the tanks but occasionally may place smaller bottles on the harness waist strap.

Argon Regulator Choice

An argon drysuit inflation system consists of a first stage, a hose and a pressure relief valve (PRV). The first stage should be "detuned" to lower the intermediate pressure. A PRV must be installed to protect from a first stage failure. If a diver does not use a PRV and the first stage creeps, this may cause the drysuit to inflate constantly and could even cause a hose to rupture. The hose is a 24-inch drysuit hose and is run from the first stage under the waist belt of the harness to the chest-mounted inflator.

Anatomy of a Technical Diver

Argon bottle properly attached to doubles.

Anatomy of a Technical Diver

Backplates

The conventional backplate may be constructed from different materials with aluminium or stainless steel being the best alternative. The backplate, complete with a strong adjustable webbing, is then bolted to the tank assembly. This attachment method allows the diver to customize a secure and comfortable fit while maintaining complete flexibility for adjustment and an absolute minimum profile in the water.

Backplate and wings assembled on a set of double 104 ft^3 tanks

Backplate Harness

The harness is the central component to the tank mounting system and requires an individual's careful attention. The harness should be constructed from a continuous piece of webbing, avoiding two-piece designs and quick-release buckles. Interrupting the single-weave design creates unnecessary points of weakness that may cause very dangerous failures. The failure of a two-piece design or the accidental release of a buckle system could easily result in a diver's tanks falling from his body. Without the weight of his tanks, the diver would likely rapidly ascend to the surface, resulting in serious injury or death. Individuals are occasionally confused into believing that convenience at the surface is a more important concern than safety during the dive.

Anatomy of a Technical Diver

It is **NEVER** a reasonable trade-off to accept a potentially fatal risk in favour of a minor convenience. Another unrealistic concern that occasionally leads divers into the use of quick-release buckles involves the belief that a diver should be able to quickly remove his equipment at the surface. Again the diver should not place himself at a higher risk during a dive due to an irrational fear over an unlikely and easily-managed surface episode.

Additional Considerations:

1. One-piece webbing designs are usually less expensive and lack the failure points inherent in other systems often touted as "technical" solutions.
2. A chest strap is usually unnecessary and may impede a diver's ventilation, yet some divers appreciate its use.
3. Stainless steel buckles are much stronger than plastic designs and create a more reliable hold.

Backplates vs. Integrated Units

While some divers have been lured away from the use of a conventional backplate, the backplate/harness/wing system remains a favourite of explorers around the world. The use of integrated units with padding and built-in pockets is really not appropriate for more advanced diving techniques. A conventional backplate has less drag, is more secure and more versatile than integrated units such as those distributed by DiveRite, ScubaPro and OMS.

Additional Considerations:

1. A diver can add weight behind the backplate or use a heavier stainless plate, but one must first evaluate the weight requirements of one's wetsuit or drysuit. The diver should not be under- or over-weighted.
2. While plastic backplates are very strong, aluminum or stainless steel is generally preferable.
3. Be aware that some manufacturers use a steeper or shallower angle on the centre section of the backplate, requiring shorter or longer bolts, which may create compatibility problems between various backplates and sets of doubles.

Anatomy of a Technical Diver

Stainless steel backplate with continuous webbing.

In the basic harness there is one D-ring on each side of the chest webbing section and one D-ring at the left waist.

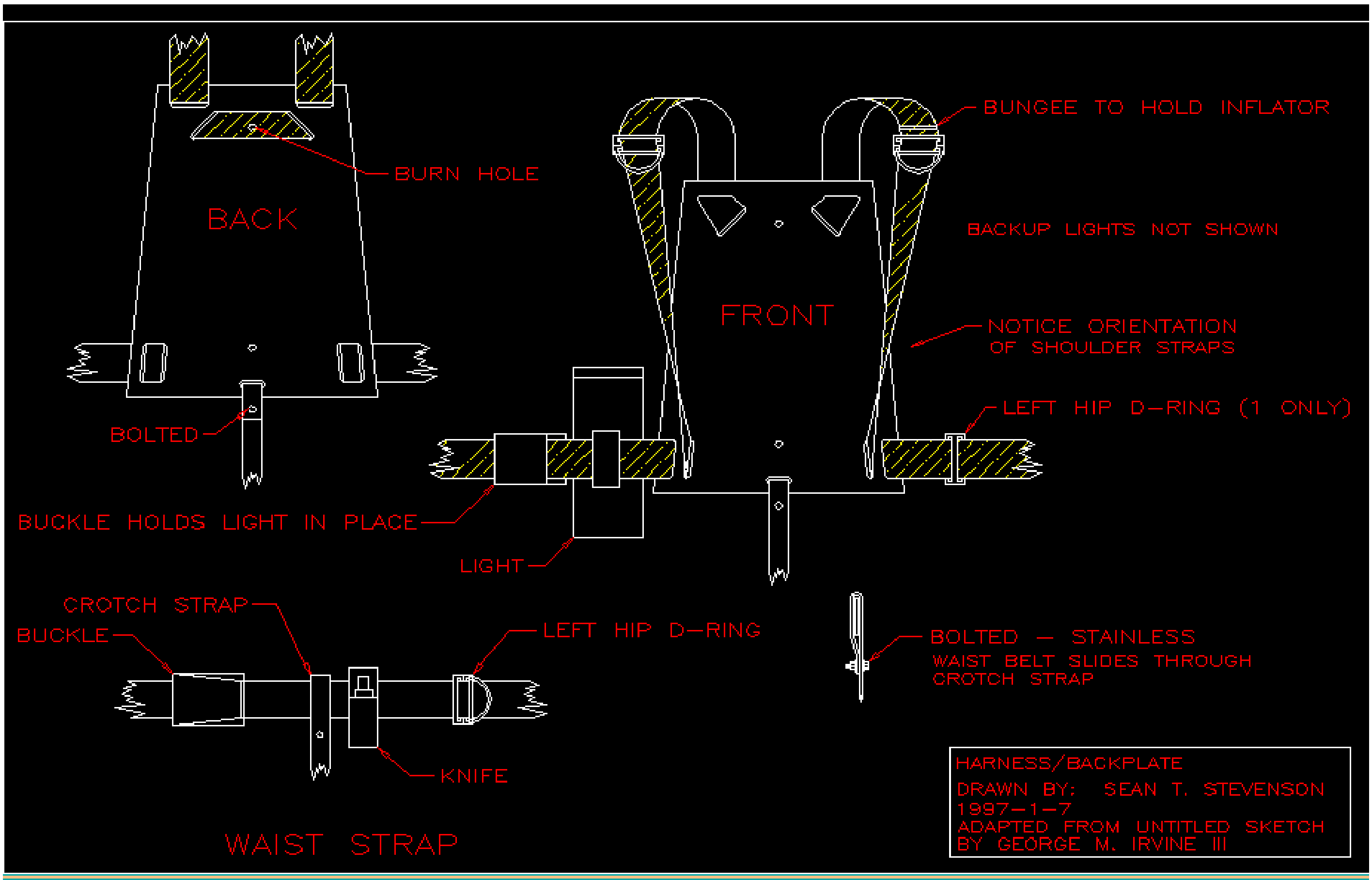
The crotch strap is also one piece, and has a loop in the front through which the belt passes. The belt buckle must be to the right side (as worn) so as not to get opened by the crotch strap. There is a scooter d-ring just below the loop. The crotch strap is necessary to hold the rig in place on the diver. Any upward pressure on the diaphragm created by unstrapped rigs increases the breathing rate and discomfort of the diver markedly.

