

# Closed-Circuit Mixed-Gas UBA Diving

## 17-1 INTRODUCTION

Closed-circuit mixed-gas underwater breathing apparatus (UBA) is primarily employed by Naval Explosive Ordnance Disposal (EOD) and Special Warfare (SPECWAR) forces. This equipment combines the mobility of a free-swimming diver with the depth advantages of mixed gas. UBAs in this category permit completely autonomous diver operations without an umbilical. The term *closed-circuit* refers to the recirculation of 100 percent of the mixed-gas breathing medium. This results in bubble-free operation, except during ascent or inadvertent gas release. This capability makes closed-circuit UBAs well-suited for special warfare operations and for operations requiring a low acoustic signature. The U.S. Navy's use of the mixed-gas closed-circuit UBA was developed to satisfy the operational requirements of SPECWAR combat swimmers and EOD divers. Improvements in gas usage, dive duration, and depth capabilities provided by the UBA greatly increase the effectiveness of these divers. Dives to 150 feet of seawater (fsw) can be made when N<sub>2</sub>O<sub>2</sub> (air) is used as a diluent and to 300 fsw when HeO<sub>2</sub> (84/16–82/18) is used as a diluent. Current certification limits the MK 16 UBA diving to 200 fsw.

**17-1.1 Purpose.** This chapter provides general guidelines for MK 16 UBA diving, operations and procedures (Figures 17-1 and 17-2). For detailed operation and maintenance instructions, see technical manual SS600-AH-MMA-010 (MK 16).

**17-1.2 Scope.** This chapter covers MK 16 UBA principles of operations, operational planning, dive procedures, and medical aspects of mixed-gas closed-circuit diving. Refer to Chapter 16 for procedures for mixing divers' breathing gas.

## 17-2 PRINCIPLES OF OPERATION

The U.S. Navy closed-circuit mixed-gas UBA is a constant partial-pressure-of-oxygen rebreather. To conserve the gas supply and extend underwater duration, the efficiency of gas use is improved by:

- Removing carbon dioxide produced by metabolic action of the body.
- Adding pure oxygen to the breathing gas to replace the oxygen consumed.
- Recirculating the breathing gas for reuse.



**Figure 17-1.** MK 16 MOD 0 Closed-Circuit Mixed-Gas UBA.

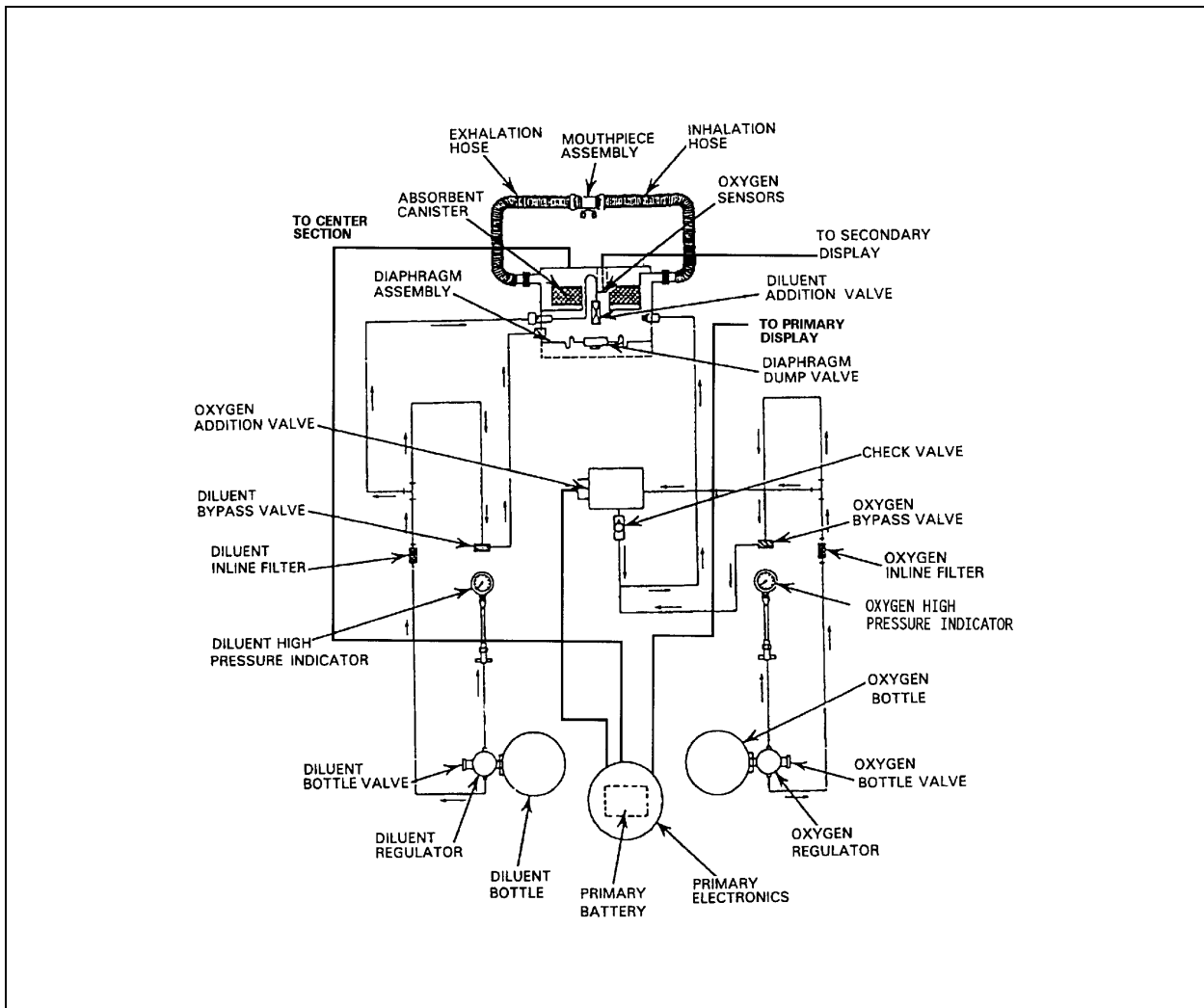


Figure 17-2. MK 16 MOD 0 UBA Functional Block Diagram.

- 17-2.1 **Recirculation and Carbon Dioxide Removal.** The diver's breathing medium is recirculated in a closed-circuit UBA to remove carbon dioxide and permit reuse of the inert diluent and unused oxygen in the mixture. The basic recirculation system consists of a closed loop that incorporates inhalation and exhalation hoses and associated check valves, a mouthpiece or full face mask (FFM), a carbon dioxide removal unit, and a diaphragm assembly.
- 17-2.1.1 **Recirculating Gas.** Recirculating gas is normally moved through the circuit by the natural inhalation-exhalation action of the diver's lungs. Because the lungs can produce only small pressure differences, the entire circuit must be designed for minimum flow restriction.
- 17-2.1.2 **Full Face Mask.** The FFM uses an integral oral-nasal mask or T-bit to reduce dead space and the possibility of rebreathing carbon dioxide-rich gas. Similarly, check valves used to ensure one-way flow of gas through the circuit must be close to the diver's mouth and nose to minimize dead space. All breathing hoses in the system

must be of relatively large diameter (minimum one-inch ID) to minimize breathing resistance.

- 17-2.1.3 **Carbon Dioxide Scrubber.** Carbon dioxide is removed from the breathing circuit in a watertight canister filled with a NAVSEA-approved carbon dioxide-absorbent material located in the backpack of the UBA. The bed of carbon dioxide-absorbent material chemically combines with the diver's exhaled carbon dioxide, while allowing the unused oxygen and diluent to pass through it. Inadvertent wetting of the absorbent material produces a caustic solution. Water produced by the reaction between carbon dioxide and the carbon dioxide absorbent, or by the diver himself, is collected by moisture absorbent pads above and below the canister. A major limiting factor for the MK 16 is the CO<sub>2</sub> absorbent capability. Absorbent duration is directly related to the environmental operating temperature and depth. Absorbent duration decreases as temperature decreases and as depth increases.

The canister design must provide low flow resistance while ensuring maximum contact between the gas and the absorbent. Flow resistance is minimized in the MK 16 UBA by employing a radially-designed canister to reduce gas flow distance. If the canister is improperly filled, channels may be formed through the absorbent granules permitting the gas to bypass the absorbent and allowing carbon dioxide to build up in the UBA.

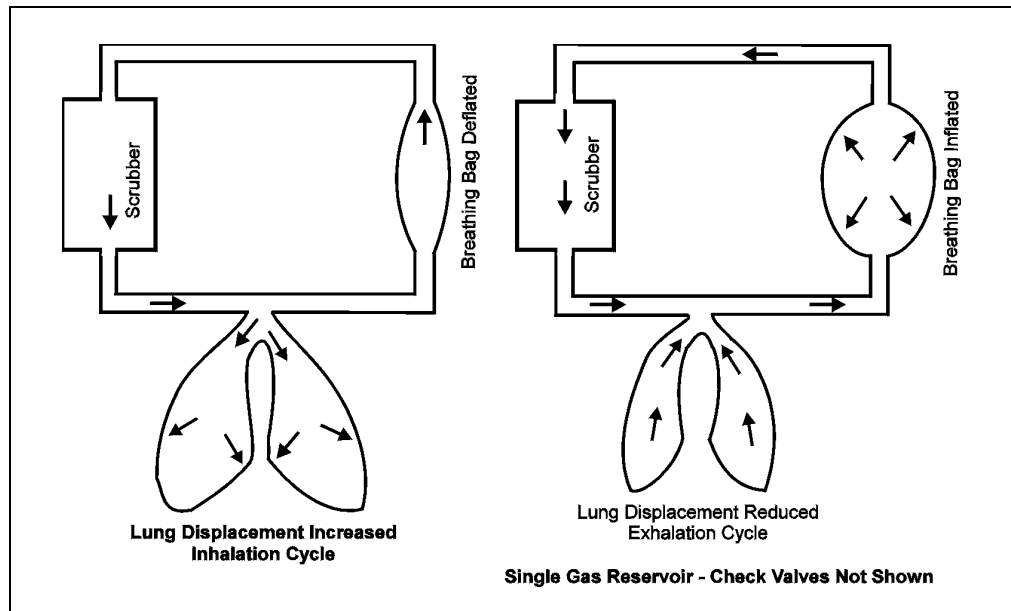
- 17-2.1.4 **Diaphragm Assembly.** A diaphragm assembly or counter lung is used in all closed-circuit UBAs to permit free breathing in the circuit. The need for such devices can be readily demonstrated by attempting to exhale and inhale into an empty bottle. The bottle, similar to the recirculation system without a bag, is unyielding and presents extreme back pressure. In order to compensate, flexible diaphragms or a breathing bag must be placed in the UBA circuit with a maximum displacement equal to the combined volume of both lungs.

Constant buoyancy is inherent in the system because the gas reservoir acts counter to normal lung action. In open-circuit scuba, diver buoyancy decreases during exhalation due to a decrease in lung volume. In closed-circuit scuba, expansion of the breathing bag keeps buoyancy constant. On inhalation, the process is reversed. This cycle is shown in Figure 17-3.

The flexible gas reservoir must be located as close to the diver's chest as possible to minimize hydrostatic pressure differences between the lungs and the reservoir as the diver changes attitude in the water.

The MK 16 UBA uses a single reservoir built into a streamlined backpack assembly. Using a single reservoir located within the backpack affords minimum encumbrance to the diver and maximum protection for the reservoir.

- 17-2.1.5 **Recirculation System.** Optimal performance of the recirculation system depends on proper maintenance of equipment, proper filling with fresh absorbent, and accurate metering of oxygen input. To ensure efficient carbon dioxide removal throughout the dive, personnel must carefully limit dive time to the specified



**Figure 17-3.** UBA Breathing Bag Acts to Maintain the Diver's Constant Buoyancy by Responding Counter to Lung Displacement.

canister duration. Any factor that reduces the efficiency of carbon dioxide removal increases the risk of carbon dioxide poisoning.

**CAUTION** The MK 16 UBA provides no visual warning of excess CO<sub>2</sub> problems. The diver should be aware of CO<sub>2</sub> toxicity symptoms.

**17-2.2 Gas Addition, Exhaust, and Monitoring.** In addition to the danger of carbon dioxide toxicity, the closed-circuit UBA diver encounters the potential hazards of hypoxia and central nervous system (CNS) oxygen toxicity (see Volume 5). It is essential that these hazards be avoided. The UBA must control the partial pressure of oxygen (ppO<sub>2</sub>) in the breathing medium within narrow limits for safe operation and be monitored frequently by the diver.

Hypoxia can occur when there is insufficient oxygen in the recirculation circuit to meet metabolic requirements. If oxygen is not added to the breathing circuit, the oxygen in the loop will be gradually consumed over a period of 2-5 minutes, at which point the oxygen in the mixture is incapable of sustaining life.

CNS oxygen toxicity can occur whenever the oxygen partial pressure in the diver's breathing medium exceeds specified concentration and exposure time limits. Consequently, the UBA must function to limit the ppO<sub>2</sub> level to the appropriate value.

The closed-circuit mixed-gas UBA uses a direct control method of maintaining oxygen concentration in the system, rather than the indirect method of a preset mass flow, common to semi-closed apparatus.

**17-2.3 Advantages of Closed-Circuit Mixed-Gas UBA.** While functionally simpler in principle, the closed-circuit mixed-gas UBA tends to be more complex than the semi-closed UBA because of the oxygen analysis and control circuits required. Offsetting this complexity, however, are several inherent advantages:

- Aside from mixed or diluent gas addition during descent, the only gas required at depth is oxygen to make up for metabolic consumption.
- The partial pressure of oxygen in the system is automatically controlled throughout the dive to a preset value. No adjustment is required during a dive for variations in depth and work rate.
- No inert gas leaves the system except by accident or during ascent, making the closed-circuit UBA relatively bubble-free and well-suited for SPECWAR and EOD operations requiring low acoustic signature.

### **17-3 USN CLOSED-CIRCUIT MIXED-GAS UBA**

The MK 16 UBA is fabricated of Acrylonitrile Butadiene Styrene (ABS) or polycarbonate, nylon, brass, neoprene and other nonmagnetic materials. By necessity, however, certain components such as oxygen and diluent bottles (high-pressure components) are fabricated of Inconel 718 which may have a magnetic signature imparted to them. The components and materials used in the MK 16 UBA have been specifically selected and assembled to exhibit a minimum magnetic signature.

**17-3.1 Diving Safety.** Closed-circuit mixed-gas UBAs are mechanically more complex than open-circuit scuba. Diving safety is achieved only when:

- The diver has been thoroughly trained and qualified in the proper use of the UBA.
- All equipment has been prepared for the specific diving conditions expected.
- The dive is conducted within specified depth and duration limits.
- The diver strictly adheres to and immediately implements all operational and emergency procedures.

**17-3.2 MK 16 UBA Basic Systems.** The MK 16 UBA is broken down into four basic systems (housing, recirculation, pneumatics, and electronics) and their subassemblies as described in the following paragraphs. These systems provide a controlled ppO<sub>2</sub> breathing gas to the diver.

**17-3.3 Housing System.** Major components of the MK 16 UBA are housed in a reinforced ABS or fiberglass, molded case. The equipment case is a contoured backpack assembly designed for minimum interference while swimming, and is equipped with an integral harness assembly. A streamlined, readily-detachable outer cover minimizes the danger of underwater entanglement. External to the

housing are components such as the mouthpiece, pressure indicators, hoses, and primary and secondary displays.

**17-3.4 Recirculation System.** The recirculation system consists of a closed loop incorporating inhalation and exhalation hoses, a mouthpiece or FFM, a carbon dioxide-absorbent canister, and a flexible breathing diaphragm. The diver's breathing gases are recirculated to remove carbon dioxide and permit reuse of the inert component of the diluent and residual oxygen in the breathing mixture. Inhalation and exhalation check valves in the mouthpiece assembly (or manifold of the FFM) ensure the unidirectional flow of gas through the system.

**17-3.4.1 Closed-Circuit Subassembly.** The closed-circuit subassembly has a removable cover, a center section attached to the fiberglass equipment case, a flexible rubber breathing diaphragm, and a CO<sub>2</sub> scrubber assembly. Moisture-absorbent pads inside the scrubber assembly absorb any condensation formed on the cover walls. The space between the scrubber canister and the cover serves as a gas plenum, insulating the canister from the ambient cold water.

**17-3.4.2 Scrubber Functions.** The scrubber has two functions:

- **Carbon Dioxide Removal.** Before the diver's exhaled breath reaches the breathing diaphragm, it passes through the scrubber canister. The scrubber canister is filled with an approved, high efficiency, granular carbon dioxide-absorbent material. Two filter discs in the scrubber canister serve as gas distributors to minimize effects of any channeling in the absorbent. After passing through the filters, the exhaled gas passes through the carbon dioxide-absorbent bed, chemically combining with the carbon dioxide created by metabolic use of the diver's breathing oxygen but allowing the diluent and unused oxygen to pass through it.
- **Water Removal.** Moisture produced by diver exhalation and the reaction between carbon dioxide and carbon dioxide-absorbent is assimilated by moisture-absorbent pads located outside the canister.

**17-3.5 Pneumatics System.** The pneumatics system comprises:

- High-pressure bottles for storing oxygen and diluent gases.
- Indicators to permit monitoring of the remaining gas supply.
- Regulators, fittings, tubing, filters and valves regulate and deliver oxygen and diluent gases to the recirculation system.

**17-3.6 Electronics System.** The electronics system maintains a constant partial pressure of oxygen in the closed-circuit UBA by processing and conditioning signal outputs from the oxygen sensors located in the breathing loop, stimulating the oxygen-addition valve, and controlling the output of the primary display.

17-3.6.1 **Oxygen Sensing.** The partial pressure of oxygen within the recirculation system is monitored by three sensors. Each sensor's output is evaluated by the primary electronics package through a voting logic circuit negating the output from a faulty sensor. Sensor averages are shown by the primary display. Backup reading of each individual sensor can be read on the secondary display which requires no outside power source.

17-3.6.2 **Oxygen Control.** Oxygen concentration in the recirculation system is measured by sensors. The sensors send signals to the primary electronics assembly and the secondary display. The primary electronics assembly compares these sensor signals with the setpoint value, providing output to the primary display and controlling the oxygen-addition valve. An actual ppO<sub>2</sub> value less than the setpoint automatically actuates the oxygen-addition valve to admit oxygen to the breathing loop.

Oxygen control involves several factors:

- **System Redundancy.** The primary electronics assembly in the MK 16 UBA treats each of the sensor signals as a vote. The sensor vote is either above or below the predetermined setpoint. If a simple majority of the sensors is below the predetermined setpoint, a drive signal is sent to the oxygen-addition valve; when a majority of the sensors is above the predetermined setpoint, the signal is terminated. In effect, the electronics circuit ignores the highest and lowest sensor signals and controls the oxygen-addition valve with the middle sensor. Similarly, the electronics circuit displays a high-oxygen alarm (flashing green) if a majority of the sensors' signals indicates a high oxygen level and displays a low-oxygen alarm (flashing red) if a majority of the sensors' signals indicates a low oxygen level. If only one sensor indicates a high oxygen level and/or only one sensor indicates a low oxygen level, the electronics circuit output alternates between the two alarm states (alternating red/green).
- **Setpoint Calibration.** The normal operational ppO<sub>2</sub> setpoint for the MK 16 UBA is 0.75 ata. Appropriate calibration procedures are used to preset the specific ppO<sub>2</sub> setting.
- **Oxygen Addition.** In response to the sensor outputs, the oxygen-addition valve admits oxygen to the breathing loop in the recirculation system. The control circuits continuously monitor the average ppO<sub>2</sub> level. If the oxygen partial pressure in the recirculation system is lower than the setpoint level, the oxygen-addition valve is energized to admit oxygen. When the ppO<sub>2</sub> reaches the required level, the automatic control system maintains the oxygen-addition valve in the SHUT position. Should the oxygen-addition valve fail in an OPEN position, the resulting free flow of oxygen in the MK 16 is restricted by the tubing diameter and the orifice size of the piezoelectric oxygen-addition valve.

