Surface-supplied Diver Training Manual

Tennessee Aquarium
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Purpose

Surface-supplied diving is defined in the Tennessee Aquarium Diving Safety Manual (TADSM) as a diving mode in which the diver in the water is supplied from the dive location with compressed gas for breathing and is in voice communication with the tender on the surface. This definition is based upon the requirements outlined in the Occupational Safety and Health Administration's Code of Federal Regulations. (29 CFR 1910 Subpart T) This federal law outlines the criteria for all commercial diving.

The surface-supplied diving mode requires gear and techniques that are not introduced in recreational diver training. This text was designed by the Tennessee Aquarium Diving Control Board to introduce Aquarium divers to the fundamental principles associated with surface-supplied diving. This text should be accompanied by proper practical training, as outlined in Appendix A, to promote safe surface-supplied diving under the auspice of the Tennessee Aquarium.

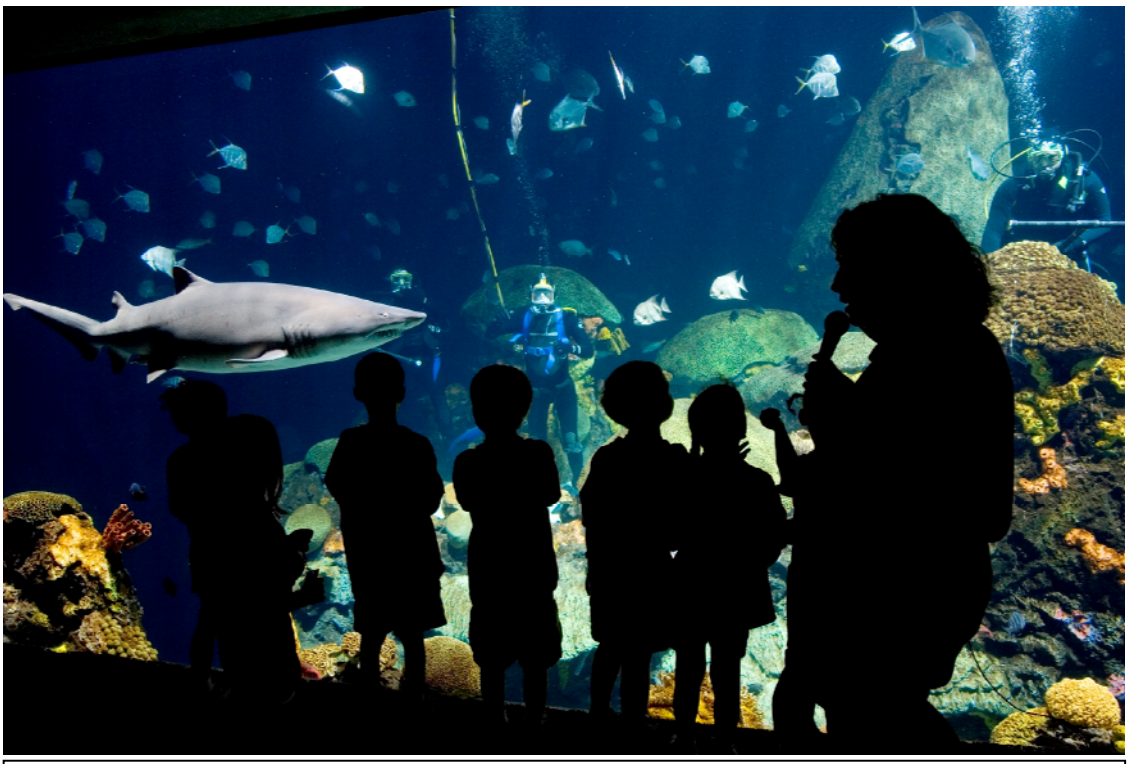


Figure 1 – Secret Reef Dive Show- A primary use of surface-supplied diving at the Tennessee Aquarium.

Introduction

There are numerous advantages to surface-supplied diving that make it an excellent choice for many diving operations. First, the diver has the benefit of an unlimited air supply. With a surface-supplied diving system, a diver can theoretically stay underwater forever. Of course, in reality, there are comfort, thermal, and decompression limits. For deep technical diving, a surface-supplied rig relieves the diver of the need to carry numerous stage bottles. It is also safer to have a continuous gas supply from one breathing source rather than switching mouthpieces several times during the dive.

The second big advantage to surface-supplied diving is that it employs hard-wired communications with the surface and between divers. This leads to increased safety and efficiency while performing duties intrinsic to Aquarium diving such as exhibit maintenance and repair. At the same time it fulfills legal obligations set forth by 29 CFR 1910.425, which requires any diver who receives breathing gas from the surface to also have voice communication with surface personnel. Further, it can afford an opportunity for Aquarium guests to interact with divers.

Many divers think that surface-supplied diving is more dangerous than scuba diving. This may stem from unfamiliarity with equipment or procedures. For instance, surface-supplied diving is typically done with only one diver in the water. This technique is frowned upon in recreational diving. However, surface-supplied diving can provide a higher level of safety and redundancy than scuba diving. Although the equipment is different from what is used in ordinary recreational scuba diving, it is no more complex than that found on many typical scuba dives. In fact, in surface-supplied diving, the diver is encumbered with far less equipment in the water than the typical scuba diver.

In the commercial diving industry it is generally accepted that surface-supplied diving is much safer than diving with scuba. Unfortunately, there is no way to do a direct statistical comparison between recreational scuba and surface-supplied commercial diving to verify this. With few exceptions, most commercial diving companies prohibit the use of scuba for working dives. However, industry statistics show that the accident rate for commercial divers is quite low. Most of the fatalities that are reported in commercial diving are actually industrial accidents rather than diving accidents.

The biggest disadvantage of surface-supplied diving is the decrease in range of travel due to the umbilical. This is not a problem while diving in the Aquarium. The longest umbilicals used on most commercial diving jobs do not exceed 600 feet, although commercial divers have done internal pipeline dives of up to 1,800 feet. The longest umbilical employed by the Tennessee Aquarium is a meager 150 feet.

Entanglement is another disadvantage to surface-supplied diving. However, entanglement is a less serious problem for the surface-supplied diver since she/he has an unlimited air supply available to problem solve.

Probably the only situation where surface-supplied diving isn't practical is in an extended cave or wreck penetration. The length of hose required for this type of diving would be impossible to handle. Also, in extended penetrations

both OSHA (Occupational Safety and Health Administration) and the U.S. Coast Guard require a standby surface-supplied diver underwater at the entrance of the confined area to tend the hose of the diver who is going inside.

Learning to use surface-supplied diving equipment for air diving is not difficult. One can learn the basics of this type of gear in a few days. Of course, there is no substitute for using the gear on a regular basis to become skilled and confident in its use. Diving with the equipment is not much different from diving with scuba, but learning emergency procedures along with how to set up the equipment and run the system topside are what is most important.

Many dive teams who use surface-supplied diving equipment don't use it frequently enough to maintain their familiarity and proficiency. This is a mistake. If a diver doesn't use the equipment often enough to become comfortable with it, she/he tends to put it aside and not use it at all. Therefore, we encourage all divers who are trained to use surface-supplied equipment to do so regularly.