The knife is in an open sheath on the waist belt left of the crotch strap

The backup lights are attached to the two chest D-rings and held to the webbing by bungee or a small section of inner tube. This puts them under the shoulder and out of the way. The primary light is worn to the right side on the waist belt.

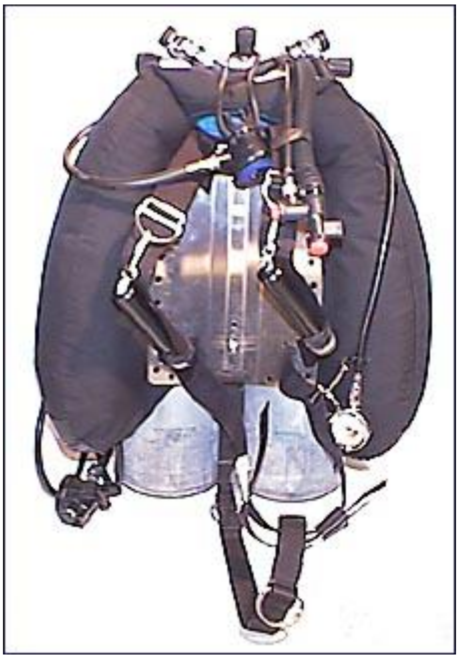
For those diving in cold water with thick gloves, the backup lights are often attached to a second set of shallow D-rings which are mounted just below the main chest D-rings. This assists in clipping on/off stage bottles by reducing clutter on the chest D-ring.

Anatomy of a Technical Diver

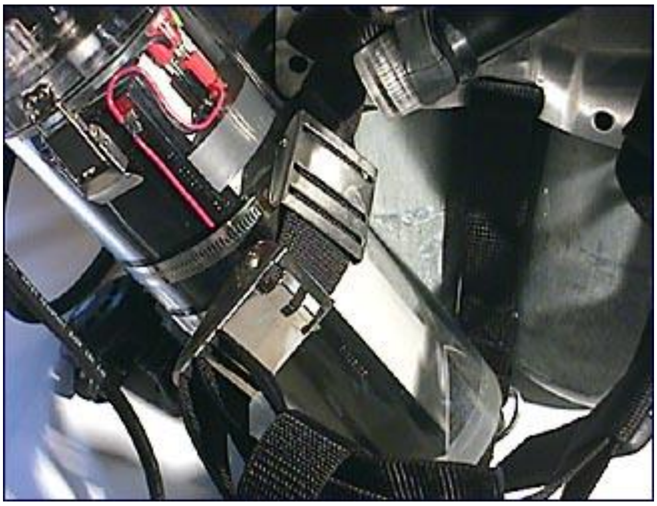


CAD rendering of the proper rigging of a backplate and harness.

Anatomy of a Technical Diver



Doubles assembled with backplate, harness, and regulators.



Right side of harness with primary light and backup light in close proximity.

The Primary light is worn to the right side on the waist belt, and is held in place by either the same buckle that fastens the waist belt, or by a second buckle slipped on as shown.
The backup light can be seen to be held in place with a small piece of inner tube.