17-3.6.3 **Displays.** The MK 16 UBA has two displays that provide continuous information to the diver about ppO<sub>2</sub>, battery condition, and oxygen sensor malfunction.

17-3.6.3.1 **Primary Display.** The primary display consists of two light-emitting diodes (LEDs) that are contained within the primary display housing. This display is normally mounted on the face mask, within the peripheral vision of the diver (Figure 17-4). The two LEDs (one red and one green) powered by the primary electronics assembly battery indicate the general overall condition of various electronic components and the ppO<sub>2</sub> in the breathing loop as follows:

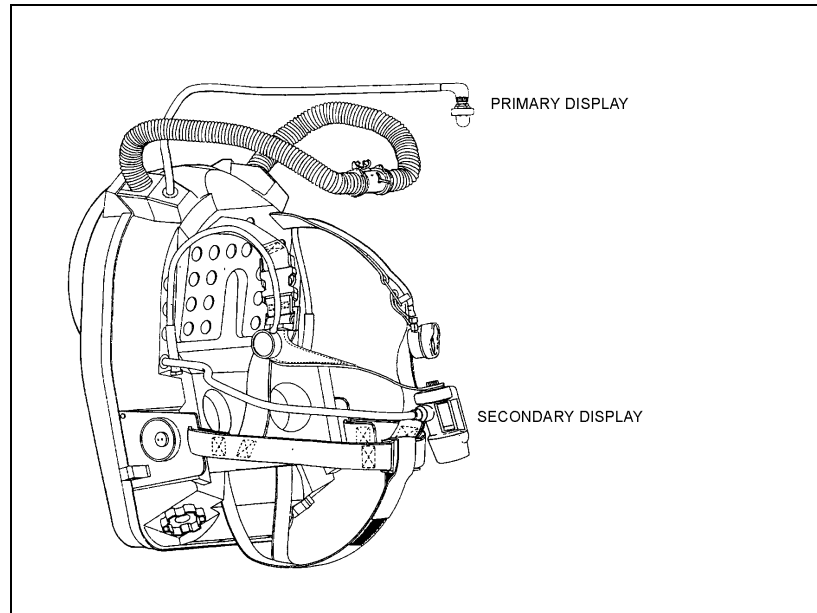
- **Steady green:** Normal oxygen range, 0.60 to 0.90 ata ppO<sub>2</sub> (using a set point of 0.75 ata)
- **Steady red or simultaneously illuminated steady red and green:** Primary electronics failure
- **Flashing green:** High oxygen content, greater than 0.90 ata ppO<sub>2</sub>
- **Flashing red:** Low oxygen content, less than 0.60 ata ppO<sub>2</sub>
- **Alternating red/green:** Normal transition period (ppO<sub>2</sub> is transitioning from normal to low, from low to normal, from normal to high, or from high to normal), one sensor out of limits, low primary battery power (displayed on secondary display) or primary electronics failure.
- **No display (display blanked):** Electronics assembly or primary battery failure.

17-3.6.3.2 **Secondary Display.** The MK 16 secondary display is designed to provide quantitative information to the diver on the condition of the breathing medium, the primary battery voltage and the condition of the secondary batteries. It also serves as a backup for the primary display in the event of a failure or malfunction to the primary electronics assembly, the primary display, or the primary battery. The secondary display functions concurrently with, but independently of, the primary display and displays the O<sub>2</sub> sensor readings and primary battery information in digital form. The secondary display is powered by four 1.5-volt batteries for illumination of the LED display only. It does not rely on the primary electronics subassembly, but receives signals directly from the oxygen sensors and the primary battery. It will continue to function in the event of a primary electronics assembly failure. See Figure 17-4.

## 17-4 OPERATIONAL PLANNING

Because the MK 16 UBA maintains a constant partial pressure of oxygen and only adds oxygen or diluent gas as needed, dives of long duration are possible. Mission capabilities, dive procedures, and decompression procedures are radically different from any other methods. This requires a high level of diver training and awareness and necessitates careful dive planning. Chapter 6 provides general guidelines for operational planning. The information provided in this section is supplemental to the MK 16 UBA O&M manual and provides specific guidelines for MK 16 UBA dive planning. In addition to any other requirements, at least half of all dive training should be at night or in conditions of restricted visibility. Units





**Figure 17-4.** Underwater Breathing Apparatus MK 16 MOD 0.

requiring a deep operational capability should allow frequent opportunity for training, ensuring diver familiarity with equipment and procedures. **Workup dives are strongly recommended prior to diving at depths greater than 130 fsw.** MK 16 diver qualifications may be obtained only by completion of the MK 16 Basic Course (A-431-0075) or the Naval Special Warfare Center MK 16 qualifications course. MK 16 qualifications remain in effect as long as diver qualifications are maintained in accordance with Military Personnel Manual article 1410380. However, a diver who has not made a MK 16 dive in the previous six months must refamiliarize himself with MK 16 EPs and OPs and must complete a MK 16 training dive prior to making a MK 16 operational dive. Prior to conducting MK 16 decompression diving, a diver who has not conducted a MK 16 decompression dive within the previous six months must complete open water decompression training dives. Refer to Table 17-1 for the personnel requirements for MK 16 diving operations.

**17-4.1 Operating Limitations.** Using combat swimmer multilevel dive (CSMD) procedures provides SPECWAR divers with the option of conducting multiple-depth diving with the MK 16 UBA if a maximum depth of 70 fsw (NEDU Report 13-83) is not exceeded at any time during the dive. Refer to Table 17-2 for equipment depth limitations. Diving Supervisors must also consider the limiting factors presented in the following paragraphs when planning closed-circuit UBA operations.

**17-4.1.1 Oxygen Flask Endurance.** In calculating the endurance of the MK 16, only the oxygen flask is considered. The endurance of the oxygen flask is dependent upon the following:

- Flask floodable volume

**Table 17-1. Personnel Requirements Chart for Mixed-Gas Diving.**

Mixed-Gas UBA Dive Team				
Designation	Optimum		Minimum	
	One Diver	Two Divers	One Diver	Two Divers
Diving Officer	(Notes 3, 4)	(Notes 3, 4)	(Notes 3, 4)	(Notes 3, 4)
Diving Medical Officer	(Note 5)	(Note 5)	(Note 5)	(Note 5)
Diving Supervisor	1	1	1 (Note 2)	1 (Note 2)
Diver	1	2	1	2
Standby Diver	1 (Note 7)	1 (Note 7)	1 (Note 7)	1 (Note 7)
Diver Tender	1 (Note 1)	2 (Note 1)	1 (Note 1)	1 (Note 1)
Standby Diver Tender	1	1	(Note 8)	(Note 8)
Timekeeper/Recorder	1	1		
EBS Operator	(Note 6)	(Note 6)	(Note 6)	(Note 6)
Total Personnel Required	6	8	4	5

**Notes:**

1. One tender per diver when divers are surface tended. If using a buddy line, one tender is required for each buddy pair.
2. May act as timekeeper/recorder.
3. EOD Diving Officer is required on site for all EOD operations that involve render safe procedure; for SPECWAR, Diving Officer is not required on station. **On station is defined as at the dive location.**
4. Diving Officer may perform any other function simultaneously (i.e., Diving Officer/Diver).
5. A Diving Medical Officer is required on station for all dives exceeding the normal working limit.
6. EBS Operator is for MK 16 in-water decompression dives.
7. At the Diving Supervisor's discretion, the standby diver shall be fully dressed with the exception of scuba or MK 16, mask, and fins. These items shall be ready to don.
8. If the Standby Diver is deployed, the Diving Supervisor shall tend the Standby Diver.

**Table 17-2. Equipment Operational Characteristics.**

Diving Equipment	Normal Working Limit (fsw) (Notes 1 and 2)	Maximum Working Limit (fsw) (Note 1)	Chamber Requirement
MK 16 UBA	150	150 (air diluent)	Note 3
	200	200 (HeO <sub>2</sub> diluent)	Note 3

**Notes:**

1. Depth limits are based on considerations of working time, decompression obligation, oxygen tolerance and nitrogen narcosis. The expected duration of the gas supply, the expected duration of the carbon dioxide absorbent, the adequacy of thermal protection, or other factors may also limit both the depth and the duration of the dive.
2. A Diving Medical officer is required on station for all dives exceeding the normal working limit.
3. Dives deeper than the normal working limits require a recompression chamber on station. **On station is defined as at the dive location.**

- Initial pre-dive pressure
- Required reserve pressure

- Oxygen consumption by the diver
- Effect of cold water immersion on flask pressure

17-4.1.1.1 **Flask Floodable Volume.** The oxygen flask floodable volume (fv) is 0.1 cubic foot (2.9 liters).

17-4.1.1.2 **Initial Pre-dive Pressure.** The initial pressure is the pressure of the oxygen flask at ambient temperature when it has cooled following charging. A reserve pressure of 500 psig is required to drive the reducer. Calculation of initial pressure must also account for gas loss resulting from UBA pre-dive calibration. Oxygen consumption by the diver is computed as 0.049 scfm (1.4 lpm). This is a conservative value for a diver swimming at 0.85 knot (Chapter 3, Figure 3-6). Refer to Table 17-3 for information on the average breathing gas consumption rates and CO<sub>2</sub> absorbent usage.

**Table 17-3.** Average Breathing Gas Consumption Rates and CO<sub>2</sub> Absorbent Usage.

Diving Equipment	Overbottom Pressure (Minimum)	Gas Consumption (Normal)	Gas Consumption (Heavy Work)	CO <sub>2</sub> Absorbent		
				Capacity (lbs.)	Duration 40°F (Note 1)	Duration 70°F (Note 1)
MK 16 UBA (Mixed-gas)	Variable with bottle pressure	12-15 psi/min	15-17 psi/min	7.75-8.0	5h	6h 40m

**Note:**

1. CO<sub>2</sub> absorbent duration is based upon a comfortable work rate (0.8-knot swimming speed).

17-4.1.1.3 **Effect of Cold Water Immersion on Flask Pressure.** Immersion in cold water will reduce the flask pressure and actual cubic feet (acf) of gas available for the diver, in accordance with Charles'/Gay-Lussac's gas law. Based upon direct measurement, available data, or experience, the coldest temperature expected during the dive is used.

17-4.1.1.4 **Calculating Gas Endurance.** Combining these factors produces the formula for MK 16 gas endurance:

MK 16 gas endurance =

$$F_V \times \frac{\left[ \left( P_I \times \frac{T_2}{T_1} \right) - P_R \right]}{VO_2 \times 14.7 \text{ psi}} \times \frac{492}{T_2}$$

Where:

- F<sub>V</sub> = Floodable volume of flask in cubic feet
- P<sub>I</sub> = Initial Pressure in psia
- P<sub>R</sub> = Reserve Pressure in psia

$VO_2$  = Oxygen consumption in medical scfm (32°F)  
 $T_1$  = Ambient air temperature in °R  
 $T_2$  = Coldest water temperature expected in °R

Rankine conversion factor:

$$°R = °F + 460$$

All pressure and temperature units must be absolute.

- 17-4.1.1.5 **Example.** The endurance of a MK 16 MOD 0 UBA charged to 2,500 psig for a dive in 50° F water when the ambient air temperature is 65° F would be computed as follows:

$$\begin{aligned}
 \text{MK 16 gas endurance} &= 0.1 \times \frac{[(2,514.7 \times 510/525) - 514.7]}{0.049 \times 14.7} \times \frac{492}{510} \\
 &= 258 \text{ minutes}
 \end{aligned}$$

This duration assumes no gas loss from the UBA during the dive and only considers metabolic consumption of oxygen by the diver. Divers must be trained to minimize gas loss by avoiding leaks and unnecessary depth changes. Clearing a flooded face mask is a common cause of gas loss from the UBA. When a full face mask (FFM) is used, gas can pass from the UBA breathing loop into the FFM and escape into the surrounding seawater due to a poor face seal. Leaks that continue unchecked can deplete UBA gas supply rapidly. Additionally, during diver ascent, the dump valve opens to discharge breathing gas into the surrounding water, thereby preventing overinflation of the breathing diaphragm. Depth changes should be avoided as much as possible to minimize this gas loss.

- 17-4.1.2 **Diluent Flask Endurance.** Under normal conditions the anticipated duration of the MK 16 diluent flask will exceed that of the oxygen flask. The MK 16 diluent bottle holds approximately 21 standard cubic feet (595 liters) of gas at a stored pressure of 3,000 psig. Diluent gas is used to maintain the required gas volume in the breathing loop and is not depleted by metabolic consumption. As the diver descends, diluent is added to maintain the total pressure within the recirculation system at ambient water pressure. Loss of UBA gas due to offgassing at depth requires the addition of diluent gas to the breathing loop either automatically through the diluent add valve or manually through the diluent bypass valve to make up lost volume. Excessive gas loss caused by face mask leaks, frequent depth changes, or improper UBA assembly will deplete the diluent gas supply rapidly.
- 17-4.1.3 **Canister Duration.** Canister duration is estimated by using a working diver scenario. This allows an adequate safety margin for the diver in any situation. Table 17-4 shows the canister duration limits and approved absorbents for the MK 16 UBA.

**Table 17-4. MK 16 Canister Duration Limits.**

Canister Duration with HeO <sub>2</sub>		
Temperature (°F)	Depth (fsw)	Time (minutes)
40 and above	0-300	300
29-39	0-100	300
35-39	101-300	240
29-34	101-300	120
Canister Duration with N <sub>2</sub> O <sub>2</sub>		
Temperature (°F)	Depth (fsw)	Time (minutes)
29 and above	0-50	300
40 and above	51-150	200
29-39	51-150	100
NAVSEA-Approved Sodalime CO <sub>2</sub> Absorbents		
Name	Vendor	NSN
High Performance Sodasorb, Regular	W.R. Grace	6810-01-113-0110
Sofnolime 4-8 Mesh NI, L Grade	O.C. Lugo	6810-01-113-0110
Sofnolime 8-12 Mesh NI, D Grade	O.C. Lugo	6810-01-412-0637

17-4.1.4 **Thermal Protection.** Divers must be equipped with adequate thermal protection to perform effectively and safely. A cold diver will either begin to shiver or increase his exercise rate, both of which will increase oxygen consumption and decrease oxygen supply duration and canister duration. Refer to Chapter 11 for guidance on thermal protection.

17-4.2 **Equipment Requirements.** Equipment requirements for closed-circuit mixed-gas UBA training dives are provided in Table 17-5. Two equipment items merit special comment:

- **Safety Boat.** A minimum of one motorized safety boat must be present for all open-water dives. A safety boat is also recommended for tended pier dives or diving from shore. Safe diving practice in many situations, however, will require the presence of more than one safety boat. The Diving Supervisor must determine the number of boats required based on the diving area, medical evacuation plan, night operations, and the number of personnel participating in the dive operation.
- **Buddy Lines.** Buddy lines are considered important safety equipment for closed-circuit UBA dives. In special diving situations, such as certain combat swimmer operations or tended diving, the use of buddy lines may not be feasible. The Diving Supervisor shall conduct dives without buddy lines only in situations where their use is not feasible or where their use will pose a greater hazard to the divers than by diving without them.

**Table 17-5. MK 16 UBA Diving Equipment Requirements.**

General	Diving Supervisor	Divers	Standby Diver
1. Motorized safety boat (Note 1)	1. Dive watch	1. Dive watch (Note 2)	1. Dive watch
2. Radio (communications with parent unit, chamber, communication between safety boats when feasible)	2. Dive Bill list	2. Face mask	2. Face mask
3. High-intensity, wide-beam light (night operations)	3. U.S. Navy Standard Air Decompression Tables	3. Fins	3. Fins
4. Dive flags and/or special operations lights as required	4. Closed-Circuit Mixed-Gas UBA Decompression Tables using 0.7 ATA Constant Partial Pressure Oxygen in Nitrogen and in Helium.	4. Dive knife	4. Dive knife
5. Sufficient (2 quarts) fresh water in case of chemical injury	5. Recall device	5. Approved life preserver	5. Approved life preserver
		6. Appropriate thermal protection	6. Appropriate thermal protection
		7. Depth gauge (Note 2)	7. UBA with same depth capability
		8. Buddy line (as appropriate for EOD/SPECWAR operations) (Note 1)	8. Depth gauge
		9. Tending line (as appropriate for EOD operations) (Note 3)	9. Weight belt (if needed)
			10. Tending line

**Notes:**

1. See paragraph 17-4.2
2. See paragraph 17-4.2.6
3. See paragraph 17-4.4.4

17-4.2.1 **Distance Line.** Any buddy line over 10 feet (3 meters) in length is referred to as a distance line. The length of the distance line shall not exceed 81 feet (25 meters). Distance lines shall be securely attached to both divers.

17-4.2.2 **Standby Diver.** When appropriate during training and non-influence diving operations, open circuit scuba may be used to a maximum depth of 130 fsw.

17-4.2.3 **Lines.** Diver marker lines shall be manufactured from any light line that is buoyant and easily marked as directed in paragraph 17-4.2.4 (one-quarter inch polypropylene is quite suitable).

17-4.2.4 **Marking of Lines.** Lines used for controlling the depth of the diver(s) for decompression diving shall be marked. This includes tending lines, marker lines, and

lazy-shot lines. Lines shall be marked with red and yellow or black bands starting at the diver(s) or clump end. Red bands will indicate 50 feet and yellow or black bands will mark every 10 feet.

17-4.2.5 **Diver Marker Buoy.** Diver marker buoys will be constructed to provide adequate visual reference to monitor the divers location. Additionally, the amount of line will be of sufficient length for the planned dive profile.

17-4.2.6 **Depth Gauge/Wrist Watch.** A single depth gauge and wrist watch may be used when diving with a partner and using a distance line.

17-4.3 **Recompression Chamber Considerations.** A recompression chamber and a Diving Medical Officer are not required on station (*on station* is defined as at the dive location) as prerequisites for closed-circuit UBA diving operations, unless the dive(s) will exceed the normal working limit. However, the following items should be determined prior to beginning diving operations:

- Location of the nearest functional recompression chamber. Positive confirmation of the chamber's availability in case of emergency should be obtained.
- Location of the nearest available Diving Medical Officer if not at the nearest recompression chamber.
- Location of the nearest medical facility for treatment of injuries and medical problems not requiring recompression therapy.
- The optimal method of transportation to the treatment chamber or medical facility. If coordination with other units for aircraft/boat/vehicle support is necessary, the Diving Supervisor shall know the telephone numbers and points of contact necessary to make these facilities available as quickly as possible in case of emergency. A medical evacuation plan should be included in the Diving Supervisor brief. Preparing an emergency assistance checklist similar to that in Chapter 6 is recommended.