Equipment

The minimum system configuration for surface-supplied diving consists of the following items:

- Air supply: This can be either a low pressure compressor or a simple, single diver air manifold used with compressed gas cylinders. Divers can also use combinations of these breathing gas sources so long as they comply with OSHA's requirement for a primary and secondary air source. At the Tennessee Aquarium, surface-supplied divers use mobile air carts which consist of the primary and secondary air sources in the form of scuba tanks, along with an air manifold. These carts are designed to accommodate two divers.
- Communications System: A diver communications module provides the ability for the diver and tender to speak to one another. The Aquarium employs two types of communication systems. A proprietary system that is permanently mounted to the Secret Reef exhibit and a portable unit that is used everywhere else in the facility that surface-supplied diving is required.
- Umbilical: The diver's hose, or umbilical, consists of a communication wire, a breathing air supply hose, a depth sensing hose (also known as a pheumofathometer or pneumo), and a strength member. Air lines must be designed to withstand collapsing when the external pressure is greater than the internal. Connectors must be corrosion resistant, and, when disconnected, they should be plugged or taped to prevent foreign matter from entering. We do not use a pneumo hose while diving in the Aquarium exhibits because we are diving to a known maximum depth.
- Harness and weights: The surface-supplied diver is required to wear a harness that is separate from his/her weight system. The harness should be made of a material strong enough to support his/her weight out of the water and have a positive buckling device, an attachment point for the umbilical, and must distribute the pull force of the line over the diver's body. Weight systems should have a quick release mechanism.

- Diver-carried emergency gas supply: Divers who exceed a depth of 100 FSW or enter into a decompression obligation must wear an emergency breathing gas supply (EGS). The diver's bail-out bottle is mounted on his/her harness. The bail-out bottle is connected to a first stage regulator and hose (whip). The regulator is equipped with an over-pressure relief valve to relieve the pressure in the whip in the event of a first stage leak, rather than blowing the hose. The whip is in turn connected to the bail-out block. The block is a valved manifold worn on the diver's harness that allows switching between the bailout bottle and primary air supply.

  The bail-out bottle is normally left on and the valve on the block is turned off. In an emergency the diver turns on the valve on the block to gain access to the contents of the bail-out bottle. The diver's umbilical is also attached to the bail-out block as the primary gas supply.
- Full face mask: The Divator MK II is connected to the bail-out block or umbilical by a single, low pressure whip.

The Surface Supply Air Cart

The Tennessee Aquarium utilizes mobile air delivery carts for all surface-supplied diving operations. These air carts were designed by aquarium divers to meets their unique needs while complying with all OSHA regulations pertaining to air delivery systems. The air cart consists of three main components: a two-wheeled hand truck, high pressure gas cylinders, and an air manifold.

The hand truck serves as the foundation for the system and provides adequate mounting area for the cylinders and manifold. Most importantly, it allows the system mobility. The truck is constructed of high grade aluminum to withstand corrosion in salt environments. It also has ten-inch pneumatic tires to facilitate transport throughout the facility and for open water diving.

The breathing air is provided by two scuba cylinders that are mounted onto the front of the hand truck. The system can accommodate a variety of cylinders ranging from 63 to 120 cubic feet. The cylinders are connected to the air manifold by two whips that employ standard 232 bar yoke connectors. There must always be two cylinders connected to the system during use. This provides one primary and one secondary air source.

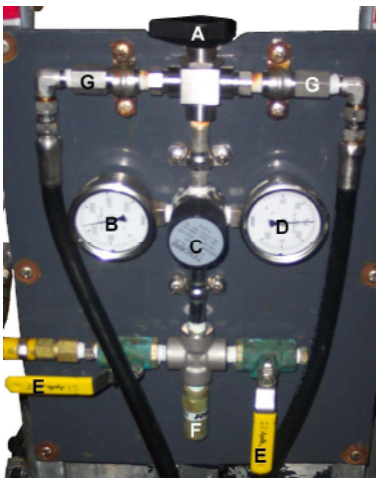


Figure 2 - A-Three-way valve; B-Tank Pressure; C-Regulator; D- Regulator Output Pressure; E- Umbilical Valve; F- Over Pressure Relief Valve; G- Check Valve

The air supply manifold allows for a great deal of diversity for the surface-supplied dive team. The base of the manifold is an adjustable high pressure regulator (Fig. 2, C). This regulator can supply ample pressure for several divers and is adjustable to compensate for increased depth. The manifold is supplied from a three-way valve (Fig.2, A) which allows the manifold operator to select the cylinder the diver is breathing from. This valve also provides the isolation

between the two cylinders so they are considered separate air sources. The three-way valve is connected to each tank whip by a check valve (Fig. 2, G). These check valves allow the operator to disconnect either cylinder without the possibility of backflow. That means that spent cylinders can be continually changed without interrupting the dive if the diver is carrying EGS. Two pressure gauges are attached to the regulator. The gauge on the left (Fig. 2, B) indicates the current cylinder pressure (regardless of the cylinder in use). The right side gauge (Fig. 2, D) indicates the regulator output pressure. Following the output side of the regulator, the next features are the two yellow-handled umbilical valves (Fig. 2, E). These valves are used to isolate the airflow from the diver. They also provide the versatility to supply either one or two divers at a time. The final component of the manifold is the OPV or over pressure relief valve (Fig. 2, F). This is a safety feature which will prevent the catastrophic failure of the umbilical should the regulator fail. The OPV will open if the pressure exceeds 300 psi.

The Divator MK II Full Face Mask

The AGA Divator Full Face Mask was developed in the 1950's in Sweden. It was the first single-hose regulator with a second stage located at the diver's face. The product was originally developed by a company known as AGA Spiro. Interspiro was sold by AGA and is now owned by a French company called Comasec. There have been three different generations of the Divator mask. Each one has had different internal features and slight changes in appearance, but all the masks have functioned almost identically. The correct technical name for the mask is the Divator MK II, although most divers simply refer to it as the Divator or continue to use its original name AGA.

Figure 3 - The Interspiro Divator MK II

The Divator MK II is composed of three major sub-systems. The basic mask is composed of the frame, face seal, and lens. The breathing system consists of the regulator and the oral nasal pocket. The communications system is composed of an easily removable communications module. Each of these systems can be further broken down into their component parts. The Divator MK II mask incorporates a number of unique features, yet it is an easy mask to use. It was one of the best performing breathing systems in U.S. Navy regulator tests because, among other features, it has a very low internal volume and a minimum dead air space in the oral nasal mask.

Mask Frame and Face Seal

The mask frame of the Divator MK II provides rigidity and strength that cannot be found in simple rubber full face masks like those made by other companies. Several of the components of the mask connect to the frame, including the face seal and the regulator. The frame is made from an exceptionally strong nylon material. With normal use the frame should never need to be replaced.

The silicone face seal is designed to seal on a wide variety of faces. Due to the internal positive pressure of the mask pressing the seal against the diver's face, it will seal easily on most divers, even those with very thin, small faces or beards. This is the reason the Tennessee Aquarium chose this mask. The silicone of the face seal also provides an anchoring point for the spider head harness.

To provide for ear equalization, a special, adjustable equalizing device is built into the mask. The device is a simple notched rubber pad that snaps onto a metal frame inside the mask. This equalization pad is typically referred to as the "pig snout." The height of the pad can be adjusted by removing the pad and installing it on a higher or lower notch.

Figure 4 - Divator MK II second stage

Breathing System

The breathing system on the Divator MK II has a number of special features that one should understand to take full advantage of the mask's performance. Like all demand regulators, the Divator MK II provides air only when the diver inhales. Since the mask encloses both the nose and mouth one can breathe much more freely than when using an ordinary scuba regulator. Admittedly, most people find they tend to use more air when they are using a full face mask, particularly if they are using communications. The regulator is designed to provide a 20 mm water column of positive pressure inside the mask.