Anatomy of a Technical Diver

Attachment Hardware

Divers often have occasion to secure different pieces of equipment to their body and have several options for methods of attachment. Attachment hardware is manufactured in many different sizes with some styles capable of accidentally clipping into rope, cable or other items found within some diving sites. Clips that can arbitrarily clip into other items are often referred to as suicide clips, reflecting the concern that they may cause the diver to become trapped. Wreck divers are especially prone to clipping into more dangerous items such as cable and discarded fishing line and should pay special attention to this concern. However, all divers can avoid the risk of accidental attachment by utilizing a bolt-style clip or snap. Divers should also consider the use of stainless steel clips as they are of far superior quality and will not oxidize and prevent the diver from operating the mechanism. Furthermore, attachment hardware should be attached so that it may be cut free should the clip become damaged and locked closed. While this risk is greatly reduced with quality stainless steel clips, divers should avoid securing the attachment with metal items.

Assortment of double-enders, bolt-snaps, and suicide clips

Anatomy of a Technical Diver

The smaller bolt snaps are used for regulators and backup lights, the larger ones for stages.

Bolt snaps in both brass and the preferred stainless steel.

Left and centre: standard D-rings. The "half" D-ring to the right is often used by cold-water divers who are forced to dive with gloves. It is placed beneath the standard D-ring and is used for back-up light attachment, thereby reducing clutter on the standard D-ring.

Assorted D-rings

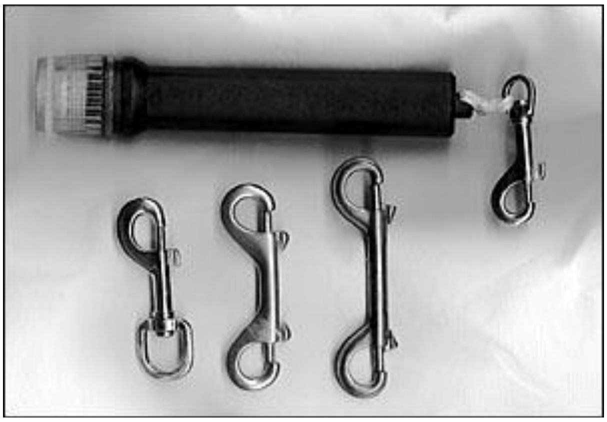
Anatomy of a Technical Diver

On the top left we see a steel weight retainer and D-ring; all that is needed to mount a D-ring to webbing. On the bottom left we see a D-ring which has been welded to the retainer. The welded D-ring attempts to force the ring to stay in place on the webbing, thus making it easier to find and clip to. In reality, the lack of movement of this design is more of a problem and the unit becomes an entrapment point. As the clip isn't easily repositioned, it often places the attached device too far from the diver's body.

On the right we see a piston bolt and a boat shackle. Some divers believe that the convenience of the boat shackle outweighs the positive clip-and-release of the piston bolt However, the entrapment possibility of the shackle makes it an inferior choice.

The clip-mounted D-ring and the swivel bolt snap are always preferred over the welded D-ring and fixed snap.

Anatomy of a Technical Diver



Preferred stainless steel bolt snaps and double-enders. Note proper attachment to back-up light with cave line.

Both the standard and butterfly suicide clips should be avoided for all types of overhead diving. Both are prone to accidental clipping off onto a line or cable.

Anatomy of a Technical Diver

Primary Lights

The type of primary light an individual should consider is certainly going to vary depending on the dive chosen. For more technical dives most divers tend to use a separate battery canister and light head. Canister lights come in two primary styles: cylindrical and square. Obviously, cylindrical lights are more pressure resistant. Divers should avoid the less pressure resistant square canisters, either new or used. Currently all major manufacturers are producing cylindrical lights, making it easier to avoid square designs.

Extreme Exposure canister light

Light heads are typically either test tube or projector bulb design. Test tube style lights are more common, with easily removable halogen bulbs and bright far-reaching light beams. Projector style light heads are sometimes preferred for their tough casings and broad beams, yet realistically are less effective and more cumbersome than test tube designs.

High Intensity Discharge lamps are the latest innovation in underwater lighting. HID lights draw far less power than halogen lamps at several times the intensity. HID lighting also produces a bright white light that approaches the colour temperature of sunlight, making them very attractive for videography and photography. Preferably, all members of a team will have the same type of lighting. GUE discourages the mixed use of halogen and HID lighting among dive teams. If one or more divers in a team are using HIDs while the others are using halogen, special care must be made to make sure that the duller, dimmer halogen beam is visible to all team members.

Anatomy of a Technical Diver

Additional Considerations:

1. Do not rely on manufacturer claims about light burn time as mathematical calculations and real world use are rarely similar.
2. Be wary of cheap batteries as they will yield reduced burn time and fewer total cycles. All batteries should be tested in real time by the user. Voltages below 10 volts do not provide ample lighting.
3. Be sure that hip mounted canisters are pulled back along the belt and under the shoulder to keep them streamlined and beyond the reach of one's kick cycle.

Anatomy of a Technical Diver

Reserve Lights

Reserve or back-up lights are undoubtedly an essential portion of the overhead diver's equipment and remain a common aspect of most technical configurations. Open water divers will have to evaluate their needs depending on the dive undertaken. Dives that require the use of a light to return to the surface (such as in overhead diving) should always employ at least one primary light and two reserve lights. These lights must be reliable, unobtrusive and conveniently located. In overhead situations each reserve light must have sufficient burn time to allow a diver to manage a delayed exit. This should be easily accomplished with a light with a burn time at least equal to the expected bottom time. Following a primary light failure the diver must switch to the reserve light and initiate an exit. Reserve lights should not use rechargeable batteries as they tend to have a more unreliable burn time when not frequently used.