17-4.4 **Diving Procedures for MK 16.**

17-4.4.1 **Employing a Single, Untended EOD Diver.** Generally, it is safer for divers to work in pairs rather than singly. However, to do so when diving on underwater influence ordnance doubles the diver bottom time expended, increases the risk to life from live ordnance detonation, and increases the risk of detonation caused by the additional influence signature of the second diver. The EOD Diving Officer may authorize the employment of a single, untended diver when it is deemed that the ordnance hazard is greater than the hazard presented by diving alone. All single, untended divers must use a full face mask (FFM). The EOD Diving Officer or Diving Supervisor shall consider the following factors when deciding whether to operate singly or in pairs:

- Experience of the diver
- Confidence of the team

- Type and condition of ordnance suspected
- Environmental conditions
- Degree of operational urgency required

17-4.4.2 **Simulated Training Scenarios.** Simulated ordnance training scenarios do not constitute a real threat, therefore single untended divers shall not be used in training operations. The diver shall be surface tended or marked by attaching a buoy to him.

17-4.4.3 **EOD Standard Safety Procedures.** The following standard safety procedures shall be observed during EOD diving operations:

- An EOD Diving Officer shall be on scene during all phases of an explosive ordnance disposal diving operation involving a Render Safe Procedure (RSP).
- When diving on unknown or influence ordnance, the standby diver's equipment shall be the same type as the diver neutralizing the ordnance.

17-4.4.4 **Diving Methods.** Diving methods include:

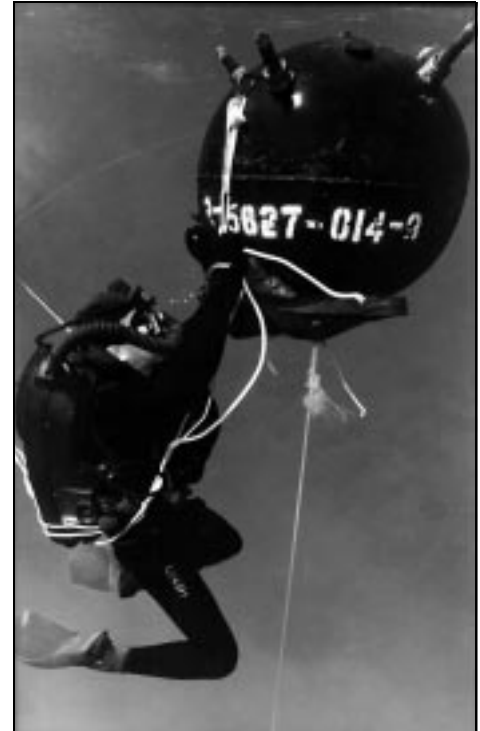
- **Single Marked Diving.** Consists of a single diver with FFM marked with a lightweight buoyant line attached to a surface float. Upon completion of a dive requiring decompression, the diver will signal the diving supervisor that he is ready to surface. The diving boat will then approach the surface float and recover the diver.
- **Paired Marked Diving.** Procedures for paired marked diving are identical to the procedures for a single marked diver, but with the addition of the second diver connected by a buddy/distance line.



- **Tended Diving.** Tended diving consists of a single surface-tended diver or a pair of divers using a buddy/distance line, with one diver wearing a depth-marked line that is continuously tended at the surface (Figure 17-5). A dive pair working off a master reference buoy is closely and continuously monitored at the surface. Divers shall each be positively attached to the system or one diver positively attached to the system and the other positively attached to the first.

**17-4.5 Ship Safety.** When operations are to be conducted in the vicinity of ships, the guidelines provided in the Ship Repair Safety Checklist (see Chapter 6) must be followed.

**17-4.6 Operational Area Clearance.** Notification of intent to conduct diving operations should be coordinated in accordance with local directives.



**Figure 17-5.** Single Surface-Tended Diver.

## 17-5 PREDIVE PROCEDURES

**17-5.1 Diving Supervisor Brief.** A thorough, well-prepared dive briefing reinforces the confidence level of the divers and increases safety, and is an important factor in successful mission accomplishment. It should normally be given by the Diving Supervisor, who will be in charge of all diving operations on the scene. The briefing shall be given separately from the overall mission briefing and shall focus on the diving portion of the operation, with special attention to the items shown in Table 17-6. MK 16 UBA line-pull dive signals are listed in Table 17-7. For MK 16 UBA diving, use the appropriate checklist provided in the MK16 UBA O&M Manual. It is recommended that the Dive Record Sheet shown in Figure 17-6 be used by Diving Supervisors for MK 16 diving.

**17-5.2 Diving Supervisor Check.** As the divers set up their UBAs prior to the dive, the Diving Supervisor must ensure that each diver checks his own equipment, that setup is completed properly by checking the UBA, and that each diver completes a UBA pre-dive checklist from the appropriate UBA operation and maintenance manual. The second phase of the Diving Supervisor check is a pre-dive inspection conducted after the divers are dressed. The Diving Supervisor ensures that the UBA and related gear (life preserver, weight belt, etc.) are properly donned, that mission-related equipment (compass, depth gauge, dive watch, buddy lines,

**Table 17-6. MK 16 UBA Dive Briefing.**

<p><b>A. Dive Plan</b></p> <ol style="list-style-type: none"> <li>1. Operating Depth</li> <li>2. Dive times</li> <li>3. CSMD tables or decompression tables</li> <li>4. Distance, bearing, and transit times</li> <li>5. All known obstacles or hazards</li> </ol> <p><b>B. Environment</b></p> <ol style="list-style-type: none"> <li>1. Weather conditions</li> <li>2. Water/air temperatures</li> <li>3. Water visibility</li> <li>4. Tides/currents</li> <li>5. Depth of water</li> <li>6. Bottom type</li> <li>7. Geographic location</li> </ol> <p><b>C. Personnel Assignments</b></p> <ol style="list-style-type: none"> <li>1. Dive pairs</li> <li>2. Diving Supervisor</li> <li>3. Diving Officer (Note 1)</li> <li>4. Standby diver</li> <li>5. Diving medical personnel</li> <li>6. Base of operations support personnel</li> </ol> <p><b>D. Special Equipment for:</b></p> <ol style="list-style-type: none"> <li>1. Divers (include thermal garments)</li> <li>2. Diving Supervisor</li> <li>3. Standby diver</li> <li>4. Medical personnel</li> </ol> <p><b>E. Review of Dive Signals</b></p> <ol style="list-style-type: none"> <li>1. Hand signals</li> <li>2. MK 16 UBA Line-Pull Dive Signals (Table 17-7)</li> </ol>	<p><b>F. Communications</b></p> <ol style="list-style-type: none"> <li>1. Frequencies, primary/secondary</li> <li>2. Call signs</li> </ol> <p><b>G. Emergency Procedures</b></p> <ol style="list-style-type: none"> <li>1. Symptoms of CO<sub>2</sub> buildup</li> <li>2. Review of management of CO<sub>2</sub> toxicity, hypoxia, chemical injury, unconscious diver</li> <li>3. UBA malfunction (refer to maintenance manual for detailed discussion)             <ul style="list-style-type: none"> <li>■ Oxygen sensor failure</li> <li>■ Low partial pressure of oxygen</li> <li>■ High partial pressure of oxygen</li> <li>■ Electronics failure</li> <li>■ Low battery</li> <li>■ Diluent free flow</li> <li>■ Diluent addition valve failure</li> <li>■ System flooding</li> </ul> </li> <li>4. Lost swim pair procedures</li> <li>5. Omitted decompression plan</li> <li>6. Medical evacuation plan             <ul style="list-style-type: none"> <li>■ Nearest available chamber</li> <li>■ Nearest Diving Medical Officer</li> <li>■ Transportation Plan</li> <li>■ Recovery of other swim pairs</li> </ul> </li> </ol> <p><b>H. Times for Operations</b></p> <p><b>I. Time Check</b></p>
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Note 1: EOD Diving Officer is not required on site except during render safe procedure.

**Table 17-7. MK 16 UBA Line-Pull Signals.**

Signal	From	To	Meaning
1 Pull	Diver	Tender	Arrived at lazy shot (given on lazy shot)
7 Pulls	Diver	Tender	I have started, found, or completed work.
2-3 Pulls	Diver	Tender	I have decompression symptoms.
3-2 Pulls	Diver	Tender	Breathing from EBS
4-2 Pulls	Diver	Tender	Rig Malfunction
2-1 Pulls	Diver Tender	Tender Diver	Unshackle from the lazy shot.

tactical equipment, etc.) are available, and that the UBA functions properly before allowing the divers to enter the water. Appropriate check lists to confirm proper functioning of the UBA are provided in the MK 16 O&M manual.

## 17-6 WATER ENTRY AND DESCENT

**The maximum descent rate is 60 feet per minute.** During descent, the UBA will automatically compensate for increased water pressure and provide an adequate volume of gas for breathing. During descent the oxygen partial pressure may increase as oxygen is added to the breathing mixture as a portion of the diluent. Depending on rate and depth of descent, the primary display on the MK 16 UBA may illuminate flashing green. It may take from 2 to 15 minutes to consume the additional oxygen added by the diluent during descent. While breathing down the  $ppO_2$ , the diver should continuously monitor the primary and secondary display until the  $ppO_2$  returns to setpoint level.

## 17-7 UNDERWATER PROCEDURES

**17-7.1 General Guidelines.** The divers should adhere to the following guidelines as the dive is conducted:

- Monitor primary and secondary display frequently (every 2-3 minutes)
- Wear adequate thermal protection
- Know and use the proper amount of weights for the thermal protection worn and the equipment carried
- Check each other's equipment carefully for leaks at the start of the dive
- Do not exceed the UBA canister duration and depth limitations for the dive (paragraph 17-4.1.3)
- Minimize gas loss from the UBA (avoid mask leaks and frequent depth changes, if possible)
- Maintain frequent visual or touch checks with buddy
- Be alert for symptoms suggestive of a medical disorder (paragraph 17-11)
- Use tides and currents to maximum advantage

**17-7.2 At Depth.** If the UBA is performing normally at depth, no adjustments will be required. The  $ppO_2$  control system will add oxygen from time to time. Monitor UBA primary and secondary displays and high pressure gauges in strict accordance with the MK 16 O&M manual. Items to monitor include:

- **Primary Display.** Check the primary display frequently as outlined in the MK 16 O&M manual (paragraph 3-4.6.1) to ensure that the oxygen level remains

MK 16 MOD 0 DIVE RECORD SHEET										
Diving Supervisor							Date			
Water Temp			Air Temp				Depth (fsw)			
Table		Schedule			Planned Bottom Time					
Required EBS Pressure					Actual EBS Pressure					
	Name	Repet Group	Rig No.	O <sub>2</sub> Pressure	Diluent Pressure	Batt %	LS	LB	RS	TBT
Diver 1										
Diver 2										
Standby Diver										
Descent Rate	Scheduled Time at Stop		Stop Depth	Actual Time at Stop		Travel Time	Remarks			
	Divers	Standby		Divers	Standby					
			10							
			20							
			30							
			40							
			50							
			60							
			70							
			80							

Figure 17-6. MK 16 MOD 0 Dive Record Sheet.

at the setpoint during normal activity at a constant depth (the oxygen-addition valve operation on the MK 16 cannot be heard).

- **Secondary Display.** Check the secondary display frequently (every 2-3 minutes) as outlined in the MK 16 O&M manual (paragraph 3-4.6.2) to ensure that all sensors are consistent with the primary display and that plus and minus battery voltages are properly indicating.
- **High-Pressure Indicators.** Check the oxygen- and diluent-pressure indicators frequently as outlined in the MK 16 O&M manual (paragraph 3-4.6.3) to ensure that the gas supply is adequate to complete the dive.

## 17-8 ASCENT PROCEDURES

**The maximum ascent rate for the MK 16 is 30 feet per minute.** During ascent, when water pressure decreases, the diaphragm dump valve compensates for increased gas volume by discharging the excess gas into the water. As a result, oxygen in the breathing gas mixture may be vented faster than  $O_2$  is replaced by the addition valve. In this case, the primary display may alternate red/green before the low- $ppO_2$  signal (blinking red) appears. This is a normal transition period and shall not cause concern. Monitor the secondary display and add oxygen by depressing the bypass valve during this instance.

## 17-9 POSTDIVE PROCEDURES

Postdive procedures shall be completed in accordance with the appropriate postdive checklists in the MK 16 UBA O&M manual.

## 17-10 DECOMPRESSION PROCEDURES

When diving with an open-circuit UBA,  $ppO_2$  increases with depth. With a closed-circuit UBA,  $ppO_2$  remains constant at a preset level regardless of depth. Therefore, standard U.S. Navy decompression tables cannot be used.

**17-10.1 Use of Constant  $ppO_2$  Decompression Tables.** Closed-circuit UBA users must use constant  $ppO_2$  decompression tables Oxygen in Nitrogen (air diluent), and Oxygen in Helium (Helium-Oxygen diluent). Closed-circuit, mixed-gas UBA decompression tables (Table 17-14 and Table 17-15) are included at the end of this chapter.

**17-10.2 Monitoring  $ppO_2$ .** During decompression, it is very important to frequently monitor the secondary display and ensure a 0.7  $ppO_2$  is maintained as closely as possible. Always use the appropriate decompression table when surfacing, even if UBA malfunction has significantly altered the  $ppO_2$ .

**NOTE Surface decompression is not authorized for MK 16 operations. Appropriate surface decompression tables have not been developed for constant 0.7 ata  $ppO_2$  closed-circuit diving.**

**17-10.3 Rules for Using 0.7 ata Constant ppO<sub>2</sub> in Nitrogen and in Helium Decompression Tables.**

**NOTE The rules using the 0.7 ata ppO<sub>2</sub> tables are the same for nitrogen and helium; however, the tables are not interchangeable.**

- These tables are designed to be used with MK 16 UBA (or any other constant ppO<sub>2</sub> closed-circuit UBA) with an oxygen setpoint of 0.7 ata or higher.
- When using helium as the inert gas, the amount of nitrogen must be minimized in the breathing loop. Flush the UBA well with helium-oxygen using proper purge procedure in the MK 16 UBA O&M manual.
- Tables are grouped by depth and within each depth group is a limit line. These tables are designed to be dived to the limit line. Schedules below the limit line provide for unforeseen circumstances when a diver might experience an inadvertent downward excursion or for an unforeseen reason overstay the planned bottom time.
- Tables/schedules are selected according to the maximum depth obtained during the dive and the bottom time (time from leaving the surface to leaving the bottom).
- General rules for using these tables are the same as for standard air tables:
  1. Enter the table at the listed depth that is exactly equal to or is next greater than the maximum depth attained during the dive.
  2. Select the bottom time from those listed for the selected depth that is exactly equal to or is next greater than the bottom time of the dive.
  3. Never attempt to interpolate between decompression schedules.
  4. Use the decompression stops listed for the selected bottom time.
  5. Ensure that the diver's chest is maintained as close as possible to each decompression depth for the number of minutes listed.
  6. Maximum ascent rate is 30 feet per minute.
  7. Begin timing each stop on arrival at the decompression stop depth and resume ascent when the specified time has elapsed. Do not include ascent time as part of stop time.
  8. The last stop may be taken at 20 fsw if desired. After completing the prescribed 20-fsw stop, remain at any depth between 10 fsw and 20 fsw inclusive for the 10-fsw stop time as noted in the appropriate decompression table.

9. Always use the appropriate decompression table when surfacing even if UBA malfunction has significantly altered  $ppO_2$ .
- In emergency situations (e.g., UBA flood-out or failure), immediately ascend to the first decompression stop according to the original decompression schedule if deeper than the first stop, and shift to the Emergency Breathing System (EBS). The subsequent decompression is modified according to the diluent gas originally breathed.
    - **Helium-Oxygen Diluent.** Follow the original  $HeO_2$  decompression schedule without modification while breathing air.
    - **Nitrogen-Oxygen (Air) Diluent.** Double all remaining decompression stops while breathing air. If the switch to emergency air is made while at a decompression stop, then double the remaining time at that stop and all shallower stops. If a planned decompression dive falls within a no-decompression limit and a switch to EBS has occurred, a mandatory 10-minute stop at 20 fsw is required.

If either of these procedures is used, the diver should be closely observed for signs of decompression sickness for 2 hours following the dive, but need not be treated unless symptoms arise.

- When selecting the proper decompression table, all dives within the past 12 hours must be considered. Repetitive dives are allowed. Repetitive diving decompression procedures vary depending on the breathing medium(s) selected for past dives and for the current dive. If a dive resulted in breathing from the EBS then no repetitive dives shall be made within the next 12 hours. Refer to the following tables:
  - Table 17-8a for Repetitive Dive Procedures for Various Gas Mediums.
  - Figure 17-7 for the Dive Worksheet for Repetitive 0.7 ata Constant Partial Pressure Oxygen in Nitrogen Dives.
  - Table 17-9 for the No-Decompression Limits and Repetitive Group Designation Table for No-Decompression 0.7 ata Constant Partial Pressure Oxygen in Nitrogen Dives.
  - Table 17-10 for the Residual Nitrogen Timetable for Repetitive 0.7 ata Constant Partial Pressure Oxygen in Nitrogen Dives.

**17-10.4 PPO<sub>2</sub> Variances.** The  $ppO_2$  in the MK 16 UBAs is expected to vary slightly from 0.6 - 0.9 ata for irregular brief intervals. This does not constitute a malfunction. The decompression tables were calculated and tested using functioning or prototype MK 16 UBAs. When addition of oxygen to the UBA is manually controlled,

**Table 17-8a. Repetitive Dive Procedures for Various Gas Mediums.**

**WARNING**  
**No repetitive dives are authorized after an emergency procedure requiring a shift to the EBS.**

Selection of Repetitive Procedures for Various Gas Mediums		
Previous Breathing Medium (Refer to Notes 1, 2, and 3)	Current Breathing Medium	Procedure from Table 17-8b
N <sub>2</sub> O <sub>2</sub>	N <sub>2</sub> O <sub>2</sub>	A
Air	N <sub>2</sub> O <sub>2</sub>	B
N <sub>2</sub> O <sub>2</sub>	Air	C
HeO <sub>2</sub>	HeO <sub>2</sub>	D
HeO <sub>2</sub>	Air	E
Air	HeO <sub>2</sub>	F
HeO <sub>2</sub>	N <sub>2</sub> O <sub>2</sub>	G
N <sub>2</sub> O <sub>2</sub>	HeO <sub>2</sub>	H

**Notes:**

1. If a breathing medium containing helium was breathed at any time during the 12-hour period immediately preceding a dive, use HeO<sub>2</sub> as the previous breathing medium.
2. If 100 percent oxygen rebreathers are used on a dive in conjunction with other breathing gases, treat that portion of the dive as if 0.7 ATA O<sub>2</sub> in N<sub>2</sub> was breathed.
3. If both air and 0.7 ATA O<sub>2</sub> in N<sub>2</sub> are breathed during a dive, treat the entire dive as an air dive. If the 0.7 ata O<sub>2</sub> in N<sub>2</sub> is breathed at depths 80 fsw or deeper, add the following correction factors to the maximum depth when selecting the appropriate air table.