The regulator requires a minimum of 90 psi over bottom pressure. There is also a safety relief valve in the regulator that opens at approximately 200 psi. This device helps to avoid any damage to the hose in case too much pressure is fed to the mask through the supply hose. When the pressure is lowered, the relief valve will close, and the dive can continue. Regulator vibration during inhalation can occur when the supply pressure exceeds 150 psi over bottom pressure (OBP). To avoid vibration, the supply pressure should not exceed 110 psi OBP.

The air flows from the regulator, through the non-return valve and is directed into the mask through two channels located on either side of the oral nasal mask. The air is directed over the lens to help keep the mask clear. There is no need for any additional defogging agent. The air is then drawn through two, one-way (non-return) valves located on either side of the oral nasal mask to the diver's nose and mouth. When the diver exhales, the one-way valves close and the exhaled gas goes out through the exhaust side of the regulator.

Safety Features

Some of the Aquarium masks are fitted with an Ambient Breathing Valve (ABV). This valve, located on the right side of the mask lens, allows the diver to breathe atmospheric air when on the surface. The valve is rotated counterclockwise to open it and allow ambient air to flow into the mask; when it is turned clockwise, it seals and the diver breathes through the mask regulator. The ambient breathing valve can be used during an out-of-air emergency to facilitate quick access to air. During an out-of-air situation, the diver can activate the ambient breathing valve while performing a controlled emergency swimming

ascent. The diver will then have access to atmospheric air once his/her head breeches the surface. If the diver is using a mask without an ABV, the mask must be removed at the surface to access air.

The Divator MK II is also fitted with an internal non-return valve. This valve prevents air from escaping the mask should the umbilical be severed. This should provide great comfort to the diver because at relatively moderate depths escaping air can cause enough vacuum pressure on the mask to dislodge the diver's eyes from their sockets.

Mask Preparation

Several steps should be taken to prepare the mask itself for diving:

- Check the mask harness carefully for any cracking. It must be in good condition. If it is not, it must be replaced.
- Examine the face seal for any cracking or tears. A torn face seal will cause the mask to leak, the regulator to free flow, and the air supply to be rapidly depleted.
- Inspect the mask lens and make sure that it is not broken. If water drops have dried inside the lens they should be wiped off prior to diving.
- Check the equalization device (pig snout) to ensure it is in the proper position and is firmly seated in its mounting. The correct adjustment is when the diver can breathe freely through his/her nose without any restriction caused by the device. In addition, there should be no vibration of the device caused by breathing. Check to see that the diver can equalize by pushing the bottom of the mask upwards until the pig snout seals against his/her nostrils.
- Make sure all internal parts are in place and secure. Check that the screws holding the pig snout frame, microphone, and oral nasal mask are snug. Ensure that the non-return valves in the oral nasal mask are in place and properly oriented. Check that the Ambient Breathing Valve is intact and the flapper valve is not folded.
- Always be sure to test breathe the mask and check the air supply before dressing in.

Communications Equipment

There are several communications systems designed to be used with the Divator MK II. The systems are modular in nature and give a great variety of configurations to cater to the dive team's needs. Variations include all manner of control systems and mask modules with differing types of microphones and ear pieces.

The Aquarium utilizes a standard communications module for the mask to allow for the greatest flexibility and uniformity for the diver. The module consists of an aviation-type microphone and two speakers. It connects to the umbilical with a four-pin underwater connector.

The microphone is a membrane unit designed to sit lightly on the user's lip. Due to its construction, it does not work when wet. Any water drops sitting on the membrane prevent it from vibrating, resulting in feedback. Because of this, it is imperative that the microphone stay dry throughout the dive day.

The diver's speakers are referred to as bone phones. They are designed to sit on the rear portion of the diver's temporal bone, directly behind the ear. The sound waves are transmitted through the skull to the eardrum. If the bone phone is placed over the ear, the sound waves can be distorted and will cause the speaker to sound muffled. The bone phones are designed to transfer sound waves through exposure suits and work well on the outside of a neoprene hood or in the pockets of a helmet liner.

The Aquarium uses two surface communications systems; one is a commercially produced portable unit and the other is a proprietary unit designed by the audio visual department at the Aquarium. The Aquarium's system receives the heaviest use as it is employed for the daily educational presentations in the Secret Reef exhibit.

Figure 5 - The TA Secret Reef communications unit

The Secret Reef dive show communications system (Fig. 5), as any other dive system, allows the diver and tender to speak. But, it also has the ability to send a signal to the gallery outside the show platform. This allows an educator in the public area to converse with the diver. Though this system has many more features than a standard communications box, it is not extremely complicated to use. The tender's box has two umbilical ports to support two divers. It also has a removable tender's microphone and a permanent tender's speaker. The microphone connects to the appropriately labeled outlet in the box with a standard mic jack. The external speaker is powered and has an independent on/off switch. The heart of the unit consists of two mixers. Each mixer has a power button on the right front corner which must be turned on prior to use. All the mixer controls, with the exception of one, are preset and should not be adjusted. The exception is the knob labeled "Dive Mic Vol Gallery." This control connects the dive system with the gallery system. If it is turned off, the diver and tender cannot be heard in the gallery. When it is turned to the three o'clock position, (as indicated on the unit) the diver and tender can be heard if the gallery controls are turned on. A tender check sheet is kept in the communications box as reference.

The portable communications system (Fig. 6) is used throughout the facility where surface-supplied diving is conducted. It can also be used in field diving operations. This system is a bit more simplistic than the Secret Reef unit. It is designed to accommodate two divers. The tender microphone and speaker are built into the unit. This system has an external power inverter that allows it to run off of a standard 110V outlet. The system uses the same high use marine connectors for the umbilical connection which allows all TA umbilicals to be uniformly configured.

Figure 6 – Ocean Technology Systems portable communications unit

Procedures

Surface-supplied Diving Team

Surface-supplied dive teams will vary in composition depending on the job and complexity of the dive. Outlined below are the minimum personnel requirements for several scenarios. At the minimum, the surface-supplied diving team is made up of the following crew members: a diver, a standby diver (except when conducting a non-penetration dive within the Aquarium), a tender, a manifold operator and the Designated Person in Charge (DPIC).

Aquarium Dives

For dives within the Aquarium that do not include penetration into an overhead the minimum team consists of: 1 diver, 1 tender (the tender can act as the manifold operator), 1 DPIC. If the dive is in the Secret Reef exhibit the standard guard diver requirement still applies and will add to the minimum dive team requirements.

If the dive plan requires penetration or there is topside-tended equipment (i.e., pumps, welding gear), or an extended air gap to the water, the minimum team requirements are: 2 divers, 1 tender (one of the divers or the tender can act as the manifold operator), 1 DPIC. The second diver is a safety diver and remains on the surface, fully dressed, in the event of an emergency. If the dive is in the Secret Reef exhibit the standard guard diver requirement still applies and will add to the minimum dive team requirements. The safety diver cannot act as a guard. He/she must remain ready at the surface in the event of an emergency.

Open Water Dives

- For dives to 80 FSW with no decompression: 2 divers, 1 tender (one of the divers or the tender can act as the manifold operator), 1 DPIC. This may be reduced by one person if there is no hazard of entrapment, the location is not remote, there is no penetration required, there is no topside tended equipment (i.e., pumps, welding gear), and there is not an extended air gap to the water.
- For dives between 80-130 FSW or above 80 with decompression: 2 divers, 2 tenders (one of the divers can act as the manifold operator), 1 DPIC
- For dives between 130-190 FSW: 1 non-diving supervisor, 2 divers, 2 tenders, 1 DPIC
- For mixed gas dives: 1 non-diving supervisor (DPIC), 2 divers, 2 tenders, one hyperbaric technician.