Reserve lights can be stored in several places yet they should be easily accessed and configured in a streamlined or unobtrusive manner. When placed on one's harness below the arms, reserve lights tuck neatly out of the way and are essentially snag-free. A diver experiencing a primary light failure with no other divers immediately around will find that a light which can be turned on prior to its removal can be very beneficial. If dropped this light can now be easily retrieved. Also, one can activate the reserve light and leave it affixed while managing any other equipment issues. Lights located on the harness and below the arms are easy to remove, simple to activate, more convenient to replace and do not require that one add additional equipment like clamps and d-rings to the tank.

Far too many people allow their reserve lights to dangle from their rig and yet claim to be efficiently configured. Some divers try to place the lights on their tanks, in waist-mounted pouches or otherwise out of sight and beyond easy reach. Reserve lights mounted in these out-of-the-way locations will be less likely--or impossible--to be seen if a light that has accidentally activated, and the diver will not be able to activate the light prior to retrieval.

Anatomy of a Technical Diver

Additional Considerations:

1. Avoid lights that are "over-volted." These lights use a higher voltage than the light was designed for to make the light brighter, increasing the risk of bulb failure.
2. Look for smaller, less obtrusive lights. These lights are not as likely to snag on line or other objects such as the in line three c cell light. Using a light larger than a four c cell light is likely to be too cumbersome.
3. Make sure that the light is rugged and not prone to easy damage. If it seems cheap it probably is.
4. Be wary of inexpensive lights, especially ones that are hand-sized or smaller.

Different models of backup lights. While the larger two lights are fine for cavern diving, only the smaller lights on the right and bottom are appropriate (as back-up lights) for cave and wreck diving.

Anatomy of a Technical Diver

Although many options exist for wearing a primary light canister, the most common and versatile method is to secure the canister to the hip. When secured on the hip and positioned under the shoulder, one's primary light is easy to manage, convenient to remove and replace and easily freed from possible entanglement. Securing the light in other locations can create a range of unwelcome issues including insecure attachment, higher profile, instability, excess cord length, difficulty removing entanglements and damage from double tank strain.

Proper placement of light canister, on right hip parallel to tanks and wings.

Goodman light head, as held on the left hand.

Anatomy of a Technical Diver

Buoyancy Compensator

A diver's BC is an important piece of life support equipment, requiring careful observance and sincere attention. The best approach to the selection of a buoyancy compensator is usually found through attention to quality rather than quantity. A diver cannot eliminate the need for careful attention by using multiple buoyancy devices but instead must insure that each device used is as reliable as possible. Many divers consider the use of a drysuit sufficient for redundant buoyancy but this should be verified by each individual. As with most equipment one should reluctantly add additional equipment. While most divers manage with a single BC, individuals should consider the nature of their dive and ability to manage potential variables. In general, most cave divers avoid multiple BCs, yet some deep ocean divers choose to make use of a dual bladder system.

Backplate and Wings

Buoyancy compensators generally range in lift capacity from 35 lbs of lift to about 100 lbs, with higher lift capacity designs gaining popularity. While high lift capacity is becoming more popular, the vast majority of divers have no use for a BC with more than about 50 lbs of lift. Remember that excessive lift increases the size of a BC, creating more drag. Furthermore, an over-inflation failure can result in a rapid and dangerous rise to the surface, a problem compounded by a large lift capacity. Some manufacturers offer high lift capacity BCs with a surgical tube retaining system designed to reduce the drag of the unit.

Anatomy of a Technical Diver

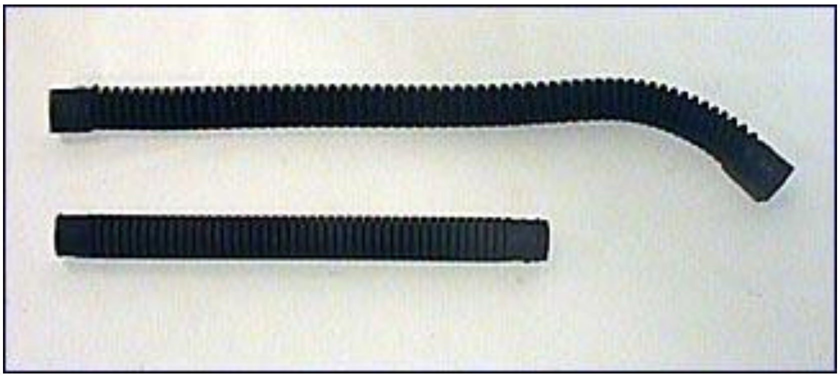
While this device may offer a limited improvement it may be dangerous if over-tightened, preventing the unit from inflating sufficiently. Oddly enough, some of these units have lift approximating that of bladders of a smaller design, making the tubing redundant. In general, lift capacities larger than around 50 lbs are useless and force unnecessary accommodations.

Buoyancy compensators typically utilize an inner bladder and an outer protective casing. Both the bladder and casing thickness may vary considerably, although tougher outer shells generally reduce bladder damage. Divers may also opt to protect the bladder with a protective liner placed under the outer shell. For example, one may size a rubber innertube to fit around the bladder, significantly reinforcing the bladder walls. Designs with tough outer casings may limit the need for this measure while some casings may be too small to allow for additional protection. Some buoyancy compensators do not have an inner bladder but instead rely on a sealed outer casing to confine the air.