Maximum Depth on N <sub>2</sub> O <sub>2</sub>	Correction Factor
Not exceeding 80 FSW	0
81-99	Plus 5
100-119	Plus 10
120-139	Plus 15
140-150	Plus 20



**Table 17-8b. Repetitive Dive Procedures for Various Gas Mediums.**

**Notes:**

- A. (1) Use the Worksheet (Figure 17-7) for calculations.
  - (2) Determine the repetitive group letter for depth and time of dive conducted from Table 17-9 for no-decompression dives or from the Closed-Circuit Mixed-Gas UBA Decompression Tables (Table 17-14 and Table 17-15) for decompression dives. If the exact time or depth is not found, go to the next longer time or the next deeper depth.
  - (3) Locate the repetitive group letter in Table 17-10. Move across the table to the correct surface interval time. Move down to the bottom of the column for the new group designation.
  - (4) Move down the column of the new group designation to the depth of the planned dive. This is the residual nitrogen time (RNT). Add this to the planned bottom time of the next dive to find the decompression schedule and the new group designation.
  - (5) RNT Exception Rule: If the repetitive dive is to the same depth or deeper than the depth of the previous dive, and the RNT is longer than the original bottom time, use the original bottom time.
- B. Use the repetitive group designation from the standard air decompression table or the no-decompression limits and repetitive group designation table for no-decompression air dives to enter Table 17-10. Compute the RNT as in procedure A. Do not use the residual nitrogen timetable for repetitive air dives to find the RNT.
- C. (1) Determine the repetitive group designation for depth and time of dive conducted from Table 17-9 or Table 17-14. If the exact time or depth is not found, go to the next longer time or the next deeper depth.
  - (2) Locate the repetitive group letter in Table 17-10. Move across the table to the correct surface-interval time. Move down to the bottom of the column for the new group designation.
  - (3) Use the repetitive group designation from Table 17-10 as the new group designation in the residual nitrogen timetable for repetitive air dives (Chapter 10) to find the RNT.
- D. Add the bottom time of the current dive to the sum of the bottom times for all dives within the past 12 hours to get the adjusted bottom time. Use the maximum depth attained within the past 12 hours and the adjusted bottom time to select the appropriate profile from Table 17-15.
- E. Add the bottom times of all dives within the past 12 hours to get an adjusted bottom time. Using the standard air decompression table, find the maximum depth attained during the past 12 hours and the adjusted bottom time. The repetitive group from this air table may then be used as the surfacing repetitive group from the last dive. The residual nitrogen timetable for repetitive air dives is used to find the repetitive group at the end of the current surface interval and the appropriate residual nitrogen time for the current air dive.
- F. Compute the RNT from the residual nitrogen timetable for repetitive air dives using the depth of the planned dive. Add the RNT to the planned bottom time to get the adjusted bottom time. Use Table 17-15 for the adjusted bottom time at the planned depth.
- G. Add the bottom times of all dives within the past 12 hours to get an adjusted bottom time. Using Table 17-14, find the maximum depth attained during the past 12 hours and the adjusted bottom time. The repetitive group from the table may then be used as the surfacing repetitive group from the last dive. Table 17-10 is used to find the repetitive group at the end of the current surface interval and the appropriate RNT for the current dive.
- H. Compute the RNT from Table 17-10 using the depth of the previous dive. Add the RNT to the planned bottom time to get the adjusted bottom time. Use Table 17-14 for the adjusted bottom time at the planned depth.

<b>REPETITIVE DIVE WORKSHEET FOR 0.7 ATA N<sub>2</sub>O<sub>2</sub> DIVES</b>	
Part 1. Previous Dive:	_____ minutes _____ feet _____ repetitive group designator from Table 17-9
Part 2. Surface Interval:	_____ hours _____ minutes on the surface _____ final repetitive group from Table 17-10
Part 3. Equivalent Single Dive Time:  Enter Table 17-10 at the depth row for the new dive and the column of the final repetitive group to find the corresponding Residual Nitrogen Time (RNT).	
_____ + _____ = _____	minutes RNT minutes planned bottom time minutes equivalent single dive time
Part 4. Decompression Schedule for the Repetitive Dive:	
_____ _____	minutes equivalent single dive time from Part 3 feet, depth of the repetitive dive.

**Figure 17-7.** Dive Worksheet for Repetitive 0.7 ata Constant Partial Pressure Oxygen in Nitrogen Dives.

**Table 17-9. No-Decompression Limits and Repetitive Group Designation Table for 0.7 ata Constant Partial Pressure Oxygen in Nitrogen Dives.**

Depth	No-Decompression Limits (min)	Repetitive Group Designation																
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z	
10	Unlimited	720																
20	720	154	423	720														
30	720	31	50	73	98	128	165	211	273	373	634	720						
40	367	17	27	38	50	63	76	91	107	125	144	167	192	222	258	304	367	
50	143	12	19	26	34	42	50	59	68	78	88	99	111	123	137	143		
60	74	9	14	20	25	31	37	43	50	57	64	71	74					
70	51	7	11	16	20	25	30	34	39	45	50	51						
80	39	6	10	13	17	21	25	29	33	37	39							
90	32	5	8	11	14	18	21	24	28	31	32							
100	27	5	7	10	13	15	18	21	24	27								
110	24	4	6	9	11	14	16	19	21	24								
120	19	4	6	8	10	12	15	17	19									
130	16	3	5	7	9	11	13	15	16									
140	13	3	5	7	8	10	12	13										
150	11	3	4	6	8	9	11											
Limit Line		<hr/>																
160	9	3	4	6	7	9												
170	8	3	4	5	7	8												

**Table 17-10. Residual Nitrogen Timetable for Repetitive 0.7 ata Constant Partial Pressure Oxygen in Nitrogen Dives.**

															<b>A</b>	0:00 4:46*
															<b>B</b>	0:00 2:35 6:03*
														<b>C</b>	0:00 1:57 3:29 6:57*	
														<b>D</b>	0:00 1:50 2:49 4:21 7:49*	
											<b>E</b>	0:00 1:15 2:42 3:42 5:13 8:42	0:00 1:16 2:43 3:43 5:14 8:42	0:00 1:51 2:50 4:22 7:49*		
											<b>F</b>	0:00 0:44 2:08 3:34 4:34 6:06 9:34*	0:00 0:45 2:09 3:35 4:35 6:07 9:34*	0:00 1:37 3:01 4:27 5:27 6:59 10:26*		
										<b>G</b>	0:00 0:54 1:36 3:00 4:26 5:26 6:58 10:26*	0:00 1:05 1:47 2:29 3:53 5:20 6:19 7:51 10:18*	0:00 1:16 1:58 2:39 3:21 4:45 6:12 7:12 8:43 12:10*			
								<b>H</b>	0:00 1:04 1:46 2:28 3:52 5:19 6:18 7:50 10:18*	0:00 1:05 1:47 2:29 3:53 5:20 6:19 7:51 10:18*	0:00 1:16 1:57 2:38 3:20 4:44 6:11 7:11 8:42 12:10*	0:00 0:43 2:07 2:49 3:31 4:13 5:36 7:03 8:03 9:35 12:43*				
							<b>I</b>	0:00 1:15 1:57 2:38 3:20 4:44 6:11 7:11 8:42 12:10*	0:00 1:05 1:47 2:29 3:53 5:20 6:19 7:51 10:18*	0:00 1:16 1:58 2:39 3:21 4:45 6:12 7:12 8:43 12:10*	0:00 0:43 2:07 2:49 3:31 4:13 5:36 7:03 8:03 9:35 12:43*	0:00 0:54 1:36 3:00 4:24 5:06 6:30 7:26 8:56 10:28 10:55*				
							<b>J</b>	0:00 0:43 2:07 2:49 3:31 4:13 5:36 7:03 8:03 9:35 12:43*	0:00 0:54 1:36 3:00 4:24 5:06 6:30 7:26 8:56 10:28 10:55*	0:00 1:05 1:47 2:29 3:53 5:20 6:19 7:51 10:18*	0:00 0:43 2:07 2:49 3:31 4:13 5:36 7:03 8:03 9:35 12:43*	0:00 0:33 1:57 2:37 3:21 4:45 5:26 6:08 6:50 8:14 9:41 10:40 12:12 12:12				
							<b>K</b>	0:00 0:53 1:35 2:59 3:41 4:23 5:05 6:29 7:25 8:55 10:27 10:55*	0:00 0:33 1:56 2:36 3:20 4:44 5:25 6:07 6:49 8:13 9:40 10:39 12:11 15:39*	0:00 0:43 1:25 2:49 3:31 4:13 5:37 6:19 7:01 7:42 9:06 10:33 11:33 13:04 13:04	0:00 0:42 1:24 2:48 3:30 4:12 5:36 6:18 7:00 7:41 9:05 10:32 11:32 13:03 16:31*					
							<b>L</b>	0:00 0:42 1:24 2:48 3:30 4:12 5:36 6:18 7:00 7:41 9:05 10:32 11:32 13:03 16:31*	0:00 0:33 1:56 2:36 3:20 4:44 5:25 6:07 6:49 8:13 9:40 10:39 12:11 15:39*	0:00 0:43 1:25 2:49 3:31 4:13 5:37 6:19 7:01 7:42 9:06 10:33 11:33 13:04 13:04	0:00 0:42 1:24 2:48 3:30 4:12 5:36 6:18 7:00 7:41 9:05 10:32 11:32 13:03 16:31*					
							<b>M</b>	0:00 0:33 1:56 2:36 3:20 4:44 5:25 6:07 6:49 8:13 9:40 10:39 12:11 15:39*	0:00 0:43 1:25 2:49 3:31 4:13 5:37 6:19 7:01 7:42 9:06 10:33 11:33 13:04 13:04	0:00 0:42 1:24 2:48 3:30 4:12 5:36 6:18 7:00 7:41 9:05 10:32 11:32 13:03 16:31*	0:00 0:42 1:24 2:48 3:30 4:12 5:36 6:18 7:00 7:41 9:05 10:32 11:32 13:03 16:31*					
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							<b>Z</b>	0:00 0:53 1:35 2:59 3:41 4:23 5:05 6:29 7:25 8:55 10:27 10:55*	0:00 0:33 1:56 2:36 3:20 4:44 5:25 6:07 6:49 8:13 9:40 10:39 12:11 15:39*	0:00 0:43 1:25 2:49 3:31 4:13 5:37 6:19 7:01 7:42 9:06 10:33 11:33 13:04 13:04	0:00 0:42 1:24 2:48 3:30 4:12 5:36 6:18 7:00 7:41 9:05 10:32 11:32 13:03 16:31*					

**New Group Designation**

10																12:00
20														12:00	7:03	2:34
30							12:00	10:34	6:13	4:33	3:31	2:45	2:08	1:38	1:13	0:50 0:31
40	6:07	5:04	4:18	3:42	3:12	2:47	2:24	2:05	1:47	1:31	1:16	1:03	0:50	0:38	0:27	0:17
50	3:10	2:23	2:17	2:03	1:51	1:39	1:28	1:18	1:08	0:59	0:50	0:42	0:34	0:26	0:19	0:12
60	2:30	1:40	1:30	1:20	1:14	1:11	1:04	0:57	0:50	0:43	0:37	0:31	0:25	0:20	0:14	0:09
70	2:10	1:20	1:10	1:05	1:00	0:51	0:50	0:45	0:39	0:34	0:30	0:25	0:20	0:16	0:11	0:07
80	1:10	1:05	1:00	0:55	0:50	0:45	0:39	0:37	0:33	0:29	0:25	0:21	0:17	0:13	0:10	0:06
90	1:00	0:55	0:50	0:45	0:42	0:40	0:32	0:31	0:28	0:24	0:21	0:18	0:14	0:11	0:08	0:05
100	0:50	0:45	0:42	0:40	0:38	0:35	0:30	0:27	0:24	0:21	0:18	0:15	0:13	0:10	0:07	0:05
110	0:45	0:40	0:37	0:35	0:33	0:30	0:25	0:24	0:21	0:19	0:16	0:14	0:11	0:09	0:06	0:04
120	0:40	0:38	0:35	0:33	0:30	0:28	0:25	0:20	0:19	0:17	0:15	0:12	0:10	0:08	0:06	0:04
130	0:35	0:34	0:32	0:30	0:28	0:25	0:23	0:20	0:16	0:15	0:13	0:11	0:09	0:07	0:05	0:03
140	0:35	0:30	0:28	0:27	0:25	0:23	0:20	0:19	0:16	0:13	0:12	0:10	0:08	0:07	0:05	0:03
150	0:30	0:29	0:27	0:25	0:23	0:20	0:19	0:18	0:16	0:13	0:11	0:09	0:08	0:06	0:04	0:03
160	0:30	0:28	0:25	0:24	0:23	0:20	0:19	0:18	0:15	0:13	0:10	0:09	0:07	0:06	0:04	0:03
170	0:25	0:24	0:23	0:22	0:20	0:19	0:18	0:17	0:15	0:13	0:10	0:08	0:07	0:05	0:04	0:03

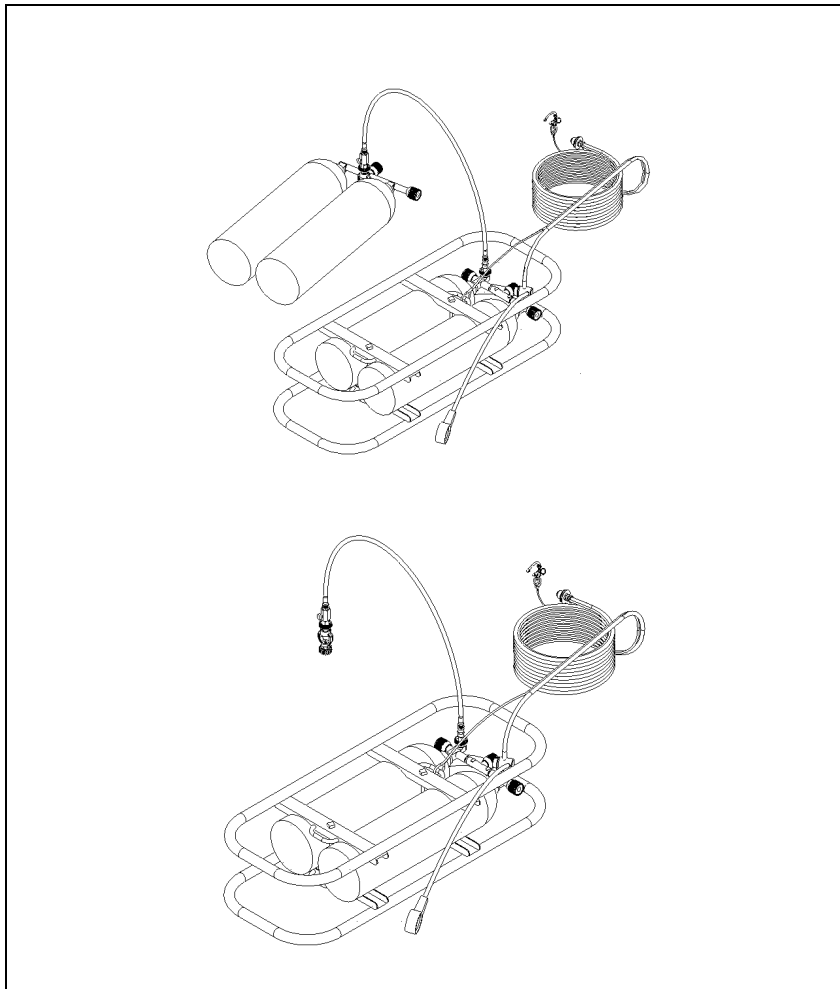
**Residual Nitrogen Times (Minutes)**

\* No RNT After This Time

ppO<sub>2</sub> should be maintained in accordance with techniques and emergency procedures listed in the MK 16 O&M manual.

The Diving Supervisor and medical personnel should recognize that a diver who has been breathing a mixture with ppO<sub>2</sub> lower than 0.6 ata for any length of time may have a greater risk of developing decompression sickness. Such a diver requires observation after surfacing, but need not be treated unless symptoms of decompression sickness occur.

- 17-10.5 Emergency Breathing System (EBS).** The Emergency Breathing System provides an alternate breathing source for decompressing diver(s) in the event of a MK 16 failure. The two types of EBS available for use are EBS Type I and EBS Type II MK 1 Mod 0. The systems have been designed and tested as an accurate method for topside to control and monitor breathing gas being supplied to a diver(s) during decompression. The EBS shall be deployed whenever MK 16 decompression diving is anticipated. In the event of MK 16 failure or malfunction, the diver(s) will transfer to the EBS as soon as possible and continue to use the EBS to complete the decompression profile. It is to be used only for its designed purpose as discussed in paragraph 17-10.3 as an emergency breathing source and not as a surface-supplied diving system.
- 17-10.5.1 **EBS Type I.** The EBS type I was designed and is intended to be used only in support of diving up to 200 fsw. NAVSEA Operation and Maintenance manual S9592-AN-MMO-010 provides detailed equipment descriptions, reference data, and information on operation and maintenance. This type of EBS is a non-certified system (Figure 17-8)
- 17-10.5.2 **EBS Type II MK 1 Mod 0.** The EBS II is a certified surface-supplied, in-water emergency life-support system, with capabilities to support two divers during decompression for dive profiles to 300 fsw (Figure 17-9). The EBS II enables voice communication capabilities between topside personnel and divers while the divers are using the MK 24 FFM (Figure 17-10). PEO MINEWAR technical manual SS600-AL-MMA-010 provides detailed equipment descriptions, reference data, and information on operation and maintenance.
- 17-10.5.3 **Required Gas Supply for the EBS.** When a decompression dive is planned, the Diving Supervisor must calculate the volume of gas required should a diver be required to breathe from the EBS throughout decompression.
- 17-10.5.3.1 **Calculating EBS Gas Requirements.** The following steps may be used to calculate EBS gas requirements (Figure 17-11):
1. Determine decompression profiles from appropriate closed-circuit mixed-gas UBA decompression tables using 0.7 ata constant partial pressure of oxygen.
  2. Multiply the time of each decompression stop by the gas consumption rates (scfm) in Table 17-11 to obtain total volume required per stop. Table 17-11 assumes a light work rate (gas consumption = 0.63 acfm).



**Figure 17-8.** EBS Type 1.

3. Total the volumes required per stop to obtain total volume for decompression. The total should be rounded up to the nearest whole scf.
4. Multiply the total volume for decompression by a safety factor of 10 percent and add the product to the volume for decompression for total air volume required.