Team Member Responsibilities

To dive with surface-supplied diving equipment one must be an experienced diver, be comfortable in the water and have a good understanding of the surface-supplied diving system.

Surface-supplied diving is normally done with a single diver in the water at a time. For this reason, a standby diver is considered an essential member of any surface-supplied diving team. The standby diver is always dressed in, with the exception of his mask, and ready to go to the aid of the diver in the water. This means that the standby diver has everything else in place and ready to go: fins, gloves, bail-out bottle, weight belt, etc. The standby diver must be capable of rescuing the diver if needed. Inside the Aquarium, the surface support/tender will

typically assume the duties of the standby diver due to the shallow, unimpeded configuration of the dive area. There is no reason for safety personnel to enter the water to tend to an injured diver. The diver can be pulled to the entry platform by his/her umbilical and treated on the platform. The exception to this would be if the dive plan calls for penetration into a confined area or the dive area has risk of entanglement (i.e. the Flooded Amazon Exhibit).

The tender on a surface-supplied dive team has many responsibilities. It is the tender's job to help the diver get dressed, to assist the diver in and out of the water, and to tend the diver's umbilical. Tenders must never let go of the diver's umbilical. A truly experienced tender can tell exactly what the diver is doing just by the feel of the umbilical. In Aquarium diving, the tender also fills the role of manifold operator and general surface support.

The manifold operator must be familiar with surface-supplied diving operations. He holds the diver's life in his hands! A wrong turn of a valve could leave the diver without breathing gas. At no time should the manifold operator leave the diver's breathing gas manifold unattended. If the operation involves mixed gas, the manifold operator must understand the mixed gas decompression schedules. Experienced manifold operators can tell the diver's state of mind by listening to what the diver says and the sound of the divers breathing. Above all, the manifold operator must be capable of making sound decisions regarding the diver's safety because he/she is in control of the dive.

The Designated Person in Charge is the Aquarium staff diver who has been designated to oversee all aspects of the diving operation affecting the safety and health of dive team members. The DPIC will have experience and training in the conduct of the assigned diving operation and emergency procedures. They will be available to the dive team at any time during the dive operation. The DPIC for each operation will be indicated during the dive briefing.

To recap, the standard surface-supplied dive team diving within the confines of the Aquarium consists of, at minimum, three people. The DPIC, who is a staff diver; the diver; and the surface support diver who will be acting as tender, manifold operator and will take the place of safety diver. If a dive plan requires confined area penetration, decompression, the dive location presents an entanglement hazard, or is outside the confines of the Aquarium facility, the dive team will be adjusted as outlined above.

Setting up for Surface-supplied Diving Operations

In a surface-supplied diving operation, there must be good teamwork between a number of people. There is a bit more gear than would be used during a scuba dive and it's a lot easier to set up with the right help. Setting the gear up correctly is essential to a successful operation. It's also important that each person on the team participate in the equipment set-up so people know where things are in the event of an emergency.

Situating the Air Cart

To set up the surface-supplied system, the first thing to do is to connect the surface air supply to the diver's breathing gas manifold. The air diving carts employed at the Aquarium make this process extremely easy. Two scuba tanks are mounted on the hand truck. They are then connected to the breathing manifold on the cart with standard fill whips. The whips are attached to the tank in the same manner that a scuba regulator attaches. (Fig. 7) Once the yoke

connection is made, ensure that the thumb screw on the yoke assembly is snug by turning it clockwise. There is no need to apply a great deal of pressure to the thumb screw, just ensure it is seated. Now open the valves on BOTH scuba tanks.

Figure 7 – Surface supply cart tank connection

Once the air tanks are connected and their valves are opened, it's time to check their pressure. The three-way valve on the top of the manifold (Fig. 8, A) should be indexed toward the left tank (the arrow embossed on the top of the valve should point left). This indicates that the system is drawing air from the left tank. The left gauge (Fig. 8, B) will indicate the tank pressure (regardless of the tank being used) and the right gauge (Fig. 8, D) indicates the line pressure going to the mask, or the Over Bottom Pressure. Record the pressure in the left tank by reading the left gauge. It should have a minimum of 2500 psig prior to the start of the dive. Next, index the three-way valve so the arrow points to the tank on the right side of the cart. Purge the system by slightly opening an unused umbilical valve (Fig. 8, E) or pressing the purge button on the mask for a second. This will allow for an accurate reading on the new tank. Record the pressure in the right hand tank by reading the gauge on the left of the manifold. It should have a minimum of 2500 psig prior to the beginning of the dive.

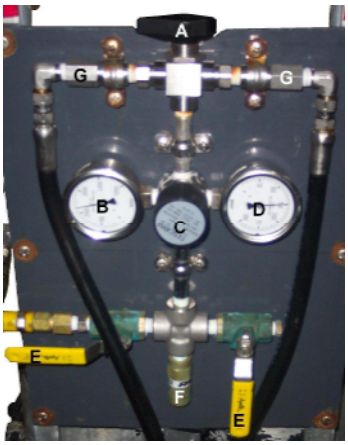


Figure 8 - A-Three-way valve; B-Tank Pressure; C-Regulator; D- Line Pressure; E- Umbilical Valve

Unlike with a standard scuba setup, the pressure going to a surface-supplied diver's second stage must be manually adjusted according to depth. A scuba diver's regulator is self adjusting because the first and second stages of the regulator are at the same atmospheric pressure. Because the first stage regulator (Fig. 8, C) for the surface-supplied rig is at the surface, it must be adjusted by the manifold operator as the diver moves up and down the water column. This setting is referred to as the Over Bottom Pressure (OBP). OBP is calculated with a simple formula that varies slightly with the dive apparatus being used. For the Divator MK II the OBP = [depth (feet) * 0.5] + 135. With the shallow depths experienced at the Aquarium, the OBP can be set for the maximum depth of the exhibit and left for the duration of the dive. OBP for the majority of dives in Aquarium exhibits should be between 145psig and 150psig. When experiencing pressure changes greater than one atmosphere during a dive, the OBP must be adjusted to ensure the diver has sufficient air supply without creating a free-flow.

Pre-dive Safety Checks

It is the responsibility of all divers and the manifold operator to ensure all gear is in good working order prior to the dive. All gear must be systematically inspected and checked for function. Any malfunctioning gear should be reported to the Dive Office and serviced or replaced prior to the dive operation continuing.

Testing the Air Supply

Once the air supply is connected and OBP is adjusted, the mask should be test breathed to ensure it is working. Inspect the mask as outlined above and test breathe it. Ensure that the gauges are holding pressure and turn the three-way valve on the manifold to ensure that air is available from each tank.

Situating the Diver Communications

After the topside air supply is situated, the next step would be to connect the communications wire from the umbilical to the communications control unit. This connection is a standard high use marine connector. The female side of the connector on the umbilical is keyed so it will only plug in one way. The connector should be screwed all the way into the outlet on the communications box so the connection is snug. Each communications unit has two outlets to allow two divers to use each box. Both outlets are live and it doesn't matter which one is used with only one diver.