Additional Considerations:

1. Many manufacturers distribute their buoyancy compensators with an exceedingly long corrugated hose. This long corrugated hose actually makes it more difficult to release air, is more likely to become entangled, and in low places will drag in the sediments.
2. When utilizing dual bladder BCs, the diver should leave only one unit connected to the power inflation system. Power inflators are historically unreliable units and over time tend to allow air to escape into the bladder. When both bladders are connected to an air source, one may fill with air unintentionally, leading to an accidental buoyant ascent.
3. Some manufacturers use a large ball connected to the rear pull dump which can cause the valve to open when using stage bottles. The diver should remove the ball and operate the valve with the attached string or utilize the teardrop-style pull which is less likely to auto-dump.
4. Some BCs have a corrugated hose that is connected to a pull dump allowing the diver to pull the hose releasing air from the bladder. This feature encourages the diver to frequently pull on a vital piece of life support equipment. If a diver accidentally pulled the corrugated hose free from the BC, the bladder would rapidly empty its air supply, leaving the diver without buoyancy control. Individuals are encouraged to avoid this feature as it could easily prove life-threatening.

Anatomy of a Technical Diver



Long and short inflator hoses.

Inflator hoses on doubles should be 13 inches or shorter, or just long enough to reach your dry suit inflator while holding the power inflator for your wings.

The inflator hose for the wings runs over the left shoulder and through a small bungee attached to the webbing of the left chest D-ring. This keeps the inflator where it can be located instantly. The inflator must be long enough that it can reach the mouth, the dry suit inflation valve, and the nose for ease of operation with one hand while controlling all three manoeuvres. It must be long enough that it can be breathed by holding both buttons down at once (never "rebreathed", only breathed). The inflator mechanism itself must not be air-balanced or high-speed; it must be a slow inflator so that runaways are easier to deal with. The diver must anticipate his inflation needs, part of the good form which is the hallmark of the safe diver.

Anatomy of a Technical Diver

Regulators

Regulator Choice

The choice of regulators is driven by a number of key design criteria.

The regulators should not be of an "upstream" design as that design requires the use of a pressure relief valve in the first stage, which is a additional failure point.

The second stage NEEDS to be able to be stripped under water, just in case there is debris under the exhaust valve or it has moved (i.e. folded back) causing the second stage to breathe wet. As such, the face plate needs to be removable without any tools, while wearing gloves.

Avoid regulators which have custom hose fittings, as these can be difficult to source in some diving destinations around the world. For instance, Apex uses a custom half-inch hose which should be replaced with a standard off-the-shelf hose. You may be tempted to use an adaptor to accomplish this, however Apex provides a half-inch plug and O ring (part numbers AP1487 & AP1410 respectively) which is used to block the half-inch port. The diver may then use the other standard-size ports.

Second stages need to be installed "finger-tight" on the hose so the diver can interchange them if necessary in the event of a failure underwater.

Hose routing considerations

The intent of DIR hose routing is to avoid having hoses stick out unnecessarily, where they could damage (or be damaged by) parts of the cave or wreck or entrap the diver. All hoses use hose protectors as strain relief in order to minimize movement and wear.

Anatomy of a Technical Diver

A simple pressure gauge is all that is needed with a technical diving rig.

1st stage properly mounted on a stage bottle. Note the shortened high pressure hose on the pressure gauge.

Anatomy of a Technical Diver

Exposure Protection

Individuals must choose thermal protection that is in keeping with the temperature of water and the type of dive being done. In many cases, the water temperature and a diver's exposure time will not require any special equipment. However, longer exposures or cold water may require the use of a drysuit to increase comfort and safety. The diver should not allow himself to become too chilled as this can increase decompression sickness risk through decreased perfusion and a cold tissue's capacity to absorb more inert gas.

Wetsuits

A wetsuit works by trapping water that is warmed by the body and minimizing its circulation with the colder surrounding water. A wetsuit that fits loosely will allow water to circulate, forcing the body to continually heat new water, drastically effecting the wetsuit's effectiveness. A good-quality wetsuit with a snug fit is sufficient for most divers. In warmer water, many divers choose to utilize a lycra suit or thin 1/8th" suit, occasionally incorporating this with a hood or vest. For slightly cooler water temperatures, divers may chose a 1/4" suit with a hooded vest. Some divers exposing themselves to colder conditions but not ready for a dry suit may consider a semi-dry suit which can significantly reduce water flow across a diver's body through the use of neoprene seals at the neck, wrists and ankles.

Drysuits

Divers entering cold water or engaging in more extreme exposures will often choose to utilize a drysuit for increased warmth. Drysuits are typically of two primary types: shell-type or neoprene. Neoprene drysuits may come in different thickness, adding to their insulation. However, a thicker neoprene suit adds buoyancy, increasing a diver's need for extra weight. One of the disadvantages to neoprene suits is that they will become thinner at depth, decreasing their thermal advantage and requiring additional insulation.

This insulation, coupled with the positive nature of the neoprene, can further add to the buoyant nature of the suit. At shallower depths, the crushable tendency of neoprene is less significant, giving the suit more natural insulation.

Anatomy of a Technical Diver

One of the greatest advantages to the neoprene suit is its limited drag. Neoprene suits are generally very similar in drag to wetsuits, especially when fitted properly with limited excess material. However, neoprene wrist and neck seals are not typically as effective as the latex seals found on many shell-type suits and generally allow some water migration. Individuals may chose to use latex seals on a neoprene suit or utilize a double wrist seal system: a latex seal that is covered by a protective neoprene seal. Shell suits are constructed from a variety of materials and rely on undergarments to provide insulation. These suits typically depend on latex wrist seals which are generally more effective at preventing water from passing into the suit. Thinner latex seals are more effective barriers to water yet are more easily damaged, while thicker seals resist damage but are less effective at preventing water migration.