The volume of gas available in the EBS I may be obtained from Table 17-12 when twin 80-cubic foot scuba bottles are employed or from the following formula when other EBS configurations are used.

$$\text{EBS Volume Available (SCF)} = \frac{F_V \times N \times (P_1 - P_R)}{14.7}$$

Where:

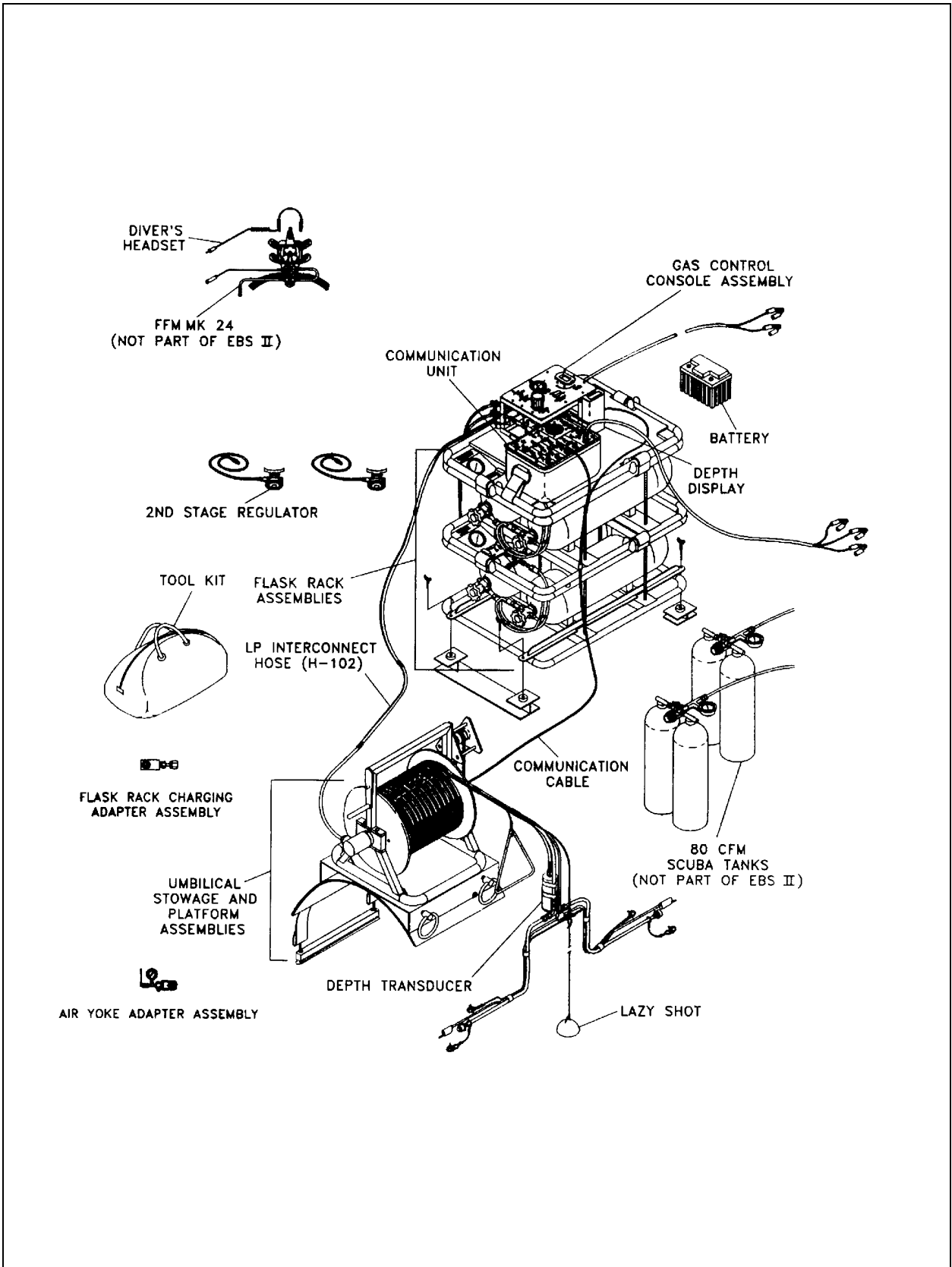


Figure 17-9. EBS II Major Assemblies and Ancillary Equipment.

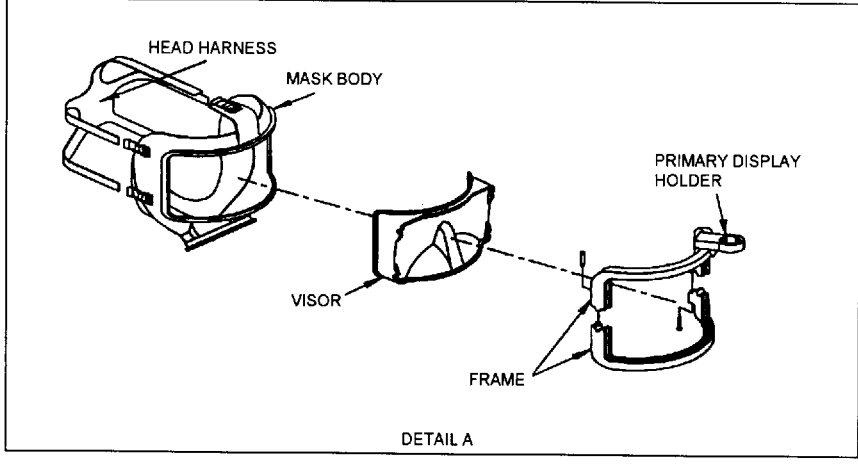
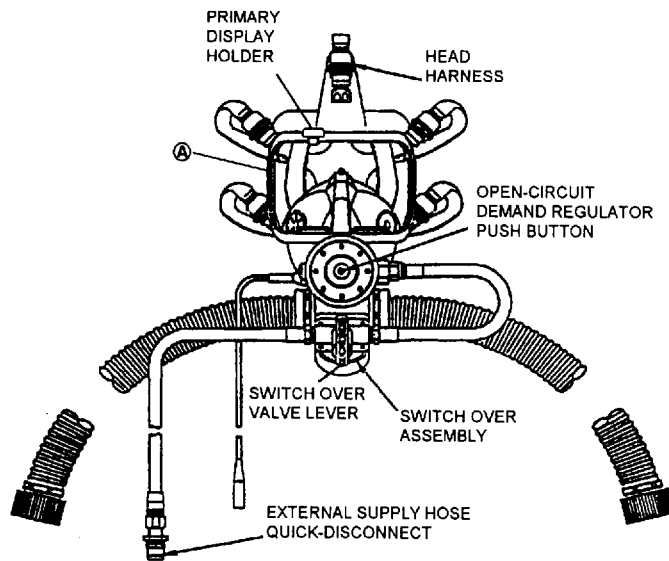


Figure 17-10. Full Face Mask MK 24 MOD 0.



### EBS BREATHING GAS VOLUME WORKSHEET

Depth (fsw)	Time (min)	Consumption (scfm)	Total Volume (scf)
150			
140			
130			
120			
110			
100			
90			
89			
70			
60			
50			
40			
30			
20			
10			
Total volume for decompression			
Add 10% safety factor			
Total standard cubic feet required (scfr)			

**Figure 17-11.** Total EBS Volume Requirements for Decompression.

**Table 17-11.** EBS Gas Consumption at a Light Dive Work Rate.

Depth (fsw)	Gas Consumption (scfm)
10	0.80
20	1.00
30	1.20
40	1.40
50	1.60
60	1.80
70	2.00
80	2.20
90	2.30
100	2.50
110	2.70
120	2.90
130	3.10
140	3.30
150	3.50

**Table 17-12.** EBS Type I Gauge Pressure Versus SCF Available (for Twin 80-Cubic Foot Scuba Bottles).

PSIG	SCF
3000	149.3
2900	143.8
2800	138.4
2700	133.0
2600	127.6
2500	122.1
2400	116.7
2300	111.3
2200	105.8
2100	100.4
2000	95.0
1900	89.6
1800	84.1
1700	78.7
1600	73.3
1500	67.8
1400	62.4
1300	57.0
1200	51.5
1100	46.1
1000	40.7
900	35.3
800	29.8
700	24.4
600	19.0

- $F_V$  = Cylinder Floodable Volume in cubic feet
- $N$  = Number of cylinders
- $P_I$  = Initial pressure in psig
- $P_R$  = Reserve pressure in psig

**Example:** A set of twin 80-cubic foot scuba cylinders is charged to 2,800 psig. The floodable volume of one cylinder is 0.399 cubic foot.

After equalization, a reserve pressure of 250 psig is assumed.

$$\begin{aligned} \text{EBS volume available} &= \frac{0.399 \times 2 \times (2,800 - 250)}{14.7} \\ &= 138.4 \text{ scf} \end{aligned}$$

The following floodable volume numbers are provided for reference:

Scuba 72	0.420
Scuba 80	0.399
Scuba 90	0.398
K Bottle	1.620
EBS II Bottle	0.926

The volume of gas available in the EBS II may be obtained from its O&M technical manual, Appendix B.

The above formula may be rearranged as shown below to determine the minimum bank pressure that will just provide the required EBS volume ( $V_R$ ):

$$P_I = \frac{V_R \times 14.7}{F_V \times N} + P_R$$

#### 17-10.5.4 **EBS Deployment Procedures.**

1. When directed by the Diving Supervisor, the EBS tender shall attach the EBS to either a descent line or the diver's marker float and lower the EBS to 10 fsw below the diver's first decompression stop.
2. Upon arrival at the EBS, the diver(s) shall signal arrival at the EBS (one on the lazy shot). The EBS tender shall report signal receipt to the Diving Supervisor, who will control the divers' ascent to the first decompression stop and continue to control their ascent and stops throughout in-water decompression.

**17-10.6 Omitted Decompression.** Certain emergencies may interrupt or prevent specified decompression. UBA failure, exhausted diluent or oxygen gas supply, and bodily injury are examples that constitute such emergencies. Omitted decompression must be made up to avoid later difficulty. Table 17-13 contains specific guidance for the initial management of omitted decompression in an asymptomatic MK 16 diver. For further information on omitted decompression, see Chapter 21.

**17-10.6.1 At 20 fsw or Shallower.** If the deepest decompression stop omitted is 20 fsw or shallower, the diver may be returned to the water stop at which the omission occurred.

- If the surface interval was less than 1 minute, add 1 minute to the stop time and resume the planned decompression at the point of interruption.
- If the surface interval was greater than 1 minute, compute a new decompression schedule by multiplying the 20- and/or 10-foot stop time(s) by 1.5. After

**Table 17-13. Initial Management of Omitted Decompression in an Asymptomatic MK 16 Diver.**

Deepest Decompression Stop Omitted	Decompression Status	Surface Interval	Action	
			Chamber Available	No Chamber Available
None	No decompression stops required	NA	Observe on surface for 1 hour	Observe on surface for 1 hour
20 fsw or shallower	Decompression stops required	<1 min	Return to depth of stop. Increase stop time by 1 minute. Resume decompression according to original schedule.	Return to depth of stop. Increase stop time by 1 minute. Resume decompression according to original schedule.
		> 1 min	Return to depth of stop. Multiply 20-fsw and/or 10-fsw stop times by 1.5. Resume decompression. Or: Treatment Table 5 for surface interval < 5 min Or: Treatment Table 6 for surface interval > 5 min	Return to depth of stop. Multiply 20-fsw and/or 10-fsw stop times by 1.5. Resume decompression.
Deeper than 20 fsw	Decompression stops required (<30 min missed)	<5 min	Treatment Table 5	Descend to the deepest stop omitted. Multiply all stops 40 fsw and shallower by 1.5. Resume decompression
		>5 min	Treatment Table 6	Descend to the deepest stop omitted. Multiply all stops 40 fsw and shallower by 1.5. Resume decompression
	Decompression stops required (>30 min missed)	Any	Treatment Table 6	Descend to the deepest stop omitted. Multiply all stops 40 fsw and shallower by 1.5. Resume decompression

arrival at the decompression stop at the Diving Supervisor’s discretion the oxygen partial pressure may be manually adjusted to 1.3 ata (increased-rate oxygen supply depletion shall be taken into consideration).

- Ascend on the new decompression schedule. Alternatively, the diver may be removed from the water and treated on Treatment Table 5 (Figure 21-7) if the surface interval is less than 5 minutes, or Treatment Table 6 (Figure 21-8) if the surface interval is greater than 5 minutes.

17-10.6.2 **Deeper than 20 fsw.** If the deepest decompression stop omitted is deeper than 20 fsw, a more serious situation exists. The use of a recompression chamber when immediately available is mandatory.

- If less than 30 minutes of decompression were missed and the surface interval is less than 5 minutes, treat the diver on Treatment Table 5.
- If less than 30 minutes of decompression were missed but the surface interval exceeds 5 minutes, treat the diver on Treatment Table 6.

- If more than 30 minutes of decompression were missed, treat the diver on Treatment Table 6 regardless of the length of the surface interval.

17-10.6.3 **Deeper than 20 fsw/No Recompression Chamber Available.** If the deepest decompression stop omitted is deeper than 20 fsw and a recompression chamber is not immediately available, recompression in the water is required. Recompress the diver in the water using the appropriate 0.7 ata constant  $ppO_2$  decompression table. Descend to the deepest decompression stop omitted and repeat this stop in its entirety. Complete decompression on the original schedule, lengthening all stops 40 fsw and shallower by multiplying the stop time by 1.5. If the deepest stop was 40 fsw or shallower, this stop should also be multiplied by 1.5. After arrival at 40 fsw or shallower, the oxygen partial pressure may be manually adjusted to 1.3 ata (increased-rate oxygen supply depletion shall be taken into consideration). When recompression in the water is required, keep the surface interval as short as possible. The diver's UBA must be checked to ensure that it will sustain the diver for the additional decompression obligation. Switching to a standby UBA may be necessary so that the decompression time will not be compromised by depletion of gas supplies or carbon dioxide-absorbent failure. Maintain depth control, keep the diver at rest, and provide a buddy diver.

17-10.6.4 **Evidence of Decompression Sickness or Arterial Gas Embolism.** If the diver shows evidence of decompression sickness or arterial gas embolism before recompression for omitted decompression can be carried out, immediate treatment using the appropriate oxygen or air treatment table is essential. Guidance for table selection and use is given in Chapter 21. Symptoms that develop during treatment of omitted decompression should be managed in the same manner as recurrences during treatment.

## 17-11 MEDICAL ASPECTS OF CLOSED-CIRCUIT MIXED-GAS UBA

When using a closed-circuit mixed-gas UBA, the diver is susceptible to the usual diving-related illnesses (i.e., decompression sickness, arterial gas embolism, barotrauma, etc.). Volume 5 gives in-depth coverage of all diving-related illnesses. For closed-circuit mixed-gas UBAs there are special medical considerations that must be addressed.

17-11.1 **Central Nervous System (CNS) Oxygen Toxicity.** Toxic effects may result from breathing oxygen at high partial pressures. CNS oxygen toxicity is usually not encountered unless the  $ppO_2$  exceeds 1.6 ata. Environmental factors, however, such as cold and exercise, can make a diver more susceptible. Though the MK 16 UBA maintains a  $ppO_2$  of approximately 0.7/0.75 ata, a rapid descent may not allow the oxygen already in the circuit to be consumed fast enough. In addition, malfunctioning oxygen sensors or oxygen-addition valves can cause a hazardous oxygen level.

17-11.1.1 **Preventing CNS Oxygen Toxicity.** All pre-dive checks must be performed to ensure proper functioning of the oxygen sensors and oxygen-addition valves. Monitoring the primary and secondary displays will help ensure that the proper  $ppO_2$  is maintained. When high levels of oxygen are displayed, the descent must

be slowed. If the diver is in less than 20 fsw, little danger of oxygen toxicity exists. If the diver is deeper than 20 fsw, the O<sub>2</sub> bottle valve shall be secured and manually controlled to maintain the ppO<sub>2</sub> below 1.3 ata.

17-11.1.2 **Symptoms of CNS Oxygen Toxicity.** Symptoms of CNS oxygen toxicity include convulsion (the most serious symptom) and nonconvulsive symptoms. The symptoms may be remembered by the mnemonic device VENTIDC:

- V:** Visual symptoms. Tunnel vision, a decrease in the diver's peripheral vision, and other symptoms, such as blurred vision, may occur.
- E:** Ear symptoms. Tinnitus is any sound perceived by the ears but not resulting from an external stimulus. The sound may resemble bells ringing, roaring, or a machinery-like pulsing sound.
- N:** Nausea or spasmodic vomiting. These symptoms may be intermittent.
- T:** Twitching and tingling symptoms. Any of the small facial muscles, lips, or muscles of the extremities may be affected. These are the most frequent and clearest symptoms.
- I:** Irritability. Any change in the diver's mental status including confusion, agitation, and anxiety.
- D:** Dizziness. Symptoms include clumsiness, incoordination, and unusual fatigue.
- C:** Convulsions. The first sign of CNS oxygen toxicity may be a convulsion with little or no warning.

17-11.1.3 **Treating Nonconvulsive Symptoms of CNS Oxygen Toxicity.** If nonconvulsive symptoms of CNS oxygen toxicity occur, action must be taken immediately to lower the oxygen partial pressure. Such actions include:

- Ascending. Boyle's law will lower the oxygen partial pressure.
- Adding diluent to the breathing loop.
- Securing the oxygen cylinder if oxygen addition is uncontrolled.

17-11.1.4 **Treating CNS Oxygen Toxicity Convulsions.** If a diver convulses:

1. Ventilate the UBA with diluent to lower the ppO<sub>2</sub> and maintain depth until the convulsion subsides.
2. Make a controlled ascent to the first decompression stop.
  - If the diver regains control, continue with appropriate decompression.
  - If the diver remains incapacitated, surface at a moderate rate, establish an airway, and treat for symptomatic omitted decompression as outlined in paragraph 17-10.6.

Frequent monitoring of the primary and secondary displays (every 2-3 minutes) as well as the oxygen- and diluent-bottle pressure gauges will keep the diver well informed of his breathing gas and rig status.

Additional information on recognizing and treating oxygen toxicity is contained in Chapter 3.

- 17-11.2 Oxygen Deficiency (Hypoxia).** Oxygen deficiency, or *hypoxia*, results from breathing a gas mixture in which the partial pressure of oxygen is too low to meet the metabolic demands of the body.
- 17-11.2.1 Causes of Hypoxia.** During a rapid ascent, particularly in shallow water, Boyle's law may cause the  $ppO_2$  to fall faster than can be compensated for by the oxygen-addition system. If, during ascent, low levels of oxygen are displayed, slow the ascent. Add oxygen if necessary. Depletion of the oxygen supply, or malfunctioning oxygen sensors or oxygen-addition valves, can also lead to a hypoxic gas mixture.
- 17-11.2.2 Symptoms of Hypoxia.** In hypoxia, the diver may have no warning symptoms prior to loss of consciousness. Other symptoms that may appear include incoordination, confusion, and dizziness.
- 17-11.2.3 Treating Hypoxia.** If symptoms of hypoxia develop, the diver must take immediate action to raise the oxygen partial pressure. If unconsciousness occurs, the buddy diver should add oxygen to the rig while monitoring the secondary display. If the diver does not require decompression, the buddy diver should bring the afflicted diver to the surface at a moderate rate, remove the mouthpiece or mask, and have him breathe air. If the event was clearly related to hypoxia and the diver recovers fully with normal neurological function shortly after breathing surface air, the diver does not require treatment for arterial gas embolism.
- 17-11.2.4 Treatment of Hypoxic Divers Requiring Decompression.** If the divers require decompression, the buddy diver should bring the afflicted diver to the first decompression stop.
- If consciousness is regained, continue with normal decompression.
  - If consciousness is not regained, ascend to the surface at a moderate rate (not to exceed 30 fpm), establish an airway, administer 100-percent oxygen, and treat for symptomatic omitted decompression as outlined in paragraph 17-10.6. If possible, immediate assistance from the standby diver should be obtained and the unaffected diver should continue normal decompression.
- 17-11.3 Carbon Dioxide Toxicity (Hypercapnia).** Hypercapnia, an abnormally high level of carbon dioxide in the body, may be caused by inadequate carbon dioxide absorption resulting from channeling, flooding of the canister, or carbon dioxide saturation of the absorbent material. Hypercapnia may also be caused by skip breathing or controlled ventilation by the diver.