Testing the Comm System

Once the umbilical is connected to the communications box, the system should be powered up and tested. The best way to test the mask is to have one of the teammates operate the communications box while another holds the mask up to his/her face. With the box turned on, and the speaker and tender microphone connected properly, they should be able to communicate easily. Make sure that the bone phones are functioning properly.

The communications can be tested by a single individual by turning on the topside box, positioning the mask within hearing distance of the box, and lightly tapping on the microphone in the mask. The sound should easily be heard. Be sure to point the mask away from the box to avoid annoying feedback. With the volume to the diver turned up, tap on the microphone on the communications box and the sound of tapping should be heard from the bone phones in the mask.

Dressing in for the Dive

Prior to donning the mask the diver should have all of his /her equipment on, including the hood. The last equipment that should be donned will be the harness, bail-out bottle (if applicable), and the mask.

The tender should assist the diver with donning the harness and mask. Once the harness is adjusted properly, the tender should ensure that the umbilical is securely connected to the harness. It is standard practice for the diving umbilical to be fitted with a stainless steel snap hook that attaches to the harness. This helps the tender avoid putting a direct pull on the diver's mask. This connection should be on the diver's right hip. The breathing hose is then routed behind the diver and under his/her left arm. It is now time to don the mask.

Donning and Adjusting the Mask

One of the cardinal rules of full-face mask diving is that the diver must have the ability to don, adjust, and remove the mask by his/herself. This is fundamental to the diver's safety. If these basic skills cannot be performed, one must not dive with this mask. Without the ability to remove the mask by oneself, one could suffocate in the event of an out-of-air emergency.

Prior to donning the mask, the diver should have all of his/her other equipment on, including the hood, and the umbilical attached to the harness.

To don the mask, loosen the spider head harness so that it is at its maximum opening. Lift the mask over the head and hold it securely against the face without tightening the spider. (DO NOT turn the spider inside out over the front of the mask and peel it over the head. This puts an undue amount of stress on the buckles and can cause irreparable damage if a buckle is torn out of the skirt.) (Fig. 9) Ensure that the hood and/or hair do not interfere with the mask seal. Test breathe the mask to ensure adequate air supply. Check the purge button on the mask to be sure that it is operating correctly.

If everything on the mask checks out, go ahead and tighten the spider straps. Start by tightening the bottom straps first. Pull the straps around the contour of the head as if trying to cross the hands behind it. DO NOT pull the straps out from the head. This could cause the buckles to be torn out of the mask skirt. (Fig. 9) Tighten the straps alternately to pull up tension evenly to avoid having the mask tighter on one side or the other. This will cause leaking.

It is essential to make sure the mask is snug on the face. It does not need to be tight, but it does need to be snug. If the mask is too tight it will become extremely uncomfortable after a very short time. If the mask is too loose, it will create additional air space inside the mask, causing excess buoyancy and a free flow. The cup of the spider should be positioned so that it is on the center of the back of the head, low, but not on the neck.

Figure 9 – Proper donning technique for the Divator MK II. Never pull the straps away from the head. The bone phone should be positioned just behind the ear.

After the harness has been tightened, the diver should hold his/her breath and listen for any leakage from the mask. There should be nothing interfering with the seal of the mask. If there is leakage, it must be corrected. In most cases, hair or the hood under the face seal is the cause of leakage. Some individuals may experience leakage around the temple area. Latex tubing can be inserted into the mask skirt to fine tune fit.

Equalizing

Figure 10 - Equalizing

As in all diving, equalization should start on the surface. Be sure to equalize early and often. Push the bottom part of the mask up gently against the face until the equalizing device (pig snout) is blocking the nostrils. (Fig. 10) The mask should not have to be moved far, probably less that ¼ inch. The diver can then close

his/her mouth and exhale through the nose to equalize the pressure in his/her ears (Valsalva method). Release the mask when equalization has been accomplished.

Underwater with the Divator MK II

Most divers will find that diving with the Divator MK II Full Face Mask is easy and comfortable. The regulator breathes extremely well.

One can adjust the spider during the course of the dive. Adjustment is very rapid and is easily accomplished by pushing the mask against the face and loosening or tightening the straps. Each diver will want to experiment with the adjustments to discover what combination of tension on the top and bottom straps work best.

When diving surface-supplied it is essential to keep track of the umbilical at all times. Try to dive with the minimum amount of slack possible. This is easy to do because the diver will be in constant communication with the tender. The diver will need to direct the line tender when it is time to take up slack and when it is time to feed more. With a little practice, it is easy to become a smoothly functioning team.

Surface-supplied Diving Procedures

The conduct of a surface-supplied dive differs from that of a scuba dive in that the tender and manifold operator are in charge of the dive. Once the diver is dressed in, actions concerning depth, movement, dive time, decompression status, breathing gas alterations and emergencies should be verbally communicated. Even if the diver is using a dive computer, the tender or manifold operator should keep track of bottom time. During a surface-supplied dive the diver must take direction from the surface regarding safety during the dive. One cannot run the dive from the bottom. All actions throughout the dive should be communicated and verified by the surface personnel. They are in charge of dive time and decompression.

When the diver is dressed in, the tender leads him/her through the pre-dive safety checks. These include final breathing gas checks (including cycling through the use of the EGS system if applicable), final communications checks, and final gas supply verification. Once the equipment is verified it is time to dive.

The tender will then assist the diver to the entry platform. The diver will make final adjustments such as donning gloves and fins if needed. Once the diver is ready to enter the water, he/she should notify the tender. Remember, all actions by the diver or manifold operator should be communicated verbally. Once the diver is on bottom and the manifold operator has verbally verified his/her location and condition, the diver is free to begin the planned dive task. The diver must always be aware of the location of his/her umbilical. Any time an obstruction is encountered underwater the diver should go over it, not under it. It is imperative that the diver always leave him/herself a clear path to the surface with no obstructions that can block the way.

In an air diving operation, the manifold operator has three primary responsibilities. These are to make sure the diver is getting the right air pressure for the mask to function properly (145-150 psig in the Aquarium), to make sure that there is a sufficient air supply for the remainder of the dive and any emergencies, and to keep track of the diver's depth and bottom time. When the diver's primary gas supply cylinder reaches 500psig, the thee-way valve is switched to the alternate cylinder and the diver is informed of his/her remaining gas supply. This depleted cylinder can only be replaced if the diver is wearing EGS. The diver should be informed that the cylinder is being disconnected so he/she is prepared to use the EGS in an emergency. If the diver does not have EGS, the cylinder cannot be removed from the cart while he/she is underwater. The dive is terminated when the second cylinder reaches 500psig.
When diving mixed or multiple gases or when decompression is encountered the manifold operator is in charge of gas switches and deco stops.

The diver is responsible for conducting the assigned task and communicating with the manifold operator.

Surface-supplied Communications

As you have read, one of the major tenets of surface-supplied diving is having voice communication between the diver and surface. Effective voice communication with the Divator MK II requires several measures. The diver must position the microphone correctly inside the mask. It must lightly contact the divers lip. The greater the distance between the diver's mouth and the mic, the less effective the mic becomes. The diver should also lower his/her voice and speak slowly and in short messages while enunciating each word. The manifold operator must also speak in a low, deliberate fashion. He/she must also remember that the diver may have difficulty hearing during exhalation and should time his/her messages accordingly. Each exchange between the diver and surface should be repeated by the recipient for verification.