The drag associated with a shell-style suit depends on the material and the fit. For example, Viking drysuits are constructed from a thick material yet tend to be prone to a high degree of drag. The DUI TLS-350 suit has a telescoping torso design that allows for a tighter fit while maintaining ease of entry. The suit is also made from a trilaminate design that allows for a durable and flexible material allowing divers a greater range of motion. Generally speaking, shell-type suits are more flexible and less prone to water leakage than neoprene suits, yet can develop punctures or failures that allow significant water leakage. Drysuit manufacturers are always experimenting with new, stronger materials. In 2000, DUI introduced its CLX-450 suit with a shell of laminated Cordura. The CLX appears to have durability qualities more in line with compressed neoprene but with the flexibility, rapid drying time, and lighter weight of the TLS. Some undergarments incorporate insulation materials such as 3M Thinsulate that maintain most of their insulation properties even when flooded. Some suit manufacturers try to combine the durable advantages of neoprene drysuits with the consistent buoyancy of shell suits.

Crushed and compressed neoprene suits can limit the buoyancy changes of conventional neoprene by pre-crushing the material. The pre-crushed material provides more insulation than a fabric suit, yet is less buoyant than a conventional neoprene style suit. The DUI CF-200 suit is one of the most popular of these crushed neoprene styles and is widely known as one of the toughest suit materials currently used. However, a crushed neoprene suit is very heavy and takes significant time to dry. Furthermore, even crushed neoprene suits are less flexible than shell suits.

Anatomy of a Technical Diver

Additional Considerations

1. Drysuits that are not form-fitting will add significantly to a diver's drag. The diver should attempt to limit the air in his drysuit to reduce air transfer and increase proficiency.
2. The diver must ensure that he is weighted such that he can remain negative with empty cylinders. This may require substantial weight for a diver using a drysuit. This weight may be in the form of a heavier stainless backplate or from weight placed under the diver's tanks.
3. Some manufacturers have chosen to use a non-standard connection on the drysuit inflation inlet, limiting a diver's flexibility. The diver should consider replacing non-standard connections to allow the exchange of buoyancy compensator inflation and drysuit inflation hoses.

Anatomy of a Technical Diver

Overboard Discharge

The overboard discharge or "pee valve" is a must for any male drysuit diver doing moderate to long exposures. Without a way to relieve himself, the diver will often intentionally keep himself in a state of dehydration. This practice may not only be ineffective, but is also potentially dangerous. Hydration is almost certainly a key component to effective decompression and a dehydrated diver is acting irresponsibly. The overboard discharge allows the male diver to dive in comfort while remaining hydrated.

Balanced discharge valve

Several individuals manufacture overboard discharge valves, and for convenience they can be broken up into two different categories: those with a balance chamber and those without. One of the first readily available overboard discharge valves was distributed by Roger Werner and is still available today. It is a relatively simple device, consisting of a piece of surgical tubing that connects to a medical condom catheter available from companies such as Mentor. The other end of the connector is secured into the suit and allows the diver to relieve himself either by removing a bolt or through a "pee through" screw.

Anatomy of a Technical Diver

Condom catheter installed on valve

The disadvantage to this early--yet effective--product is that the individual is forced to remove or turn a bolt in order to relieve himself. In most situations this presents no real problem, but may be an issue for cold water divers wearing gloves or mitts. Furthermore, the simple design of this device forces the diver to urinate against the pressure built up in the tubing. To counteract both of these problems, more recent valves use a balance chamber to equalize the pressure within the tube to the pressure in the suit. These devices also typically employ a one-way valve eliminating the need for the diver to manipulate anything. It is still prudent to carry a bolt or other device to plug the port in the highly unlikely event that both the one-way valve and the condom catheter were to fail on the same dive.

For women, and men who don't have a drysuit with a pee valve, there is a simple solution. There are several types of disposable undergarments on the market. Depends brand makes the "traditional" blue plastic diaper with tape on the sides, which is bulky and crinkly but does the job. Depends also makes a more form-fitting "disposable protective underwear" which is constructed of soft, breathable paper with an absorbent pad. For extended dives, a Poise brand "incontinence pad" can be added. These come with self-stick tape to attach to the Depends. The Ultra Absorbency type will last the longest. The diver may choose to wear flannel boxer shorts over the nappies to absorb small leaks and protect the drysuit underwear. Leaks are less likely to occur if the diver can urinate slowly, allowing it to be absorbed.

Anatomy of a Technical Diver

Mask

The mask is unquestionably one of the most vital portions of a diver's equipment, yet it is often given very little serious attention. The importance of one's mask goes well beyond the obvious desire to see in an alien environment. It is a vital piece of safety equipment, the loss of which could prove highly dangerous. The ideal mask must be reliable, fit comfortably, and have a low-volume construction to minimize drag and to allow for quick clearing. The strap must be secure and resilient so as to limit the risk of dislodging the mask or breaking the strap.

Primary mask (top)
and smaller reserve mask (bottom)

After-market neoprene straps are usually quite comfortable and seem to be nearly unbreakable. Some masks have removable lenses for vision correction; divers must make certain that a reliable attachment method is in use as the lenses may become dislodged accidentally during a dive.

Additional Considerations:

1. Avoid cheap masks that will be less reliable, generally uncomfortable and more likely to leak.
2. Ensure that attachment methods for removable lenses are secure.
3. Utilize lower-volume masks that reduce drag, reduce visual obstruction and are easier to clear.