- 17-11.3.1 **Symptoms of Hypercapnia.** Symptoms of hypercapnia include labored breathing, headache, and confusion. Unconsciousness, however, may occur with little or no warning.
- 17-11.3.2 **Treating Hypercapnia.** If symptoms of hypercapnia develop, the diver should immediately stop work and take several deep breaths. This will reduce the level of carbon dioxide both in the rig and in the diver's lungs. If symptoms do not rapidly abate, the diver should ascend to lower the carbon dioxide partial pressure in both the rig and in the diver's lungs. If unconsciousness occurs, take the actions described above for hypoxia.

### WARNING

**Hypoxia and hypercapnia may give the diver little or no warning prior to onset of unconsciousness.**

- 17-11.4 **Chemical Injury.** The term chemical injury refers to the introduction of a caustic solution from the carbon dioxide scrubber of the UBA into the upper airway of a diver.
- 17-11.4.1 **Causes of Chemical Injury.** A caustic alkaline solution results when water leaking into the canister comes in contact with the carbon dioxide absorbent. When the diver is in a horizontal or head down position, this solution may travel through the inhalation hose and irritate or injure the upper airway.
- 17-11.4.2 **Symptoms of Chemical Injury.** Before actually inhaling the caustic solution, the diver may experience labored breathing or headache, which are symptoms of carbon dioxide buildup in the breathing gas. This occurs because an accumulation of the caustic solution in the canister may be impairing carbon dioxide absorption. If the problem is not corrected promptly, the alkaline solution may travel into the breathing hoses and consequently be inhaled or swallowed. Choking, gagging, foul taste, and burning of the mouth and throat may begin immediately. This condition is sometimes referred to as a "caustic cocktail." The extent of the injury depends on the amount and distribution of the solution.
- 17-11.4.3 **Management of a Chemical Incident.** If the caustic solution enters the mouth, nose, or face mask, the diver must take the following steps:
1. Immediately assume an upright position in the water.
  2. Depress the manual diluent bypass valve continuously.
  3. If the dive is a no-decompression dive, make a controlled ascent to the surface, exhaling through the nose to prevent overpressurization.
  4. If the dive requires decompression, shift to the EBS or another alternative breathing supply. If it is not possible to complete the planned decompression, surface the diver and treat for omitted decompression as outlined in paragraph 17-10.6.



Refer to the appropriate operations and maintenance manual for specific emergency procedures.

Using fresh water, rinse the mouth several times. Several mouthfuls should then be swallowed. If only sea water is available, rinse the mouth but do not swallow. Other fluids may be substituted if available, but the use of weak acid solutions (vinegar or lemon juice) is not recommended. Do not attempt to induce vomiting.

A chemical injury may cause the diver to have difficulty breathing properly on ascent. He should be observed for signs of an arterial gas embolism and should be treated if necessary. A victim of a chemical injury should be evaluated by a physician or corpsman as soon as possible. Respiratory distress which may result from the chemical trauma to the air passages requires immediate hospitalization.

**NOTE** **Performing a careful dip test during pre-dive setup is essential to detect system leaks. Additionally, dive buddies shall check each other's equipment carefully before leaving the surface at the start of a dive.**

**17-11.5 Decompression Sickness in the Water.** Decompression sickness may develop in the water during MK 16 diving. The symptoms of decompression sickness may be joint pain or may be more serious manifestations such as numbness, loss of muscular function, or vertigo.

Managing decompression sickness in the water will be difficult in the best of circumstances. Only general guidance can be presented here. Management decisions must be made on site, taking into account all known factors. The advice of a Diving Medical Officer should be sought whenever possible.

**17-11.5.1 Diver Remaining in Water.** If the diver signals that he has decompression sickness but feels that he can remain in the water:

1. Dispatch the standby diver to assist.
2. Have the diver descend to the depth of relief of symptoms in 10-fsw increments, but no deeper than two increments (i.e., 20 fsw).
3. Raise the oxygen partial pressure in the rig manually to 1.3 ata.
4. Compute a new decompression profile by multiplying all stops by 1.5. If recompression went deeper than the depth of the first stop on the original decompression schedule, use a stop time equal to 1.5 times the first stop in the original decompression schedule for the one or two stops deeper than the original first stop.
5. Ascend on the new profile, controlling the rig manually at 1.3 ata until leaving the 20-fsw stop.
6. Lengthen stops as needed to control symptoms. Do not combine the 20-fsw and 10-fsw stops.

7. Upon surfacing, transport the diver to the nearest chamber. If he is asymptomatic, treat on Treatment Table 5. If he is symptomatic, treat in accordance with the guidance given in Volume 5, Chapter 21 (Figure 21-3).

17-11.5.2 **Diver Leaving the Water.** If the diver signals that he has decompression sickness but feels that he cannot remain in the water:

1. Surface the diver at a moderate rate (not to exceed 30 fpm).
2. If a recompression chamber is on site (i.e., within 30 minutes), recompress the diver immediately. Guidance for treatment table selection and use is given in Chapter 21.

If a recompression chamber is not on site, follow the management guidance given in Volume 5. MK 16 DIVING EQUIPMENT REFERENCE DATA

Figure 17-12 outlines the capabilities and logistical requirements of the MK 16 UBA mixed-gas diving system. Minimum required equipment for the pool phase of diving conducted at Navy diving schools and MK 16 RDT&E commands may be modified as necessary. Any modification to the minimum required equipment listed herein must be noted in approved lesson training guides or SOPs.

## **MK 16 UBA General Characteristics**

### **Principle of Operation:**

Self-contained closed-circuit constant ppO<sub>2</sub> system

### **Minimum Equipment:**

1. MK IV or MK 6 (Shadow 806 LM) Life Jacket with four 30-34-gram CO<sub>2</sub> cartridges
2. Dive knife
3. Swim fins
4. Face mask or full face mask (FFM)
5. Weight belt (as required)
6. Dive watch or Dive Timer/Depth Gauge (DT/DG) (as required)
7. Depth gauge or DT/DG (as required)

### **Principal Applications:**

1. EOD operations/Special warfare
2. Search and inspection
3. Light repair and recovery

### **Advantages:**

1. Minimal surface bubbles
2. Optimum efficiency of gas supply
3. Portability
4. Excellent mobility
5. Communications (when used with MK 24 FFM)
6. Modularized assembly
7. Low magnetic signature (lo-mu)
8. Low acoustic signature

### **Disadvantages:**

1. Extended decompression requirement for long bottom times or deep dives.
2. Limited physical and thermal protection
3. No voice communications (unless FFM used)
4. Extensive pre-dive/post-dive procedures

### **Restrictions:**

Working limit 150 feet, air diluent; 200 fsw, HeO<sub>2</sub> diluent

### **Operational Considerations:**

1. Dive team (Table 17-1)
2. Safety boat(s) required
3. MK 16 decompression schedule must be used (unless using CSMD procedure 70 fsw and shallower, or air decompression procedures 70 fsw and shallower)

**Figure 17-12.** MK 16 UBA General Characteristics.

**Table 17-14.** Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Nitrogen.  
(DESCENT RATE 60 FPM-ASCENT RATE 30 FPM)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw) Stop Times (min)											Total Ascent Time (min:sec)	Repet Group			
			130	120	110	100	90	80	70	60	50	40	30			20	10	
<b>40</b>	367	1:20														0	1:20	Z
	Limit Line																	
	370	1:00														1	2:20	*
	380	1:00														2	3:20	*
	390	1:00													3	4:20	*	
<b>50</b>	143	1:40														0	1:40	O
	150	1:20														4	5:40	O
	160	1:20														8	9:40	O
	170	1:20														12	13:40	O
	180	1:20														16	17:40	Z
	190	1:20														19	20:40	Z
	200	1:20														22	23:40	Z
	210	1:20														25	26:40	Z
	220	1:20														29	30:40	Z
	230	1:20														33	34:40	Z
	240	1:20														38	39:40	Z
	250	1:20														42	43:40	Z
	260	1:20														46	47:40	Z
	270	1:20														49	50:40	Z
	280	1:20														53	54:40	Z
	290	1:20														56	57:40	Z
	300	1:20														59	60:40	Z
	310	1:20														62	63:40	Z
	320	1:20														64	65:40	Z
	330	1:20														67	68:40	Z
Limit Line																		
	340	1:20														70	71:40	*
	350	1:20														73	74:40	*
	360	1:20														77	78:40	*
	370	1:20														80	81:40	*
	380	1:20														84	85:40	*
	390	1:20														87	88:40	*
<b>60</b>	74	2:00														0	2:00	L
	80	1:40														4	6:00	L
	90	1:40														9	11:00	M
	100	1:40														13	15:00	N
	110	1:40														17	19:00	O
	120	1:40														25	27:00	O
	130	1:40														32	34:00	O
	140	1:40														39	41:00	O
	150	1:40													45	47:00	Z	
	160	1:40													50	52:00	Z	

\* Repetitive dives are not authorized for dives below the Limit Line.

**Table 17-14.** Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Nitrogen (Continued).  
(DESCENT RATE 60 FPM-ASCENT RATE 30 FPM)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw) Stop Times (min)												Total Ascent Time (min:sec)	Repet Group		
			130	120	110	100	90	80	70	60	50	40	30	20			10	
<b>60</b>	170	1:40													56	58:00	Z	
	180	1:20												4	56	65:00	Z	
	190	1:20												8	62	72:00	Z	
	200	1:20												12	65	79:00	Z	
	210	1:20												16	68	86:00	Z	
	220	1:20												19	71	92:00	Z	
	230	1:20												22	74	98:00	Z	
	240	1:20												25	76	103:00	Z	
	250	1:20												28	79	109:00	Z	
	260	1:20												30	82	114:00	Z	
	270	1:20												32	85	119:00	Z	
	280	1:20												36	87	125:00	Z	
	Limit Line																	
	290	1:20													40	89	131:00	*
300	1:20													44	92	138:00	*	
310	1:20													47	94	143:00	*	
320	1:20													51	96	149:00	*	
330	1:20													54	98	154:00	*	
340	1:20													57	100	159:00	*	
350	1:20													60	102	164:00	*	
360	1:20													63	105	170:00	*	
370	1:20													66	108	176:00	*	
380	1:20													68	111	181:00	*	
390	1:20													71	114	187:00	*	
<b>70</b>	51	2:20													0	2:20	K	
	60	2:00													9	11:20	L	
	70	2:00													18	20:20	L	
	80	2:00													25	27:20	N	
	90	1:40												3	28	33:20	N	
	100	1:40												8	33	43:20	O	
	110	1:40												12	39	53:20	O	
	120	1:40												16	45	63:20	Z	
	130	1:40												19	51	72:20	Z	
	140	1:40												22	56	80:20	Z	
	150	1:40												29	58	89:20	Z	
	160	1:40												36	62	100:20	Z	
	170	1:40												43	65	110:20	Z	
	Limit Line																	
180	1:40													48	70	120:20	*	
190	1:20												1	53	73	129:20	*	
200	1:20												2	57	76	137:20	*	
210	1:20												6	57	80	145:20	*	
220	1:20												11	56	84	153:20	*	
230	1:20												14	59	86	161:20	*	
240	1:20												18	62	89	171:20	*	

\* Repetitive dives are not authorized for dives below the Limit Line.

**Table 17-14.** Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Nitrogen (Continued).  
(DESCENT RATE 60 FPM-ASCENT RATE 30 FPM)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw) Stop Times (min)										Total Ascent Time (min:sec)	Repet Group				
			130	120	110	100	90	80	70	60	50	40			30	20	10	
<b>70</b>	250	1:20												21	65	92	180:20	*
	260	1:20												24	69	93	188:20	*
	270	1:20												27	71	97	197:20	*
	280	1:20												29	75	99	205:20	*
	290	1:20												31	78	102	213:20	*
	300	1:20												33	81	105	221:20	*
	310	1:20												35	83	110	230:20	*
	320	1:20												37	86	113	238:20	*
	330	1:20												42	85	118	247:20	*
	340	1:20												45	86	124	257:20	*
	350	1:20												49	88	127	266:20	*
<b>80</b>	39	2:40													0	2:40	J	
	40	2:20													1	3:40	J	
	50	2:20													15	17:40	K	
	60	2:20													27	29:40	L	
	70	2:00												9	28	39:40	M	
	80	2:00												18	28	48:40	N	
	90	2:00												25	34	61:40	O	
	Limit Line																	
	100	1:40												3	28	42	75:40	*
	110	1:40												8	28	50	88:40	*
	120	1:40												12	29	57	100:40	*
	130	1:40												16	36	57	111:40	*
	140	1:40												19	42	62	125:40	*
	150	1:40												21	49	66	138:40	*
	160	1:40												24	55	70	151:40	*
	170	1:40												29	57	75	163:40	*
	180	1:40												36	57	79	174:40	*
	190	1:40												43	56	84	185:40	*
	200	1:20											1	47	60	86	196:40	*
	210	1:20											2	52	64	89	209:40	*
	220	1:20											3	56	68	92	221:40	*
	230	1:20											7	56	73	96	234:40	*
	240	1:20											11	56	77	99	245:40	*
	250	1:20											14	57	80	104	257:40	*
	260	1:20											18	57	84	109	270:40	*
	270	1:20											21	59	85	116	283:40	*
	280	1:20											24	63	85	123	297:40	*
	290	1:20											27	66	85	130	310:40	*
	300	1:20											29	70	88	133	322:40	*
	310	1:20											31	73	91	137	334:40	*
	320	1:20											33	76	94	141	346:40	*

\* Repetitive dives are not authorized for dives below the Limit Line.

**Table 17-14.** Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Nitrogen (Continued).  
(DESCENT RATE 60 FPM-ASCENT RATE 30 FPM)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw) Stop Times (min)											Total Ascent Time (min:sec)	Repet Group				
			130	120	110	100	90	80	70	60	50	40	30			20	10		
<b>90</b>	32	3:00													0	3:00	J		
	40	2:40													14	17:00	J		
	50	2:20												3	28	34:00	L		
	60	2:20												17	28	48:00	M		
	70	12:00												1	28	28	60:00	N	
	Limit Line																		
	80	2:00													10	29	34	76:00	*
	90	2:00													19	28	43	93:00	*
	100	2:00													26	28	52	109:00	*
	110	1:40										4	28	32	57	124:00	*		
120	1:40										9	28	40	62	142:00	*			
130	1:40										13	28	49	66	159:00	*			
140	1:40										16	29	56	72	176:00	*			
150	1:40										19	36	56	76	190:00	*			
160	1:40										22	42	57	81	205:00	*			
170	1:40										24	49	57	88	221:00	*			
180	1:40										26	55	61	91	236:00	*			
190	1:40										32	56	67	94	252:00	*			
<b>100</b>	27	3:20													0	3:20	I		
	30	3:00													6	9:20	J		
	35	3:00													17	20:20	J		
	40	3:00													28	31:20	K		
	45	2:40													10	28	41:20	L	
	50	2:40													19	28	50:20	L	
	55	2:40													27	29	59:20	M	
	60	2:20													7	28	28	66:20	N
	65	2:20													14	28	28	73:20	O
	Limit Line																		
70	2:20														20	28	31	82:20	*
75	2:20														26	28	36	93:20	*
80	2:00										3	28	29	41	104:20	*			
90	2:00										13	28	28	52	124:20	*			
100	2:00										21	28	33	61	146:20	*			
110	2:00										27	29	43	65	167:20	*			
<b>110</b>	24	3:40													0	3:40	I		
	25	3:20													3	6:40	I		
	30	3:20													17	20:40	J		
	35	3:00													2	28	33:40	K	
	40	3:00													14	28	45:40	K	
	45	3:00													25	28	56:40	L	
	Limit Line																		
50	2:40														7	28	28	66:40	*
55	2:40														16	28	29	76:40	*
60	2:40														25	28	28	84:40	*

\* Repetitive dives are not authorized for dives below the Limit Line.

**Table 17-14.** Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Nitrogen (Continued).  
(DESCENT RATE 60 FPM-ASCENT RATE 30 FPM)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw) Stop Times (min)										Total Ascent Time (min:sec)	Repet Group								
			130	120	110	100	90	80	70	60	50	40			30	20	10					
<b>110</b>	65	2:20												4	29	28	32	96:40	*			
	70	2:20												12	28	28	38	109:40	*			
	80	2:20												24	28	29	50	134:40	*			
	90	2:00												7	28	28	33	65	164:40	*		
<b>120</b>	19	4:00															0	4:00	H			
	20	3:40															1	5:00	I			
	25	3:40															12	16:00	J			
	30	3:20														4	24	32:00	J			
	35	3:20														14	29	47:00	K			
	40	3:00													5	23	28	60:00	L			
	Limit Line																					
	45	3:00													12	28	28	72:00	*			
	50	2:40													2	21	28	28	83:00	*		
	55	2:40													6	27	29	28	94:00	*		
60	2:40													14	29	28	32	107:00	*			
70	2:20													3	28	28	29	48	140:00	*		
80	2:20													17	28	28	30	68	175:00	*		
<b>130</b>	16	4:20															0	4:20	H			
	20	4:00															6	10:20	I			
	25	3:40														5	17	26:20	J			
	30	3:20														3	9	27	43:20	K		
	35	3:20														7	20	28	59:20	L		
	40	3:00													1	14	27	28	74:20	M		
	Limit Line																					
	45	3:00													7	20	28	28	87:20	*		
50	3:00													13	26	28	29	100:20	*			
60	2:40													7	26	28	28	42	135:20	*		
70	2:40													23	28	28	28	66	177:20	*		
<b>140</b>	13	4:40															0	4:40	G			
	15	4:20															2	6:40	H			
	20	4:00															4	7	15:40	J		
	25	3:40														4	7	21	36:40	J		
	30	3:20														2	7	13	28	54:40	L	
	Limit Line																					
	35	3:20														5	12	23	28	72:40	*	
	40	3:00														1	10	16	28	29	88:40	*
	45	3:00														4	14	24	28	28	102:40	*
	50	3:00														10	17	28	28	34	121:40	*
	60	2:40													6	16	29	28	28	59	170:40	*
	70	2:40													14	28	28	29	34	79	216:40	*

\* Repetitive dives are not authorized for dives below the Limit Line.



**Table 17-14.** Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Nitrogen (Continued).  
(DESCENT RATE 60 FPM-ASCENT RATE 30 FPM)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw) Stop Times (min)												Total Ascent Time (min:sec)	Repet Group		
			130	120	110	100	90	80	70	60	50	40	30	20			10	
<b>150</b>	11	5:00														0	5:00	F
	15	4:20													2	4	11:00	H
	20	4:00												2	7	10	24:00	J
	25	3:40											3	6	8	24	46:00	K
	30	3:20									1	7	8	17	29	67:00	L	
	Limit Line																	
	35	3:20										4	8	14	26	28	85:00	*
	40	3:20										7	15	19	28	28	102:00	*
	45	3:00									2	13	14	28	28	34	124:00	*
	50	3:00								8	14	21	28	28	48	152:00	*	
60	2:40							4	14	22	28	29	30	75	207:00	*		
70	2:40							11	22	29	28	28	50	91	264:00	*		
<b>160</b>	Limit Line																	
	9	5:20														0	5:20	*
	10	5:00														1	6:20	*
	15	4:20												1	4	5	15:20	*
	20	4:00											1	6	7	13	32:20	*
	25	3:40									1	7	7	10	26	56:20	*	
	30	3:40									7	7	10	20	29	78:20	*	
	40	3:20								7	11	14	23	28	35	123:20	*	
50	3:00							5	14	14	26	28	29	63	184:20	*		
<b>170</b>	Limit Line																	
	8	5:40														0	5:40	*
	10	5:20														3	8:40	*
	15	4:20											1	3	3	7	19:40	*
	20	4:00										1	4	7	7	17	41:40	*
	25	4:00										7	7	6	13	28	66:40	*
	30	3:40									6	7	7	13	24	28	90:40	*
	40	3:20							6	8	14	14	27	28	44	146:40	*	
50	3:00						3	13	14	17	28	28	35	75	218:40	*		

\* Repetitive dives are not authorized for dives below the Limit Line.