In the event that the surface-supplied dive team loses voice communications, line pull signals allow for communication. Line pull signals are a series of distinct tugs on the umbilical that indicate commands. It is somewhat like conversing in Morse code. These signals are useless if the tender does not remain in contact with the diver's umbilical. As with voice commands, each message relayed by the diver or tender must be returned by the recipient to verify the message with the exception of a noted few. For example, the tender gives one distinct pull on the umbilical which means "Are you alright?" The diver would then reply with one distinct pulls to confirm she/he is okay. Three signals are not answered immediately. Two are from diver to tender, "Haul me up" (4 pulls), and "haul me up immediately" (4-4-4). Tender acknowledgment consists of the action. The other is from tender to diver; it is "come up" (4 pulls). The diver will not acknowledge the signal until she/he is ready to leave bottom (4 given, 4 returned). There is a list of standard line pull signals in Appendix B of this manual. Special signals may be arranged between the divers and surface personnel before a particular operation.

Safety Considerations for Full Face Mask Diving

Like any piece of diving equipment, there are safety considerations for diving with full face masks. A full face mask is no more dangerous than any other piece of diving equipment, be it a spear gun, a dry suit, or a buoyancy compensator. However, when used improperly, without proper training, or without proper maintenance, a full face mask can be a contributing factor in a diving accident. There are always risks in diving. Sometimes a full face mask can help to reduce those risks. Outlined below are procedures for dealing with the most common emergencies encountered while diving surface-supplied.

Emergency Procedures

While all of the principles of conventional scuba apply to full face mask diving, there are some special procedures that will need to be followed in emergencies. None of these situations is especially dangerous with the exception of an out-of-air emergency. But an out-of-air emergency can be dealt with routinely if the diver is properly trained and equipped.

Loss of Communications

Losing communications is a definite hindrance. In surface-supplied diving, the loss of voice communications with the surface signals the end of the dive. Ultimate authority rests with the tender who will be using line pull signals to communicate with the diver until she/he is out of the water.

Free Flow Regulator

If the regulator on the mask goes into a free flow while on scuba, the diver needs to sort out the problem quickly, particularly if she/he is deep. But, a surface supplied diver with a much larger air supply has plenty of time to solve the problem. With the high flow breathing characteristics of the Divator MK II one can lose a large quantity of air in a very short time during a free flow. In addition, aside from the loss of air, communications will be virtually impossible during any free flow episode.

Diving in conditions of heavy silt, mud, or turbulent sand can make the regulator free flow by preventing the exhalation valve from closing properly. Check to see if this is the problem by pushing the free flow button several times to see if this can loosen anything that is causing it to stick. If the diver cannot correct the problem after one or two attempts then this is probably not the cause of the problem.

When a free flow cannot be corrected immediately the diver must surface and return to his/her support station. Do not continue the dive under any circumstances since there is risk of running out of air.

Mask Flood

It is very difficult for a Divator MK II Full Face Mask to flood, but clearing the mask is virtually automatic. If the mask has been dislodged, the positive pressure of the mask will probably have it cleared by the time it is sealed on the diver's face again. Hold the mask in position with one hand and push the purge button this will rapidly force any remaining water out of the mask.

Out of Air

While wearing a full face mask, running out of air is a serious emergency if one is not properly trained. There are several options to optimize diver response

to this emergency. If the diver is equipped with a manifold block and diver carried emergency gas supply, then it is a simple matter of opening the valve on the block and breathing from the back-up supply. As soon as the diver goes on his/her back-up supply the dive must be discontinued. If the diver is not wearing a back-up gas supply, the proper emergency procedure is an Emergency Swimming Ascent. If the mask is equipped with an Ambient Breathing Valve, it can be opened during the swimming ascent so that ambient air is available as soon as the diver breaches the surface. Without the Ambient Breathing Valve, the diver must remove the mask to get air.

Entanglement

If, at any point during the dive, the diver suspects that she/he is entangled, she/he must stop, evaluate the situation and communicate it to the surface. The manifold operator should notify the diver of remaining gas supply and decompression status. The DPIC and safety diver should be notified and the safety diver should prepare to be deployed. Under most circumstances, the diver can free him/herself. If this is not possible within a prudent amount, the safety diver should be deployed to aid the primary diver. Once the diver is freed, the decision can be made to continue or terminate the dive. Remember, any dive that presents the potential for entanglement or penetration must have a safety diver on the crew regardless of depth or site.

Diver Injury

If a diver sustains an injury during the course of a dive she/he should immediately report it to the surface personnel and terminate the dive. If the diver becomes unresponsive, line pull signals should be attempted. Should the diver remain unresponsive, the DPIC should be notified immediately and the safety diver deployed. Or, in the event of exhibit diving, the diver should be brought to the surface by his/her tender. The diver should be evaluated and standard emergency protocols followed. All dive gear should be left in working condition and set aside for examination by an incident inspector.

Severance of Umbilical

Should a diver's umbilical be severed, the EGS should be activated. Once the EGS is activated the DPIC and safety diver should be notified and the dive terminated. If the diver has a decompression obligation, the safety diver should be deployed with a new hose to attach to the primary divers block. The dive should still be terminated and proper decompression procedures followed. If the diver is not carrying an EGS, the appropriate response would be an emergency swimming ascent and activation of the Ambient Breathing Valve or removal of the mask on the surface.

Example Emergency Scenarios

Communications Failure

Problem Presentation: Inability to communicate with either the diver or tender

Solution: Establish line pull signals beginning with one pull (are you okay?). The tender will end the dive by signaling with three pulls (prepare to surface). The diver will answer when area is clear. The tender will signal "come up" with four pulls. The diver will reply and begin ascent.

Out of Air

Problem Presentation: No air available to diver

Solution: Manifold operator attempts to reestablish the gas supply, or the diver activates the EGS, if available. If neither of these options is successful or available, the diver conducts a controlled emergency swimming ascent. If the gas supply is restored, the standby diver is alerted and the diver is instructed to terminate the dive and proceed to the exit point. Should the diver experience any difficulty, the safety diver will be deployed.

Any Air Cart Failure

Problem Presentation: Obvious leak in some part of the system, gauge malfunction, etc.

Solution: Terminate dive and prepare for an out-of-air situation

Reporting Dive Incidents

All diving incidents must be reported in accordance with the Tennessee Aquarium Diving Safety Manual 2.8.2.

Required Incident Reports

All diving incidents requiring recompression treatment, or resulting in moderate or serious injury, or death, shall be reported to the Diving Control Board. The Diving Control Board shall investigate and document any incident of pressure-related injury within 45 days of the incident and prepare a report, which is to be retained for 5 years. A copy will be forwarded during the annual reporting cycle. This report will contain, at a minimum, the following information:

A. Completed Incident Report Form (Appendix J).
B. A written descriptive report containing:
    1. Name, address, and phone number(s) of the principal parties involved.
    2. Summary of experience of the divers involved.
    3. Location and description of the dive site, and description of conditions leading to the incident.
    4. Description of symptoms, including depths and time of onset.
    5. Description and results of treatment.
    6. Disposition of the case.
    7. Recommendations to avoid repetition of incident.

Post-Dive System Breakdown

After the dive the maintenance of the system is very simple. First, close the umbilical valve on the air cart and bleed the line by pressing the purge button on the mask. Then shut down and disconnect the communications line from the box. At this point the mask can be rinsed and disinfected per standard protocol.

While the mask soaks, the dive cart and umbilical should be prepped for storage. Turn off both scuba tank valves. Bleed the air from the manifold by

opening the unused umbilical valve slightly or by reopening the umbilical valve in use and purging the mask.