Reserve mask

Some divers swear by the need for an extra mask, yet most divers opt not to burden themselves with a spare mask. Good-quality masks are generally quite reliable and their failure very unlikely. Most explorers surveyed only use the spare mask in long exposures or where the loss of a mask would be particularly threatening. The reserve mask should be as small as possible, fairly easy to access and unobtrusive. Some divers place a spare mask on the primary light canister or in a spare pouch on the belt but it is generally preferable to store it in a pocket on the side of one's suit, reducing clutter and drag. Be aware that when a spare mask is removed from any of the above locations and placed on one's head it will often immediately begin to fog. Pre-treating the mask with defog can drastically reduce this tendency and some individuals have had success with storing the mask in a watertight bag. The reserve mask must be frequently checked to ensure viability, and for frequent divers this may be unlikely to happen before each dive, lending credibility to the practice of reserve mask use only on more demanding dives.

Additional Considerations

1. Use a small, unobtrusive mask that will still provide a functional fit.
2. Review anti-fogging options to prevent an unusable reserve mask.

Anatomy of a Technical Diver

Fins

Although dive manufacturers release more new fin designs every year than just about any other piece of equipment, no fin is better suited for overhead or technical diving than the ScubaPro Jet Fin. Based on a design that is at least 30 years old, the Jet Fin is a perfect example of a low-tech solution to better gear design. Jet Fins are manufactured out of negatively buoyant black rubber. They are very stiff, all the better for modified flutter and frog kicks. The strap connections are moulded into the fin. Unlike the "quick release" plastic connectors now in vogue, there is no leading edge groove to potentially catch cave line.

If you can find the old Oceanic spring heel straps, they make an appropriate addition to the Jet Fin. The spring heel straps don't have the extra length of heel strap that is usually taped down to the fin. The spring straps may be attached to the fins using nickel wire, stainless steel welding wire, or cave line.

Guideline Reels

Line

Many different diving scenarios may give rise to a need for a guideline, and the choice of an effective method to deploy this line may prove central to comfortable, efficient and safe diving. The type of guideline used will vary with different environments. For example, most cave divers use a relatively thin, braided nylon line on their reels. The most commonly used is a #24-size line. Some wreck divers will use a thicker line to resist the sharper angles found in these environments. Commonly, this line may be #36 or even #42.

Primary Reel

Guideline Reels

Guideline reels may typically be divided into two primary categories: open- and closed-faced. Open-faced reels are the most common and allow divers to get at line on the spool, hopefully correcting any entanglements. Closed-face reels utilize a cover over the spool to reduce the risk of slack line slipping over the side of the reel and becoming entangled. While they are marginally effective at reducing line snarls, they must be dismantled when entanglements occur. Most divers opt for an open-faced reel, acknowledging that the actual responsibility for entanglements is a lower level of guideline proficiency.

With some practice, the entanglement issue becomes moot, and the inability to reach the spool of line becomes a clear disadvantage.

Anatomy of a Technical Diver

Guideline reels may contain varying amounts of line on them depending on the purpose for which they were designed. In cave diving there are five popular sizes. While these sizes may be available in either open- or closed-face designs, open-faced reels are a clear favorite and consequently have a much wider representation.

Primary and Exploration Reels

The primary reel contains approximately 400' of line and is used by cave divers to bridge the distance from the open water to a permanent guideline, typically installed approximately two hundred feet back in the cave. Exploration reels used by divers exploring the new caves are often more customized for specific use and may hold from 600' to more than 1,500'.

Jump and Safety Reels

The jump reel contains approximately 50' of line and is used by cave divers to connect to different lines while performing jumps or gaps. The safety reel contains approximately 100' of line and is used by cavern and cave divers or even other overhead divers for emergency purposes. These emergencies would include repairing broken guidelines, searching for a lost dive buddy and searching for lost guideline. Every overhead diver should have an emergency reel as a standard part of their equipment.

Cavern Reels

The cavern reel contains approximately 150' of line and is used by cavern divers to explore the entrance area of a cave commonly termed the cavern zone. Some divers will use an additional cavern style reel as an emergency guideline. In this case a dive team of two divers may have three cavern reels. Two functioning as safety reels and one as a penetration guideline.

Anatomy of a Technical Diver

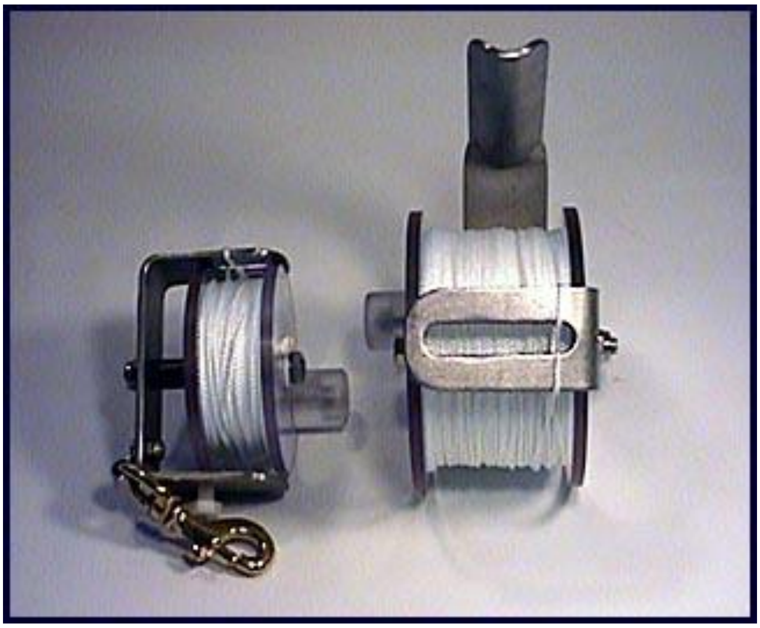
Spools

Guideline spools have been very popular with cave explorers for many years but only recently been introduced to new overhead divers. A certain degree of resistance to new ideas and a lack of understanding impeded their early progress in the cave community but this picture seems to be changing rapidly. The clear advantage of spools can be found in their small size and convenient operation. Clearly the low-profile, less cumbersome nature of spools is a big advantage but it is their easy jam-proof design that makes them a clear favourite.