**Table 17-15.** Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Helium.  
(DESCENT RATE 60 FPM-ASCENT RATE 30 FPM)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw) Stop Times (min)														Total Ascent Time (min:sec)				
			190	180	170	160	150	140	130	120	110	100	90	80	70	60		50	40	30	20
<b>40</b>	300	1:20																		0	1:20
	370	1:20																		0	1:20
	Limit Line																				
	380	1:20																		0	1:20
	390	1:20																		0	1:20
<b>50</b>	205	1:40																		0	1:40
	210	1:20																		3	4:40
	220	1:20																		9	10:40
	230	1:20																		15	16:40
	240	1:20																		20	21:40
	250	1:20																		25	26:40
	Limit Line																				
	260	1:20																		29	30:40
	270	1:20																		34	35:40
	280	1:20																		38	39:40
	290	1:20																		42	43:40
	300	1:20																		45	46:40
	310	1:20																		49	50:40
	320	1:20																		52	53:40
	330	1:20																		55	56:40
	340	1:20																		58	59:40
350	1:20																		61	62:40	
360	1:20																		63	64:40	
370	1:20																		66	67:40	
380	1:20																		68	69:40	
390	1:20																		70	71:40	
<b>60</b>	133	2:00																		0	2:00
	140	1:40																		8	10:00
	150	1:40																		20	22:00
	160	1:40																		30	32:00
	170	1:40																		40	42:00
	Limit Line																				
	180	1:40																		50	52:00
	190	1:40																		59	61:00
	200	1:40																		67	69:00
	210	1:40																		75	77:00
	220	1:40																		83	85:00
	230	1:40																		90	92:00
	240	1:40																		97	99:00
	250	1:40																		103	105:00
	260	1:40																		109	111:00
	270	1:20																	2	112	116:00
280	1:20																	7	113	123:00	
290	1:20																	12	113	128:00	
300	1:20																	17	113	133:00	

**Table 17-15.** Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Helium (Continued).  
(DESCENT RATE 60 FPM-ASCENT RATE 30 FPM)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw)															Total Ascent Time (min:sec)					
			Stop Times (min)																				
			190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10		
<b>60</b>	310	1:20																		21	113	137:00	
	320	1:20																		25	113	141:00	
	330	1:20																		29	113	145:00	
	340	1:20																		33	113	149:00	
	350	1:20																		37	113	153:00	
	360	1:20																		40	113	156:00	
	370	1:20																		43	113	159:00	
	380	1:20																		46	113	162:00	
	390	1:20																		49	113	165:00	
<b>70</b>	81	2:20																		0	2:20		
	90	2:00																		6	8:20		
	100	2:00																		13	15:20		
	110	2:00																		19	21:20		
	120	2:00																		35	37:20		
	130	2:00																		50	52:20		
	140	2:00																		65	67:20		
	Limit Line																						
	150	2:00																		79	81:20		
	160	2:00																		92	94:20		
	170	2:00																		104	106:20		
	180	1:40																		7	109	118:20	
	190	1:40																		14	113	129:20	
	200	1:40																		25	112	139:20	
	210	1:40																		34	113	149:20	
220	1:40																		44	112	158:20		
230	1:40																		52	113	167:20		
240	1:40																		60	113	175:20		
250	1:40																		68	113	183:20		
260	1:40																		76	112	190:20		
270	1:40																		83	112	197:20		
<b>80</b>	51	2:40																		0	2:40		
	60	2:20																		6	8:40		
	70	2:20																		14	16:40		
	80	2:20																		25	27:40		
	90	2:20																		33	35:40		
	100	2:00																	3	43	48:40		
	110	2:00																	9	58	69:40		
	120	2:00																	14	72	88:40		
	Limit Line																						
	130	2:00																		19	85	106:40	
140	2:00																		23	99	124:40		
150	2:00																		33	105	140:40		
160	2:00																		43	111	156:40		

**Table 17-15.** Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Helium (Continued).  
(DESCENT RATE 60 FPM-ASCENT RATE 30 FPM)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw)													Total Ascent Time (min:sec)						
			190	180	170	160	150	140	130	120	110	100	90	80	70		60	50	40	30	20	10
<b>80</b>	170	2:00																	55	113	170:40	
	180	2:00																	69	113	184:40	
	190	2:00																	82	113	197:40	
<b>90</b>	37	3:00																	0	3:00	3:00	
	40	2:40																	4	7:00	7:00	
	50	2:40																	15	18:00	18:00	
	60	2:20																	1	23	27:00	
	70	2:20																	7	31	41:00	
	80	2:20																	12	38	53:00	
	90	2:20																	23	42	66:00	
	100	2:20																	31	60	94:00	
	110	2:00																	1	37	77	118:00
	120	2:00																	7	37	93	140:00
	Limit Line																					
	130	2:00																	12	45	101	161:00
	140	2:00																	16	54	108	181:00
150	2:00																	20	65	112	200:00	
160	2:00																	23	80	112	218:00	
<b>100</b>	29	3:20																	0	3:20	3:20	
	30	3:00																	2	5:20	5:20	
	35	3:00																	11	14:20	14:20	
	40	3:00																	19	22:20	22:20	
	50	2:40																	10	22	35:20	
	60	2:40																	19	26	48:20	
	70	2:20																	3	22	37	65:20
	80	2:20																	7	31	39	80:20
	90	2:20																	12	37	58	110:20
	100	2:20																	21	38	76	138:20
	Limit Line																					
	110	2:20																	30	37	96	166:20
	120	2:20																	36	50	102	191:20
130	2:00																	5	37	61	109	215:20
140	2:00																	10	37	75	113	238:20
<b>110</b>	22	3:40																	0	3:40	3:40	
	25	3:20																	3	6:40	6:40	
	30	3:20																	14	17:40	17:40	
	35	3:00																	3	22	28:40	
	40	3:00																	12	22	37:40	
	50	2:40																	4	22	22	51:40
	60	2:40																	14	22	31	70:40
	70	2:40																	21	27	37	88:40

**Table 17-15.** Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Helium (Continued).  
(DESCENT RATE 60 FPM-ASCENT RATE 30 FPM)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw) Stop Times (min)														Total Ascent Time (min:sec)					
			190	180	170	160	150	140	130	120	110	100	90	80	70	60		50	40	30	20	10
<b>110</b>	80	2:20														4	22	37	54	120:40		
	90	2:20														8	30	38	75	154:40		
	100	2:20														12	37	38	95	185:40		
	Limit Line																					
	110	2:20														21	37	51	103	215:40		
	120	2:20														29	37	64	109	242:40		
	130	2:20														35	38	80	113	269:40		
	140	2:20														3	38	50	88	113	295:40	
<b>120</b>	18	4:00																	0	4:00		
	20	3:40																	3	7:00		
	25	3:20																1	12	17:00		
	30	3:20																6	21	31:00		
	35	3:20																17	21	42:00		
	40	3:00															5	22	21	52:00		
	50	3:00															20	22	23	69:00		
	60	2:40															9	22	22	36	93:00	
	70	2:40															17	22	33	50	126:00	
	80	2:20															1	22	28	37	72	164:00
	Limit Line																					
	90	2:20															5	23	37	38	93	200:00
	100	2:20															8	32	37	49	104	234:00
110	2:20															12	38	37	64	111	266:00	
120	2:20															21	37	40	83	112	297:00	
<b>130</b>	13	4:20																	0	4:20		
	15	4:00																	1	5:20		
	20	4:00																	9	13:20		
	25	3:40																	7	17	28:20	
	30	3:20																3	14	22	43:20	
	35	3:20																8	22	22	56:20	
	40	3:00															1	18	22	22	67:20	
	50	3:00															14	22	22	26	88:20	
	60	2:40															5	22	21	25	47	124:20
	70	2:40															13	22	23	37	69	168:20
	Limit Line																					
	80	2:40															19	22	35	38	91	209:20
	90	2:20															2	22	30	38	44	107
100	2:20															5	25	38	37	62	113	284:20
110	2:20															7	34	38	38	85	113	319:20
120	2:20															13	37	38	54	92	113	351:20
<b>140</b>	11	4:40																	0	4:40		
	15	4:20																	4	8:40		
	20	4:00																6	9	19:40		

**Table 17-15.** Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Helium (Continued).  
(DESCENT RATE 60 FPM-ASCENT RATE 30 FPM)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw)													Total Ascent Time (min:sec)																	
			190	180	170	160	150	140	130	120	110	100	90	80	70		60	50	40	30	20	10											
<b>140</b>	25	3:40															5	9	21	39:40													
	30	3:20															1	10	19	22	56:40												
	35	3:20															6	16	22	22	70:40												
	40	3:20															12	22	22	22	82:40												
	50	3:00															9	22	21	22	32	110:40											
	60	3:00															22	22	22	29	64	163:40											
	70	2:40															9	22	22	28	38	90	213:40										
	Limit Line																																
	80	2:40															16	22	26	38	38	113	257:40										
	90	2:40															21	23	37	38	61	113	297:40										
	100	2:20															2	22	34	37	38	86	113	336:40									
<b>150</b>	9	5:00																				0	5:00										
	10	4:40																				1	6:00										
	15	4:20																				3	6	14:00									
	20	4:00																				3	9	12	29:00								
	25	3:40																				2	10	12	22	51:00							
	30	3:40																				9	11	22	22	69:00							
	35	3:20																				4	10	22	21	22	84:00						
	40	3:20																				7	20	21	22	22	97:00						
	45	3:20																				16	21	22	22	29	115:00						
	50	3:00																				3	22	22	22	21	53	148:00					
	55	3:00																				11	22	21	22	26	72	179:00					
	60	3:00																				17	22	22	22	34	86	208:00					
	Limit Line																																
	70	2:40																				6	21	22	22	34	38	113	261:00				
	80	2:40																				13	22	21	33	38	63	113	308:00				
	90	2:40																				18	22	38	38	37	88	113	351:00				
<b>155</b>	9	5:10																								0	5:10						
	10	4:50																								2	7:10						
	15	4:10																							1	4	7	17:10					
	20	3:50																							1	5	9	14	34:10				
	25	3:50																							6	9	15	21	56:10				
	30	3:30																							3	9	14	22	22	75:10			
	35	3:30																							8	12	22	22	22	91:10			
	40	3:10																							2	10	22	22	22	21	104:10		
	45	3:10																							4	19	22	22	22	39	133:10		
	50	3:10																							11	22	22	22	21	65	168:10		
	55	3:10																							19	22	22	22	27	83	200:10		
	60	2:50																							4	22	22	22	21	36	99	231:10	
	Limit Line																																
	70	2:50																							14	22	22	22	37	49	113	284:10	
	80	2:50																							22	22	22	36	37	76	113	333:10	
	90	2:30																							5	22	22	35	37	38	100	113	377:10

**Table 17-15.** Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Helium (Continued).  
(DESCENT RATE 60 FPM-ASCENT RATE 30 FPM)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw) Stop Times (min)															Total Ascent Time (min:sec)			
			190	180	170	160	150	140	130	120	110	100	90	80	70	60	50		40	30	20
<b>160</b>	8	5:20																		0	5:20
	10	5:00																		3	8:20
	15	4:20																2	4	8	19:20
	20	4:00															2	7	9	16	39:20
	25	4:00															9	9	17	22	62:20
	30	3:40														7	9	17	22	21	81:20
	35	3:20													2	9	16	22	22	22	98:20
	40	3:20													5	14	22	22	22	24	114:20
	45	3:20													9	22	22	22	22	50	152:20
	50	3:20													19	22	22	22	21	77	188:20
	Limit Line																				
	55	3:00													6	21	22	22	29	95	222:20
	60	3:00													13	21	22	23	37	111	254:20
	70	2:40													2	21	22	24	38	62	309:20
	80	2:40													9	22	24	38	37	89	359:20
	90	2:40													15	22	22	38	42	110	404:20
<b>165</b>	8	5:30																		0	5:30
	10	5:10																		4	9:30
	15	4:30																	4	3	22:30
	20	4:10															4	8	9	18	44:30
	25	3:50														3	9	10	19	21	67:30
	30	3:30														1	9	9	20	22	88:30
	35	3:30														6	9	19	22	22	105:30
	40	3:30														9	18	21	22	34	131:30
	45	3:10														3	14	22	21	63	172:30
	50	3:10														5	22	22	22	89	209:30
	Limit Line																				
	55	3:10														14	22	21	32	107	245:30
	60	3:10														21	22	25	46	113	276:30
	70	2:50														11	22	27	37	113	335:30
	80	2:50														19	21	28	38	102	385:30
<b>170</b>	7	5:40																		0	5:40
	10	5:00																	1	4	10:40
	15	4:20																1	4	5	24:40
	20	4:00															1	5	9	19	48:40
	25	4:00															6	10	9	21	73:40
	30	3:40															4	10	9	22	94:40
	35	3:40															10	9	22	21	111:40
	40	3:20															4	9	21	46	150:40
	45	3:20															7	17	22	74	191:40
	50	3:20															13	22	22	102	231:40
	Limit Line																				
	55	3:00															1	21	39	112	266:40
	60	3:00															8	22	60	113	300:40

**Table 17-15.** Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Helium (Continued).  
(DESCENT RATE 60 FPM-ASCENT RATE 30 FPM)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw)																Total Ascent Time (min:sec)				
			Stop Times (min)																				
			190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10		
<b>170</b>	70	3:00												20	21	22	22	30	37	90	113	360:40	
	80	2:40											6	22	22	22	30	38	42	113	113	413:40	
<b>175</b>	7	5:50																			0	5:50	
	10	5:10																		2	4	11:50	
	15	4:30															3	3	6	10		27:50	
	20	4:10															3	6	9	9	21	53:50	
	25	3:50														1	9	9	11	22	21	78:50	
	30	3:50															8	9	12	22	22	100:50	
	35	3:30														4	9	13	22	21	22	122:50	
	40	3:30															8	11	22	22	22	168:50	
	Limit Line																						
	45	3:10													1	10	21	22	22	22	22	86	211:50
	50	3:10													3	18	22	22	22	22	26	112	252:50
	55	3:10													9	21	22	22	22	22	53	113	289:50
60	3:10													16	22	22	22	22	29	73	113	324:50	
70	2:50												7	21	22	22	22	32	38	104	113	386:50	
80	2:50												15	22	22	22	34	37	57	113	113	440:50	
<b>180</b>	7	6:00																			0	6:00	
	10	5:20																		4	3	13:00	
	15	4:40															4	4	7	9		30:00	
	20	4:00														1	4	6	10	10	22	59:00	
	25	4:00														4	9	9	13	22	22	85:00	
	30	3:40														2	10	9	15	21	22	107:00	
	35	3:40														8	9	15	22	22	22	140:00	
	40	3:20												3	9	14	15	22	22	22	68	188:00	
Limit Line																							
45	3:20													5	13	22	22	22	21	22	101	234:00	
50	3:20													7	22	22	22	22	22	39	113	275:00	
55	3:20													17	22	22	22	21	22	69	113	314:00	
60	3:00												3	22	22	22	22	21	32	87	113	350:00	
70	3:00												16	21	22	22	22	35	43	113	113	413:00	
<b>185</b>	7	6:10																			0	6:10	
	10	5:10																		1	4	3	14:10
	15	4:30															2	3	4	8	10	33:10	
	20	4:10															2	4	8	10	12	21	63:10
	25	3:50														1	6	9	10	15	22	21	90:10
	30	3:50														6	9	9	18	22	21	22	113:10
	35	3:30														2	10	9	18	22	22	47	158:10
	40	3:30														6	10	18	22	21	22	81	208:10
	Limit Line																						
	45	3:30														9	17	21	22	22	23	112	254:10
50	3:10													2	13	22	22	22	22	54	112	297:10	



**Table 17-15.** Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Helium (Continued).  
(DESCENT RATE 60 FPM-ASCENT RATE 30 FPM)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw) Stop Times (min)															Total Ascent Time (min:sec)			
			190	180	170	160	150	140	130	120	110	100	90	80	70	60	50		40	30	20
<b>185</b>	55	3:10										4	21	22	22	22	22	23	83	113	338:10
	60	3:10										12	22	21	22	22	22	34	101	113	375:10
	70	2:50									3	22	21	22	22	23	37	58	113	113	440:10
<b>190</b>	6	6:20																		0	6:20
	10	5:20																2	4	3	15:20
	15	5:40													3	4	4	9	9	35:20	
	20	4:20												4	4	9	10	13	22	68:20	
	25	4:00											2	8	10	9	17	22	22	96:20	
	30	4:00												9	10	9	20	22	21	119:20	
	35	3:40											6	9	10	21	22	22	58	175:20	
	40	3:20										1	9	10	21	22	22	21	22	228:20	
	Limit Line																				
	45	3:20										4	9	20	22	22	22	22	36	276:20	
	50	3:20										6	17	22	22	22	22	22	68	320:20	
	55	3:20										12	22	21	22	22	22	25	97	362:20	
	60	3:20										20	22	22	22	22	22	38	113	399:20	
70	3:10									12	22	21	22	22	25	38	74	113	468:20		
<b>195</b>	6	6:30																		6:30	
	10	5:30															3	4	4	17:30	
	15	4:30												1	3	4	5	9	11	39:30	
	20	4:10											2	3	6	9	10	15	22	73:30	
	25	4:10											4	10	9	9	20	21	22	101:30	
	30	3:50										4	9	9	10	22	22	22	31	135:30	
	35	3:30									1	9	9	12	22	21	22	22	69	193:30	
	40	3:30									5	9	12	22	22	22	22	22	106	248:30	
	Limit Line																				
	45	3:30									8	11	22	22	22	21	22	51	113	298:30	
	50	3:10								1	9	21	22	22	22	22	22	83	113	343:30	
	55	3:10								2	18	22	22	22	21	22	28	111	113	387:30	
	60	3:10								7	22	22	22	21	22	23	55	112	113	425:30	
<b>200</b>	6	6:40																		6:40	
	10	5:20														1	3	4	4	18:40	
	15	4:40												2	4	4	6	9	12	43:30	
	20	4:20											3	4	7	9	10	17	21	77:30	
	25	4:00										2	6	9	9	10	21	22	22	107:30	
	30	4:00										7	10	9	12	22	22	22	42	152:30	
	35	3:40									4	10	9	15	21	22	22	22	81	212:30	
	Limit Line																				
	40	3:40									9	9	15	22	22	22	22	28	113	268:30	
	45	3:20								3	9	15	22	21	22	22	22	65	113	320:30	
	50	3:20								5	13	21	22	22	22	22	22	100	113	368:30	
	55	3:20								7	21	22	22	22	22	22	41	113	113	411:30	
	60	3:20								16	21	22	22	22	22	25	70	112	113	451:30	