The umbilical should be stored in a standing figure-eight configuration. To accomplish this, the umbilical should be coiled in large loops with alternating over-hand and under-hand coils. Once secured, the umbilical assembly should be rinsed in fresh water. Incorrect coiling will lead to twists or kinks and handling problems during the next dive. It is the responsibility of the tender to ensure the umbilical is stored properly.

To properly store the surface supply cart, depleted scuba tanks should be removed from the cart and replaced with full tanks. The cart should be rolled into the compressor room and the umbilical hung to dry. Ensure that the mask is hanging in an up-side-down posture and drain all water out of the oral nasal mask and the main mask skirt. If using the portable communications box, it should be wiped down and stored beside the cart. Any maintenance issues should be reported to the Dive Office immediately.

Appendix A

SURFACE-SUPPLIED TRAINING PROGRESSION

ELIGIBILITY

All surface-supplied diver trainees must have completed entry-level training under the auspice of the Tennessee Aquarium as outlined in the TA Diving Safety Manual (TADSM) Section 4. The diver must also hold an active dive status as outlined in Section 5.3 of the same manual.

Surface-supplied diving instructors must comply with all statutes set forth by Section 5.1.4 of the TADSM.

ACADEMICS

All surface-supplied diving trainees must have a thorough knowledge of equipment, procedures, communications, and emergency protocols as outlined in this manual.

1. Trainees will study all material contained in the Surface-supplied Diver's Training Manual
2. The instructor will review material and clarify any questions
3. The trainees will complete a written exam related to each section of the manual. This exam will be filed with the diver's records to serve as proof of training.

PRACTICAL TRAINING

All surface-supplied diving trainees must complete practical application exercises to ensure proper understanding of procedures. These exercises will include diving and surface duties dealing with dive planning, execution and emergency procedures.

1. Trainees will complete two surface-supplied dives as surface support.
    a. Dive 1: Skills will include equipment setup, diver dress, air cart use, and proper use of communications units.
    b. Dive 2: Skills will include all those listed above with the addition of emergency procedures dealing with air cart failure and loss of communications.
2. Trainees will complete two surface-supplied dives as the diver.
    a. Dive 1: Skills will include equipment setup, diver dress, equalization and proper communications.
    b. Dive 2: Skills will include all those listed above with the addition of emergency procedures dealing with loss of breathing gas and loss of communications.
3. Divers will also demonstrate proper post-dive gear care.

Additional Training Requirements for Show Divers

Any diver holding a current diver status with the Tennessee Aquarium who wishes to conduct dive shows must complete the Surface-supplied Diver Training Course. She/he must also complete exhibit training equivalent to that required of docents for the Secret Reef exhibit. Further, the prospective show diver must complete a module outlining the Aquarium image, proper guest interaction, and brand integrity.

Waiver of Requirements

As per section 4.6 of the TADSM, if an applicant for a diving status can show evidence of qualifying experience, the Diving Safety Officer and/or the Diving Control Board may grant a waiver for specific TA requirements of training and experience.

If the diver's entry-level training was not under the control of the TA, the Diving Safety Officer or designee may evaluate the diver and verify that they possess the knowledge and skills substantially similar to those stated above.

Appendix B

SURFACE-SUPPLIED LINE PULL SIGNALS

From Tender to Diver	
1 Pull	"Are you all right? When diver is descending, one pull means "Stop".
2 Pulls	"Going Down". During ascent, 2 pulls mean "You have come up too far; go back down until we stop you".
3 Pulls	"Stand by to come up".
4 Pulls	"Come up".
From Diver to Tender	
1 Pull	"I am all right". When descending, one pull means "Stop" or "I am on the bottom".
2 Pulls	"Lower" or "Give me slack".
3 Pulls	"Take up my slack".
4 Pulls	"Haul me up".
Emergency Signals from the Diver	
2-2-2 Pulls	"I am fouled and need the assistance of another diver".
3-3-3 Pulls	"I am fouled but can clear myself".
4-4-4 Pulls	"Haul me up immediately"
ALL EMERGENCY SIGNALS WILL BE ANSWERED AS GIVEN EXCEPT 4-4-4	

Appendix C – Attachment 1
SECRET REEF SURFACE-SUPPLIED TENDER CHECKLIST

PRE-DIVE:

1. Check Pressure in Both Tanks
- Turn on Both Tank Valves
- Turn 3-way valve so arrow points left (Fig. 1,A)
- Read Pressure on left gauge
  - verify ≥ 2500 psig
- Verify line pressure on right gauge = 150 psig (Fig. 1,B)
- Turn 3-way Valve so arrow points right
- Depress Mask purge button for 1 second
- Read pressure on left gauge
  - verify ≥ 2500 psig

2. Replace any tank with < 2500 psig
- Turn off Tank Valve
- Open Bleeder Valve thumb screw on attachment whip (Fig.3,A)
- Unscrew Yoke connector (Fig. 3,B)
- Remove bungee
- Replace tank with known full AL80
- Attach bungee
- Screw Yoke Connector onto Tank Valve
- Screw down Bleeder Valve (do not over tighten)
- Turn on Tank Valve
- Verify pressure by repeating section 1

3. Connect umbilical to cart with quick release (works just like a BC inflator hose) and open umbilical valve

4. Prepare Communications box
- Plug communication line into "Diver 1" receptacle on right side of box
  - ensure plug is fully seated and threads are snug
  - stow outlet cover inside Communications box
- Open Communications Box
- Plug microphone into outlet labeled "Tender Mic"
  - Mic is located inside Communications Box
  - -Verify switch on Mic Body is in "Off" position
- Turn on both mixer units
  - Press square button on front right of each mixer
  - Ensure power is on by checking for green lights on each unit
- Turn on tender speaker
  - There is a rocker switch on the back of the speaker
  - Ensure power is on by verifying red light on front of speaker.
  - Volume adjustment on speaker is for that speaker only and does not affect show.

5. Complete Air check with Show Diver

6. Complete Sound check with Show Diver

DIVE:

Locate knob labeled "Dive Mic Vol Galleries" on left side of lower mixer
- Turn knob as far to the right as it will go

CAUTION: Tender Microphone will be live to audience during show

ATTENTION: All settings on Comm.'s Boxes are fixed except the one mentioned above.

Please Do Not adjust other knobs.

- Turn "Dive Mic Vol galleries" back to "Off" position as diver exits

POST DIVE:

1. Ensure “Dive Mic Vol Galleries” is “Off”
2. Diver removes mask
   - Remind to loosen straps completely
3. Turn power off to both mixer units and speaker
4. Unplug Tender Mic
   - Mic cord should be loosely coiled in comm.’s box
5. Close Audio Box
6. Unscrew Communications Line from Audio Box
   - Replace rubber cover on outlet (mask can now be rinsed)
7. Rinse Mask
   - Submerge mask in fresh water bath
   - Place mask in disinfectant for 10 minutes
     - Ensure no latex tubing goes into disinfectant
   - Spray sanitizer off mask with Rinse tank sprayer
8. Turn Umbilical Valve off
9. Turn both Tank Valves off
10. Replace any Tank with less than 2500 psig
11. Coil Umbilical in standing figure-eight
    - Repeat sequence of 1 overhand coil and 1 underhand coil
    - Secure umbilical with rope
12. Detach Umbilical from air cart
13. Stow Cart in Compressor Room
    - Hang Umbilical on Black Hook
    - Ensure Mask is hanging upside down
    - Drain all water out of Mask Gaskets
14. Report any gear, health, animal problems to DPIC
15. Log Dive