Divers attempting to deploy a safety reel often entangle the reel before they are able to utilize it effectively. Spools eliminate this problem, making operation for emergency purposes ideal. Many divers also use them as jump or gap reels. However, gap spools should not be used for long distances as they hold limited line and are not effective for winding over long distances.

Closed primary reel. Note the clear acrylic covering over the line. While a closed reel might reduce the possibility of line entanglements, they are difficult to fix if they become jammed.

Anatomy of a Technical Diver



Open jump and primary reels.

Gap, safety, and primary reels.

Safety spool and safety reel.

Line Markers

Line arrows are triangular shapes that the diver attaches to the line, pointing toward the exit. They are designed to insure that the diver does not confuse the exit direction. Most divers carry at least three of these line arrows. The existing lines in most cave systems are permanently marked with arrows, which are sometimes marked with distance from the exit or the names of notable rooms within the cave system. Additionally, in some localities, it is customary to mark the location of a jump by permanently placing two line arrows in a row on the main line in the area to be used to tie off for the jump. These arrows also point in the direction of the exit.

Clothespins are another popular method for marking the line. Plastic clothespins are unaffected by immersion but are more likely to fall apart or break. Clothespins are typically less popular as directional markers as they cannot be pointed in a particular direction. Instead, clothespins can be placed on the exit side of the junction of any two lines to mark the outgoing line. These markers are also especially convenient to mark position without direction when a diver wishes to reference a location without the risk of placing incorrect directional information. For example, a passage that may have two exit directions (such as in a traverse) should have the arrows pointed toward the more expedient exit. A diver wishing to mark his position, for instance in planning a traverse, but unaware of his location respective to the two exits, should choose to use a clothespin as a marker rather than a line arrow. This will avoid confusion by other teams diving in the system at the same time. While clothespins are quicker to install, they are potentially more likely to be knocked off the line.

Each device has its use and when deployed properly can add to the safety and convenience of every dive. The diver should permanently mark both line arrows and clothespins with his name.

Oxygen Analysers

Any diver actively using variable oxygen mixtures should have access to his own oxygen analyser. While most divers will have their mixtures done in a dive shop where the gas can be analysed, the diver can easily find himself later in numerous situations that will require the verification of the gas mixture. While an ideal world would find every diving area filled with qualified individuals and reliable equipment, the reality is often somewhat different, and divers entering more advanced levels should be prepared for all reasonable eventualities.

Over the last several years, the variety of oxygen analysers has grown dramatically and many acceptable units are available. The oxygen analyser consists of a display unit and an oxygen sensor, usually with a cord connecting the two. In some of the newer models the sensor and the display are integrated into one small box. The sensor reacts with the oxygen producing a voltage that is read by the display unit and converted to a corresponding percentage. It is possible to build a "do-it-yourself" unit with an oxygen sensor and a volt meter, however, the reading in volts must then be converted to a representative oxygen percentage. This method does result in a financial savings but is typically inconvenient and more prone to operator error.

Oxygen analysers need to be calibrated prior to each use. Most divers calibrate using air, as it is convenient and typically close to the desired range of use. For example, calibrating to 100% oxygen while analysing a mix at 32% may increase the margin for error. Oxygen analysers, like most equipment, are susceptible to error with most units averaging up to about 2% error over the range of the gauge. Ideally, an analyser should be calibrated under the same conditions that it will measure the gas. If, for example, one is analysing a gas under flow (often 2L/min) then it would be more accurate to calibrate under flow conditions. The margin for error induced by calibrating under static conditions and measuring under flow is a subject of debate but seems not to induce a very large error. However, individuals should be aware that the gauge reading may not exactly correlate to what they have in their mixture. Common sense mixing practices which allow for some error margin in the dive profile are always advisable.

Anatomy of a Technical Diver

Flow Regulators

Given that divers are interested in measuring the percentage in a particular high pressure cylinder some provision must be made to pass the mixture from the cylinder across the membrane of the oxygen sensor. Some divers attempt to meter the flow from a tank by feathering the tank valve. This practice tends to be imprecise and sometimes difficult. Instead, most divers meter the high pressure from a cylinder via two popular mechanisms: the flow regulator or the restricted orifice. Flow regulators suffer from the disadvantage of increased bulk and expense (usually $100-$300) but allow for more a precise manipulation of the gas, more flexibility, and the convenience of use with surface-supplied oxygen delivery in the event of an emergency.

Common flow regulators in use by divers are often limited to 15L/min (less than the recommended 25L for medical use) but may be beneficial or may be exchanged for higher flow units.

Another available option for individuals not interested in a flow regulator is the use of a restricted orifice. Reducing the pressure from a high pressure cylinder can be accomplished directly with a restrictive orifice or may use the diver's first stage regulator to reduce the pressure to 140psi. The diver may then use the restrictive orifice on a power inflator hose, reducing the flow to the desired rate. The restricted orifice units are convenient due to their size and cost but may require the diver to use his diving regulator, increasing the wear on his air delivery system. Pressure reduction systems that operate independent of the diver's air delivery system offer good convenience and reasonable benefits with minimal inconvenience.