**Table 17-15.** Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Helium (Continued).  
(DESCENT RATE 60 FPM-ASCENT RATE 30 FPM)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw)														Total Ascent Time (min:sec)					
			190	180	170	160	150	140	130	120	110	100	90	80	70	60		50	40	30	20	10
<b>205</b>	6	6:50																		0	6:50	
	10	5:30															2	3	4	4	19:50	
	15	4:50													4	3	4	7	9	13	46:50	
	20	4:10											1	4	3	9	9	10	18	22	82:50	
	25	4:10											4	7	9	10	11	22	21	22	112:50	
	30	3:50										2	9	9	9	15	22	22	22	52	168:50	
	35	3:50										8	9	10	17	22	22	22	22	93	231:50	
	Limit Line																					
	40	3:30									3	10	9	19	22	21	22	22	43	112	289:50	
	45	3:30									7	9	18	22	22	22	22	22	80	112	342:50	
	50	3:30									9	17	21	22	22	22	22	25	113	112	391:50	
	55	3:10								1	14	22	21	22	22	22	22	58	113	113	436:50	
60	3:10								3	21	22	22	22	21	22	27	86	113	113	478:50		
<b>210</b>	5	7:00																		0	7:00	
	10	5:40															3	3	4	5	22:00	
	15	4:40												1	4	4	3	9	9	14	51:00	
	20	4:20											3	3	5	9	9	9	21	22	88:00	
	25	4:00										1	4	9	10	9	13	22	22	22	119:00	
	30	4:00										5	9	10	9	18	21	22	22	63	186:00	
	35	3:40									3	9	9	9	21	22	22	22	21	107	252:00	
	Limit Line																					
	40	3:40									7	9	10	22	22	22	21	22	56	113	311:00	
	45	3:20								1	10	9	22	22	22	22	21	22	96	112	366:00	
	50	3:20								4	9	21	21	22	22	22	22	41	112	113	416:00	
	55	3:20								5	18	22	22	22	21	22	22	76	113	113	463:00	
60	3:20								11	22	21	22	22	22	22	29	101	113	113	505:00		
<b>215</b>	5	7:10																		0	7:10	
	10	5:50															4	4	3	5	23:10	
	15	4:50												3	3	4	4	9	9	16	55:10	
	20	4:30											4	4	6	9	9	10	21	22	92:10	
	25	4:10										3	5	10	9	9	16	21	22	29	131:10	
	30	3:50									1	8	9	9	9	21	22	21	22	74	213:10	
	Limit Line																					
	35	3:50									6	10	9	11	22	22	21	22	29	113	272:10	
	40	3:30								2	9	9	13	22	22	22	22	22	69	113	332:10	
	45	3:30								5	10	13	22	21	22	22	22	22	111	113	390:10	
	50	3:30								8	12	22	21	22	22	22	22	57	113	113	441:10	
	60	3:10								1	18	22	22	22	22	22	21	38	111	113	112	531:10
<b>220</b>	5	7:20																		0	7:20	
	10	5:40														1	4	4	3	6	25:20	
	15	5:00													4	4	3	5	10	9	17	59:20
	20	4:20											2	4	3	8	9	9	11	22	22	97:20

**Table 17-15.** Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Helium (Continued).  
(DESCENT RATE 60 FPM-ASCENT RATE 30 FPM)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw)																Total Ascent Time (min:sec)				
			Stop Times (min)																				
			190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10		
<b>220</b>	25	4:00											1	4	7	9	9	18	22	22	38	146:20	
	30	4:00										3	9	9	10	10	22	22	21	22	85	220:20	
	Limit Line																						
	35	3:40									1	9	9	9	14	22	22	22	22	40	113	290:20	
	40	3:40									6	9	9	16	22	22	22	22	22	84	113	354:20	
	45	3:40									9	10	16	22	22	22	22	22	35	113	112	412:20	
	50	3:20								3	9	16	22	21	22	22	22	22	75	112	113	466:20	
55	3:20								4	14	22	21	22	22	22	22	26	107	113	112	514:20		
<b>225</b>	5	7:30																			0	7:30	
	10	5:50															2	4	4	3	7	27:30	
	15	4:50												2	3	4	4	6	9	9	19	63:30	
	20	4:30											3	4	4	9	9	9	13	22	22	102:30	
	25	4:10										2	4	9	9	9	10	19	22	22	47	160:30	
	30	4:10										7	9	9	9	13	22	22	22	21	98	239:30	
	Limit Line																						
	35	3:50									4	10	9	9	17	22	22	22	22	54	113	311:30	
	40	3:50									10	9	9	20	22	21	22	22	22	100	113	377:30	
	45	3:30								4	9	9	21	22	22	22	21	22	51	113	113	436:30	
50	3:30								7	9	20	21	22	22	22	22	22	91	113	113	491:30		
55	3:30								8	18	22	22	22	21	22	22	38	112	113	113	540:30		
<b>230</b>	5	7:40																			0	7:40	
	10	6:00															3	4	4	4	7	29:40	
	15	5:00												3	4	3	4	7	9	10	19	66:40	
	20	4:20										1	4	4	4	9	10	9	15	21	22	106:40	
	25	4:20										4	5	9	10	9	9	22	22	22	57	176:40	
	30	4:00									2	8	9	10	9	15	22	22	22	22	110	258:40	
	Limit Line																						
	35	4:00									8	9	10	9	20	22	22	21	22	68	112	330:40	
	40	3:40								4	9	10	10	22	22	22	21	22	24	113	113	399:40	
	45	3:40								8	9	12	22	21	22	22	22	22	67	113	113	460:40	
50	3:20							1	10	11	22	21	22	22	22	22	23	107	113	113	516:40		
55	3:20							3	9	22	22	22	22	22	22	21	56	113	112	113	566:40		
<b>235</b>	5	7:50																			0	7:50	
	10	5:50														1	3	4	4	4	8	31:50	
	15	4:50											1	3	4	4	3	9	9	9	21	70:50	
	20	4:30										3	3	4	6	9	10	9	16	22	22	111:50	
	25	4:10									2	4	6	10	9	9	11	22	22	22	68	192:50	
	30	4:10									4	10	9	9	9	18	22	22	22	30	113	275:50	
	Limit Line																						
	35	3:50								3	9	9	9	11	22	21	22	22	22	81	113	381:50	
	40	3:50								8	9	10	13	22	22	22	22	21	39	113	113	421:50	
	45	3:30							3	9	9	15	22	22	22	22	22	21	85	113	113	485:50	
50	3:30							5	10	15	22	21	22	22	22	22	35	113	113	112	541:50		

**Table 17-15.** Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Helium (Continued).  
(DESCENT RATE 60 FPM-ASCENT RATE 30 FPM)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw)														Total Ascent Time (min:sec)								
			190	180	170	160	150	140	130	120	110	100	90	80	70	60		50	40	30	20	10			
<b>240</b>	5	8:00																		0	8:00				
	10	6:00													2	3	4	4	4	8	33:00				
	15	5:00										2	4	3	4	4	9	9	10	22	75:00				
	20	4:20								1	3	4	4	7	9	10	9	18	22	23	118:00				
	25	4:20								4	3	9	9	9	9	14	22	21	22	79	209:00				
	30	4:00							1	7	9	9	10	9	20	22	22	22	42	113	294:00				
	Limit Line																								
	35	4:00								6	10	9	9	13	22	22	22	22	22	95	113	373:00			
	40	3:40							3	9	9	9	17	22	22	22	22	22	53	113	113	444:00			
	45	3:40							7	9	9	19	22	22	22	21	22	22	102	112	112	510:00			
50	3:40							9	10	19	22	21	22	22	22	22	52	113	113	113	568:00				
<b>245</b>	5	7:50																		1	9:10				
	10	6:10													3	3	4	4	4	9	35:10				
	15	5:10										3	4	4	3	5	9	10	11	22	79:10				
	20	4:30								2	4	3	4	9	9	9	10	20	22	31	131:10				
	25	4:10								1	4	5	9	9	9	10	15	22	22	90	226:10				
	Limit Line																								
	30	4:10								3	8	10	9	9	11	21	22	22	22	55	113	313:10			
	35	3:50							1	9	9	10	9	16	22	22	22	22	22	111	113	395:10			
	40	3:50							7	9	9	9	21	21	22	22	22	22	69	113	113	467:10			
	45	3:30						1	10	9	10	22	21	22	22	22	22	28	111	113	113	534:10			
50	3:30						4	9	11	22	21	22	22	22	22	22	70	113	113	113	590:10				
<b>250</b>	5	8:00																		1	9:20				
	10	6:20													4	4	3	4	5	9	37:20				
	15	5:00									1	4	3	4	4	6	9	9	14	21	83:20				
	20	4:40									3	4	4	5	9	9	9	10	21	22	40	144:20			
	25	4:20									3	4	6	9	9	10	9	18	21	22	102	243:20			
	Limit Line																								
	30	4:00							1	5	9	9	9	10	13	21	22	22	22	68	113	332:20			
	35	4:00							5	9	9	9	10	19	22	21	22	22	34	113	113	416:20			
	40	3:40							1	9	10	9	11	22	22	21	22	22	22	86	113	113	491:20		
	45	3:40							5	10	9	13	22	22	22	22	22	21	44	113	113	113	559:20		
50	3:40							8	9	15	22	21	22	22	22	22	22	89	113	113	112	620:20			
<b>255</b>	5	8:10																		2	10:30				
	10	6:10													1	4	4	3	4	6	9	39:30			
	15	5:10													2	4	4	3	4	7	9	10	14	22	87:30
	20	4:30									1	4	4	3	6	10	9	9	11	22	22	49	158:30		
	25	4:10									1	4	3	8	9	10	9	9	20	22	22	21	113	259:30	
	Limit Line																								
	30	4:10								3	6	9	10	9	9	16	22	21	22	22	82	113	113	352:30	
	35	4:10								8	10	9	9	10	21	22	22	22	22	47	113	113	113	436:30	
	40	3:50								5	9	9	10	14	22	22	22	21	22	22	103	113	112	514:30	
	45	3:50								9	9	10	17	22	22	21	22	22	22	61	113	112	113	583:30	
50	3:30								3	9	9	19	22	21	22	22	22	27	102	113	113	113	647:30		

**Table 17-15.** Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Helium (Continued).  
(DESCENT RATE 60 FPM-ASCENT RATE 30 FPM)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw)															Total Ascent Time (min:sec)				
			Stop Times (min)																			
			190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	
<b>260</b>	5	8:20																			2	10:40
	10	6:20													2	4	4	3	4	6	10	41:40
	15	5:20										3	4	4	4	3	8	10	9	16	22	91:40
	20	4:40								3	3	4	4	7	10	9	9	13	22	22	58	172:40
	25	4:20							2	4	4	9	10	9	9	9	22	22	22	32	113	275:40
	Limit Line																					
	30	4:00						1	3	9	9	9	9	10	18	22	21	22	22	95	113	371:40
	35	4:00						3	9	9	10	9	12	22	22	22	22	21	63	113	113	458:40
	40	4:00						9	9	9	10	17	22	22	22	22	21	31	110	112	113	537:40
	45	3:40					4	9	9	10	20	22	22	22	22	22	22	78	113	113	112	608:40
<b>265</b>	5	8:30																			3	11:50
	10	6:30													3	4	4	3	4	7	9	42:50
	15	5:10								1	4	4	3	4	4	9	9	9	19	22	96:50	
	20	4:30							1	3	4	4	3	9	10	9	9	15	22	22	68	187:50
	25	4:30							4	4	5	10	9	9	9	12	22	22	21	45	113	293:50
	Limit Line																					
	30	4:10						2	5	9	9	10	9	9	21	22	22	21	22	109	113	391:50
	35	4:10						6	10	9	9	9	16	22	22	21	22	22	78	113	113	480:50
	40	3:50					3	10	9	9	9	21	22	22	22	22	22	42	113	113	113	560:50
	45	3:50					8	9	9	12	22	22	22	22	21	22	22	97	112	113	113	634:50
<b>270</b>	5	8:40																			3	12:00
	10	6:20											1	3	4	4	3	4	8	9	45:00	
	15	5:20								2	4	4	4	3	5	9	9	10	20	21	100:00	
	20	4:40							2	4	3	4	5	9	9	10	9	17	22	22	77	202:00
	25	4:20						2	4	3	8	9	9	9	10	13	22	22	22	56	113	311:00
	Limit Line																					
	30	4:20						4	7	9	9	9	10	10	22	22	22	21	32	113	113	412:00
	35	4:00						1	9	9	10	9	9	18	22	22	22	22	93	113	112	502:00
	40	4:00						7	10	9	9	12	21	22	22	22	22	60	113	112	113	585:00
	45	3:40				3	9	9	9	16	22	21	22	22	22	22	22	104	113	112	113	660:00
<b>275</b>	5	8:50																			4	13:10
	10	6:30											2	3	4	4	4	3	9	9	47:10	
	15	5:30								4	4	3	4	4	5	10	9	9	22	22	105:00	
	20	4:50							3	4	4	4	6	9	9	10	9	19	22	22	87	217:00
	Limit Line																					
	25	4:30						4	3	4	9	9	9	10	9	16	22	21	22	69	113	329:00
	30	4:10					2	3	9	9	10	9	9	13	22	22	22	21	45	113	113	431:00
	35	4:10						5	9	9	9	10	9	21	22	22	22	21	27	104	113	525:00
	40	3:50				2	9	9	10	9	15	22	21	22	22	22	22	77	113	113	113	610:00
	45	3:50				7	9	9	9	19	22	22	22	22	22	21	44	110	113	113	113	686:00

**Table 17-15.** Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Helium (Continued).  
(DESCENT RATE 60 FPM-ASCENT RATE 30 FPM)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw)																Total Ascent Time (min:sec)			
			190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40		30	20	10
<b>280</b>	5	8:40																	1	4	14:20	
	10	6:40												3	3	4	4	4	3	9	10	49:20
	15	5:20							1	4	4	4	3	4	7	9	9	12	21	22	109:20	
	20	4:40						1	4	4	3	4	8	9	9	9	10	21	22	22	98	231:20
	Limit Line																					
	25	4:20				1	4	4	5	9	9	10	9	9	18	22	22	22	80	113	346:20	
	30	4:20				3	5	10	9	9	9	10	15	22	22	22	21	59	113	113	451:20	
	35	4:00				1	7	10	9	9	9	12	22	22	21	22	22	37	109	113	113	547:20
40	4:00				6	9	9	9	10	18	22	22	21	22	22	22	95	113	112	113	634:20	
45	3:40			1	9	10	9	10	22	22	22	21	22	22	22	59	113	113	113	113	712:20	
<b>285</b>	5	8:50																	1	4	14:30	
	10	6:50											4	3	4	4	4	4	9	11	52:30	
	15	5:30							3	3	4	4	4	3	8	9	10	13	22	23	115:30	
	20	4:50						3	4	3	4	4	9	9	9	9	12	22	22	21	108	248:30
	Limit Line																					
	25	4:30				3	4	3	7	9	10	9	9	9	9	21	22	22	21	94	112	364:30
	30	4:10				1	4	7	9	9	10	9	9	18	22	22	22	22	73	113	113	472:30
	35	4:10				3	9	9	10	9	9	14	22	22	22	22	22	48	113	113	113	569:30
40	4:10				10	9	9	9	10	21	22	22	22	21	22	32	101	113	113	113	658:30	
45	3:50			5	9	10	9	14	21	22	22	22	22	22	22	78	113	113	112	113	738:30	
<b>290</b>	5	9:00																	2	4	15:40	
	10	6:40										1	4	3	4	4	4	5	9	12	55:40	
	15	5:40							4	4	3	4	4	4	9	9	9	15	22	31	127:40	
	20	4:40						1	3	4	4	3	5	9	10	9	9	14	22	27	112	263:40
	Limit Line																					
	25	4:20				1	4	3	4	8	10	9	9	9	11	22	22	21	26	102	113	383:40
	30	4:20				3	9	9	10	9	9	14	22	22	22	22	22	48	113	113	113	492:40
	35	4:20				6	10	9	9	9	10	17	22	22	22	21	22	66	112	113	113	592:40
40	4:00				4	9	10	9	9	12	22	22	22	21	22	44	107	113	112	113	682:40	
45	4:00			9	9	10	9	17	22	22	22	22	21	22	27	92	113	113	112	113	764:40	
<b>295</b>	5	9:10																	3	3	15:50	
	10	6:50										2	4	3	4	4	4	5	9	14	58:50	
	15	5:30							2	3	4	4	4	3	5	9	9	9	18	22	38	139:50
	20	4:50						2	4	3	4	4	6	9	9	10	9	16	22	36	113	278:50
	Limit Line																					
	25	4:30				2	4	4	4	10	9	9	9	10	12	22	22	22	34	106	113	401:50
	30	4:10				1	4	5	9	9	9	10	9	10	22	22	22	27	97	113	113	513:50
	35	4:10				2	8	9	10	9	9	9	21	22	21	22	22	81	113	113	113	610:50
40	4:10				8	9	9	10	9	15	22	22	22	22	21	58	113	112	113	113	707:50	
<b>300</b>	5	9:20																	3	4	17:00	
	10	7:00											3	4	3	4	4	4	6	9	15	62:00

**Table 17-15.** Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Helium (Continued).  
(DESCENT RATE 60 FPM-ASCENT RATE 30 FPM)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw) Stop Times (min)															Total Ascent Time (min:sec)					
			190	180	170	160	150	140	130	120	110	100	90	80	70	60	50		40	30	20	10	
<b>300</b>	15	5:40							3	4	3	4	4	4	5	9	9	10	19	22	45	151:00	
	20	5:00					4	3	4	4	3	8	9	9	10	9	18	22	22	47	112	294:00	
	Limit Line																						
	25	4:40				4	4	3	6	10	9	9	9	10	15	22	21	22	44	109	113	420:00	
	30	4:20			2	4	7	9	10	9	9	9	13	22	22	22	22	37	101	113	113	529:00	
	35	4:20			5	9	9	9	10	9	10	22	22	22	22	22	26	93	113	112	113	638:00	
40	4:00		3	9	9	9	10	9	18	22	22	22	22	22	22	73	113	112	113	113	733:00		
<b>310</b>	Limit Line																						
	6	9:00																3	4	4	3	24:20	
	10	7:00										1	4	4	3	4	4	4	7	10	17	68:20	
	15	5:40						2	4	3	4	4	3	4	8	9	9	12	22	21	60	175:20	
	20	5:00				3	3	4	4	4	4	9	10	9	9	11	22	22	21	67	113	325:20	
	25	4:40			3	4	4	4	9	9	9	10	9	9	20	22	22	22	65	113	113	457:20	
	30	4:20		2	4	5	9	9	9	10	9	9	18	22	22	22	22	57	111	113	113	576:20	
	35	4:20		3	9	9	9	10	9	9	17	21	22	22	22	22	48	103	113	113	113	684:20	
40	4:00	1	9	9	10	9	9	13	22	21	22	22	22	22	22	36	94	112	113	113	782:20		
<b>320</b>	Limit Line																						
	6	9:00																1	4	3	4	4	26:40
	10	7:20											3	4	4	3	4	4	4	9	9	20	74:40
	15	5:40						1	3	4	4	4	3	4	4	9	10	9	16	21	22	75	199:40
	20	5:00			2	4	3	4	4	4	4	7	9	9	10	9	16	22	21	25	88	112	359:40
	25	4:40		3	4	3	4	7	9	10	9	9	9	13	22	22	22	28	87	113	113	497:40	
	30	4:20	1	4	4	9	9	9	9	10	9	11	21	22	22	22	26	82	113	112	113	618:40	
	35	4:20	3	7	9	10	9	9	9	10	22	22	21	22	22	22	73	113	113	113	112	731:40	
40	4:20	9	9	9	9	10	9	19	22	22	21	22	22	22	22	60	107	113	113	113	833:40		

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