Figure 1

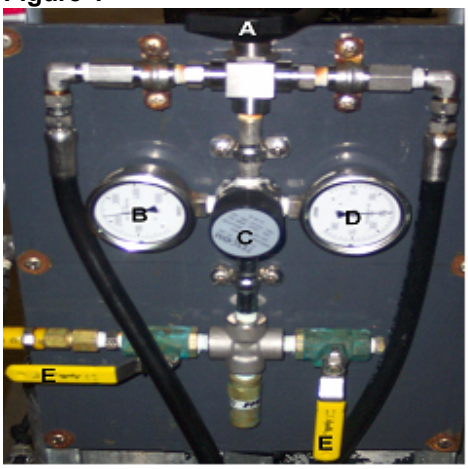
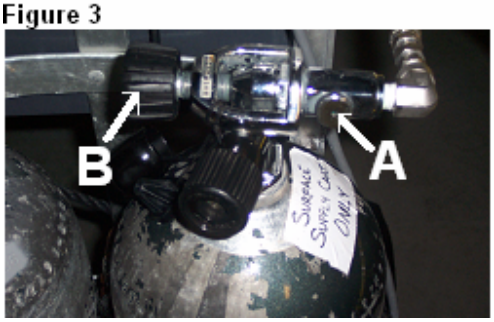


Figure 2

Figure 3



Appendix C – Attachment 2
PORTABLE UNIT SURFACE-SUPPLIED TENDER CHECKLIST

PRE-DIVE:

1. Check Pressure in Both Tanks
- Turn on Both Tank Valves
- Turn 3-way valve so arrow points left (Fig. 1,A)
- Read Pressure on left gauge
  - verify ≥ 2500 psig
- Verify line pressure on right gauge = 150 psig (Fig. 1,B)
- Open Umbilical Valve (Fig. 1,E)
  - Yellow handle in-line with yellow hose
- Turn 3-way Valve so arrow points right
- Depress Mask purge button for 1 second
- Read pressure on left gauge
  - verify ≥ 2500 psig

2. Replace any tank with < 2500 psig
- Turn off Tank Valve
- Open Bleeder Valve thumb screw on attachment whip (Fig.3,A)
- Unscrew Yoke connector (Fig. 3,B)
- Remove bungee
- Replace tank with known full AL80
- Attach bungee
- Screw Yoke Connector onto Tank Valve
- Screw down Bleeder Valve (do not over tighten)
- Turn on Tank Valve
- Verify pressure by repeating section 1

3. Secure Umbilical rope to handrail or other fixed object on surface (Fig. 4)

4. Prepare Communications box
- Plug communication line into outlet 1 on left side of box
  - ensure plug is fully seated and threads are snug
  - stow outlet cover inside Communications box
- Open Communications Box and Inverter Box
- Plug inverter jumper into outlet labeled “12 VOLT EXT POWER”
  - Ensure Red/Black on plug lines up with Red/Black on outlet
- Plug inverter power cord into 110V outlet
- Turn on power to both inverter and Comm.’s unit
  - Ensure power is on by checking for green lights on each unit

5. Adjust setting on comm.’s unit for diver
  - Set “Diver Select” toggle to number 1
  - Switch “Speaker” toggle to ON
  - Adjust volume controls

6. Complete Air check with Show Diver

7. Complete Sound check with Show Diver

DIVE:

1. Verify volume control for tender and diver
- Turn speaker volume control up to comfortable level
- Ensure “Diver Select” setting matches the umbilical plug number
- Adjust the “Diver to Tender” and “Tender to Diver” controls for appropriated diver number so everyone can be heard comfortably

2. “Push to Talk” button transform the communications box speaker into a microphone for the tender

3. Two divers require that the “Diver Select” toggle be set to “BOTH”
- Ensure volume for both Diver 1 and Diver 2 are adjusted and tested
- “Cross Talk” allows divers to communicate with one another
- Multiple divers should be referred to by their comm.’s port number to alleviate confusion

4. All actions regarding depth, time, planned tasks, emergencies, and breathing gas should be communicated

POST DIVE:

1. Diver removes mask
   - Remind to loosen straps completely
2. Ensure all volume controls are off
3. Flip speaker toggle to OFF
4. Flip power toggle on comm.'s box to OFF
5. Turn inverter box off
6. Unplug jumper from inverter to comm.'s box
7. Unplug inverter from 110V outlet
8. Wipe communications unit with dry diaper to remove any water
9. Close both inverter and communications boxes
10. Unscrew Communications Line from Audio Box
    - Replace rubber cover on outlet (mask can now be rinsed)
11. Rinse Mask
    - Submerge mask in fresh water bath
    - Place mask in disinfectant for 10 minutes
        a. Ensure no latex tubing goes into disinfectant
    - Spray sanitizer off mask with Rinse tank sprayer
12. Turn Umbilical Valve off
13. Turn both Tank Valves off
14. Replace any Tank with less than 2500 psig
15. Coil Umbilical in standing figure-eight
    - Repeat sequence of 1 overhand coil and 1 underhand coil
    - Secure umbilical with rope
16. Detach Umbilical from railing and stow rope
17. Stow Cart in Compressor Room
    - Hang Umbilical on Black Hook
    - Ensure Mask is hanging upside down
    - Drain all water out of Mask Gaskets
18. Report any gear, health, animal problems to DPIC
19. Log Dive

Figure 1

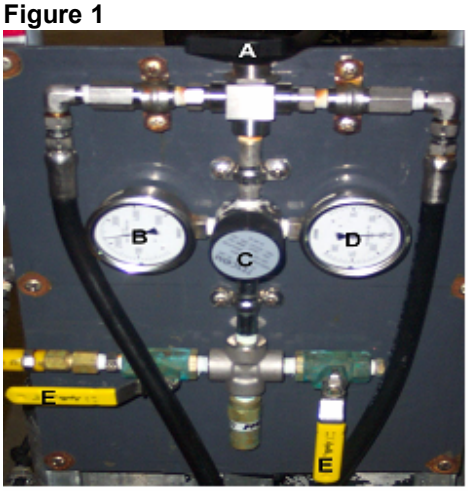
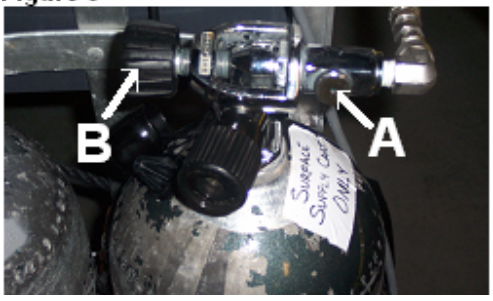


Figure 2

Figure 3



Appendix D

PROVISION FOR DIVING HOOKAH

In accordance with the Tennessee Aquarium Diving Safety Manual section 7.1.5.2 c, divers operating inside the Tennessee Aquarium are permitted to dive surface-supplied without voice communications. All other criteria for surface-supplied diving as outlined in section 7.1.5 must be followed.

Training Addendum:
All divers wishing to dive hookah under the above provision must have completed the surface-supplied diving course as outlined in this manual. Additionally, the hookah diver must conduct two supplementary training dives as outlined below.

Training dives:

1. The trainee will serve as tender. Skills will include equipment setup, diver dress, equipment observation, proper line tending and communication, and emergency procedures.
2. The trainee will serve as diver. Skills will include equipment setup, diver dress, proper equipment use including buoyancy skills, proper communication and emergency skills.